European Commission

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 1

Economics and the environment

The implementation challenge of the Water Framework Directive

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 1

Economics and the Environment – The Implementation Challenge of the Water Framework Directive

Produced by Working Group 2.6 - WATECO

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Introduction - A Guidance Document: What For?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – 'the Directive'). It focuses on the implementation of its economic elements in the broader context of the development of integrated river basin management plans as required by the Directive.

TO WHOM IS THE GUIDANCE DOCUMENT ADDRESSED?

We believe the Guidance will help you in *doing the job,* whether you are:

- Undertaking the economic analysis yourself;
- Leading and managing experts undertaking the economic analysis;
- Using the results of the economic analysis for aiding decision making and supporting the development of river basin management plans; or
- Reporting on the economic analysis to the European Commission as required by the Directive.

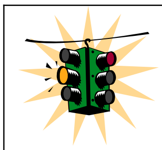
WHAT CAN YOU FIND IN THIS GUIDANCE DOCUMENT?

- **The role of economics in the Water Framework Directive.** What are the key economic elements of the Water Framework Directive? Where in the Directive are these elements made explicit or referred to? How do these elements fit with the Directive's overall river basin planning process?

- **Planning the economic analysis.** How should the process of conducting the economic analysis be planned and organised? When and how should economic expertise be integrated with non-economic expertise? How can adequate financial and human resources be allocated to the economic analysis? Which role could stakeholders and the public play in the economic analysis? How to deal with limited information and expertise? How can external consultants and advisers be used to provide external support? Which elements of the analysis should be undertaken by 2004?

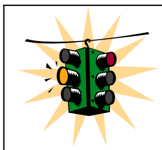
- **Methodologies for undertaking the economic analysis.** What methodology should be used to integrate economics in the preparation of river basin management plans? How can cost-effective measures be selected to build a programme of measures? How can costs and cost-recovery levels be assessed? When is it necessary to assess benefits? How and when can economics be used to support the justification for derogation?

- **Reporting the results of the economic analysis**. How should the different results of the economic analysis be reported? Which results of the economic analysis should be reported by 2004? Which indicators and variables should be computed to inform and consult the public?



Look out! The methodology from this Guidance Document must be adapted to national and regional/local circumstances

The Guidance Document proposes an overall methodological approach. Because of the diversity of circumstances within the European Union, the way to deal with the logical approach and address specific issues will vary from one river basin to the next. This proposed methodology may therefore need to be tailored to specific circumstances.



Look out! What you will not find in this Guidance Document

The Guidance Document focuses on the economic analysis required for supporting the development of River Basin Management Plans, with specific attention to the 2004 requirements of the Directive. The Guidance does not focus on:

- How to develop incentive pricing policies according to Article 9;
- How to develop and implement other economic and fiscal instruments as mentioned in Annex VI;
- How to develop an economic analysis for supporting the development of penalties that provide incentive according to Article 23.

…AND WHERE?

The role of economics in the Water Framework Directive

Section 2 – Which role for economics in the Directive?; **Annex B1** – The economic elements of the Water Framework Directive, original legal text; **Annex B2** – Glossary;
Also: **Section 3** – Roadmap to implementing the Directive's economic elements.

Planning the economic analysis

Section 5 – Ensuring coherency with the overall implementation process;
Section 4 – 2004: the first milestone for the economic analysis;
Annex C – Illustrative terms of reference for *scoping* activities and *stakeholder analysis*;
Also: **Section 3** – Roadmap to implementing the Directive's economic elements; **Annex A1** – The joint activities and working groups of the Common Implementation Strategy; **Annex A2** – Lists and contacts of the WATECO group.

Methodologies for undertaking the economic analysis

Section 3 – Roadmap to implementing the Directive's economic elements;
Annex D1 – Information sheets; and **Annex D2a** - Analysis for derogation;
Also: **Annex D3** – List of references; **Annex A1** – Relevant references and Guidance from other working groups of the Common Implementation Strategy.

Reporting the results of the economic analysis

Section 5 – Ensuring coherency with the overall implementation process;
Section 4 – 2004: the first milestone for the economic analysis;
Annex C – Key summary and reporting tables

Section 1 – Implementing the Directive: Setting the Scene

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

DECEMBER 2000: A MILESTONE FOR WATER POLICY

A Long Negotiation Process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that today form the foundation of the Water Framework Directive.

NEW CHALLENGES IN EU WATER POLICY

What is the Purpose of the Directive?

The Directive establishes a framework for the protection of all water bodies (including inland surface waters, transitional waters, coastal waters and groundwater) which:

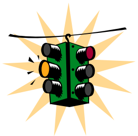
- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes a sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

… and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What Are the Key Actions that Member States Need to Take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs), and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out the inter-calibration of the ecological status classification systems by 2006 (*Article 2(22); Annex V*);
- To make operational the monitoring of water status by 2006 (*Article 8*);
- Based on sound monitoring and on the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*); and
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).



Look out!
Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be made explicit in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage in two further six- year cycles of planning and implementation of measures.

Developing the Right Process – Information, Consultation and Participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007; and
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

Integration of environmental objectives, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;

Integration of all water resources, combining fresh surface water and groundwater bodies, wetlands, transitional and coastal water resources **at the river basin scale**;

Integration of all water uses, functions, values and impacts into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good, investigating both point-source and diffuse pollution, etc.;

Integration of disciplines, analyses and expertise, combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;

Integration of water legislation into a common and coherent framework. The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;

Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;

Integration of stakeholders and the civil society in decision-making, by promoting transparency and information to the public, and by offering a unique opportunity for involving stakeholders in the development of river basin management plans;

Integration of different decision-making levels that influence water resources and water status, be local, regional or national, for an effective management of all waters; and

Integration of water management from different Member States, for river basins shared by several countries, existing and/or future Member States of the European Union.

WHAT IS BEING DONE TO SUPPORT IMPLEMENTATION?

Activities to support the implementation of the Water Framework Directive are under way both in Member States and in countries candidate for accession to the European Union. Examples of activities include public consultation, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission Agree on a Common Implementation Strategy

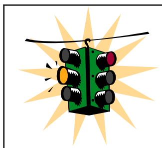
The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance (see *Annex A*). A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of the overall decision body for the Common Implementation Strategy.

The WATECO Working Group

A working group has been created for dealing specifically with economic issues. The main short-term objective of this working group named *WATECO* (for *WATer and ECOnomics*) was the development of a non-legally binding and practical guidance for supporting the implementation of the economic elements of the Water Framework Directive with emphasis on its 2004 requirements. The members of *WATECO* are economists, technical experts and stakeholders from European Union Member States and from a limited number of candidate countries to the European Union.

To ensure an adequate input and feedback during the Guidance development phase from a wider audience, and to evaluate earlier versions of the Guidance Document, the *WATECO* group has organised several discussions and feedback events such as meetings, workshops and conferences.



Look out! You can contact the experts involved in the *WATECO* activities

The list of *WATECO* members with full contact details can be found in *Annex A.* If you need input into your own activities, contact a member from *WATECO* in your country. If you want more information on specific scoping and testing pilot studies, you can also contact directly the persons in charge of carrying out these studies.

Developing the Guidance Document: An Interactive Process

Within a very short time period, a large number of experts and stakeholders have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- **Regular meetings** of around 40 experts and stakeholder members of *WATECO*;
- Organisation of **two workshops** to present and discuss the activities and preliminary output of *WATECO*:
    - ***With a larger number of stakeholders (May 2001 - Bruxelles, Belgium);***
    - ***With experts from candidate countries (November 2001 - Szentendre, Hungary).***
- A series of **scoping and testing pilot studies** to assess the feasibility of the overall economic approach (e.g. in terms of information and expertise requirements) and of specific elements of this approach (see *Annex E*).
    - ***In national river basins*** in the United Kingdom, Germany, Spain, Portugal, Sweden, Greece and France;
    - ***In the international basin of the Scheldt River*** as part of a collaborative effort between the Netherlands, France and the three Belgium regions of Wallonia, Flanders and Bruxelles.
- Regular **interactions with experts from other working groups of the Common Implementation Strategy**, mainly those dealing with the assessment of pressures and impacts, designation of heavily modified water bodies and river basin planning. For example, key to many of the above-mentioned pilot studies has been the involvement of non-*WATECO* experts and the integration between economic and technical expertise, e.g. for testing the feasibility of applying cost-effectiveness methods.

Two events for discussing and evaluating draft versions of the Guidance Document:

- A **conference** (March 2002 – Lille, France) to present and discuss the preliminary output of the *WATECO* group (draft Guidance Document, results of scoping and testing activities) to a wide range of **experts and stakeholders;** and
- A **workshop with a small group of water managers** (April 2002 – Bruxelles, Belgium) that are leading the development of river basin management plans in their respective countries, in order to evaluate expectations from water managers *vis-à-vis* the economic analysis and adapt the Guidance to ensure a better integration of the output of the economic analysis into the decision making process.

Section 2 – Which Role for Economics in the Directive?

This Section outlines the economic elements of the Water Framework Directive. It aims at: (i) providing an understanding of the role of economics in water policy making; (ii) critically reviewing the references to economics and economic requirements in the Water Framework Directive; and (iii) integrating these into the decision making process aimed at developing river basin management plans.

WHICH ROLE FOR ECONOMICS IN WATER POLICY?

With increasing scarcity of both water resources and financial resources allocated to the water sector, economic analysis and expertise is increasingly called for in supporting water management and policy decisions. Overall, a sound economic analysis can help in:

- Understanding the **economic issues and tradeoffs at stake** in a river basin – restoring water quality can impact on economic sectors that can have significant role and importance in the local, regional and national economy (be it in terms of overall economic output, trade or employment). Also, different economic sectors are often competing for the same (good quality) water resources;
- Assessing the **least-costly way** for the economy or for specific economic sectors **achieving well-defined environmental objectives** for water resources. Clearly, this ensures best use of limited financial resources allocated to the water sector;
- Assessing the **economic impact of proposed programmes of measures** aimed at improving water status (i.e. who are the *losers*, who are the *gainers*). In some cases, this assessment may stress the need for developing specific accompanying measures that would (partially) compensate *losers*, and thus facilitate the implementation of proposed measures;
- Assessing regions or water bodies where **environmental objectives need to be made less stringent to account for economic and social impacts** in a search for overall sustainability; and
- Supporting the **development of economic and financial instruments** (e.g. water prices or supplementary measures such as pollution charges or environmental taxes), that may be effective in reaching environmental objectives.

Overall, the economic analysis is a **process of providing valuable information to aid decision-making** and should be an essential part of the overall approach for supporting decisions. The economic analysis is also a source of information of interest to stakeholders and the public in the context of information and consultation activities. For example, discussing significant water management issues in a river basin is likely to require information on who pollutes, who uses, which environmental impact occurs, but also on what it costs, who pays, who gains and who suffers from the current situation.

THE ECONOMIC ELEMENTS OF THE WATER FRAMEWORK DIRECTIVE

The Water Framework Directive clearly integrates economics into water management and water policy decision-making. To achieve its environmental objectives and promote integrated river basin management, the Directive calls for the application of economic principles (for example, the *polluter-pays principle*), economic approaches and tools (e.g. cost-effectiveness analysis) and instruments (e.g. water pricing). *Table 1* summarises the key functions of the economic analysis that are referred to in the Water Framework Directive text (see *Table 2*).

Table 1 – Different functions of the economic analysis in the Water Framework Directive

- To carry out an *economic analysis of water uses* in each River Basin District;
- To assess *trends* in water supply, water demand and investments;
- To identify areas designated for the protection of *economically significant aquatic species;*
- To designate heavily modified water bodies based on the assessment of changes to such water bodies and of the *impact* (including economic impact) on existing uses and *costs* of alternatives for providing the same beneficial objective;
- To assess current levels of *cost-recovery;*
- To support the selection of a programme of measures for each river basin district on the basis of *cost-effectiveness* criteria;
- To assess the potential role of *pricing* in these programmes of measures – implications on cost-recovery;
- To estimate the need for potential (time and objective) derogation from the Directive's environmental objectives based on assessment of *costs and benefits* and *costs* of alternatives for providing the same beneficial objective;
- To assess possible derogation resulting from new activities and modifications, based on assessment of *costs and benefits* and costs of alternatives for providing the same beneficial objective;
- To evaluate the costs of process and control measures to identify a *cost-effective* way to control priority substances.

Integrating Economics into Environmental Policy: The Novelty of the Water Framework Directive

Costs, discount rate, prices, taxes… The use of economic terms in the water sector in Europe has increased over recent years – and not only on the part of economists. Economic issues affect all people – as consumers who pay for water supply and sewerage services; as taxpayers for supporting heavy investments in the water sector; and increasingly as human beings, eager to protect water resources for themselves and for future generations.

Since the 1970s, advocating the *polluter-pays principle* in water policy has become the norm rather than the exception, although the level of application of this principle remains highly heterogeneous. Furthermore, the focus was on financial aspects rather than on economic costs. It is only in the early 1990s (not long before the Directive's negotiations were initiated) that attention started switching to the economic value of water.

This led to the production of many academic studies and analyses, but with limited emphasis placed on creating a link between empirical research and policy-making. With the Water Framework Directive, it is the first time in EU environmental policy that economic principles, tools and instruments are explicitly integrated into a piece of legislation, thus opening up an unique opportunity of making that link a reality.

Table 2 – Overview of the Economic Elements in the WFD

Reference	Summary Provisions
Preambles 11, 12, 31, 36, 38 and 43	• That the **polluter should pay;** • Take into account the **economic** and social development of the Community; • Lower objectives justified if **unreasonably expensive** to achieve good status; • Carry out an **economic analysis of water uses;** • Use **economic instruments** as part of the **programmes of measures;** • Apply the **principle of cost recovery of water services (including environmental and resource costs)** in accordance with the **polluter pays principle;** • Identifying **cost-effective** combination of measures for reducing pollution of priority substances.
Article 2: Definitions 38 and 39	Definition of water services – Definition of water use
Article 4: Environmental objectives *Designation of Heavily Modified Water Bodies (4.3)* *Environmental objectives and derogations (4.4, 4.5 and 4.7)*	An economic justification can be provided for designating Heavily Modified Water Bodies (*'….for reasons of technical feasibility and **disproportionate costs**….* '). Possible economic justification for derogation: • Time derogation if … *completing the improvements within the time scale would be disproportionately expensive… ;* • Objectives derogation if … *the achievement of these objectives would be infeasible or disproportionately expensive…* and there are *no other means which are a significantly better environmental option not entailing disproportionate cost;* • Derogation for new modification or sustainable economic activity, if benefits of this activity outweigh benefits from good water status and there are *no other means which are significantly better environmental option not entailing disproportionate cost.*
Article 5: Characteristics of the river basin district, review of the environmental impact of human activity and economic analysis of water use *Annex III: Economic Analysis*	As part of the analysis of the River Basin characteristics, an **economic analysis of water uses** must be conducted. According to specifications in Annex III, *the economic analysis shall contain enough information in sufficient detail to*: • Make the relevant calculations necessary for taking into account **cost recovery of water services**, *taking account of long term forecasts of supply and demand for water in the RBD and, where necessary:* *a) Estimates of the volume, prices and costs associated with water services:* b) *Estimates of relevant investment including forecasts of such investments.* • Make judgements about the most **cost effective combination of measures** in respect of water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures.
Article 6: register of protected area & Annex IV: Protected areas	Designation of areas for the protection of **economically significant aquatic species**.
Article 9: Recovery of costs for water services	Take account of the principle of **recovery of the costs of water services**, including **environmental and resource costs**, according to the ***polluter pays principle*** *Member states shall ensure by 2010* • *that **water pricing policies** provide adequate incentives for users to use water resource efficiently, and thereby contribute to the environmental objectives of this Directive »* • *An adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services…* Possibility to account for social, environmental and **economic effects** in defining pricing policy
Articles 11: Programme of measures & Annex VI: Lists of measures to be included within the programme of measures	Establishment of programme of measures with references to the analysis performed based on Article 5 (thus, the **economic analysis** of water use according to Annex III) and including as basic measure (b) **measures deemed appropriate for the purposes of Article 9** (i.e. recovery of costs for water services) Annex VI – part B (iii) mentions ***economic or fiscal instruments***
Article 13: River Basin Management Plans & Annex VII: River basin management plans	The river basin management plan shall cover: • A **summary of the economic analysis of water use** as required by Article 5 and Annex III.
Article 16 "Priority Substances"	Use of **cost-effectiveness criteria** for identifying best combination of product and process controls for controlling priority substances
Article 23 "Penalties"	Defining penalties may build on economic input, as these penalties have to be …*effective, proportionate and dissuasive…*

Note: the text in *italics* is the exact wording of the Directive. An exhaustive list of economic references in the Directive is given in *Annex B* and can be used as support to this Section.

WHICH ECONOMIC ANALYSIS FOR SUPPORTING IMPLEMENTATION?

The Water Framework Directive includes a specific Annex dealing with the economic analysis, i.e. Annex III. However, the comparison between the economic elements of the Directive reviewed above and the content of Annex III shows that not all components of the economic analysis required to support the implementation of the economic elements of the Directive are specifically spelt out in Annex III.

A difference is made between the ***explicit*** and ***implicit*** functions of the economic analysis, the term *explicit* referring to the economic components that are specifically outlined in Article 5 and Annex III (see *Figure 1*), and the term *Implicit* referring to references made to economic issues in other parts of the Directive text that will also require some economic analysis which has not been mentioned in Article 5 and Annex III (see *Figure 2*).

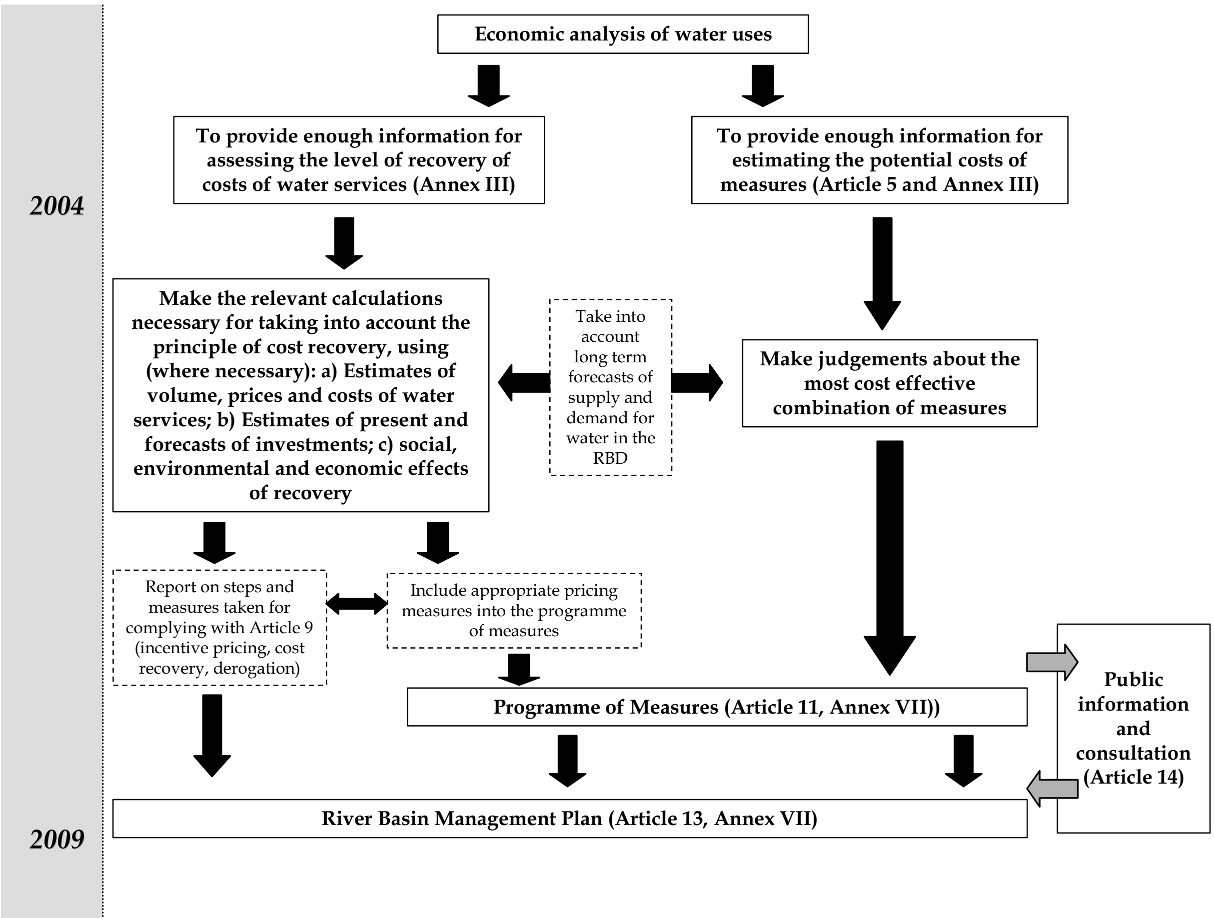


Figure 1 – The *Explicit* Economic Functions of the Economic Analysis

Look out!

Annex III indicates that the economic analysis conducted by 2004 should support the assessment of the most cost-effective combination of measures to be included in the Programme of Measures (Article 11). Such cost-effectiveness analysis requires an identification of environmental objectives for each water body, an assessment of possible measures to meet these objectives, an estimate of their costs and of their impact on the status of water bodies.

➢ *The economic analysis to be carried out by 2004 should pave the way for carrying out the cost-effectiveness analysis for the preparation of the programme of measures. Testing the cost-effectiveness of proposed measures will be carried out during the phase 2004-2009;*

➢ *The economic analysis undertaken by 2004 being the basis for output to be delivered at a later stage, it is important to ensure the information collected and analysis performed for 2004 already account for following requirements, such as the overview of significant water management issues (by 2007) or the development of integrated river basin management plans (by 2009). This may have implications, for example, on the spatial scale at which variables are computed (river basin district scale for the 2004 reporting versus more disaggregated scale for the overview of significant water management issues).*

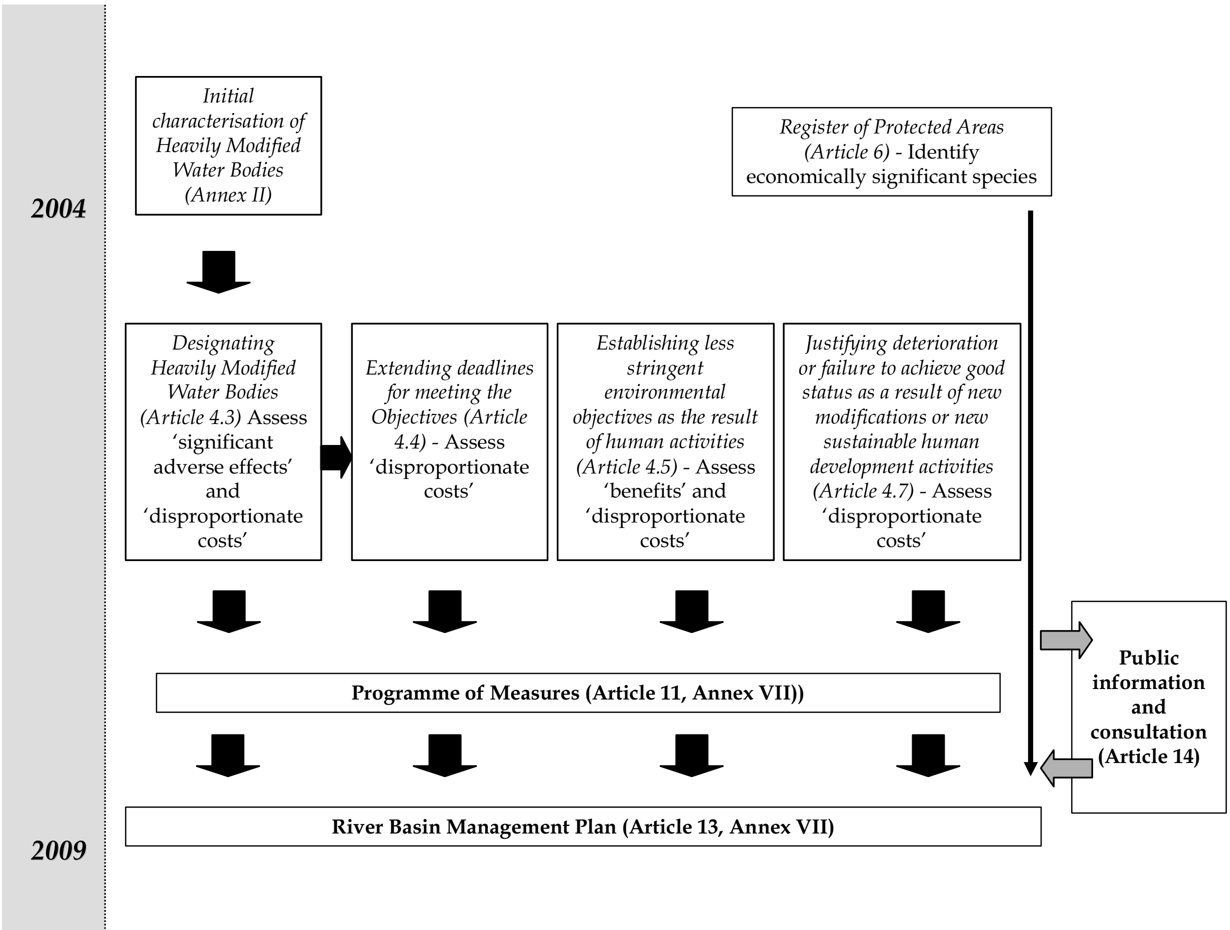


Figure 2 – The *Implicit* Economic Functions of the Economic Analysis

HOW CAN THIS GUIDANCE DOCUMENT HELP YOU?

This Guidance Document will help you to make the economic analysis a reality and to:

- Know when to establish 'knowledge links' with other disciplines for the preparation of the economic analysis and the programme of measures (*Section 3* and *Section 5*);
- Understand which information will be needed for carrying out the analysis and to fill the gaps once they have been identified (*Section 3* and *Section 5*);
- Estimate costs on the basis of common definitions (*Annexes A2* (Glossary) and *D1* (Estimating costs (and benefits)), and in particular to identify methods for estimating environmental and resource costs;
- Understand how to evaluate the role of pricing as an economic instrument (*Annex D1* (Pricing as an Economic Instrument)), but not how to develop these (*Section 3*);
- Provide some common tools for estimation of disproportionate costs (*Annex D1* (Disproportionate costs));
- Understand the timing requirements for submitting requests for derogation (*Section 3* and *Section 5*).

Dealing with economic issues and analyses: which tasks for the European Commission?

The economic analysis for supporting the development of river basin management plans and the assessment and development of pricing policies is clearly the responsibility of Member States. But the European Commission is mentioned at a few places in the Water Framework Directive in relation to economic analysis. More specifically:

- In the context of the submission of proposals of controls for priority substances (Article 16), the Commission *shall identify the appropriate* ***cost-effective*** *and proportionate level and combination of product and process controls for both point and diffuse sources…*;
- It shall also **publish a report** based (Article 18) on the summary reports submitted by Member States on the analysis required under Article 5 (Article 15), i.e. **including the economic analysis of water uses and subsequent analyses referred to in Annex III**;
- A Commission statement was added to the Directive's text at the time of adoption, stressing that *the Commission in his report will, with the assistance of the Member States, include a* ***cost-benefit study*****.**

Although scattered along the Directive's text, the different economic elements should be well integrated in the policy decision and management cycle (see *Figure 3*) to ensure it effectively aids and informs decision-making.

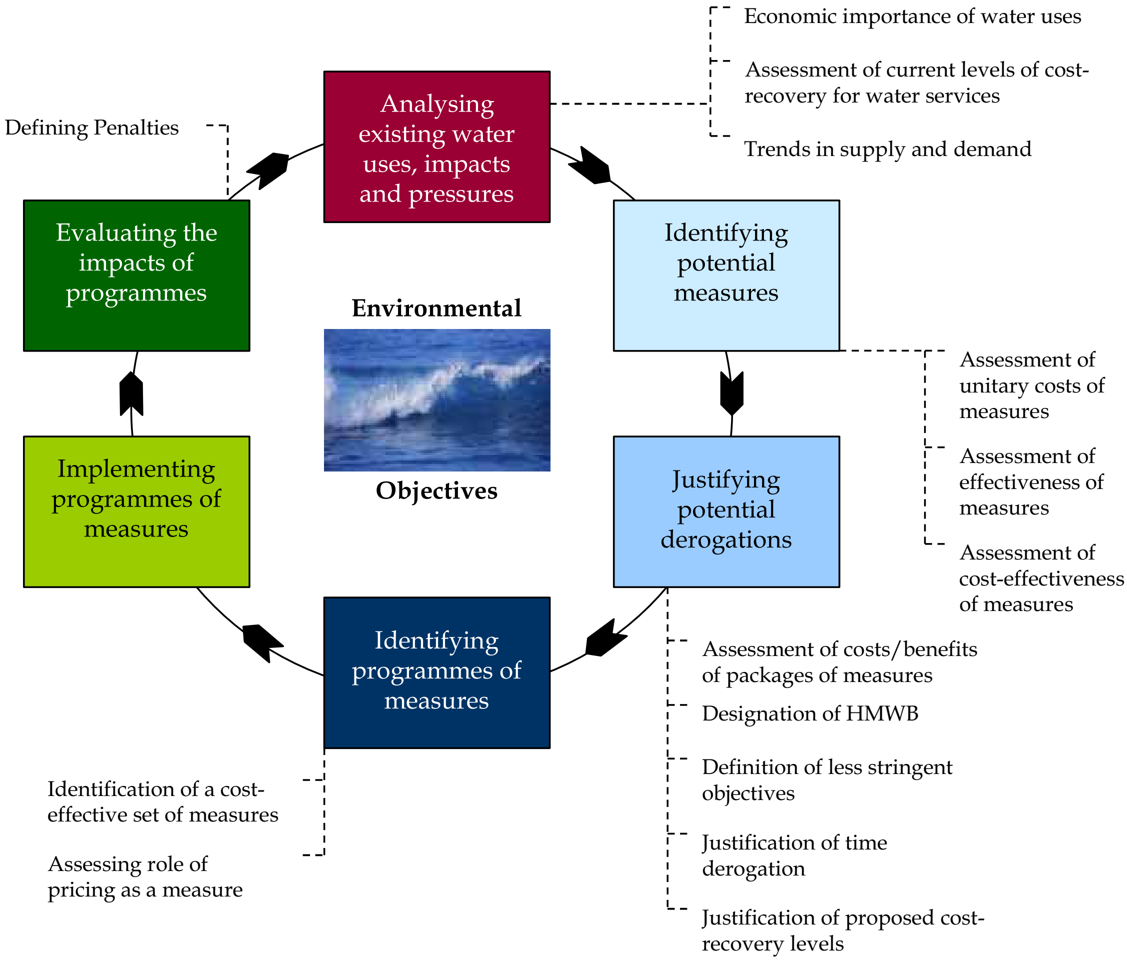
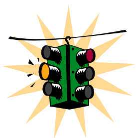
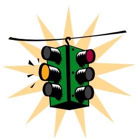


Figure 3 – Economic Elements are linked and must be integrated



Look out! There is no straight line on the economic analysis path…

Figure 3 illustrates in a simple manner the role economics can play in developing and implementing river basin management plans. In practice, however, the distinction between different tasks and the chronological order in which tasks take place is more complicated. For example, designating heavily modified water bodies requires looking simultaneously at environmental objectives, pressures and impacts, and measures for improving environmental quality.



Look out! Economics is only there to inform decision makers

Bear in mind: whether it is based on cost-effectiveness, cost-benefit assessment or any other economic method, the economic analysis does not *take the decision*! Similarly to other disciplines and expertise, it helps in taking better decisions by accounting for their economic dimensions and impact. Thus, it is important to ensure the economic analysis and its output is well integrated with other analyses and expertise aimed at supporting policy and management decisions.

Section 3 – Roadmap to Implementing the Directive's Economic Analysis

This Section lays out the key steps that you should consider going through to carry out the economic analysis to aid decision making for developing river basin management plans. This is only a roadmap: each Member State will need to find its own way based on local circumstances.

To support the development of river basin management plans, a three step economic analysis is proposed in this Section. This 3-step approach aims at providing a coherent framework to the different functions of the economic analysis required for the Water Framework Directive and identified in Section 2. It clearly integrates economic and technical issues, expertise and tools in:

- **Step 1 - Characterising the river basin** in terms of the economics of water uses, trends in water supply and demand and current levels of recovery of the costs of water services;
- **Step 2** - Identifying water bodies or group of water bodies not achieving the environmental objective of the Directive (i.**e. identifying gaps or risks of failure** in achieving objectives); and
- **Step 3** - Supporting the development of the **programme of measures** to be integrated in river basin management plans **through cost-effectiveness analysis** and justifying from an economic point of view possible (time, objective) derogation.

The objective of this Section is to set out these steps you might want to follow to carry out the economic analysis in a logical way. Section 4 will summarise what needs to be done to meet the 2004 requirements of the Water Framework Directive.

For each step, you find in this Section:	
Objective	The objective of the Step, also pointing out to the outputs to be produced in that Step.
Process	Each Step has been broken down in sub-steps and key actions. This Section distinguishes between actions to be undertaken by economists, those dealt with by technical experts (in ***green***) and those undertaken jointly (in *violet*).
Methodological Scope	For each step, there is a range of options for conducting the analysis, ranging from what is practical in the short-term to what is required by the Directive and what would constitute an economic best practice. The latter might not always be achievable due to data or human resource limitations or because of too-high supplementary costs (see *Annex C*).
References in this Guidance Document	Links with other documents in the Guidance that give you more in-depth description and illustration of what actually needs to be done.
Links with other tasks	Links with other tasks with which coordination is required for the development of integrated river basin management plans.
Likely information requirements	List of information (non-exhaustive, non-compulsory) likely to be required for the activities described in the process, from both the economic analysis and from other tasks (in ***green***). Overall, only the information that is required for the specific purpose of the economic analysis and for supporting management decision should be gathered – data should not be gathered for the sake of gathering data.

OVERALL APPROACH

In accordance to the specifications of the Water Framework Directive, the overall objectives of the three-step approach are:

- To aid decision making in selecting programmes of measures for achieving the environmental objectives of the Directive – an economic appraisal is made to rank measures and identify those that are the most cost-effective in achieving these objectives; and
- To ensure transparency in the real costs of water management interventions and help making informed decisions on the recovery of these costs for providing incentives to achieve the environmental objectives of the Directive.

In Figure 4, the graph and the timing charts on the right hand-side focus on the logical flow of the three step approach that should be followed to implement the economic aspects of the Water Framework Directive whilst respecting the Directive's own deadlines. In particular, the Figure 4 presents for each step its objectives, the type of analysis to be carried out, what the economic analysis feeds into and key deadlines. Although presented linearly, the analysis is iterative in nature: initial analysis will be based on existing information, but will be upgraded as new information and knowledge is obtained. This figure includes two areas where economic issues are at stake but that are more difficult to position in time and within this logical framework:

- The identification and designation of heavily modified water bodies (Article 4.3 of the Directive, see *Annex D2b*); and
- The assessment and justification of objective derogation because of new morphological modification, over-abstraction of aquifers or new sustainable economic activities (Article 4.7 of the Directive, see *Annex D2a*).

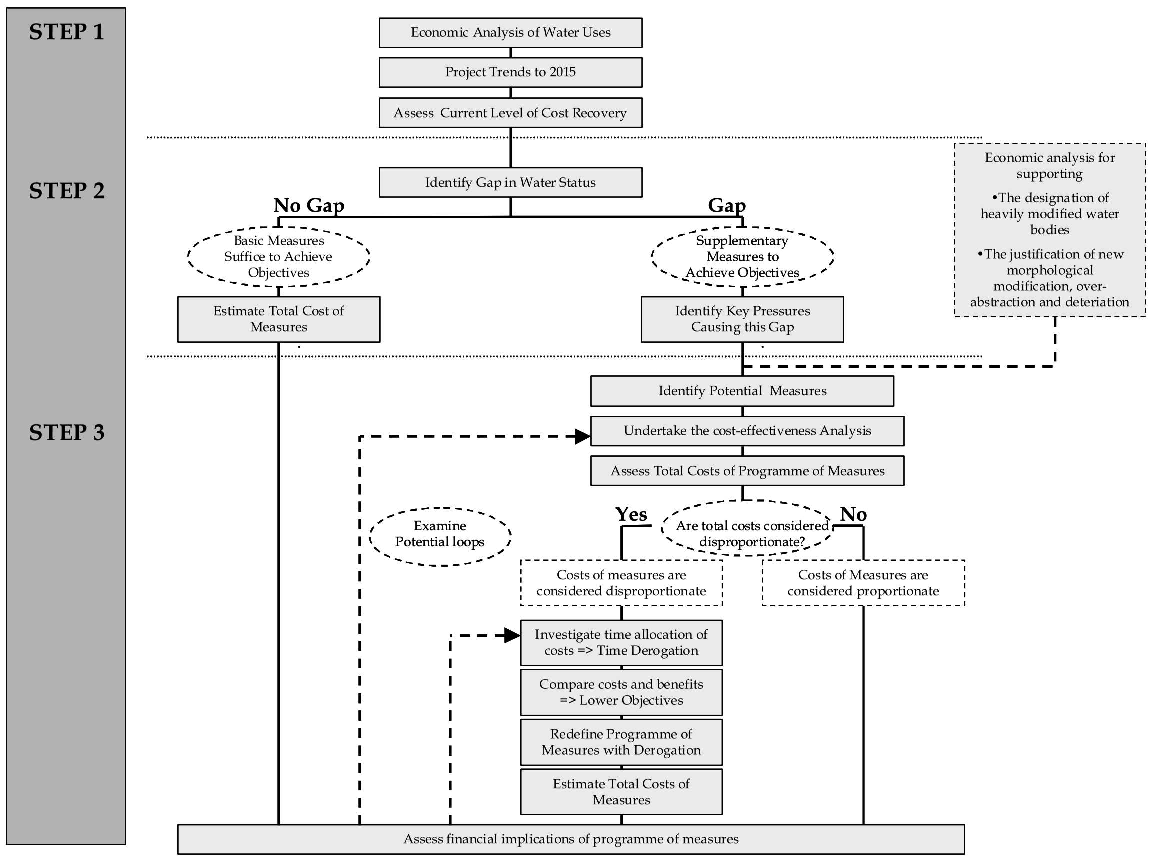
Although required in the Directive for 2008 as part of the draft river basin management plan put for consultation to the public, the designation of heavily modified water bodies and the justification for derogation resulting from new modifications and sustainable economic activities will be needed when developing the programme of measures. Thus, additional input from the economic analysis on these matters is likely to be required earlier on the basis of costs and benefits assessment.

Overall, it is important to stress that the deadlines for implementation are influenced by several drivers: (i) the Directive's own deadlines: these have been discussed in *Section 2*; (ii) logical steps for the analysis: this is what this *Section 3* focuses on (see also the critical path analysis presented in *Section 6*); (iii) interaction with other fields of competencies and with the consultation and participation process: see more on this in *Section 5*.

Before engaging in the 3-step approach, make sure to know where you are going!

Conducting a ***feasibility study*** (see *Section 5*) is recommended to assess whether the proposed approach can be made operational under actual conditions. It is important to do this assessment for future data requirements, as collecting (or creating) additional data can be long and resource-intensive. This feasibility study may include nation-wide and region-wide elements to assess the scale at which activities could best be performed.

Objective	The Three Steps	Feed Into	Timing
To characterise River Basins	STEP 1	• Economic Analysis of Water Uses • Identification of protected areas	By 2004
To identify significant water management issues and risk of non-compliance	STEP 2	• Preparatory documents for RBMP • Interim Overview of Significant Water Management Issues	By 2006 By 2007
To help identify a cost-effective programme of measures To assess cost-recovery and incentive pricing and their economic impact	STEP 3	• Draft RBMP • River Basin Management Plan • Adequate pricing and cost-recovery	By 2008 By 2009 By 2010

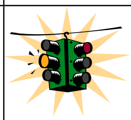


Is that it?

No, most of the steps of the economic analysis will need to be repeated at later stages as further management cycles are required and proposed. Furthermore, the Directive sets out very clear timeframes for each of these repetitions, timed slightly differently from this first iteration. Thus, be careful to respect future deadlines! The different interim evaluations specified by the Directive will be key in updating information and assumptions made doing the earlier analyses and will ensure better information is obtained for aiding decision-making.

Figure 4 - A Bird's View to the Three-Step Approach

STEP 1 – CHARACTERISING RIVER BASINS

Objectives		Look out!
To prepare an economic analysis of water use in order to analyse: ➢ Current water uses and their economic importance; ➢ Future trends in key economic drivers up to 2015; ➢ Current cost-recovery levels of water services.		This step will require a high level of coordination with other experts and stakeholders to build a common knowledge and representation of the River Basin.

Process	Look out!
STEP 1.1 – ASSESSING THE ECONOMIC SIGNIFICANCE OF WATER USES	
➢ Identify human pressures on water bodies; ➢ Localise water uses in the river basin district; ➢ Identify water uses and services by socio-economic sector (agriculture, industry, households and recreation); ➢ Assess the relative socio-economic importance of water uses; ➢ Identify areas designated for the protection of economically significant aquatic species.	*Potential indicators of importance:* ➢ ***Income, employment…;*** ➢ ***Volumes of water demands;*** ➢ ***Expression of economic and social preferences, via public consultation.***
STEP 1.2 – PROJECTING TRENDS IN KEY INDICATORS AND DRIVERS UP TO 2015	
➢ Assess trends of key hydrological and socio-economic factors/*drivers* that are likely to affect pressures (demography, climate, sector policies, e.g. common agricultural policy, technological development…); ➢ Identify proposed measures and planned investments for implementing existing water legislation; ➢ Forecast changes in pressures based on changes in economic and physical drivers and proposed water-related measures; ➢ Construct a *Business As Usual* scenario for pressuresConduct a sensitivity analysis on the baseline scenario and identify optimistic and pessimistic scenarios.	*Ensure coherence with projections and trends used for other river basins for national and EU policies and climate change.* *The business as usual scenario may first build on certain changes and thus need to be updated beyond 2004 in order to integrate changes in uncertain parameters.*
STEP 1.3 – ASSESSING CURRENT COST-RECOVERY	
➢ Estimate costs of water services, including financial, environmental and resource costs; ➢ Estimate the price/tariff currently paid by the users; ➢ Assess the extent of cost recovery by water service and sector; ➢ Assess the contribution to cost recovery from key water uses; ➢ If felt necessary, initiate review of incentive pricing properties of existing tariffs.	***This is needed to evaluate the effort needed to meet the 2010 deadline. Principles for allocating costs of water services to categories of water users will need to be defined in a coherent manner.***
	… Feed into
Key indicators of economic significance of water uses Baseline scenario and trends up to 2015 Current extent of cost-recovery } Areas designated for the protection of economically significant aquatic species	Economic Analysis of water uses by 2004. Register of Protected Areas.

Methodological Scope
➢ At the minimum, the economic role of water uses should be identified at the River Basin District (RBD) level, which is also the level of reporting to the Commission. However, this may be of little use for follow-up analyses and consultation required for developing river basin management plans that are likely to require lower disaggregation for economic information and indicators (e.g. sub-regions of the basin or sub-economic sectors); ➢ Initiating the integration of economic and technical information for developing an adequate integrated information base will be key to the activities aimed at characterising RBDs; ➢ If initiated at this stage, consultation would focus on seeking views on key issues and concerns in the RBD and on informing about the appraisal process.

References in this Guidance Document	**Links with other Tasks**
Annex D1: *Estimating costs, Reporting on Cost-recovery, Baseline scenario, Pricing as an Economic Instrument* ***Section 4***	Determination of Pressures and Impacts Characterisation of water bodies (e.g. transitional and coastal waters) Development of geo-referenced databases Overall River Basin Planning

Likely information requirements	**Look out!**
Step 1.1	
➢ Water abstractions and discharges by socio-economic categories and localisation; ➢ Economic importance of main water uses: turnover, employment, income, number of beneficiaries; ➢ Information (for example, quantity, prices or turnover, depending on availability) for characterising economically significant aquatic species.	*Key is to collect information that is relevant to water management issues in the river basin and to key economic sectors likely to be affected by the Directive Implementation. Combining biophysical and economic information will require agreement on common spatial scale of analysis and reporting.*
Step 1.2	
➢ Prospective analyses of likely development of key economic sectors/economic drivers influencing significant pressures; ➢ General information on population growth, economic growth, sector growth patterns, future policies and forecasts of the impact of climate change; ➢ Studies on existing and projected water balance; ➢ Inventory of existing measures (and costs) for complying with existing water legislation; ➢ Identification of technological developments in the water sector.	*A good understanding of regional planning issues will also be required for this step.* *Risk assessment is key: try to specify the degree of confidence when forecasting data.*
Step 1.3	
➢ Estimation of financial costs (broken down in operating, maintenance and capital costs); ➢ Evaluation of tax transfers, administrative costs and any other costs; ➢ Evaluation of environmental and resource costs as required; ➢ Extent of financial and environmental cost-recovery; ➢ If activities initiated for reviewing incentive pricing: current pricing structure and price elasticity, affordability criteria.	*Assessing incentive pricing properties of existing tariffs might be difficult in practice: it should be done so as to inform the future introduction of incentives in tariffs by 2009.* *Affordability is seen as key in some countries (e.g. candidate countries to the European Union).*

Illustration - Assessing the economic significance of water uses

The pilot projects undertaken in the context of developing this Guidance have illustrated the diversity of economic indicators that can be computed for assessing the economic significance of water uses.

- In the **Corfu** case study (see *Annex E*), tourism represents a key water use sector. Its economic importance was illustrated with absolute and relative (as compared to national values) values for mean annual employment (direct and indirect) and total number of nights spent by tourists in the island during the year;
- For the characterisation of the Scheldt estuary, undertaken as part of the **Scheldt** case study (see *Annex E*), the analysis concentrated mainly on navigation and harbour economic activities (leading to deepening and maintenance of the shipping channel) and economic land use in the area (agriculture, industry or harbour development leading to in-poldering and construction of dikes); and
- In addition to urban development and linked water services, the **Cidacos** case study (see *Annex E*) emphasised agricultural water use with the view to assess the indirect economic impact potential measures aimed at improving water status would have on the agricultural sector.

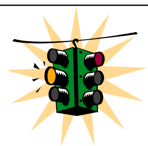
Water services, water uses and cost-recovery

The Water Framework Directive requires Member States to take account of the principle of recovery of the costs (including environmental and resource costs, see Article 9.1) of water services, also taking into account the *polluter pays principle*.

The assessment of cost recovery is relevant to water services (according to Article 2.(38)) but not to the wider circle of water uses (according to Article 2.(39)). However, the different water uses shall deliver an adequate contribution to the recovery of the costs of water services (Article 9.1), stressing the need to link water uses and services developed for mitigating the negative environmental impact of these uses.

Further issues on water services to be included in the analysis (based on transparency, effectiveness and proportionality criteria) and related implications are further developed in *Annex B3*.

STEP 2 – IDENTIFYING SIGNIFICANT WATER MANAGEMENT ISSUES

Objectives		Look out!
➢ To identify the gaps between the water status resulting from the baseline scenario and the Directive's objectives (good water status); ➢ To identify significant water management issues in each River Basin; ➢ To pave the way for the preparation of a programme of measures to address these issues.		Here, the economic analysis will use a high level of input from more technical analysis. However, sufficient economic elements should be provided to organise meaningful stakeholder consultation.

Process	Look out!
STEP 2.1 – WILL THERE BE GAPS IN WATER STATUS BY 2015?	
➢ Translate the forecast analysis of pressures and investments in the water sector into a forecast of impact; ➢ To assess the gap between the Directive's objectives with respect to water status and the water status achieved with the baseline scenario and optimistic and pessimistic variations: o If *gap* in water status ➢ ***Go to Step 2.2.a***; o If *no gap* in water status➢ ***Go to Step 2.2.b.***	***Assessing the gap in water status is equivalent of the more rigorous assessing risk of non-compliance.***
STEP 2.2.a – WHAT TO DO WHEN A "GAP" HAS BEEN IDENTIFIED?	
➢ *Gap*: identify water bodies where there is a gap; ➢ Define the main drivers of pressures (particularly, in terms of socio-economic groups) in order to facilitate the selection of appropriate measures in Step 3; ➢ Start identifying main options/measures likely to be investigated in subsequent steps as guide; ➢ Evaluate how socio-economic groups may be affected by main options/measures taken to reduce the gap.	*Public consultation is clearly specified in this Step. It will be important to have preliminary assessments of cost and socio-economic impacts to provide a basis for consultation.*
STEP 2.2.b – WHAT TO DO WHEN "NO GAP" HAS BEEN IDENTIFIED?	
➢ *No gap*: measures for complying with existing water legislation are sufficient to meet the Directive's objectives; ➢ In the preparatory documents, propose to confirm those objectives and the programme of measures required by existing water legislation; ➢ If considered necessary, estimate the costs of these basic measures and provide a first assessment of the impact of these measures on socio-economic sectors and cost-recovery ➢ Go to ***Step 3.4.***	***In Step 3, it might be necessary to reconfirm the costs of these basic measures and their cost-recovery impact in order to incorporate them in the final River Basin Management Plan.***
Key Outputs…	**… Feed into**
➢ Total costs of basic measures if *no gap* is identified; ➢ Identification of water bodies where gap is identified; ➢ Identification of the key sectors causing the gap and that might be affected and initial estimation of costs of additional measures for reaching good water status.	➢ Preparatory documents for the RBMP by 2006; ➢ Interim Overview of Significant Management Issues by 2007.

Methodological Scope
➢ Once gaps or risks of non-compliance have been identified for specific water bodies within a river basin, more detailed analysis might need to be carried out at the level of the concerned water bodies. For example, to obtain a better hand on pressures and their impact on the status of these specific water bodies; ➢ The assessment of the gap will require a good understanding of the hydrological cycle and relationships between, on one side, pressures and measures and, on the other side, impacts. The scale at which this assessment is required will be influenced by the identification of water bodies where gaps occur in the concerned river basin.

References in this Guidance Document	**Links with Other Tasks**
Annex D1: *Estimating costs* *Reporting for cost-recovery* ***Section 4***	Determination of Pressures and Impacts Overall River Basin Management

Information requirements	**Look out!**
Step 2.1	
➢ Methods and tools for transforming trends in pressures into trends in water status; ➢ Potential role of environmental modelling.	***Information for this Sub-Step will mostly come from other competencies at river basin level, such as from the experts in charge of determining pressures and impacts.***
Step 2.2.a	
➢ Identification of additional measures, including new investments, sector policies, economic instruments; ➢ Initial estimation of the costs of these additional measures; ➢ Preliminary (qualitative) assessment of socio-economic impacts on specific target groups.	***Economic analysis may play a role in the identification of key drivers for pressures. And socio-economic indicators are likely to be of interest to stakeholders and the public in the context of consultation.***
Step 2.2.b	
➢ Costs of basic measures; ➢ Estimation of the impact of basic measures on socio-economic groups.	*See for example reports of specific European water directives (e.g. Urban Waste Water Treatment Directive).*

Is that it?

Article 14 specifies that preparatory documents for the River Basin Management Plan will need to be produced three years before each future RBMP for adequate information and consultation of key stakeholders and the public. This requirement applies to the interim overview of the significant water management issues required for 2007 (and at least two years before each future plan in following planning cycles). Thus, ensuring results of the analysis respond to the demand for information from stakeholders and the public will be key to the type of information to be delivered and to the reporting format.

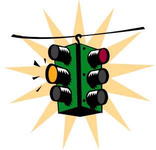
Illustrations - Using simulation models for assessing the gap in water status and supporting the cost-effectiveness analysis

Computer-based simulation models can prove useful for assessing the impact of pressures on water status and investigating the effectiveness/likely environmental impact of different measures:

- A mathematical hydrodynamic model was used in the **Alsace** case study (see *Annex E*) for investigating problems of salt (NaCl) intrusion into the groundwater aquifer. The model helped quantify the impact of planned measures on water quality, showing these measures would not be sufficient for achieving good water status;
- A simple mass balance model was developed for assessing the effectiveness of measures in the **Cidacos** case study (see *Annex E*). This model integrates sub-models for specific river reaches, and provided input into the cost-effectiveness analysis of measures targeting various economic sectors (agriculture, household, etc) and environmental issues (water quality, water quantity and over-abstraction).

Clearly, models should be used with caution, i.e. the user must understand the assumptions and information used for building and calibrating the model, and uncertainties in model prediction. However, properly developed and handled in interaction with stakeholders, they can provide effective platforms for analysis, understanding and discussion aimed at supporting decision.

STEP 3 – IDENTIFYING MEASURES AND ECONOMIC IMPACT

Objective		Look out!
➢ To provide an economic input into the definition of the programme of measures and help ranking possible measures based on cost-effectiveness criteria; ➢ To provide economic support to the assessment of derogation; ➢ To assess the potential impacts and financial implications of the programme.		This step is the key economic input into the preparation of the RBMP (*Article 13*). It is important efforts are targeted to areas and issues required for aiding decision making.

Process	Look out!
STEP 3.1 – EVALUATING THE COSTS and EFFECTIVENESS of POTENTIAL MEASURES	
➢ Identify potential measures to achieve the Directive's objectives, including basic and supplementary measures; ➢ Estimate the costs of each measure; ➢ Estimate the effectiveness (environmental impact) of each measure.	*Given potential interaction between measures, it is important to assess the effectiveness of basic measures and integrate them into the cost-effectiveness analysis.*
STEP 3.2 – CONSTRUCTING A COST-EFFECTIVE PROGRAMME of MEASURES	
➢ Assess and rank cost-effectiveness of measures; ➢ Select the most cost-effective programme of measures that can reach environmental objectives; ➢ Calculate range for the total discounted costs of this programme; ➢ Undertake a sensitivity analysis to assess robustness of results.	***Uncertainty on costs, effectiveness and time-lagged effects of measures needs to be considered in the cost-effectiveness analysis.***
STEP 3.3 – EVALUATING WHETHER COSTS ARE DISPROPORTIONATE	
➢ If total costs are judged to be proportionate ➢ Go to ***Step 3.4;*** ➢ If the total costs of the proposed programme are judged to be disproportionate, estimate whether a derogation might be needed from an economic point of view and on which basis: 1. Compare total costs to financial resources – if costs can be reduced or better managed over longer time horizon, propose time derogation; 2. Assess total costs and benefits (including water-related environmental benefits) – if total costs disproportionate as compared to benefits, propose less stringent environmental objectives – account for socio-economic and distributional implications if considered necessary. ➢ Redefine programme of measures accordingly and propose water bodies for derogation; ➢ Calculate total discounted costs of revised programme.	***How to "judge" whether costs are disproportionate is not developed here, as it encompasses many complex decisional, institutional and socio-economic elements. Judgement needs to be made prior the analysis to decide whether to embark into the analysis or not. Estimating the need for derogation will be resource intensive and will require co-ordination with other experts and consultation of key stakeholders and the public.*** ***➢ Plan it well and start early!***
STEP 3.4 – ASSESSING THE FINANCIAL IMPLICATIONS OF PROGRAMME OF MEASURES	
➢ Assess socio-economic and distributional impact of the selected programme; ➢ Assess financial and budgetary implications of the selected programme, establish alternative financial plans; ➢ Identify accompanying (financial, technical, institutional) measures for implementing the selected programme; ➢ Assess potential impact on cost-recovery and incentive pricing.	*This analysis will feed into the definition of pricing policies by 2010. It may also require loops to earlier steps of the cost-effectiveness analysis, e.g. if resulting price changes are likely to change pressures and thus the cost-effectiveness analysis.*

Key Outputs…	… Feed into
➢ Estimation of Total Costs of Programme of Measures; ➢ Economic justification for possible derogation; ➢ Financial and budgetary implications of selected programme; ➢ Assessment of cost-recovery levels with proposed measures.	Programme of measures and River Basin Management Plan

References in this Guidance Document	Links with Other Tasks
Annex D1: *Scale issues,* *Estimating costs,* *Cost-effectiveness analysis,* *Cost and benefit assessment,* *Pricing as an Economic Instrument,* *Disproportionate costs*	Definition of programme of measures Estimation of the effectiveness of measures Justification of derogation

Information requirements	Look out!
Step 3.1	
➢ Costs of potential measures, e.g.: investing to increase available supplies, demand management, wetland restoration, limiting abstractions with permits ➢ Effectiveness of potential measures	*If demand management and pricing measures are used, the effectiveness of the programme of measures might need to be revisited to account for elasticity issues.*
Step 3.2	
➢ Compile information gathered in Step 3.1.	
Step 3.3	
➢ Costs are proportionate: compile total costs of programme ➢ To assess whether costs are disproportionate: o Estimate financial resources available; o Estimate costs and environmental benefits which relate to the water body level.	***The economic analysis can only formulate recommendations: estimating the need for derogation will ultimately remain a political decision.***
Step 3.4	
➢ Forecasts of prices by 2010 based on ongoing tariff policies; ➢ Allocation of costs by water uses; ➢ Information on price elasticity (effectiveness).	

Methodological Scope
➢ The cost-effectiveness analysis is best performed at the river basin scale. Undertaking the analysis at lower scale requires an adequate integration between analyses undertaken for sub-units of the river basin; ➢ Specific care needs to be given to the choice of the effectiveness indicator. Indeed, different effectiveness indicators may lead to a different outcome for the ranking of measures. Furthermore, specific attention may be required as the effectiveness of measures can often be assessed (qualitatively) for a few environmental indicators only, and not for the range of environmental issues encompassed in the definition of water status; ➢ Care is to be given to the assessment of the different costs considered in the cost-effectiveness analysis. Often, information may not be available for specific cost types. Thus, it is important to remember the cost-effectiveness analysis is only partial and to stress the possible uncertainty existing with the ranking of measures obtained.

SELECTED ISSUES FOR CONCLUDING SECTION 3

Methodological Scope for the economic analysis	
Scale	Even though reporting in the RBMP is at the river basin district level, different types of analysis should be conducted at different scales: • Cost-effectiveness analysis should best be conducted at the *river basin level*; • In some cases, it may be more practical to undertake the analysis for *sub-basins*. However, the hydrological integrity of the basin needs to be kept, starting for example with the most up-stream sub-basin and working downwards; • Derogations can be justified (based on the assessment of costs and benefits) at the *water body level*; • Reporting on cost-recovery should be done by *socio-economic sector* (water use) or sub-sector.
Integration	Already said before, but worth repeating…. Integration between economists and other experts from the start, i.e. from the characterisation of the river basin, is key to the usefulness and effectiveness of the economic analysis in supporting decisions.
Uncertainty	Uncertainty on costs, effectiveness and time-lagged effects of measures needs to be dealt with throughout the economic analysis process, and more generally throughout the process of identifying measures and developing the river basin management plan. Sources for uncertainty are highly diverse according to situations and river basins, but will exist with regards to the assessment of pressures, impacts, baseline, costs or effectiveness. It is important that key areas of uncertainty and key assumptions made for the analysis are clearly spelt out and reported along the results of the analysis. Thus, comparison between analyses undertaken in different river basins and regular updates of the analysis will always be possible.
Sensitivity analysis	Sensitivity analysis is required for assessing the robustness of the results of the analysis (i.e. whether results are modified or not) if some parameters vary within certain acceptable limits. Sensitivity is seen as key to the development of the baseline scenario and the cost-effectiveness analysis.
Information	The collection of economic-related information should be well thought through and targeted. Apart for the specific reporting and analytical requirements of the Water Framework Directive, it is important to ensure data collection is targeted to where it is useful for supporting the decision making process, be it for the decision itself or for informing and consulting the public on this decision.
An iterative process	Although the right information may not be available today, it is important to start the analysis and develop it in iterations. Thus, as important as the results of the analysis for the different steps is the assessment of the most significant information gaps and the development of activities aimed at filling these gaps.

Illustrations - Selecting the "right" scale for the analysis?

The scoping and testing projects undertaken to support the development of this Guidance Document illustrate the importance of selecting the 'right' scale for the economic analysis:

- The economic significance of water uses can be assessed at scales that account for the hydrological functioning of the river basin, socio-economic characteristics of economic sectors, land planning and land use. Identifying homogenous units for these criteria was performed in the **Rhône-Méditterranée-Corse** case study (see *Annexes D1* and *E*). These units are often recognised by stakeholders and the public, and thus particularly important for consultation and participation. The combination of economic and biophysical information for identifying management units to which the economic analysis should concentrate was also stressed in the analysis of groundwater issues in the **Scheldt** case study (see *Annexes D1* and *E*);
- The forecast of water demand in **England and Wales**[1], undertaken by the Environment Agency, showed the importance of adopting a disaggregated approach to demand forecasting, in order to identify the key drivers of demand and in particular, the key sectors having an impact on demand. Such disaggregation is required to introduce sufficient confidence into the supply-demand balance assessments that are key to establishing a baseline water use estimation;
- The **Cidacos** case study (see *Annexes D1* and *E*) showed the importance of undertaking the cost-effectiveness analysis at the river basin scale, accounting for the hydrological functioning of the river basin. As an illustration, undertaking cost-effectiveness analyses independently for three different river reaches led to total costs estimates for the selected programme of measures that were significantly higher than the estimated costs obtained for a cost-effectiveness analysis undertaken for the three river reaches in combination;
- Activities undertaken in the **Ribble**, **Cidacos** and **Daugava**[2] (see *Annexes D1* and *E*) case studies investigated measures of relevance to different spatial scales and decision-making levels. They stressed the need for consistent approaches and feedback between scales and levels.

[1] Environment Agency. August 2001. A scenario approach to water demand forecasting.

[2] Ilona Kirhensteine. 2002 (forthcoming). Developing river basin management plans in the Daugava river basin (Latvia). Proceedings of the Lille III Conference. (see also Annexes IV.I and V.II).

Section 4 – 2004: The First Milestone for the Economic Analysis

This Section brings together the economic analyses Member States should undertake by 2004 to be on track for complying with the requirements of the Water Framework Directive.

The Water Framework Directive specifies a series of reporting dates (see *Section 1 - Introduction*) for key tasks and activities aimed at the development of river basin management plans. And 2004 is the first major deadline directly following the designation of the river basin districts and competent authorities (required for 2003). The overall objective of the 2004 deadline is a description or characterisation of the river basins as referred to primarily in Article 5 of the Directive and relevant Annexes.

Thus, 2004 is also the first milestone for the economic analysis and for economists involved in the development of river basin management plans. The present Section provides a synthesis of the economic analysis required for 2004:

- To comply with the main reporting obligations of the Directive for 2004, and identify reporting requirements to the European Commission; and
- To ensure adequate economic input into the initial steps of preparing the cost-effectiveness analysis of measures and thus support the development of river basin management plans.

This Section does not repeat the elements of the process required for developing the economic analysis as described in the previous and following Sections (see ***Section 3*** and ***Section 5***). The focus is on the main economic elements to be investigated, i.e.:

- Undertaking **the economic analyses of water uses** (*Article 5*);
- Investigating the dynamics in the river basin **– development of the baseline scenario** (*Article 5, Annex III*);
- Assessing current levels of **cost-recovery of water services** (*Annex III, Article 9*);
- Preparing for the **cost-effectiveness analysis** (*Annex III*); and
- Proposing activities for **enhancing the information and knowledge base** (*Annex III*).

It is important to ensure that the economic analyses described below are integrated with other technical analyses such as the analysis of pressures and impacts. This will ensure a common description and characterisation of the river basin is obtained, basis for the identification of the programme of measures and the development of the river basin management plan.

For many elements of the analysis proposed below (e.g. extent of recovery of environmental costs), information will not be directly available for undertaking a robust analysis by 2004. However, undertaking the analysis with existing data and information will allow Member States to identify practical steps to be followed after 2004 for improving the information and knowledge base. This will ensure that the analysis developed in following the steps effectively supports decision-making and complies in time with the requirements of the Water Framework Directive.

In addition to these economic analyses, economic input may be required in analyses and activities which timing is less well defined in the Directive. For example, the designation of heavily modified water bodies will require early economic input. This has not been specified here and will be dealt with in the respective Guidance on the identification and designation of heavily modified water bodies (see *Annex D2b*) and in the overall Guidance on best practices in river basin planning.

UNDERTAKING THE ECONOMIC ANALYSES OF WATER USES

The primary objective of the economic analysis of water uses is (i) to assess **how important water is for the economy and socio-economic development of the river basin**, and (ii) to **pave the way for the assessment of significant water uses and analysis of disproportionate costs.**

(i) The **economic analysis of water uses** is used to construct the general economic profile of the river basin and of its key water uses and significant pressures in terms of:

- Economic analysis of water uses, e.g. collating information for significant water uses on gross income, turnover, number of beneficiaries, agricultural and industrial area or employment, etc as considered relevant;
- Stressing the importance of water for economic and regional development and the evidence of this importance provided in existing economic strategies and plans; and
- Areas designated for the protection of *economically significant aquatic species*, as input into the register of protected areas required under *Article 7* and *Annex IV* of the Directive.

These general economic indicators will be computed at the **scale of the river basin or river basin district**. For economically significant aquatic species, further desegregation according to location within the river basin may be provided consistently with the maps prepared for *Article 7*. This analysis is mainly based on easily available statistics and information. Specific approaches may be used to transform existing information (often available for administrative regions or water service areas) to the scale of the river basin or river basin district.

(ii) In parallel, the economic analysis of water uses needs **to pave the way for the assessment of the significant water uses** to be reported to the public by 2007 and related understanding of the likely tradeoffs and conflicts between socio-economic development, environment and water protection that can be fed into the public information and participation process regarding the development of river basin management plans.

The indicators computed are similar to the ones listed above, complemented with variables and indicators that are specific to the significant water uses identified for the river basin considered, e.g. cropping pattern for specific irrigated schemes that impose high pressures on water resources, turnover and main products of industrial sub-sectors that are highly polluting rivers, etc. However, the computation scale or desegregation level is the **area linked to a given significant pressure or to specific economic sectors/sub-sectors.**

Overall, the analysis should remain proportionate and not entail extensive collection of new data, i.e. dealing primarily with clear conflicts/water management issues based on information of relevance to significant water uses. The spatial scale or region at which the analysis should be undertaken will be defined by both the analysis of pressures and impacts developed for the characterisation of the river basin, and the outcome of the participation process and stakeholders input/request for specific further desegregation.

INVESTIGATING THE DYNAMICS IN THE RIVER BASIN DEVELOPMENT OF THE BASELINE SCENARIO

Feeding into the **identification of significant water management issues** for 2007, the analysis needs to complement the characterisation of the river basin today by an assessment of its future likely trends and baseline scenarios. This assessment is the basis for analysing the gap between likely water status and good water status (**risk of non-compliance**) and for undertaking the subsequent **cost-effectiveness analysis of measures**.

Being a joint activity between different expertise and disciplines (see *Section 3*), the specific role of the economic analysis in the development of baseline scenarios and the analysis of the dynamics of the river basin is the assessment of forecasts in **key (non-water related) policy and economic drivers** likely to influence pressures and thus water status.

Focus is likely to be on foreseen trends in (non-exhaustive list):

- General socio-economic indicators and variables (e.g. population growth);
- Key sector policies that influence the significant water uses identified in the river basin investigated (e.g. agricultural policy);
- Production or turnover of main economic sectors/significant water uses in the river basin;
- Land planning and its effects on the spatial allocation of pressures and economic sectors;
- Implementation of existing water sector regulation and directives; or
- Implementation of environmental policies likely to affect water (e.g. *NATURA* 2000).

Some of these forecasts will be developed jointly with technical experts (see for example the implementation of water sector directives and other environmental legislation). Complemented by analysis of changes in the hydrological cycle, e.g. for accounting for climate change, it will feed into an overall assessment of changes in key pressures, including water demand, and resulting impact on water status as key input into the identification of significant water management issues for 2007.

It is important to stress that **some analyses can be organised at the national or European scale** as all river basins of a given country or of Europe will face similar changes (this is for example the case for changes in EU policies such as the Common Agricultural Policy). Other analyses such as changes in production and turnover of significant water uses and economic sectors will need to be developed **at the scale of the river basin or for parts of the river basin** according to the scale at which related pressures take place.

ASSESSING CURRENT LEVELS OF COST-RECOVERY OF WATER SERVICES

The assessment of the current levels of cost-recovery of water services is the **basis for the implementation of Article 9 of the Water Framework Directive and for ensuring transparency** on costs, prices, subsidies, cross-subsidies, etc. As such, this analysis is less directly linked to the identification of the programme of measures and the development of integrated river basin plans. But it will be called for when assessing the financial implications of the chosen programme. Key elements to be investigated may include:

- Status of key water services (e.g. number of persons connected/using the service);

- Costs of water services (financial costs, environmental and resource costs);
- Institutional set-up for cost-recovery (prices and tariff structure, subsidies, cross-subsidy);
- Resulting extent of cost-recovery levels (for financial costs, for environmental and resource costs);
- Extent of contribution of key water uses to the costs of water services (link with pollution and use information collected for the analysis of pressures and impacts); and
- Complementary information whenever relevant (e.g. affordability for key water users).

The basic **scale of analysis is linked to the water service area** or combined water service area when services are combined. However, this will be very dependent on the structure of the water service sector and related information base.

PREPARING FOR THE COST-EFFECTIVENESS ANALYSIS

Although referred to in Annex III of the Directive in the context of the 2004 deadline, it will not be possible to perform the cost-effectiveness analysis in 2004 as environmental objectives and potential measures will not be identified yet. **To ensure the cost-effectiveness analysis can be performed** at a later stage, and **because of the limited cost-information available today in a coherent format** in most countries/river basins, it is proposed to develop a cost-database for a wide range of measures likely to be investigated:

- This database should not focus solely on cost information of infrastructure (the easiest to collect). Measures such as wetland restoration, demand management measures, new pricing, voluntary agreements, etc should be included. A key first step will be to provide an initial specification of the sort of measures that might be included in river basin management plans;
- A range of costs should be collated (minimum, average, maximum) as opposed to single average values. Key parameters influencing costs should be identified to facilitate extrapolation of figures to specific sites/conditions;
- Costs to be collected should include all costs that are non site-specific, e.g. limited to financial costs of the measures or specific environmental costs (e.g. air-related), and also indirect economic costs whenever considered relevant; and
- Wider economic benefits that are non-site specific may also be added to the database whenever considered relevant. This information would facilitate follow-up disproportionate cost analysis and support to derogation.

The information should be **collected for individual measures or units of measures**, thus at a spatial or desegregation scale depending on the scale at which the measure is applied or implemented. Such efforts may be best co-ordinated at the national or European scale, especially for measures linked to policies and programmes that have a more regional or national focus.

PROPOSING ACTIVITIES FOR ENHANCING THE INFORMATION AND KNOWLEDGE BASE

Along with results of the different components of the economic analysis, it will be important to **systematically report** on:

- **Information, assumptions and approaches** used for computing key indicators. It is important that this is made transparent (i) to ensure easy updating/upgrading of results as new information is made available and (ii) to facilitate comparisons between results obtained in different river basins or sub-basins (especially in transboundary river basins).

Practical steps and measures will be identified and proposed for **filling key information and knowledge gaps:**

- Identified during the first analysis aimed at **characterising the river basin in economic terms** - for ensuring key indicators (e.g. cost-recovery levels) can be **further improved and refined**; and

- **Likely to arise when developing integrated river basin management plans –** for ensuring the **cost-effectiveness analysis can be performed at a later stage**. This indeed requires **undertaking the *feasibility study*** (see *Section 5*) for the entire economic analysis process (which information to be collected, at which scale, which data collection or computation method, which periodicity, etc).

Although it is too early to specify the main focus of such activities, as they will be based on both general and local assessments of information and knowledge needs, likely candidates that will require further work combining economic and technical expertise include:

- The assessment of water-related environmental costs (benefits) and the development/strengthening of environmental costs databases;

- Methods for assessing the direct economic impact of range of measures for key economic sectors (e.g. industrial sub-sectors, agricultural sub-sectors);

- Methods for assessing the effectiveness of measures or combination of measures.

The costs of activities proposed for enhancing the information and knowledge base will be assessed and reported. Feedback to research programmes may also be developed to ensure research needs are tackled in a timely manner.

DOING AND REPORTING THE ECONOMIC ANALYSIS FOR 2004 – A SUMMARY

Table 3 summarises the different economic analyses and activities to be performed by 2004. It stresses reporting obligation to the European Commission defined in the Water Framework Directive. Clearly, these reporting obligations will need to be complemented by, integrated with, existing regional or national reporting obligations. Further reporting requirements may also arise from the participatory process developed by Member States for developing river basin management plans.

Table 3 - Summary of the different economic analyses and activities to be performed by 2004

Title	Addressing	Likely elements of the analysis	Reporting to the European Commission in the management plan of the river basin district	Feeding into
Undertaking the economic analysis of water uses	**What is the economic importance of key water uses in the river basin?**	• The economic importance of the main water uses is analysed for the river basin district. Relevant economic indicators are computed; • Further analysis is performed for lower disaggregation levels according to scale of significant pressures (jointly with pressures and impacts analysis); • Areas designated for the protection of *economically significant aquatic species* are investigated.	• Economic analysis of water uses at the river basin district scale.	**Characterisation of the river basin.** **Overview of significant water management issues.** **Register of protected areas.**
Investigating the dynamics of the river basin – developing the baseline scenario	**How will key policy and economic drivers evolve up to 2015?**	• Forecast in key economic drivers are investigated (different scale of analysis for different drivers); • The impact of these forecasts on key pressures is estimated (at the scale of significant water management issues, at the scale of the district).	• Trends in key economic and policy drivers at the river basin district scale.	**Overview of significant water management issues/ water status gap/risk of non-compliance.**

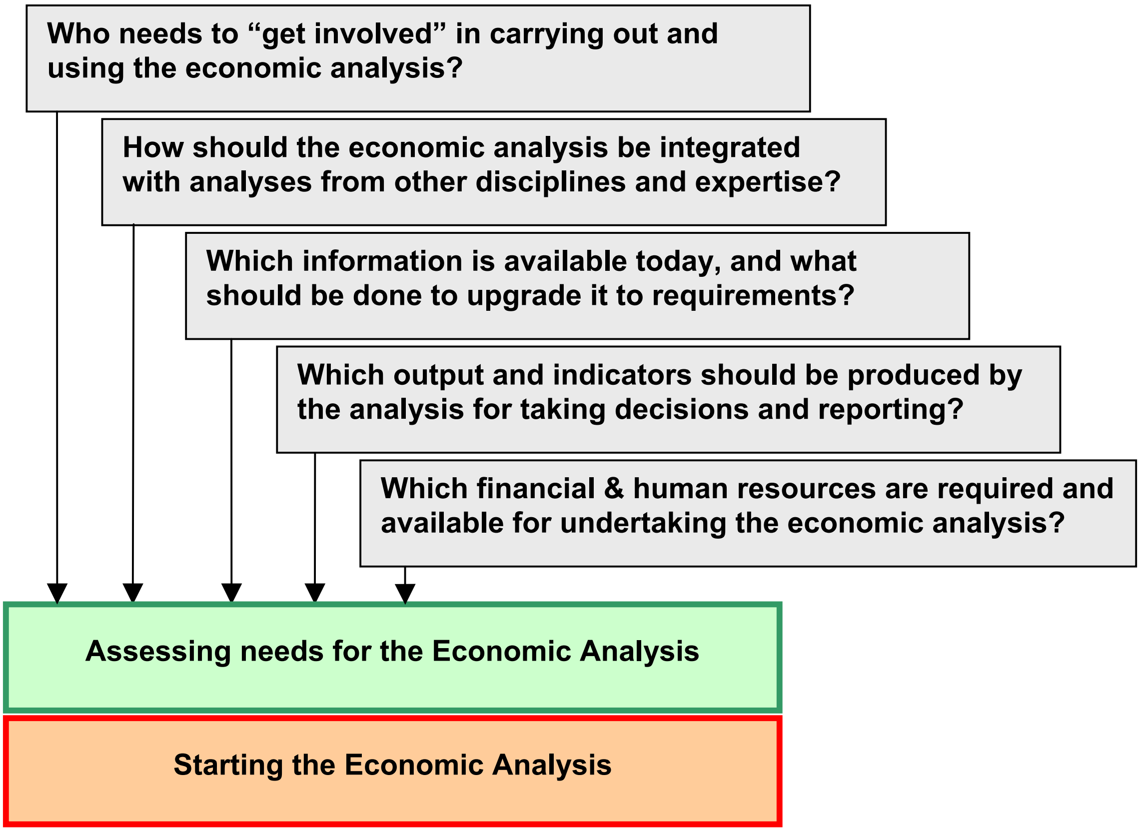
Title	Addressing	Likely elements of the analysis	Reporting to the European Commission in the management plan of the river basin district	Feeding into
Assessing current levels of cost-recovery **Assessing current levels of cost-recovery (continued)**	**What are current levels of recovery of costs of water services?** **Which contribution to the costs of water services from key water uses?**	• Collection of information on costs, prices, subsidies (water services, combined services, regional areas, etc) as seen appropriate; • Analysis of information and assessment of the extent of (financial, environmental and resource) cost recovery; • Description of the institutional mechanisms in place for cost recovery; • Analysis of the extent key water uses contribute to the recovery of costs of water services (linking with information on pressures and impacts).	• Financial cost-recovery; • Environmental and resource cost recovery; • Institutional mechanism for cost-recovery; • Contribution from key water uses (agriculture, households, industry) to the recovery of the costs of water services.	**Implementation of Article 9** **Financial implications of the selected programme of measures**
Preparing for the cost-effectiveness analysis	**What are costs of potential measures that will feed into the cost-effectiveness analysis?**	• Existing cost information is collected for a range of measures. A database easily accessible is developed.		**Selection of the programme of measures, cost-effectiveness analysis.**
Proposing activities for enhancing the information and knowledge base	**What are current information and knowledge gaps that need to be filled for taking decision?**	• Key assumptions and information sources, computation methods and uncertainty are made transparent for all elements of the analysis; • Identification of key information and knowledge missing for developing the economic analysis for the programme of measures and development of the integrated river basin plan; • Proposed data collection activities for filling gaps; • Assessment of the costs of data collection.	• Key assumptions and information sources, computation methods and uncertainty are made transparent for all elements of the analysis; • Identification of key information missing for developing economic analysis for integrated river basin plans; • Proposed data collection activities and related costs.	**Refining the economic analysis of water uses, ensuring the cost-effectiveness analysis can be performed and aid decision making.**

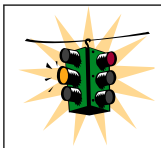
Section 5 – Making the economic analysis operational and ensuring Coherency with the Overall Implementation Process

This Section brings attention to key issues related to developing the economic analysis and the need to ensure coherency and integration with the process of preparing River Basin Management Plans.

Before starting the economic analysis itself (see *Section 3*), it is important to ensure that you have defined the right process for undertaking this analysis. You will need to carefully review a series of issues so that you can deliver what is expected from the economic analysis so it aids decision-making. Some of these issues are rather straightforward; others will need further elaboration and discussions with experts, water managers or stakeholders. Overall, most of what is described in this Section will need to be co-ordinated with other experts and disciplines involved in the development of river basin management plans.

ISSUES TO FOCUS ON INCLUDE…





Look out! Before starting the economic analysis, make sure:

- That you know who is going to use the information you produce, for which purpose, and what are the expectations *vis-à-vis* the economic analysis;
- That you have enough financial and human resources for undertaking the required economic analysis and meet expectations.

WHO NEEDS TO GET INVOLVED IN CARRYING OUT AND USING THE ECONOMIC ANALYSIS?

Assessing "who needs to get involved" requires addressing some of the following questions:

- Who will be responsible for the economic analysis?
- Who will undertake the economic analysis?
- Who will provide input into the economic analysis?
- Who will control the quality of the economic analysis?
- Who will use the results of the economic analysis?
- Who will pay for the economic analysis?

Answers to these "*Who*" questions are likely to include a wide range of organisations, stakeholders and individuals according to questions. For example, experts from the Ministry of Environment or other ministries (land planning, economic affairs, agriculture, etc), experts from river basin agencies or regional authorities, managers in charge of developing river basin management plans, ministry heads of water departments, researchers and consultants, economists and non-economists, the public and a wide range of stakeholders that have developed expertise in specific fields (see *Table 4*) and are involved in water management.

Developing a *stakeholder analysis* with possible involvement of key stakeholders can be an appropriate step for finding answers to these questions (see *Annex C2*). It also helps in identifying key steps in the analytical process when involvement or input from specific stakeholders is required (different "*Who*" for different steps).

Information, consultation and participation is a requirement of the Directive – it will also make implementation more effective

Article 14 promotes the *active participation of all interested parties* in the development of River Basin Management Plans, and requires Member States to *inform and consult the public*. Stakeholder participation is important as it can fulfil many functions:

- Developing a process agreed by all will increase the legitimacy of its outcome;
- Stakeholders can be a useful source of information and have expertise of direct use for the economic analysis (see *Table 4*);
- Surveys of the public can be useful to understand how people value improvements in the environment and quality of our waters, and how far they are ready to pay for environmental improvements;
- Public involvement and the network of partners developed through participation can be useful to develop a sense of ownership over the River Basin Management Plans and may increase the effectiveness of measures taken to meet the Directive's objectives.

The Directive only specifies key dates for consultation, but rightly does not specify dates for the participation process, as this will depend on local institutions and socio-economic set-up. However, it will be important to start the participation process early (eg. as part of the characterisation of the river basin before 2004) to improve its effectiveness.

Table 4 – Key Stakeholders can be a Very Important Source of Information and Expertise

Key Stakeholders	Where they can help with information and expertise
Water Service Suppliers	➢ Characterising water services; ➢ Assessing costs & recovery of financial costs; ➢ Developing trends in water service investments.
Experts from Ministries (agriculture, transport, planning, finance…) -	➢ Characterising water uses and their economic importance; ➢ Assessing changes in key national and regional policies and drivers for the trend analysis; ➢ Defining coherent methodologies for assessing key variables at Member State level.
Environmental NGOs	➢ Identifying key environmental issues; ➢ Assessing environmental impacts and costs; ➢ Developing methodologies for estimating environmental costs and benefits.
Economic sectors (farmers, industrialists, etc)	➢ Assessing trends in economic sectors; ➢ Identifying possible measures and assess their costs; ➢ Providing input into the assessment of disproportionate costs.
Researchers/Experts	➢ Assessing key policies/drivers for the trend analysis; ➢ Assessing impact of such policies on pressures; ➢ Assessing impact of climate change; ➢ Assessing the impact of pressures on water status (e.g. via modelling); ➢ Assessing effectiveness of measures; ➢ Assessing environmental and resource costs.
Stakeholders/civil society/public	➢ Assessing changes in key policies/drivers for the trend analysis; ➢ Assessing (local, regional, national) priorities *vis-à-vis* water quality improvements; ➢ Providing input into the assessment of disproportionate costs and analysis aimed at explaining derogation; ➢ Providing input into the assessments of socio-economic impacts and costs.

Illustrations - Building on the knowledge from stakeholders and the public for undertaking the economic analysis

There are different approaches for integrating stakeholders' and public concerns and knowledge into the economic analysis.

- Questionnaire surveys and stakeholder focus groups have been used for investigating the economic values placed on a wetland surrounding Kalloni Bay on the Island of **Lesvbos**[3] in Greece (see *Annex E*);
- Public forums followed by individual interviews (around 1,500) have been organised by the French Water Agency **Artois-Picardie**[4] in 1999/2000. The main objectives were the identification of key water management issues in the river basin (as part of the assessment of a baseline scenario), the identification of the main potential costs linked to future water policy and the ranking of possible future policy options;
- A stakeholder analysis was performed in two research projects in **France**[5,6] as the preliminary step of the economic analysis in a watershed to map actors, the main interest at stake and existing conflicts over water use. The knowledge and information obtained from stakeholders proved useful in identifying specific water management issues and potential measures of direct relevance for a follow-up cost-effectiveness analysis but that had not been envisaged by experts;
- From the scoping activity in the **Ribble** case study (see *Annex E*), key issues of relevance for implementing the consultation and participation were identified. Overall, it is essential to: (i) focus on why, when, where and how stakeholders should be consulted and involved; (ii) to relate the consultation process to the specific decision-making contexts and processes in the WFD (be it national, regional or local); (iii) To take account of the boundaries these different decision making levels place on the consultation; (iv) to take account of resource constraints, both for the authorities and stakeholders, to carrying our the consultation process; and
- Input from stakeholders was collected in the **Cidacos** (see *Annex E*) case study for discussing whether costs estimated as a result of the cost-effectiveness analysis could be considered as disproportionate. Along similar lines, a panel of experts was used in the **Scheldt** (see *Annexes D1* and *E*) case study to assess whether the costs of measures for reaching the ecological objectives in the Scheldt estuary were disproportionate or not.

[3] Skourtos, M.S., Kontogianni, A., Langford I.H., Bateman I.J and S. Georgiou. 2000. *Integrating stakeholder analysis in non-market valuation of environmental assets*. CSERGE Working Paper GEC 2000-22, United Kingdom

[4] Agence de l'Eau Artois-Picardie. 2001. Un débat public sur l'Eau.

[5] Garin, P., Rinaudo J.D. and J. Rulhman. 2001. Linking expert evaluation with public consultation to design water policy at the watershed level. Proceedings of the World Water Congress, 15-19 October 2001. IWA, Berlin.

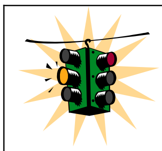
[6] Rinaudo, J.D. and P. Garin. 2002. Participation du public et planification de la gestion de l'eau: nouveaux enjeux et éléments de méthode. Actes de la Conférence Directive Cadre et eaux souterraines, 13 et 14 Mars 2002. SHF, Paris.

HOW SHOULD THE ECONOMIC ANALYSIS BE INTEGRATED WITH ANALYSES FROM OTHER DISCIPLINES AND EXPERTISE?

Up until recently, economic analyses, if at all developed, are often undertaken in isolation from other analyses and expertise. By contrast, the Water Framework Directive requires that economics be integrated with other disciplines and expertise for developing River Basin Management Plans. This means the economic analysis will build on key inputs from other disciplines and expertise, as shown in the Table 5 below.

Table 5 - Integration of economics with other disciplines and expertise for developing River Basin Management Plans

Key Inputs from the Economic Analysis	Steps	Key inputs from other Disciplines
➢ Economic analysis of water uses; ➢ Assess trends and baseline scenario; ➢ Assess cost-recovery levels.	*Step 1* Characterising River Basins	➢ Assess key pressures and impacts (*Annex II*); ➢ Analyse point source and diffuse pollutions; ➢ Investigate future trends in key pressures.
➢ If no gap, estimate total costs of basic measures of baseline.	*Step 2* Identifying Significant Water Management Issues	➢ Assess the impact of trends in pressures on water status; ➢ Assess environmental objectives and physico-chemical, hydromorphological and biological indicators; ➢ Assess gap in water status; ➢ Identifying key pressures causing this gap.
➢ Identify potential measures and assess their costs; ➢ Cost-effectiveness analysis; ➢ Economic input into the justification of derogation; ➢ Assess cost-recovery levels; ➢ Economic/financial impact of proposed programme of measures.	*Step 3* Identifying Measures and Economic Impact	➢ Identify potential measures and assess their technical feasibility; ➢ Assess the effectiveness of individual measures/combined measures; ➢ Assess the remaining environmental impact.



Look out! Designating heavily modified water bodies and justifying derogation

The designation of heavily modified water bodies or the justifications of derogation from the Directive's objectives are areas where the interaction between technical/biophysical and economic expertise are key to the analysis. For example, the designation of heavily modified water bodies requires (see *Annex D2b*):

- An assessment of the impact on existing uses of returning to natural conditions; and
- The comparison between the existing modification and alternatives for providing the same beneficial objectives in terms of their technical feasibility, their environmental impact and their economic impact (investigating the costs of different alternatives versus the existing modification).

What does "integrating economics with other disciplines" mean in practice?

- **Understanding each other!!**

- **Agreeing on common definitions;**

- **Agreeing on a common representation (i.e. characterisation) of the river basin investigated**, i.e. the spatial structure of the river basin, the key spatial units (either based on hydrological or economic variables) and the level at which biophysical and economic indicators will be computed and can be compared;

- **Developing a common baseline scenario for the river basin**, i.e. how will the river basin and its key pressures evolve up to 2015 taking account of policies and measures already planned. The development of the baseline will require economic expertise (e.g. analysis of changes in macro-economic/sectoral policies, trends in investments, trends in water demand) and technical/biophysical expertise (e.g. changes in key pressures and land-use, impact on water status of changes in pressures and planned investment). See for example the **Oise** case study (see *Annexes D1* and *E*) that deals with the development of baseline scenario;

- **Undertaking the appraisal of measures jointly,** e.g. the cost-effectiveness analysis as illustrated by the **Scheldt**, the **Cidacos**, the **Ribble** (see *Annexes D1* and *E*) or the **Daugava**[7] (see *Annex D1*) case studies, or the disproportionate cost analysis and the assessment of possible objective derogation as illustrated by the **Scheldt** or the **Alsace** (see *Annexes D1*and *E*) case studies;

- **Developing common information and databases** that are geo-referenced (use of Geographic Information Systems) – This is rather new for most economists that rarely integrate spatial dimensions into their analysis and databases. See for example the **Corfu** case study (see *Annex E*) that has integrated biophysical and economic data into a common Geographic Information System (GIS).

[7] Ilona Kirhensteine. 2002 (forthcoming). *Developing river basin management plans in the Daugava river basin (Latvia)*. Proceedings of the Lille III Conference.

The economics Guidance Document should be linked with other Guidance Documents produced by working groups of the Common Implementation Strategy

Several working groups created in the context of the Common Implementation Strategy are developing or have developed Guidance Documents for supporting experts in European Union Member States and candidate countries in their implementation tasks. It is important that these Guidances are used in a coherent and co-ordinated manner. Of particular relevance to the economic analysis and its integration with other disciplines and expertise are:

- The Guidance on ***Best practices in river basin planning*** (WFD Technical Report No. 2) that provides the overall framework for developing integrated river basin management plans;
- The Guidance on ***Information, consultation and participation of the public and stakeholders*** (WFD CIS Guidance Document No. 8) that provides methodological and illustrative elements of direct use for involving stakeholders and ensuring the economic analysis produces pertinent results for information and consultation of the public;
- The Guidance of the ***Analysis of pressures and impacts*** (WFD CIS Guidance Document No. 3) that needs to link with the present Guidance Document for producing by 2004 a joint and coherent characterisation of the river basin as required by Article 5 of the Water Framework Directive; and
- The Guidance on the ***Identification and designation of Heavily Modified Water Bodies*** (WFD CIS Guidance Document No. 4) where technical, biophysical and economic expertise and analyses are combined for designating heavily modified water bodies.

See *Annex A* for a list of Working Groups and Guidance Documents.

WHICH INFORMATION IS AVAILABLE TODAY, AND WHAT SHOULD BE DONE TO UPGRADE IT TO REQUIREMENTS?

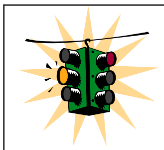
The availability of economic information is key to the usefulness of the economic analysis in the characterisation of river basins and the development of River Basin Management Plans.

Checklist for assessing existing information, its quality and existing gaps

- Which information is available?
- Who has collected the information?
- Who has the information? (organisation, person)
- Is it accessible? To everybody, to selected experts/government departments?
- At which costs?
- At which spatial scale is the information available?
- For which year(s) or period?
- What is the quality of the information?
- What are the levels of confidence attached to the available information?

Although the Water Framework Directive provides clear deadlines for reporting, the economic analysis remains an iterative process with constant improvements in the information base, methodology and expertise. If the "right" information (i.e. the required variable at the required spatial and temporal scales with an "acceptable" uncertainty) is not available today for supporting decisions, proxies or benchmark values should be used to provide first rough answers. However, as important as undertaking the analysis itself are:

- To be transparent and clearly report on the quality and uncertainty of the information used and on the assumptions made for doing the analysis; and
- To identify key data gaps and plan activities for collecting missing information and improving the analysis. For example, the economic analysis of water uses delivered for 2004 will likely need to be updated and upgraded at a later stage for supporting a robust cost-effectiveness analysis for defining the programme of measure.



Look out! Information for the economic analysis may be difficult to access due to confidentiality requirements

The area of water services is becoming increasingly competitive with large water service providers competing across borders. Information about water demand and investments might be considered commercially sensitive and will therefore risk not being provided, even though they represent key input for the economic analysis.

- ***Early in the process, it is important to identify who is holding exclusive commercial information and whether confidentiality issues are at stake. The identification of aggregation levels/scales where confidentiality is not an issue anymore but where information is still relevant for water management will be key to discussions with relevant stakeholders. Also, the signing of non-disclosure agreements may help lifting confidentiality constraints.***

However, accessing publicly owned information may also be a difficult task requiring specific agreements with organisations or individuals.

Illustrations - Which information for the economic analysis? From existing constraints to filling the gaps

Case studies undertaken in the different countries for supporting the development of the present Guidance have shown that the availability of economic-information is likely to represent a short-term constraint for undertaking the economic analysis. This is particularly true for environmental and resource costs information (e.g. not available at all in the **Corfu** (see *Annex E*) and **Vouga** (see *Annex E*) case studies), but it is also valid for more general cost information that remains incomplete, piecemeal and unevenly spread in space and time.

Of importance, however, is to carefully review existing information sources prior to launching any new data collection (as this may prove costly). The **Middle-Rhein** case study (see *Annex E*), for example, illustrated that information required for assessing cost-recovery is available with existing statistics in the pilot area considered. Similarly, effectiveness information for measures aimed at reducing water demand for households and industry was collected for the **Scheldt** case study (see *Annex E*) from relevant water supplier, industry and environmental NGOs.

In many cases, different elements of economic information are not available at spatial scales of relevance to water management. Most economic information linked to water services in the **Vouga** case study (see *Annex E*) is available for different administrative units (municipal, regional). Thus, consistent criteria must be developed to partition municipal and regional values into river basin/sub-basins values. Moreover, as stressed for example by the **Daugava** case study[8], it may be difficult and time-consuming to collect the information available for countries with a wide range of private and public organisations.

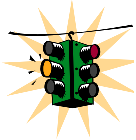
The **Corfu** case study (see *Annex E*) illustrated how a Geographic Information System could be developed to combine biophysical, climatic, land use and economic information. In addition to their presentation and analytical capabilities, such systems may help allocating values obtained for administrative units into information of relevance for water/river basin units.

WHICH FINANCIAL AND HUMAN RESOURCES ARE REQUIRED AND AVAILABLE FOR UNDERTAKING THE ECONOMIC ANALYSIS?

Collecting information, analysing it, involving stakeholders, integrating experts and disciplines, producing reports and providing input into information and consultation activities is likely to require money and people, both resources being scarce in many water administrations of both European Union Member States and candidate countries.

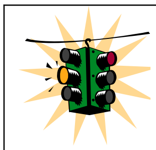
Ensuring that available resources match required ones is key to avoid false expectations and disappointments. If resources are not there, it is important to clearly assess and agree on priorities with other experts, stakeholders and organisations involved in/responsible for the development of river basin management plans and the implementation of the Water Framework Directive.

[8] – Ilona Kirhensteine. 2002 (forthcoming). *Developing river basin management plans in the Daugava river basin (Latvia)*. Proceedings of the Lille III Conference.



Look out! Conducting the economic analysis can be costly

Do not underestimate the resources required for developing the right process for the economic analysis, i.e. assessing the demand for economic input into the decision-making process and information/consultation activities. However, financial resources for developing the economic analysis will remain minimal as compared to those required for implementing measures for achieving the environmental objectives of the Directive!



Look out! Capacity-building will be key to ensuring success

Applied and practical economic expertise is rare, both in European Union Member States and in candidate countries! Thus, capacity-building activities may be required very early in the Water Framework Directive implementation process for ensuring timely delivery of the economic analysis requirements of the Directive.

WHICH OUTPUT AND INDICATORS SHOULD BE PRODUCED BY THE ECONOMIC ANALYSIS FOR TAKING DECISIONS AND REPORTING?

The Water Framework Directive has specific reporting obligations with regards to the economic analysis (Table 6). Most of these obligations refer to computed indicators at the scale of the river basin or river basin district. The assessment of the demand from policy makers and the public (i.e. which information and output do you want from the economic analysis) is likely to yield complementary reporting requirements in terms of the type of indicators and the spatial and temporal scale at which these indicators need to be computed.

Table 6 - WFD reporting obligations with regards to economic analysis

Component of the economic analysis	Reporting requirements defined in the Water Framework Directive	Possible interest from water managers, policy makers, stakeholders and the public
Characterisation and trend analysis	• Economic importance of water uses (RB); • Trends in key drivers and pressures, e.g. water supply and water demand (RB); • When required: trends in investments (RB).	• Current economic importance and likely trends of key economic sectors and policy driver in the river basin (RB, SRB, SES, SWU).
Economic analysis for selecting measures	• Total costs of cost-effective set of measures (RB); • Benefits and costs of alternatives measures in case of derogation (WB, possibly SRB).	• Benefits (economic, social, environmental) of proposed measures (RB/SRB/ES/SES); • Budgetary requirements (RB); • Impact on specific economic and social groups (SES, specific users).
Assessing cost-recovery and pricing	• Cost-recovery for water services (RB); • Contribution of water uses (agriculture, industry, households) to cost-recovery (RB/ES); • Social, economic and environmental impact for justifying proposed cost-recovery (RB/ES).	• Cost-recovery for key sub-sectors (e.g. a specific polluting industrial sector or sub-agricultural sector) (SRB, SES); • Current and proposed role of pricing as incentive (SES, specific users).
Key assumptions and information use	• Quality and uncertainties of information used and assumptions made (RB); • Proposed data collection (and related costs) for filling key information gaps (RB, possibly national proposals).	

Scale issues for reporting — RB = river basin; SRB = sub-river basin or coherent group of water bodies; ES = economic sector; SES = sub-economic sector; WB = specific water body; SWU = significant water use

Assessing the feasibility of the economic analysis: a pre-requisite to the economic analysis for increasing chances of success?

The objectives of a ***feasibility study*** are to prepare the economic analysis through:

- Assessing whether the proposed economic approach can be made operational;
- Evaluating the consistency of the proposed approach with other activities and processes developed for supporting the development of river basin management plans;
- Identifying key steps that need to be followed for removing constraints and problems likely to be faced when undertaking the economic analysis.

Key issues investigated during the activity include (list non-exhaustive):

1. Information and knowledge

- What are the information and knowledge requirements for undertaking the economic analysis?
- Which output (e.g. indicators computed at specific spatial scales) is expected from the economic analysis and for which purpose (taking a decision, informing, reporting, etc)?
- Which information and knowledge is currently available and accessible?
- How is economic and technical information integrated?
- What are the current gaps in information and knowledge for undertaking the analysis?
- What are possible means (short-term, long-term) for reducing these gaps?

2. Resources required for undertaking the economic analysis

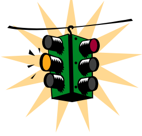
- Which human and financial resources are required for undertaking the economic analysis within the required timeframe?
- Which are the human and financial resources effectively available?
- What are the gaps in human and financial resources?
- What are possible means (short-term, long-term) for overcoming these gaps?

3. Information and consultation of the public, participation of stakeholders

- Which consultation and participation means are required for undertaking the economic analysis and disseminating its results?
- What are the existing information, consultation and participation means?
- What are the gaps in information, consultation and participation means?
- What are possible options (short-term, long-term) for overtaking existing constraints?

This assessment should be based on reviews of existing reports, documents and information/databases and on interviews with key experts, stakeholders and decisions makers. It can focus on a single representative river basin or have a more national focus. Workshops for sharing results of this assessment with a wider audience can prove useful in validating the results, identifying other solutions for removing constraints and announcing the forthcoming economic analysis.

Examples of Terms of Reference for a feasibility study are presented in Annex C.



Look out! The *feasibility study* should be a shared activity

Although proposed here in relation to the economic analysis, economists and non-economists should be undertaking this assessment jointly for the entire appraisal system aimed at developing integrated River Basin Management Plans.

Section 6 – Conclusion: What lies ahead?

As a way of conclusion, this Section looks at what remains to be done for implementing the Directive and by when, both by Member States in each River Basin and in a cooperative manner, at the European level.

A CRITICAL PATH ANALYSIS TO DETERMINE KEY LANDMARKS

2004 is the next key date for the implementation of the economic elements of the Directive. It may feel that it is a long time away, but it really is already tomorrow. When looking at what needs to be done by then and walking backwards, one might quickly realise that some of the steps should have really been initiated… the day before yesterday!

A big task lies ahead: start early!

To make sure they meet the Directive's deadlines, Member States and candidate countries may want to carry out a "critical path analysis", to identify what needs to be done by when and to logically link the economic analysis with other activities required for the River Basin Management Plans.

Figure 5 lays out a generic framework for such critical path analysis. The time needed for gathering information and consulting the public would of course depend on local circumstances, on the availability of information and on existing institutional structures. Therefore, each country would need to tailor this framework to its needs.

Figure 5 highlights a number of important points about the Directive's timing:

- To meet the 2004 requirements, significant economic analysis will have to take place. Some of this analysis feeds into each other: for example, the prospective analysis of pressures needs to be completed by 2004 to enable the determination of the *business as usual* (BAU) scenarios and identify water bodies where risk of non-compliance is likely to occur. This co-ordination with experts in charge of determining impacts and pressures will be crucial and planning ahead the scheduling of those tasks will allow avoiding any undue delays;

- Deadlines for the completion of the economics tasks required by the Directive are skewed towards the end the River Basin Management Plan (RBMP) period (2009). However, long lead times are required to complete these tasks and a number of important activities must be carried out well in advance to achieve those ultimate deadlines; and

- For some types of analysis (such as the *business as usual*, cost-effectiveness and disproportionate costs analyses), it might be preferable to first carry out a simple analysis, followed by a more in-depth analysis in the most contentious cases. This means that the simplest analyses might need to be carried out early on, which raises again timing issues.

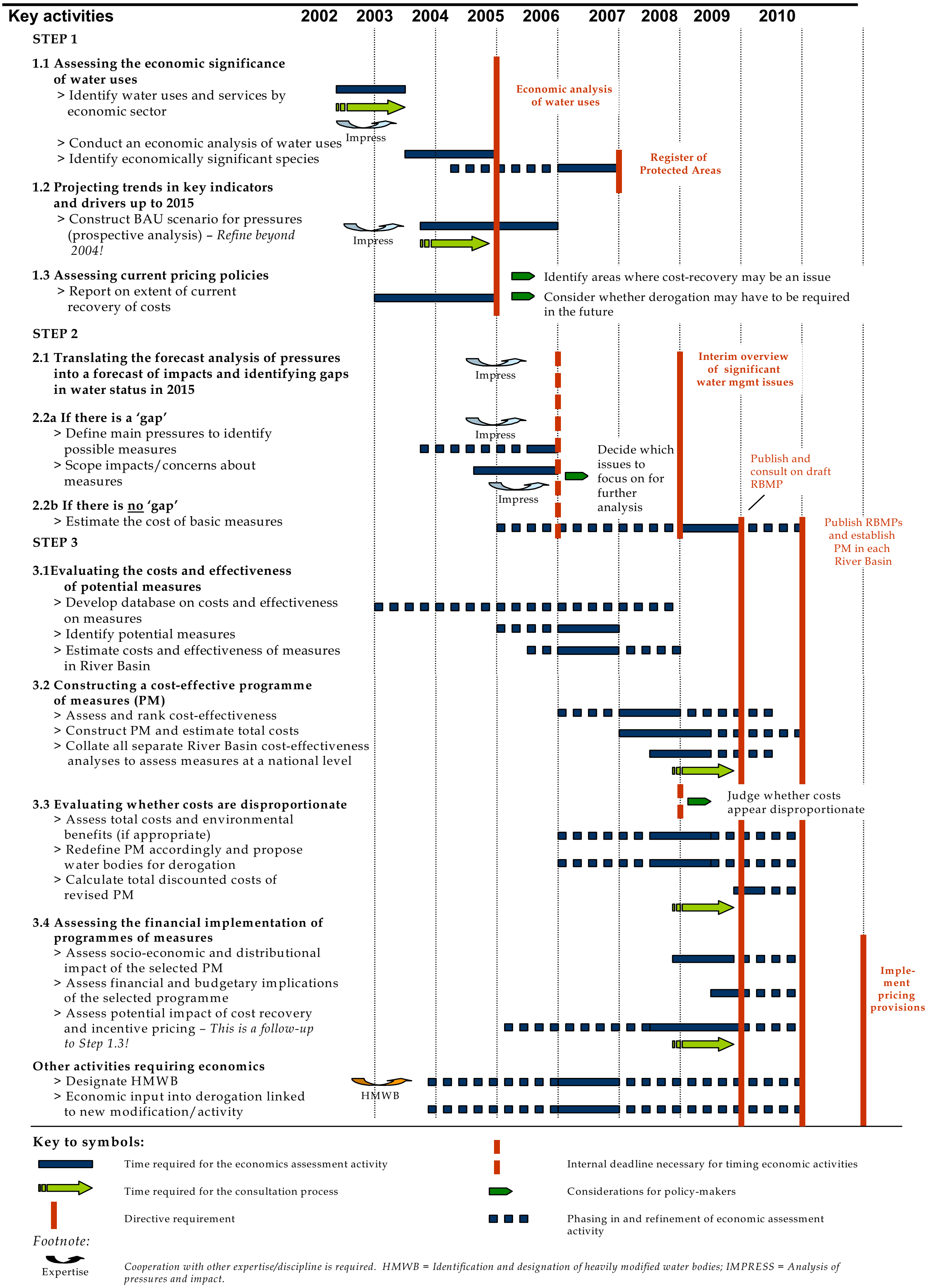


Figure 5 - Proposed Key Steps of the Critical Path

KEY ISSUES REMAIN TO BE EXPLORED…

The preparation of this Guidance Document has highlighted some outstanding issues that will need to be further examined in the years leading up to the river basin management plans. Although the application of the Guidance and the carrying out of the economic analysis by 2004 will help develop a practical knowledge base, some methodological issues are likely to require more time for in-depth research and analysis integrating technical and economic expertise. Selected issues can already be identified as requiring further methodological development, for example:

- How to assess **environmental and resource costs**: how can methods for assessing environmental costs (developed at an academic level) be made operational in the context of the development of river basin management plans?

- How to deal with **uncertainty:** which approaches can be proposed to water managers for integrating uncertainty into decision making, and for developing adequate communication on uncertainty towards the public and stakeholders?

- How to assess the **effectiveness** of measures or combination of measures: clearly, this issue departs from the scope of pure economics. But it will need to be solved to ensure cost-effectiveness analysis can be performed;

- How to assess the **direct and indirect economic impact** of a range of measures on key economic sectors? (e.g. industrial and agricultural economic sectors/sub-sectors).

…AND BEFORE YOU JUMP, REMEMBER: YOU ARE NOT ALONE!

Overall, using the present Guidance will help in developing practical experience, will increase the knowledge base and will develop capacity in the integration of economics into water management and policy. As much work lies ahead, the process that has been launched at the European level will not end with the production of this Guidance. Continuing this collaborative effort will be instrumental in moving forward and ensuring progress is made for an effective implementation of the Water Framework Directive.

Such collaborative efforts will include:

- Providing **support to the use of the Guidance** and implementation process and collating feedback and lessons from this process;

- Ensuring **integration** between economics and other expertise (working groups) through specific joint activities for integrated testing of guidance in pilot river basins; and

- Making operational specific economic **methodologies and approaches** (e.g. development of databases on water-related environmental costs/benefits).

Collaborating at European level to ensure integration with other expertise

Further co-operation with other areas of expertise remains essential for addressing a number of issues:

- How can economic information be used in order to take part in the process of identifying the need for **derogation**?
- What is the role of economics in the designation of **Heavily Modified Water Bodies** and how should the process of designation be carried out?
- What information on **pressures** is required for the economic analysis and how should the *Business as Usual* scenario be built by combining technical and economic expertise?

Integration with other expertise will be fostered at the European level through integrated testing of the Guidance Documents produced by the various working groups set up through the Common Strategy.

Integrated testing of guidance in pilot river basins

A specific working group of the Common Implementation Strategy (see Annex A) has been established for undertaking an integrated testing of all Guidance Documents in pilot river basins. The aim is to ensure coherence amongst Guidance Documents and their cross-applicability. A series of pilot river basins have been proposed by Member States and testing activities are presently being launched. Pilot projects will also be developed in candidate countries to the European Union with support from the European Commission.

Collaborating at European level to develop methodological tools and databases

On all of those issues, Member States might wish to collaborate in order to join their forces. Methodological developments are likely to be costly and information can be usefully shared and transferred in order to avoid duplication. In parallel with the implementation of the Directive at Member States level, activities are likely to continue at the European level in order to develop methodologies and shared databases.

Developing common databases on key data for the analysis

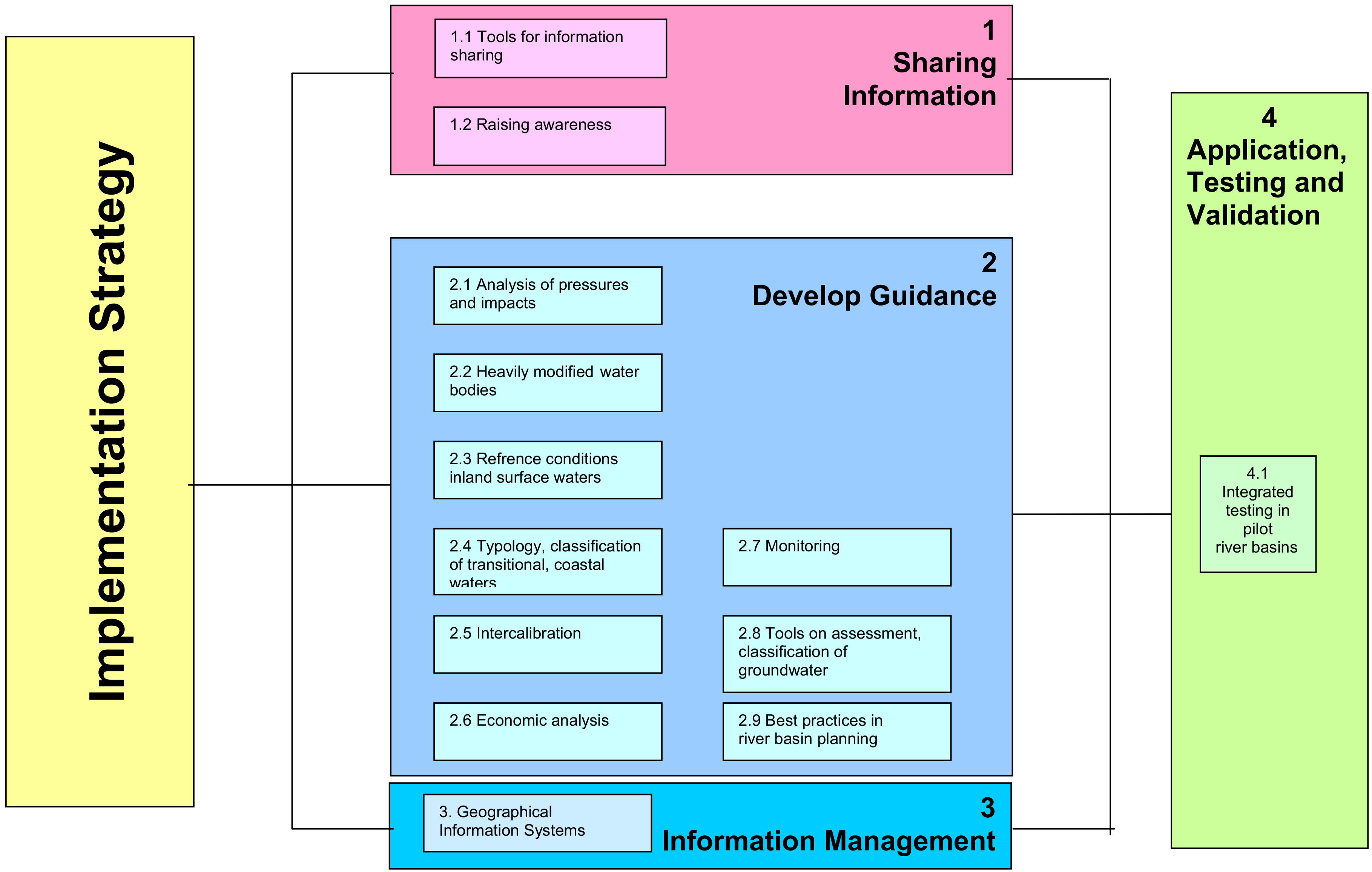
The development of common databases is likely to be instrumental in speeding up the process of data collection, providing some points of reference for the analysis and reducing the costs of carrying out full studies. It might be useful, for example, to develop databases on the costs and effectiveness of measures before 2004, as basis for undertaking the cost-effectiveness analysis by 2008. It would be necessary to identify the types of measures to be examined and what sort of cost data could already be collected. This data would need to be updated as information from monitoring systems start coming in from 2006 onwards. Similar efforts may be launched for developing environmental costs/benefits databases.

And finally…

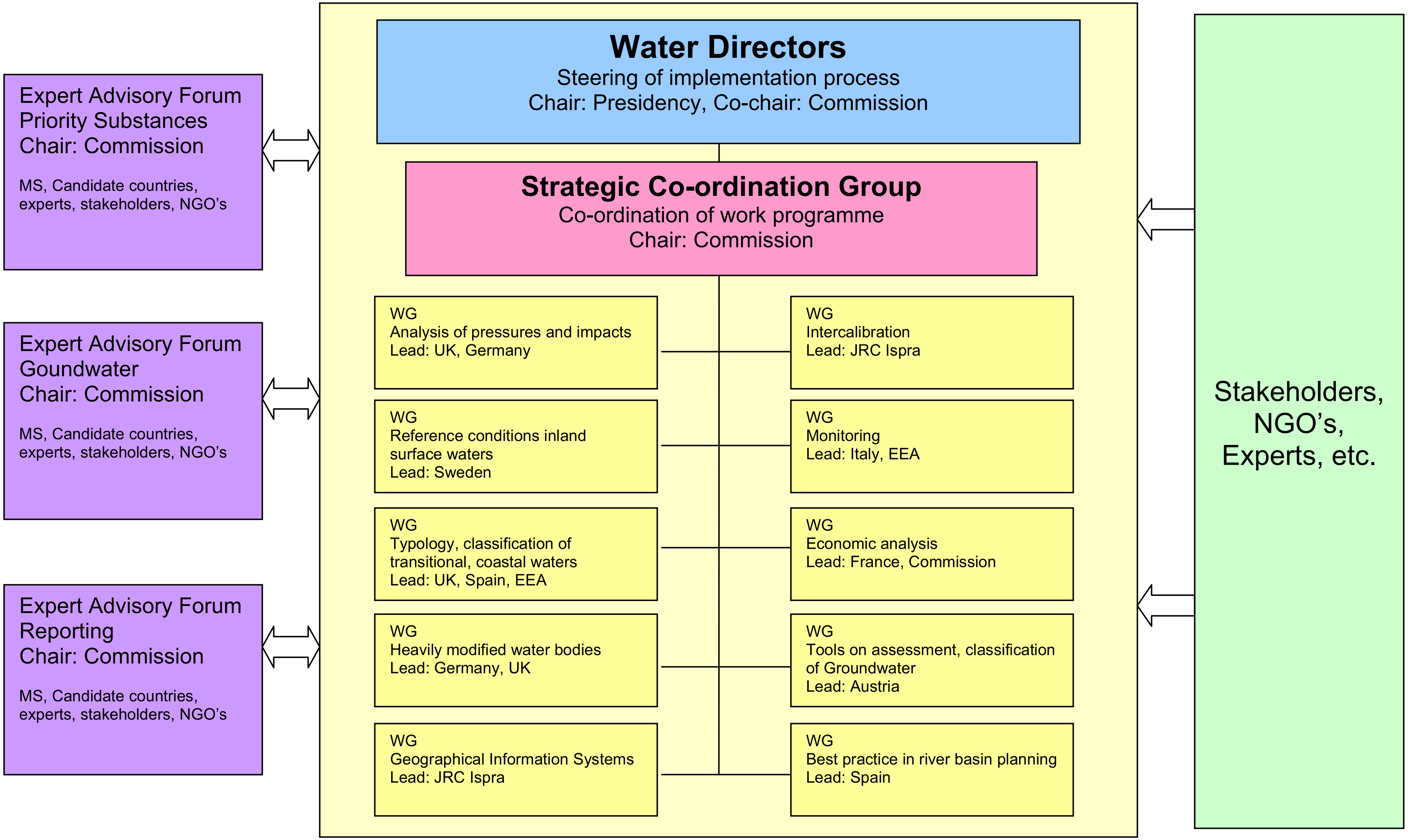
Improving and updating this Guidance Document might be required at a future stage, after the 2004 deadlines have been met and new information and experience has been gained. This possibility will be examined depending on lessons collated from the use of the Guidance and from the information that will have emerged.

Annex A – Implementation of the Water Framework Directive

ANNEX A1 The Common Implementation Stategy



Overall organisational structure of the Common Implementation Strategy



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Typology and classification of transitional and coastal waters	VINCENT	Claire	United Kingdom	Environment and Heritage Service	Calvert House 23 Castle Place BELFAST UK-BT1 IFY	+44 2890 254823	+44 2890 254761	Claire.vincent@doeni.gov.uk
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Annex B - Definitions

ANNEX B1 Economic elements of the Water Framework Directive: Legal text

Title	Specification	Provision
Preambles		
	No. 11	'[...] environmental damage should, as a priority, be rectified at source and the polluter should pay.'
	No. 12	'[...] the Community is to take account of available technical data, environmental conditions in the various regions of the Community, and the economic and social development of the Community as a whole and the balanced development of its regions as well as potential costs and benefits of action or lack of action.'
	No. 29	'[...] Member States may phase implementation of the programme of measures in order to spread the costs of implementation.'
	No. 31	In cases where a body of water is so affected by human activity or its natural condition is such that it may be infeasible or unreasonably expensive to achieve good status, less stringent objectives may be set [...] and all practicable steps should be taken to prevent any further deterioration of the status of waters.'
	No. 36	'It is necessary to undertake analyses of the characteristics of a river basin and the impacts of human activity as well as an economic analysis of water use [...]'
	No. 38	'The use of economic instruments by Member States may be appropriate as part of a programme of measures. The principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter pays principle. An economic analysis based on long-term forecasts of supply and demand for water in the RBD will be necessary for this purpose.'
	No. 43	'Pollution through the discharge, emission or loss of priority hazardous substances must cease or be phased out. The European Parliament and Council should [...] agree [...] on the substances to be considered for action as a priority and on specific measures to be taken against pollution of water by those substances, taking into account all significant sources and identifying the cost-effective and proportionate level and combination of controls.'
	No. 53	'Full implementation and enforcement of existing environmental legislation for the protection of waters should be ensured. It is necessary to ensure the proper application of the provisions implementing this Directive [...] by appropriate penalties [...]. Such penalties should be effective, proportionate and dissuasive.'
Article 2	*Definitions*	
	Paragraph 38	"Water services" means all services which provide, for households, public institutions or any economic activity: (a) abstraction, impoundment, storage, treatment and distribution of surface water or groundwater (b) waste water collection and treatment facilities which subsequently discharge into surface water.'
	Paragraph 39	"Water use" means water services together with any other activity identified under Article 5 and Annex II having a significant impact on the status of water. This concept applies for the purposes of Article 1 and of the economic analysis carried out according to Article 5 and Annex III, point (b).'

Title	Specification	Provision
Article 4	*Environmental objectives*	
	Paragraph 4.3	'Member States may designate a body of surface water as artificial or heavily modified, when: (a) the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects [...].'(b) the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option. Such designation and the reasons for it shall be specifically mentioned in the RBMPs required under Art. 13 and reviewed every six years.'
	Paragraph 4.4	'The deadlines established under paragraph 1 may be extended for the purposes of phased achievement of the objectives for bodies of water, provided that no further deterioration occurs in the status of the affected body of water when all of the following conditions are met: (a) Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales set out in that paragraph for at least one of the following reasons: [...] (ii) completing the improvements within the timescale would be disproportionately expensive (b) Extension of the deadline, and the reasons for it, are specifically set out and explained in the RBMP required under Art. 13 [...].'
	Paragraph 4.5	'Member States may aim to achieve less stringent environmental objectives than those required under Paragraph 1 for specific bodies of water when they are so affected by human activity, as determined in accordance with Art. 5.1, or their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive and all of the following conditions are met: (a) the environmental and socio-economic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs; (b) Member States ensure, - for surface water, the highest ecological and chemical status possible is achieved, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution; - for groundwater, the least possible changes to good groundwater status, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution; [...] (d) the establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the RBMP required under Art. 13 and those objectives are reviewed every six years.'
	Paragraph 4.6	'Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause [...] or the result of circumstances due to accidents [...] when all of the following conditions have been met: (a) all practicable steps are taken to prevent further deterioration in status and in order not to compromise the achievement of the objectives of this Directive in other bodies of water not affected by those circumstances; (b) the conditions under which circumstances that are exceptional or that could reasonably have been foreseen may be declared, including the adoption of the appropriate indicators, are stated in the RBMP; [...] (d) [...] all practicable measures are taken with the aim of restoring the body of water to its status prior to the effects of those circumstances as soon as reasonably practicable; (e) a summary of the effects of the circumstances and of such measures taken or to be taken in accordance with paragraphs (a) and (d) are included in the next update of the RBMP.'
	Paragraph 4.7	'Member States will not be in breach of this Directive when: failure to achieve good groundwater status, good ecological status or, where relevant, good ecological potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of new modifications to the physical characteristics of a surface water body or alteration to the level of bodies of groundwater, or failure to prevent deterioration from high status to good status of a body of surface water is the result of new sustainable human development activities and all the following conditions are met: ... (d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.'
Article 5	*Characteristics of the River Basin District, review of the environmental impact of human activity and the economic analysis of water use*	

Title	Specification	Provision
	Paragraph 5.1	‘Each Member State shall ensure that for each RBD or for the portion of an international RBD falling within its territory an analysis of its characteristics, a review of the impact of human activity on the status of surface waters and on ground water, and an economic analysis of water use is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.’
	Paragraph 5.2	‘The analyses and reviews mentioned under paragraph 1 shall be reviewed, and if necessary updated at the latest 13 years after the date of entry into force of this Directive [2013] and every six years thereafter.’
Article 6	*Register of Protected Areas*	
	Paragraph 6.1	‘Member States shall ensure the establishment of a register or registers of all areas lying within each RBD which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water. They shall ensure that the register is completed the latest four years after the date of entry into force of this Directive.’
	Paragraph 6.2	‘The register or registers [of protected areas] shall include all bodies of water identified under Article 7(1) and all Protected Areas covered by Annex IV [i.e. ...areas designated for the protection of economically significant aquatic species...].’
Article 9	*Recovery of costs for water services*	
	Paragraph 9.1	‘Member States shall take account of the principle of recovery of costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle. Member States shall ensure by 2010: (i) that water pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive (ii) an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III and taking account of the polluter pays principle. Member States may in do doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected.’
	Paragraph 9.2	‘Member States shall report in the RBMPs [to be published at the latest 9 years after the date of entry into force of this Directive, 2009] on the planned steps towards implementing paragraph 1 [...] which will contribute to achieving the environmental objectives of this Directive and on the contribution made by the various water uses to the recovery of the costs of the water services.
	Paragraph 9.3	‘Nothing in this Article shall prevent the funding of particular preventative or remedial measures in order to achieve the objectives of this Directive.’
	Paragraph 9.4	‘[...] Member States shall report the reasons for not fully applying paragraph 1, second sentence, in the RBMPs.’
Article 11	*Programme of measures*	

Title	Specification	Provision
	Paragraph 11.1	'Each Member State shall ensure the establishment for each RBD, or for the part of an international RBD [IBRD] within its territory, of a programme of measures, taking account of the results of the analyses required under Art. in order to achieve the objectives established under Art. 4 [...]'
	Paragraph 11.2	'Each programme of measures shall include the "basic" measures specified in paragraph 3 and, where necessary, "supplementary" measures.'
	Paragraph 11.3	"Basic" measures are the minimum requirements to be complied with and shall consist of [...] (b) measures deemed appropriate for the purposes of Art. 9. (c) measures to promote an efficient and sustainable water use in order to avoid compromising the achievement of the objectives specified in Art. 4. [...] (i) for any other significant adverse impacts on the status of water identified under Art.. 5 and Annex II.'
	Paragraph 11.4	"Supplementary" measures are those measures designed and implemented in addition to the basic measures, with the aim of achieving the objectives established pursuant to Art. 4.'
	Paragraph 11.7	'The programmes of measures shall be established at the latest nine years after the date of entry into force of this Directive [2009] and all the measures shall be made operational at the latest 12 years after that date [2012].'
Article 13	*River basin management plans*	
	Paragraph 13.1	'Member States shall ensure that a RBMP is produced for each RBD lying entirely within their territory.'
	Paragraph 13.2	'In the case of international RBD falling entirely within the Community, Member States shall produce a single International RBMP. Where such a plan is not produced, a RBMP should be produced covering at least those parts of the IRBMP falling within its territory to achieve the objectives of this Directive.'
	Paragraph 13.4	'The RBMP shall include the information detailed in Annex VII.'
	Paragraph 13.5	'RBMPs may be supplemented by the production of more detailed programmes and management plans for sub-basin, sector, issue or water type, to deal with particular aspects of water management. Implementation of these measures shall not exempt Member States from any of their obligations under the rest of this Directive.'
	Paragraph 13.6	'RBMPs shall be published at the latest nine years after the date of entry into force of this Directive (2009).'
	Paragraph 13.7	'RBMPs shall be reviewed and updated at the latest 15 years after the date of entry into force of this Directive and every six years thereafter.'
Article 14	*Public Information and Consultation*	
	Paragraph 1	'Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the River Basin Management Plans. Member States shall ensure that, for each River Basin District, they publish and make available for comments to the public, including users: (a) a timetable and work programme for the production of the plan […] at least three years before the beginning of the period to which the plan refers; (b) an interim overview of the significant water management issues identified in the river basin at least two years before […]; (c) draft copies of the River Basin Management Plan, at least one year before […].
Article 15	*Reporting*	

Title	Specification	Provision
	Paragraph 15.2	'Member States shall submit summary reports of the Reporting of the analyses under Article 5 [...] undertaken for the purposes of the first RBMP within 3 months of their completion.'
Article 16	*Strategies against pollution of water*	
	Paragraph 16.6	'For the priority substances, the Commission shall submit proposals of controls for the progressive reduction of discharges, emissions and losses of the substances concerned and, in particular, the cessation or phasing out of discharges [...]. In doing so it shall identify the appropriate cost-effective and proportionate level and combination of product and process controls for both point and diffuse sources [...].'
Article 17	*Strategies to prevent and control pollution of groundwater*	
	Paragraph 17.2	'In proposing measures, the Commission shall have regard to the analysis carried out according to Article 5 and Annex II [due in at the latest 4 years after the implementation of this Directive, i.e. 2004].'
Article 23	*Penalties*	'Member States shall determine penalties applicable to breaches of the national provisions adopted pursuant to this Directive. The penalties thus provided for shall be effective, proportionate and dissuasive.'
Annex II	*Identification of pressures*	
	Paragraph 1.4	'Member States shall collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water bodies in each RBD are liable to be subject, in particular: • estimation and identification of significant point [... and...] diffuse source pollution [...]; • estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses, including seasonal variations and total annual demand, and loss of water in distribution systems; • estimation and identification of the impact of significant water flow regulation [...]; • identification of significant morphological alterations to water bodies; • estimation and identification of other significant anthropogenic impacts on the status of surface waters; and • estimation of land use patterns [...].'
Annex III	*Economic analysis*	'The economic analysis shall contain enough information in sufficient detail (taking into account the costs associated with collection of the relevant data) in order to: (a) make the relevant calculations necessary for taking into account under Art. 9 the principle of recovery of the costs of the water services, taking account of the long term forecasts of supply and demand for water in the RBD and, where necessary: • estimates of the volume, prices and costs associated with water services; and • estimates of relevant investment including forecasts of such investments (b) make judgements about the most cost effective combination of measures in respect of water uses to be included in the programme under Art. 11 based on estimates of the potential costs of such measures.'
Annex IV	*Protected areas*	
	Paragraph 1	'The register of Protected Areas required under Article 6 shall include the following types of protected areas: [...] areas designated for the protection of economically significant aquatic species [...].'

Title	Specification	Provision
Annex VI	*Lists of measures to be included within the programmes of measures*	‘The following is a non-exclusive list of supplementary measures which Member States within each RBD may choose to adopt as part of the Programme of Measures required under Art. 11(4) [...] (iii) economic or fiscal instruments [...].’
Annex VII	*River Basin Management Plans*	‘RBMPs shall cover the following elements:
	Paragraph 1	a general description of the characteristics of the RBD required under Article 5 and Annex II [...];
	Paragraph 2	a summary of significant pressures and impact of human activity on the status of surface water and groundwater, including: • estimation of point source pollution; • estimation of diffuse source pollution, including a summary of land use; • estimation of pressures on the quantitative status of water including abstractions; • analysis of other impacts of human activity on the status of water.
	Paragraph 6	a summary of the economic analysis of water use as required by Article 5 and Annex III;
	Paragraph 7	a summary of the programme or programmes of measures adopted under Art. 11, including the ways in which the objectives established under Art. 4 are thereby to be achieved:
	Paragraph 7.2	[...] a report on the practical steps and measures taken to apply the principle of recovery of the costs of water use in accordance to Art. 9;
	Paragraph 7.10	[...] details of the supplementary measures identified as necessary in order to meet the environmental objectives established;
	Paragraph 8	a register of any more detailed programmes and management plans for the RBD dealing with particular sub-basins, sectors, issues or water types, together with a summary of their contents [...].’

Abbreviations: RBMP- River Basin Management Plan, IRBMP - International River Basin Management Plan, RBD - River Basin District, IBRD - International River Basin District

ANNEX B2 Glossary

Source	Term	Definition
Information sheet – Estimating Costs (and Benefits)	Administrative costs	Administrative costs related to water resource management. Examples include costs of administering a charging system or monitoring costs.
	Affordability	The relative importance of water service costs in users' disposable income, either on average or for low-income users only.
Art. 2 (11)	Aquifer	A sub-surface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.* (2 definitions are given in the combined CIS glossary)
Art. 2 (8)	Artificial water body	A body of surface water created by human activity.* (2 definitions are given in the combined CIS glossary)
Art. 2 (27)	Available groundwater resource	The long-term annual average rate of overall recharge of the body of groundwater less the long-term annual rate of flow required to achieve the ecological quality objectives for associated surface waters specified under Article 4, to avoid any significant damage to associated terrestrial ecosystems.*
Information sheet – Baseline Scenario	Baseline Scenario	Projection of the development of a chosen set of factors in the absence of policy interventions. The definition in the combined CIS glossary is slightly different.
Art. 11 (3)	Basic measures	See Article 11(3) of the Directive.
Art 4 (7)	Benefits	See information sheet *Assessing Costs and Benefits*
Art. 2 (12)	Body of groundwater	A distinct volume of groundwater within an aquifer or aquifers.*
Art. 2 (10)	Body of surface water	A discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.*
Information sheet – Estimating Costs (and Benefits)	Capital costs	For the purpose of this Guidance Document divided into three categories: ➢ *New investments*. Cost of new investment expenditures and associated costs (e.g. site preparation costs, start-up costs, legal fees); ➢ *Depreciation*. Annualised cost of replacing existing assets in future. ➢ *Cost of capital*. Opportunity cost of capital, i.e. an estimate of the rate of return that can be earned on alternative investments.
Art. 2 (7)	Coastal water	Surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.* 2 definitions are given in the combined CIS glossary, but one is for 'coastal water body'
Art. 2 (36)	Combined approach	The control of discharges and emissions into surface waters according to the approach set out in Article 10.*
Art. 2 (16)	Competent authority	An authority or authorities identified under Article 3(2) or 3(3).*

Source	Term	Definition
Information sheet – Assessing Costs and Benefits	Contingent valuation	Valuation of commodities not traded in markets, e.g. clean air, landscapes and wildlife. The valuation is based upon the responses of individuals to questions about what their actions would be if a particular hypothetical situation were to occur. When the average of responses has been calculated, with weighting if necessary, the valuation of a **public good** is ascertained.**
Information sheet – Assessing Costs and Benefits	Cost-benefit analysis	The evaluation of an investment project with a long-perspective from the viewpoint of the economy as a whole by comparing the effects of undertaking the project with not doing so.**
Information sheet – Cost-effectiveness analysis	Cost-effectiveness analysis	An analysis of the costs of alternative programmes designed to meet a single objective. The programme which costs least will be the most cost effective.**
Annex III	Cost-effective combination of measures	A combination of measures chosen subject to a cost-effectiveness analysis (see 'cost-effectiveness analysis')
Information sheet – Assessing Costs and Benefits	Damage function	A function of how pollution damage varies with the level of pollution emitted, giving a monetary value for that damage.***
Information sheet – Cost-effectiveness Analysis	Direct cost	A production cost directly attributable to the cost of producing one unit of a particular output.**
Art. 2 (32)	Direct discharge to groundwater	Discharge of pollutants into groundwater without percolation throughout the soil or subsoil.*
Information sheet – Estimating Costs (and Benefits)	Discounting	A method used to value at the same date economic flows and stocks which have originated at different dates.**
Information sheet – Estimating Costs (and Benefits)	Discount rate	The rate used for discounting future values to the present. In cost-benefit analysis, there is a distinction between a private and a social rate of discount. A private rate of discount reflects the time preference of private consumers; a social rate is based on the government's view, which can be more long-sighted as it attempts, in most cases, to take into account the welfare of future generations.**
Art. 4 (3, 5 & 7)	Disproportionate costs	See information sheet *Disproportionate Costs*
Art. 4 (5)	Disproportionately expensive	See information sheet *Disproportionate Costs*
Art. 2 (21)	Ecological status	An expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V.**
Art. 5 (1)	Economic analysis	See Annex III of the Directive
Information sheet – Estimating Costs (and Benefits)	Economic costs	See 'opportunity costs'**
Art. 2 (41)	Emission controls	Controls requiring a specific emission limitation, for instance an emission limit value, or otherwise specifying limits or conditions on the effects, nature or other characteristics of an emission or operating conditions which affect emissions. Use of the term 'emission control, in the Directive in respect of the provision of any other Directive shall not be held as reinterpreting those provisions in any respect.*
Art. 2 (40)	Emission limit values	The mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during any one or more periods of time. Emission limit values may also be laid down for certain groups, families or categories of substances, in particular for those identified under Article16.*
Information sheet – Estimating Costs (and Benefits)	Environmental costs	Represent the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils).
Art. 2 (34)	Environmental objectives	The objectives set out in Article 4.*

Source	Term	Definition
Art. 2 (35)	Environmental quality standard	The concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment.*
Section 2	Explicit economic function	Refers to the economic components that are specifically outlined in Annex III of the Directive.
Information sheet – Estimating Costs (and Benefits)	External cost	An external cost exists when the following two conditions prevail 1. An activity by one agent causes a loss of welfare to another agent; and 2. The loss of welfare is uncompensated.***
Information sheet – Cost Recovery	Financial costs of water services	Include the costs of providing and administering these services. They include all operation and maintenance costs, and capital costs (principal and interest payment), and return on equity where appropriate).
Art. 2 (23)	Good ecological potential	The status of a heavily modified or an artificial body of water, so classified in accordance with the relevant provisions of Annex V.*
Art. 2 (22)	Good ecological status	The status of a body of surface water, so classified in accordance with Annex V.*
Art. 2 (25)	Good groundwater chemical status	The chemical status of a body of groundwater, which meets all the conditions set out in Table 2.3.2 of Annex V.*
Art. 2 (28)	Good quantitative status	The status defined in Table 2.1.2 of Annex V.*
Art. 2 (18)	Good surface water status	The status achieved by a surface water body when both its ecological status and its chemical status are at least 'good'.*
Art. 2 (24)	Good surface water chemical status	The chemical status required to meet the environmental objectives for surface waters established in Article 4(1)(a), that is the chemical status achieved by a body of surface water in which concentrations of pollutants do not exceed the environmental quality standards established in #Annex IX and under Article 16(7), and under other relevant Community legislation setting environmental quality standards at Community level.*
Art. 2 (2)	Groundwater	All water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.* 2 definitions are given in the combined CIS glossary
Art. 2 (19)	Groundwater status	The general expression of the status of a body of groundwater, determined by the poorer of its quantitative status and its chemical status.*
Art.2 (29)	Hazardous substances	Substances or groups of substances that are toxic, persistent and liable to bioaccumulate, and other substances or groups of substances which give rise to an equivalent level of concern.*
Art. 2 (9)	Heavily modified water body	A body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II.*
Information sheet – Scale issues	Homogenous areas	Geographical areas that: ➢ Present homogeneous socio-economic characteristics today (a given economic sector or sub-sector localised in one geographical area of the river basin); and ➢ Are likely to react in a homogenous manner to measures or interventions.
Section 2	Implicit economic functions	Refers to references made to economic issues in other parts of the Directive text that will also require some economic analysis but which have not been mentioned nor made explicit in Annex III.
Information sheet – Estimating Costs (and Benefits)	Indirect cost	Overhead and other costs not directly attributable to the cost of producing one unit of output; a fixed cost.**

Source	Term	Definition
Art. 2 (3)	Inland water	All standing or flowing water on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of territorial waters is measured.*
Art. 2 (5)	Lake	A body of standing inland surface water*
Information sheet – Estimating Costs (and Benefits)	Maintenance costs	Costs for maintaining existing (or new) assets in good functioning order till the end of their useful life.
Information sheet – 'Disproportionate Costs' and 'Analysis of derogation for new modifications/ activities based on Article 4.7' (Annex D2a of this Guidance Document)	New modifications	All direct modifications to the physical characteristics of a surface or groundwater body, or alterations to the level of bodies of groundwater (e.g. straightening a river reach and alterations to the level of groundwater bodies). It does not deal with the chemical and ecological dimensions of good water status. *
Analysis of derogation for new modifications/ activities based on Article 4.7 (Annex D2a of this Guidance Document)	New sustainable human development activities	*New human development activities* are activities that relate to changes from high to good status in surface water. It includes all ecological, qualitative and quantitative elements in the definition of the water status. The focus is on the use that leads to the change in the water status. *Sustainable new human development activities* are activities described above that considers and integrates social, economic and environmental impacts with a temporal dimension (e.g. future generations) and potentially, a global dimension. See also *Annex D.2* of this Guidance Document.
Information sheet – Estimating Costs (and Benefits)	Operating costs	All costs incurred to keep an environmental facility running (e.g. material and staff costs).
Information sheet – Estimating Costs (and Benefits)	Opportunity costs	The value of the alternative foregone by choosing a particular activity.**
Art. 2 (31)	Pollutant	Any substance liable to cause pollution, in particular those listed in Annex VIII.*
Art. 2 (33)	Pollution	The direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems, which result in damage to material property, or which impair or interfere with amenities and other legitimate uses of the environment.*
	Price elasticity of demand	The responsiveness of quantity demanded of a good or service to a change in its price or in a consumer's income.**
Art. 2 (30)	Priority substances	Substances identified in accordance with Article 16 (2) and listed in Annex X. Among these substances there are 'priority hazardous substances' which means substances identified in accordance with Article 16 (3) and (6) for which measures have to be taken in accordance with Article 16(1) and 16(8).*
Art. 2 (26)	Quantitative status	An expression of the degree to which a body of groundwater is affected by direct and indirect abstractions.*
Art. 6 (2)	Register of protected areas	Shall include all bodies of water identified under Article 7 (1) and all protected areas covered by Annex IV.* The definition in the combined CIS glossary is longer.

Source	Term	Definition
Information sheet – Estimating Costs (and Benefits)	Resource costs	Represents the costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater).
Art. 2 (4)	River	Body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course.*
Art. 2 (13)	River basin	The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.* There are 2 definitions in the combined CIS glossary
Art. 13 (4)	River basin management plan	Shall include the information detailed in Annex VII* The definition in the combined CIS glossary is longer
Art. 2 (14)	Sub-basin	The area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence).* There are 2 definitions in the combined CIS glossary.
Preamble (15)	Supply of water	A service of general interest as defined in the Commission communication on services of general interest in Europe.
Art. 2 (1)	Surface water	Inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters.* There are 2 definitions in the combined CIS glossary.
Art. 2 (17)	Surface water status	The general expression of the status of a body of surface water, determined by the poorer of its ecological status and its chemical status.* The definition in the combined CIS glossary is slightly shorter.
Information sheet – Disproportionate Cost	Time derogation	A temporary extension of deadlines to achieve the environmental objectives set out in Article 4 of the Directive.
Information sheet – Estimating Costs (and Benefits)	Unit cost	The cost of producing one unit of a product.**
	Utility	The satisfaction derived from an activity, particularly consumption.**
Water Uses and Services (Annex B3 of this Guidance Document)	Water services	All services which provide, for households, public institutions or any economic activity: ➢ Abstraction, impoundment, storage, treatment and distribution of surface water or groundwater; ➢ Wastewater collection and treatment facilities which subsequently discharge into surface water.* See also information sheet *Water Uses and Services*
Water Uses and Services (Annex B3 of this Guidance Document)	Water uses	Water services together with any other activity identified under Article 5 and Annex II having significant impact on the status of water.* See also information sheet *Water Uses and Services*

Sources:

* Water Framework Directive (2000), Article 2 ‘Definitions’.
** Donald Rutherford (1995), ‘Routledge Dictionary of Economics’, Routledge.
*** David W. Pearce and R. Kerry Turner (1990), ‘Economics of Natural Resources and the Environment’, Harvester Wheatsheaf.

ANNEX B3 Water Uses and Water Services

Directive references: *Article 1, Article 2 (paragraphs 38 & 39), Article 5* and *Article 9*

This Information Sheet helps you understand the definition of water services and water uses and how these categories are dealt with in the Directive.

What is the difference between water services and water uses?

A key objective of the Directive is to promote sustainable water use, based on a long-term protection of available water resources (Article 1). The Directive distinguishes human activities into 'water services' and 'water uses'. Those terms are defined in *Article 2* of the Directive (see *Box B3.1*) and are represented graphically in *Figure B3.1*. Water services are specifically referred to in the context of Article 9 and cost-recovery.

Box B3.1 – Water Uses and Services as Defined in Article 2

38) 'Water services' means all services, which provide, for households, public institutions or any economic activity:

(a) Abstraction, impoundment, storage, treatment and distribution of surface water or groundwater,
(b) Wastewater collection and treatment facilities, which subsequently discharge into surface water.

39) 'Water use' means water services together with any other activity identified under Article 5 and Annex II having a significant impact on the status of water. This concept applies for the purposes of Article 1 and of the economic analysis carried out according to Article 5 and Annex III, point (b).

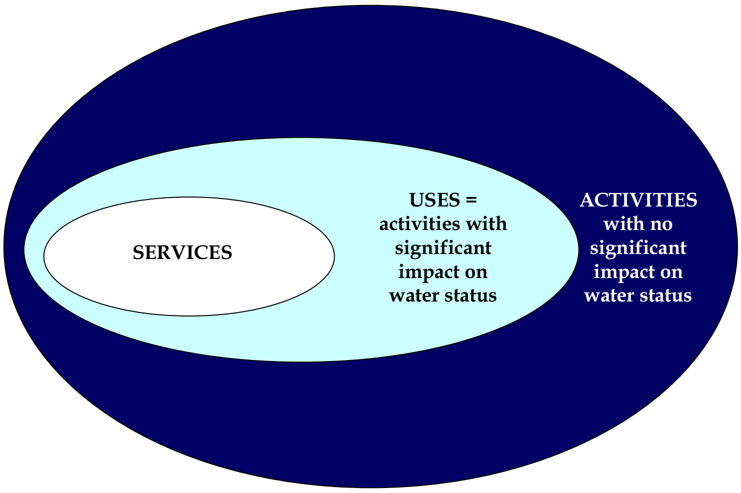
Overall, a water service represents an intermediary between the natural environment and the water use itself. The main purpose of the water service is to ensure that:

- Key characteristics of natural waters are modified (i.e. the service offered is this modification) so as to ensure it fits with the requirements of well-identified users (e.g. provision of drinking water); or
- Key characteristics of water 'discharged' by users are modified (i.e. the service offered is also this modification, e.g. waste water treatment) so that it can go back to the natural environment without damaging it.

Overall, a water service *per se* does not consume water nor produce pollution, although it can directly lead to morphological changes to the water ecosystem. Characteristics of waters that are modified through a water service include:

- Its **spatial distribution**, e.g. a water supply network for ensuring that water is reallocated spatially to every individual user;
- Its **temporal distribution**/flows, e.g. dams;
- Its **height**, e.g. weirs and dams;
- Its **chemical composition**, e.g. treatment of water, and wastewater;
- Its **temperature**, e.g. temperature impact on water.

Figure B3.1 – Water Uses and Services

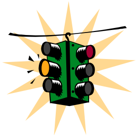


Key Points to Remember:

- ***Water Services*** include **all services** (public or private) of abstraction, impoundment, storage, treatment and distribution of surface water or groundwater, along with wastewater collection and treatment facilities. Member States shall account for the recovery of the costs of water services according to *Article 9*;

- ***Water Uses*** are all activities that have a significant impact on water status, according to the analysis of pressures and impacts developed in accordance to *Article 5 and its Annex II*. Economic analysis must be performed for all water uses *(Article 5 and Annex III).* Also, Member States shall ensure an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services *(Article 9);*

- Some ***activities*** with no significant impact on water status are neither water services nor water uses. Clearly, this distinction can not be made systematic as it is based on the analysis undertaken in accordance to *Article 5 and Annex II*, e.g. in some cases, fishing will have no impact on water status, but over-fishing has a significant impact on the ecology of a river and water status.



Look out! Read Article 9 carefully.

Be careful when you read Article 9. Overall, this article states that Member States must ensure by 2010

- That water pricing policies provide adequate incentive for users to use water resource efficiently;
- An adequate contribution of the different water uses to the recovery of the costs of water services.

In complying with this obligation, Member States may take account of the social, environmental and economic effects of the recovery.

The first sentence introduces the principle of cost recovery for ***water services***. Later, it specifies that Member States shall ensure an adequate contribution of the different ***water uses*** to the recovery of the costs of ***water services***.... Thus, Article 9 combines both water services and water uses. For example, diffuse pollution to surface water or groundwater is not a water service as defined in Article 2. However, if it has a significant impact on the status of water, it is a water use. The water user will then be asked to contribute in an adequate manner to the costs of water services they have caused (e.g. costs of water treatment), based on the economic analysis undertaken according to Annex III and in accordance with the polluter pays principle.

More work lies ahead for the definition of Water Uses

By contrast to the approach taken for water services, the Directive does not specify a list of water uses to be considered. Basically, only the activities that cause significant impacts on water bodies and therefore pose a risk to achieving good status are covered by the definition of water uses. General experience shows that navigation, hydropower generation, domestic, agriculture and industrial activities are important water uses which may cause significant impacts and therefore have to be taken in consideration.

Thus, more work is needed…

- To determine a list of main water uses based on the assessment of significant human impact on water bodies (Article 5 and Annex II) before 2004. This is the same deadline as for the economic analysis of water uses required for the overall characterisation of river basins.

This work will be developed in the context of the review of the impact of human activity on the status of surface waters and on groundwater according to Article 5 and Annex II (see WFD CIS Guidance Document No. 3 on the assessment of 'Impacts and Pressures').

Recommendations for a practical approach to assessing cost-recovery

The proposed approach is based on the application of key principles for improving decision making and ultimately water status, i.e. **transparency** and **effectiveness,** and on pragmatism and best use of available resources for targeting the analysis to aid decision making where it is most required, i.e. **proportionality**.

For the purpose of reporting and cost-recovery assessment, the following elements should be considered.

1. **Proportionality** – cost recovery is assessed (i) when water services have a significant impact on water status, and (ii) when water uses have a significant impact on water status resulting in services developed for other water users for mitigating/reducing the observed negative damage. Thus, the cost-recovery assessment for 2004 should closely link to the analysis of pressures and impacts that needs to be undertaken by the same deadline.

2. **Effectiveness** – cost-recovery is assessed when cost-recovery and pricing is seen as effective for changing behaviour and are key elements in decision-making.

3. **Transparency -** for the areas or water bodies where water services have an impact on water status, should then systematically identified and the assessment of cost-recovery and pricing is performed. This ensures **transparency** as required by the Water Framework Directive. It also provides the basis for assessing the integration between water policy and other sector policies. To achieve maximum transparency, to ensure equitable and effective treatment *vis-à-vis* the internalisation of environmental and resource costs, and to preserve competition between economic sectors, water services should, where necessary, include both services provided by third parties and self services.

In the short term, for the first characterisation of the river basin district (Article 5):

- As little may be known on the effectiveness of cost-recovery and pricing for achieving the environmental objectives of the Directive, a more systematic cost-recovery assessment of all services should be performed as sound basis for follow-up effectiveness analyses as support to targeted policy intervention;
- Mainly available information will be used. This first identification will lead to the identification of missing data required for assessing cost-recovery coherently in accordance with the proportionality and effectiveness principles mentioned above.

In the longer term, for the river basin management plans, water services to be considered for assessing cost-recovery will build on the identification of water bodies at risk of failing good water status, along with input from the public consultation on the overview on significant water management issues in the river basin.

Whatever the outcome of the cost-recovery assessment, and as specified in Article 9.1, 9.3 and 9.4 of the Directive, it will not prevent Member States deciding on the level of cost recovery of the water services being identified, and on the contribution of water uses to the costs of water services, as long as it is duly reported on in the river basin management plans.

Annex C – Support to Implementation

ANNEX C1 Illustrative Terms of Reference for a Virtual Scoping Study on Cost-effectiveness Analysis

Aims and objectives

The aim of the study is to scope out how the cost-effectiveness analysis of measures to achieve good water status and related consultation could be carried out so as to aid decision-making on these measures and identify and investigate any issues and problems regarding such economic analysis. The scoping deals with both economic and technical issues and expertise as investigated in the cost-effectiveness analysis.

Issues

The specific issues to be examined include:

- Characterise and differentiate the various stretches of water bodies in the selected basin so as to identify bodies of water for which objectives must be set and measures identified and appraised;

- Characterise the various possible measures to achieve good water status in terms of the level (e.g. national or local) at which decisions have to be taken on them and the level at which these measures have to be implemented;

- Characterise the diverse parties affected positively or negatively by the impacts of these various possible measures to achieve good quality status, so as to help inform (in subsequent research) how their views could be input to decision-makers;

- How best to use the available information given by existing scientific, risk assessment and economic appraisal systems on the environmental, economic or social impacts of the possible measures, so as to aid decision-making on them. What are the key gaps in technical expertise and information that need to be addressed to undertake cost-effectiveness analysis?

- Identify outstanding staff resourcing and capability issues. For example, are there sufficient numbers of trained staff at regional level and centrally to co-ordinate data collection and economic analysis?

- Identify outstanding specific research issues that need to be addressed in subsequent studies.

Specific Tasks to be carried out

1. Characterise and differentiate the various stretches of water bodies in the selected basin so as to identify the appraisals needed for particular stretches of water for which objectives must be set and measures identified. These could form appropriate separate building block elements of the appraisal (and subsequent monitoring) of measures in the river basin management plans (RBMPs). This might characterise the main different types of water bodies in the basin in respect of, for example:

    - Their different water quality states and the extent to which individual water bodies now fail to achieve good status and will fail to achieve good status by 2015 and 2021;

    - The pressures on water quality now and in the future;

- The different types of options to achieve good status;
- The scale of costs and complexity involved in these measures (and hence the extent of the appraisals (of varying degrees of complexity/depth) that will be needed.

The study will need to extrapolate the findings for the selected basin to other river basins to give a qualitative and approximate assessment of the various depths of economic analysis that would be needed for all river basins in the country.

2. The consultants should devise a simple schematic way of presenting information from the appraisal of individual RBMPs in a way that can be aggregated to aid decision-making at the national level.

3. Characterise the various possible measures to achieve good water status in terms of the level (e.g. national or local) at which decisions have to be taken on them and the level at which these measures have to be implemented.

4. Characterise the parties affected positively or negatively by the environmental, economic or social impacts of the options, especially who benefits and who pays for the costs of the options? In particular specify whether they live within the basin. Investigate how this geographical characterisation of the parties affected could relate to the level at which the possible measures are decided upon and implemented (see above – state where above).

5. Identify what information is needed regarding consultation for the effective implementation of the WFD under Article 14. This should take account of the complex mix of local and national decisions and parties affected by them - see above– state where above - and the need for the consultation to input views rather than determine the decisions (especially at national level).

6. Review the availability of scientific, risk assessment and economic information on the environmental, economic or social impacts of the possible measures and options and show how these could best be used in the cost-effectiveness analysis and to present information on the impacts of options for the consultation. Show how to present clearly the findings and their assumptions and limitations? Identify what additional information, analysis and appraisal processes are needed and how could these best be provided?

7. Show how to present information on measures and combinations of measures to show costs, effectiveness and other factors (e.g. benefits) where appropriate and relevant.

8. Identify what information (in what form) is needed on the costs and economic impacts of the various types of measures (see (3) above) covering the different sectors (water industry, non-water industry, agriculture and other). Review the availability of this information.

9. Indicate how much time and resources would be available to carry out the cost-effectiveness analysis of measures in the selected river basin? Estimate how much time and resource would be required to carry out a similar analysis in various types of river basins (e.g. with different sizes, different pressures and impacts, different availability of information and research results). Identify or seek means of reconciling the likely imbalance between needs and available resources (e.g. streamline the cost-effectiveness analysis process while maintaining its key elements).

10. Identify specific research subjects and pilot RBMP studies that will then be needed to research in depth and clarify particular outstanding issues and problems regarding the practical application of the various elements of the cost-effectiveness analysis.

Outputs from the Study

The intended outputs from the study include:

- Show what information (in what form) is needed to inform decision-making (at which level and for which decisions) on the various types of options;

- Show how the various elements of the cost-effectiveness analysis could best generate this information and how this information could fit together well in practice;

- Identify key information gaps and specific research needs and priorities, especially regarding the development and application of economic appraisal and analysis tools and techniques. This would then form the basis and terms of reference for specific follow up work (e.g. to improve specific tailored economic appraisal techniques).

Study Form

This is essentially a scoping and ground clearing study anchored in a specific basin.

It will entail consultants reviewing the available material (e.g. on water quality states and reasons for failure, available economic information, reports on existing consultation procedures, planning documents with forecasts for key economic sectors/water users, etc).

They would then seek out and analyse the views and knowledge of experts (e.g. from government departments and key stakeholders) on **how** they could carry out **hypothetically (or virtually),** in a specific basin, a cost-effectiveness analysis of the measures for developing the RBMPs.

This virtual study will involve no original research and the consultants should not get bogged down in any detailed investigations. Thus, where data are not currently available, the consultants should use assumed illustrative dummy data and plausible information, that might be generated by the available sources and appraisal processes, to give a virtual illustration of how the cost-effectiveness analysis could be applied in practice – i.e. use assumptions and judgement to report the type of outputs from each element, rather than do any actual data collection as such.

The consultants would interview (probably by telephone) the appropriate experts and prepare a review and issues paper. They will organise a 2-day brainstorming workshop with key experts (mostly from relevant Government departments and devolved administrations, and also from key stakeholders) to work through and thrash out the issues concerned with carrying out the cost-effectiveness analysis.

There will be close links between this study and other scoping studies and research that the government departments are carrying out in the context of the implementation of the Water Framework Directive. For example, case studies on Heavily Modified Water Bodies or studies on scientific aspects, such as specification of water quality objectives and monitoring and characterisation of river basins.

The preliminary results and draft report will be discussed in a 2 day workshop with experts from government and key stakeholders. The main objectives of the workshop will be the discussion and evaluation of the preliminary results of the scoping study, the assessment of the relevance of the results to other river basins in the country, and a first discussion with stakeholders on the economic analysis carried out and its integration into the decision making process for developing RBMPs.

Expertise Required

The successful contractors' team will have to have the following expertise:

- Project management and managing a team of diverse experts so as to pull together their views;
- Economic appraisal and presentation of economic-related information for different audiences;
- Appraisal of the control measures covering the various sectors (households, industry, agriculture, etc.);
- Stakeholder consultation;
- Experts knowledgeable about scientific and risk assessment work relevant to the appraisals for the WFD and how this could effectively input into the cost-effectiveness analysis and consultation processes in this study;
- Organising and animating workshops with diversity of participants from government departments and key stakeholders.

The study period is 6 months. Experts' input to the study is estimated at 6 full man-months.

ANNEX C2 Stakeholder Analysis: Methodology and Key Issues

Introduction

When embarking on an interactive process it is of the utmost importance to consider who will be participating in the process. To get an overview of all the relevant stakeholders (or actors) in the field of interest, a so-called "stakeholder-analysis" can be performed. This analysis reduces the risk of forgetting an important actor and will give an idea about the different angles from which the subject can be viewed. The stakeholder-analysis itself is a relatively simple and a methodological exercise, and a possible methodology is presented in this Annex along with an illustration. However, it is left to the reader to assess how this can be adapted to her/his own situation and made relevant to the economic analysis process.

Background

A stakeholder can be any *relevant* person, group or organisation with an interest in the issue, either because he is going to be affected by the subject (victim, gainer) or because he has influence, knowledge or experience with the subject. The analysis will bring transparency in identifying what stakeholders already exist and which interests they represent. Types of stakeholders are: government, local authorities, non-governmental institutions, political organisations, research institutes, industries, agriculture, households or other businesses. A stakeholder-analysis is usually performed starting from the contents of a project using the "who?" question (for example: we want to build a house, who knows how to build it?). Be aware that the problem definition must be clear from the beginning and that the problem shall be viewed from as many different angles as possible.

Besides analysing the stakeholders it can be useful to map the environment of a project to identify external influences. The map could tell something about the interests, motives and relationships of the actors identified, the field of force they operate in, and risks. For example: which stakeholders have a positive or negative influence on the project, who has power, who has the biggest monetary interest? Similar mapping can be done for *factors* influencing the process, often expressed as threats (e.g. weather, financial or human capacities).

Generally, a process consists of several stages (as illustrated in Figure C2.1). For every single stage, it should be reviewed which stakeholders are relevant to involve in the process and if the stakeholders have the same "rights". The role and involvement of the stakeholder can differ from stage to stage, and the stakeholder-analysis will make this more transparent.

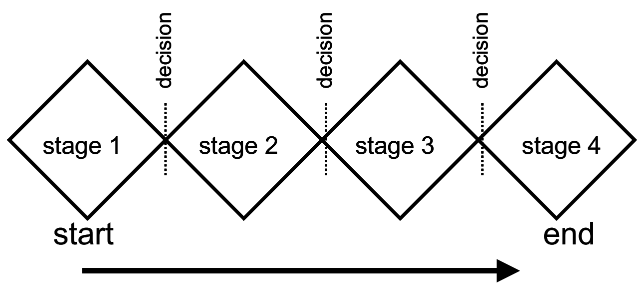


Figure C2.1: A process represented in diagram form

During the stakeholder-analysis the *degree of involvement* of every stakeholder (per stage) can be labelled as either (see Figure C2.2):

- *co-operating*: the stakeholder that will actually participate in and contribute actively to the process;
- *co-thinking*: the stakeholder of which you want input with respect to content, it is a source of knowledge like experts;
- *co-knowing*: the stakeholder which does not play an active role in the process but should be informed of its progress.

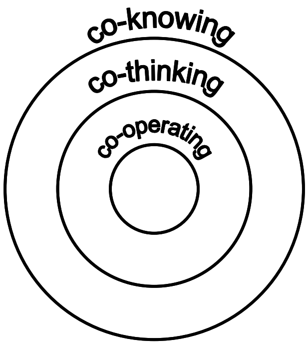


Figure C2.2: Target scheme to identify degree of involvement of stakeholder

If desired the identification approach can be refined by identifying the type of actor (see Figure C2.3):

- decision maker: stakeholders which decide about the project;
- user: stakeholders which use the result or are affected by it;
- implementer/executive: the stakeholders that have to implement the results or new policy;
- expert/supplier: stakeholders which put information, expertise or means at the disposal of the project.

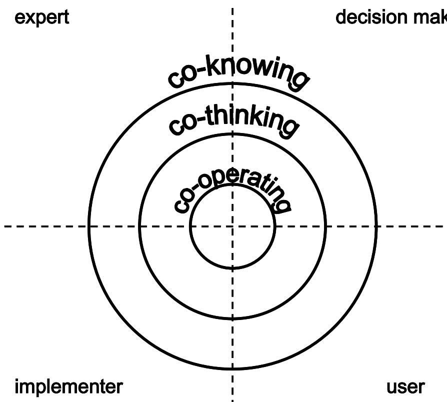


Figure C2.3: Refined target scheme to identify degree of involvement and type of stakeholder

Important! If the identified stakeholders are going to participate (actively or passively) in the project it is important to give feed-back to the stakeholder and specify clearly their role in order to avoid disappointments: management of expectations.

Stakeholder analysis: a simple methodology

Making the stakeholder analysis operational implies going through a series of steps of questioning and interaction. Although it needs to be adapted and refined to every situation, a simple methodology and series of steps is proposed below.

- Step 1 - Define the stage of the process that will be subject to a stakeholder analysis. Putting the subject in question-form makes it usually more accessible and facilitate the identification of key issues/stages. It appears rather wise to invite stakeholders (of which it is obvious that they are involved) to take part in a brainstorming session;
- Step 2 - A group, a maximum of 10 persons (the project team) including a chairman, performs a brainstorming session in which as many stakeholders and perspectives or angles linked to the selected stages are mentioned.
    - Keep it rather general, name groups or organisations, not yet concrete names or people;
    - Every suggestion is written down without judgement.
- Step 3 - Check if the main perspectives/angles can be split up into sub-units/organised in types;
- Step 4 – Allocate to the stakeholders identified a concrete name (and address/contact information);
- Step 5 - Check the result:
    - Did we check all the stages of the process?
    - Do we have the ones that benefit and the victims?
    - Is the own project organisation included?
    - Did we identify the people behind umbrella organisations?
- Step 6 - Once the stakeholders are identified, the long list can be ordered by identifying the degree of involvement of each actor in each stage:
    - Write down every actor on a Post-it notepaper;
    - Draw up the “target”-scheme with circles on a flip-over chart;
    - Be clear about the stage in the process that is effectively analysed.
- Step 7 - Put the notepapers in the right place in the “target”[9] (Figure C2.2 and if refinement is desired this can be repeated for Figure C2.3);
- Step 8 - Check if there are no big gaps;
- Step 9 - Use the result! e.g. for a communication plan to notify concerned stakeholders. Be very clear with each stakeholder about his expected role and involvement in the process (management of expectations);
- Step 10 - The brainstorming session can be continued to identify relationships between stakeholders, their interests and motives and factors that influence the process.

[9] Keep in mind that the degree of influence of the stakeholders is a factor to be considered. It might be useful more closely to involve “big” actors with much influence to ensure commitment and a supporting basis.

Illustration of the stakeholder-analysis

A small case is presented for the illustration of the methodology. The subject of the case is the pollution at the downstream part of the River Scheldt. The municipalities along the river recognise the problem and want to improve the water quality, they are initiating this case. The process is described in Figure C2.4:

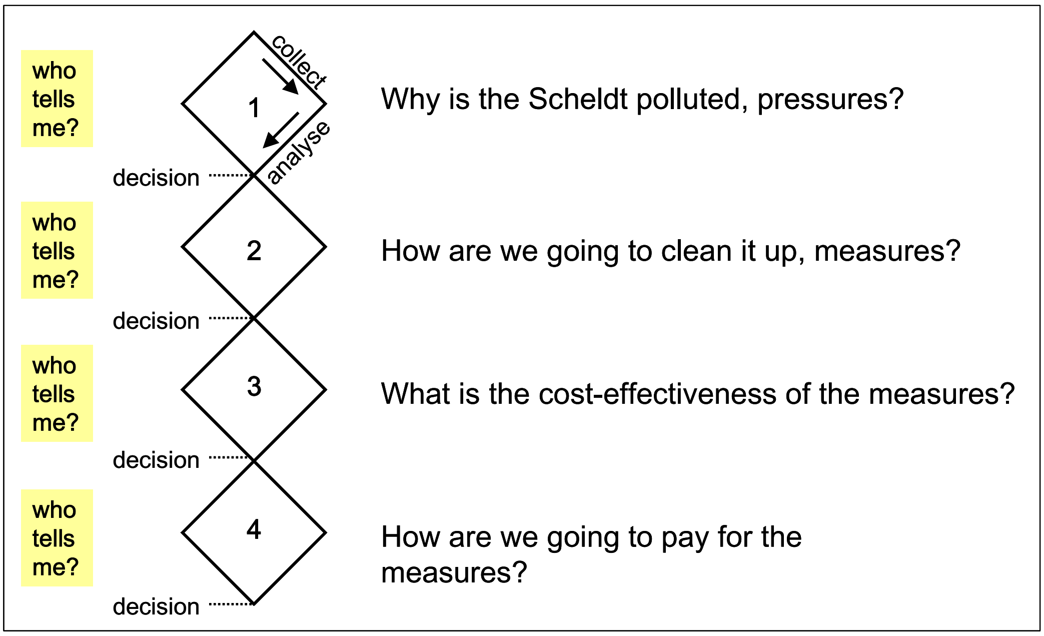


Figure C2.4: Different stages of a process concerning the pollution of the River Scheldt

Analogous to the presented methodology in the former sub-section, the possible results are presented below for the different steps of the stakeholder analysis and for the stage 1 of the process (i.e. why is the Scheldt polluted, pressures?).

- **Step 1** - Information is wanted about the pollution in the Scheldt, e.g. "Why is the Scheldt polluted?", who tells me that it is polluted?
- **Step 2** - The proposed project team will include the municipalities and they have decided to invite also representatives of the harbour of Antwerp and Vlissingen. As many different angles as possible are viewed during a brainstorming session. The output of this session is a (finite) list of stakeholders involved:

ICPS (Scheldt commission)	People in the neighbourhood
Agriculture	Harbours
Recreation	Municipalities
Dredging companies	Shipping traffic
Fisherman	Industries
Government	WWTP

- **Step 3** – More detailed discussions show that the type "Industries" can be split up into:
  - Industries with emission to the air (deposit);
  - Industries with discharge to the water.
- **Step 4** - The list is defined more precisely:

ICPS (Scheldt Commission)	**People in the neighbourhood**
Agriculture: - farmer A, B, C; - poultry farm D; - pig farm E, F.	**Harbours**: - Antwerp (B); - Ghent (B); - Terneuzen (NL); - Vlissingen (NL).
Recreation: - anglers; - canoeists; - cyclists.	**Municipalities** Antwerp, Ghent, Terneuzen, Vlissingen.
Dredging companies: - company X; - company Y.	**Shipping traffic:** EU umbrella organisation for shipping traffic.
Fisheries	**Industries:** - emissions to air: industry G; - discharge to water: industry H.
Government Belgium (Flandres, Wallonia, Brussels) The Netherlands	**WWTP** Antwerp, Ghent, Vlissingen, Terneuzen.

For all stakeholders the contact person/competent authority should be identified and the address/contact information identified.

- **Step 5** - Checking the result shows that it is unclear which shipping companies are represented by the “European umbrella organisation for shipping traffic”, as only shipping companies operating in the Scheldt area are seen as relevant. This will need further checks by the project team. It is also noticed that environmental NGO’s are missing from the list of stakeholders identified so far, and the union for the “Protection of the Scheldt landscape” is added to this list.
- **Step 6 & 7** - The degree of involvement of the stakeholders is expressed by allocating stakeholders into the target scheme (Figure C2.5). For the first stage of the process (why is the Schedlt polluted, what are pressures?), much information needs to be collected. Thus many stakeholders end up in the second circle (co-thinking) of the target scheme. Some stakeholders are known to have a great socio-economic influence and are asked to co-operate together with the project team (inner circle). The outer border of the figure show the organisations that will be informed about the project.
- **Step 8** - Check for gaps in Figure C2.5, refine it.
- **Step 9** - The results of the brainstorming session are incorporated into the project plan. Decision is taken that the harbours of Ghent and Terneuzen and Industry H, that are not yet part of the project team, will be approached for co-operation.
- **Step 10** - The brainstorming session can be continued to refine the target scheme according to Figure C2.3 and/or to map the environment. Simple questions such as: “What is the interest of Industry H?”; “What is the relationship between Municipality A or Harbour W?” will help in increasing the project teams understanding of the role and stakeholder relationships.

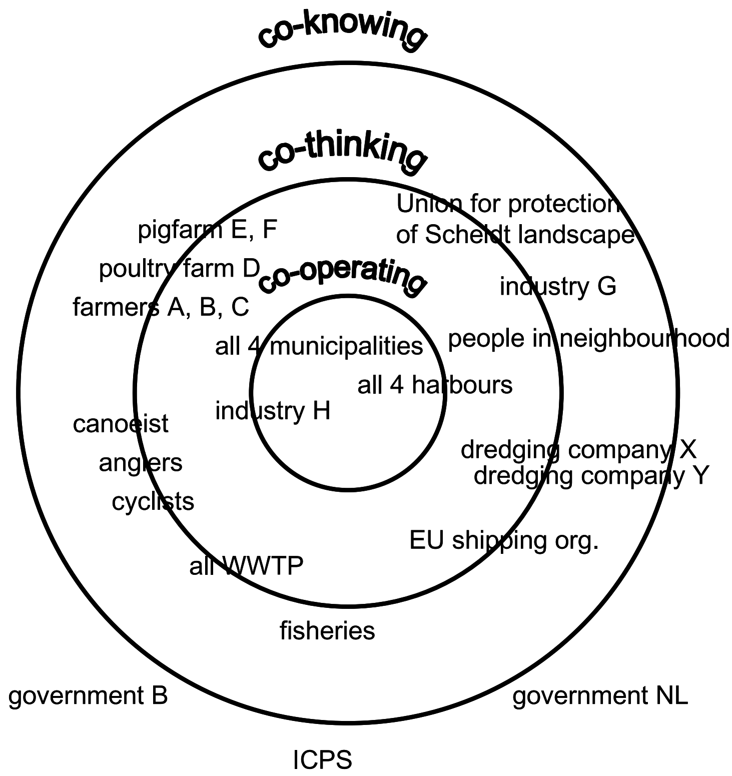


Figure C2.5: Target scheme with stakeholders who can tell about the pollution of the downstream part of the River Scheldt

Annex C2 References

1. ARB toolkit, Gereedschap voor het managen van open beleidsprocessen; *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2000.
2. WWF's preliminary comments on Public Participation in the context of the Water Framework Directive and Integrated River Basin Management; *Adam Harrison, Guido Schmidt, Charlie Avis, Rayka Hauser*, WWF, June 2001.

ANNEX C3 Possible Reporting Tables

The tables presented below are by no means exhaustive and final. They have been developed as examples to support experts in different countries and river basins in developing their own templates. The tables do not mention the information on water uses, wastewater treatment, pollution emitted, changes in hydromorphology, changes in ecology, etc. that will come from the analysis of pressures and impacts as specified in Annex II of the Water Framework Directive. Clearly, similar tables can be draw for this biophysical information. Key is to ensure consistency and coherence (e.g. in selecting spatial scale of computation and reporting) between pressures and impacts and the economic analyses.

1. Economic analysis of water uses

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
Drinking water supply 1. Population connected to public water supply system 2. Population with self-supply 3. Number of water supply companies							
Wastewater treatment 1. Population connected to sewerage system 2. Population connected with wastewater treatment plant 3. Number of wastewater treatment companies							
Economic characteristics of key water uses 1. Agriculture ➢ Total cropped area ➢ Cropping pattern ➢ Livestock ➢ Gross production ➢ Income ➢ Total farm population 2. Industry ➢ Turn over for key sub-sectors ➢ Employment for key sub-sectors 3. Hydropower ➢ Installed power capacity ➢ Electricity production							

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
4. Navigation/transport							
➢ Number of boats through key points per year							
➢ Employment linked to navigation							
➢ Quantity and value of goods transported							
➢ Quantity and value of goods through key harbours							
➢ Employment linked to harbour activities							
5. Gravel extraction							
➢ Number of extracting companies							
➢ Total employment							
➢ Total turnover							
6. Fish farming							
➢ Number of fish farms							
➢ Total employment							
➢ Total turnover							
7. Leisure fishing							
➢ Number of person-days							
8. Boating and wind-surfing							
➢ Number of person-days							
9. Water-related tourism							
➢ Total number of tourist-day							
➢ Daily expense per tourist day							
➢ Total employment in the tourism sector							
➢ Total turnover of the tourism sector							
10. Flood control							

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
➢ Total population protected ➢ Total turn-over of protected economic activities							

2. Assessing trends and baseline scenario

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
Trends in macro-economic policies 1. Existing studies and reports on trends in agricultural policy 2. Existing studies and reports on trends in industrial policy 3. Existing studies and reports on trends in energy policy 4. Existing studies and reports on trends in transport policy 5. Existing studies and reports on trends in … policies							
Trends in exogenous variables 1. Population growth 2. Changes in economic development (DGP change) 3. Changes in water pricing policies 4. Technological changes ➢ Households water use ➢ Agriculture and irrigation ➢ Industry 5. Climate change 6. …							
Planned policies and investments 1. Proposed investments in water supply and wastewater treatment							

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
2. Proposed investment in pollution reduction programmes for agriculture							
3. Proposed investments in flood protection							
4. Proposed investments in wetland restoration							
5. Proposed investments in improved technology							
6. Proposed investment in water supply enhancement							
7. Other programmes and measures							
8. …							

3. Assessing cost-recovery (for each water service considered)

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
Prices for water services 1. Current water price ➢ Price level ➢ Price structure 2. Subsidies ➢ Government/regional authorities ➢ Cross-sectors							
Financial costs of water services 1. Capital costs ➢ Historical ➢ Replacement value 2. Operation and maintenance 3. Administrative costs							
Environmental costs 1. Internalised costs through charges/taxes 2. Direct assessment ➢ Changes in environmental quality ➢ Economic value/willingness to pay 3. Costs of preventive and mitigation measures ➢ Implemented ➢ Required for restoring good water status							

4. Basic economic information and indicators

Key variable	Source of data	Date	Spatial scale, lowest disaggregation level	Quality of data (good, medium, poor)	Availability of data	Cost	Comments
1. Discount rate							
2. …							

Reporting the economic elements of the characterisation of river basins – example of an executive summary

The format of the executive summary presented below is by no means exhaustive and final. It has been developed as an illustration to support experts in different countries and river basins in developing their own reporting templates and reports. The format and tables do not mention the indicators on water uses, wastewater treatment, pollution emitted, changes in hydromorphology, changes in ecology, etc. that will be computed as a result of the analysis of pressures and impacts as specified in Annex II of the Water Framework Directive. Clearly, similar tables or maps can be draw for this biophysical information. Key is to ensure consistency and coherence (e.g. in selecting spatial scale of computation and reporting) between reporting on pressures and impacts and the economic analyses.

Example of an executive summary

Key messages with regards to the economics of water uses

1.

2.

3.

Description of the river basin and economic importance of key water uses

Table 1. Economic importance of key water uses for the river basin

Water use	Water consumption	Pollution	Total "production"	Turnover (€)	Employment	Number of beneficiaries
Use 1						
Use 2						
Use 3						
Use 4						
…						

Note: figures can be given in absolute terms and in relative terms (relative to the river basin as a whole or to the economic sector for the country if seen as of national strategic importance)

Map 1. Localisation of key water uses in the river basin

Assessing trends and identifying the baseline scenario

Table 2. Foreseen trends in key water uses in the river basin up to 2015

Water use	Change in beneficiaries	Change in production	Technological change	Overall change in pressure (qualitative)	Comments
Use 1					
Use 2					
Use 3					
Use 4					
…					

Table 3. Foreseen investments and measures targeted to the water sector up to 2015

Main policy	Planned measures	Proposed costs (€)	Likely change in water status	Comments
Policy 1				
Policy 2				
Policy 3				
…				

Assessing cost-recovery

Table 4. Current cost-recovery assessment in the river basin

Water services	Costs and prices	Use 1	Use 2	Use 3
Service 1	Financial costs			
	Tariffs for water services			
	Recovery of financial costs			
	Environmental costs			
	Internalised environmental costs			
	Recovery of environmental costs			
	Overall cost-recovery			
Service 2	Financial costs			
	Tariffs for water services			
	Recovery of financial costs			
	Environmental costs			
	Internalised environmental costs			
	Recovery of environmental costs			
	Overall cost-recovery			

Proposed activities for improving the information and knowledge base

Annex D – Methodological Tools for Undertaking the Economic Analysis

ANNEX D1 Information sheets

INTRODUCTION

This Annex contains a series of information sheets providing methodological Guidance for implementing the 3-step approach presented in the main part of this document. It is structured as follows:

- ***Scale issues***: This information sheet helps you understand at which geographical level you should carry out the economic analysis and report the results;
- ***Estimating costs (and benefits):*** This information sheet helps you understand how to estimate costs and benefits, which are seen as avoided costs;
- ***Reporting on cost recovery:*** This information sheet helps you understand what and how you should report on the recovery of costs of water services;
- ***Baseline scenario:*** This information sheet will help you develop one or several alternative baseline scenarios (or "business-as-usual" (BAU) scenarios). It proposes an optional approach to complement the forecasting analysis (to define the BAU scenarios) with prospective analysis;
- ***Cost-effectiveness analysis:*** This information sheet will help you carry out a Cost-effectiveness Analysis (CEA). The CEA is used for assessing the cost-effectiveness of potential measures for achieving the environmental objectives set out by the Directive and construct a cost-effective Programme of Measures;
- ***Pricing as an economic instrument:*** This information sheet helps you assess the effectiveness of pricing as a measure to achieve the environmental objectives of the Directive;
- ***Disproportionate costs:*** This information sheet will help you assess whether the costs of the Programme of Measures are disproportionate and whether derogation from the Directive's objectives could be justified following an assessment of costs and benefits.

SCALE ISSUES

Directive references: No specific reference in the Directive but many implicit references and key issues for making the economic analysis operational. This sheet underlies the overall (3-step) approach to the analysis.

This information sheet helps you understand at which geographical level you should carry out the economic analysis and report the results.

1. Objective

Scale issues are central to the development of integrated river basin management plans. They are key to the integration between different disciplines and expertise and to the development of activities aimed at informing, consulting and ensuring active participation of stakeholders and collecting information.

For the economic analysis, it is important to understand the level of efforts required in conducting the economic analysis in terms of:

- The type of information to be collected;
- The spatial and temporal scale at which the information needs to be collected (coverage);
- The type and the level of disaggregation of the analysis that should (or can) be performed.

Although mostly mentioned in the context of large river basins, identifying the ‘right’ scale for the analysis is relevant to all river basins.

2. What spatial scales and levels of disaggregation are mentioned in the Directive?

The Directive mentions a wide range of spatial or aggregation units (see *Table 1*). Overall, the Directive promotes the **river basin** as the basic hydrological system for characterising, analysing, defining and implementing programmes of measures. In some cases, however:

- Several river basins can be aggregated into **river basin districts** that are the basis for compliance checking and reporting by Member States. River basin districts combine hydrological and practical/administrative considerations (e.g. combining several small but similar river basins to limit planning and administrative burden). Hydrological considerations may be strengthened if river basins of a given district are inter-connected through water transfers;
- Large river basins can be sub-divided into smaller **sub-basins** to facilitate the process of developing management plans or when different countries share a river basin district that is then disaggregated into national sub-basins.

Table 1 – What does the Directive specify about data collection and analysis?

Building block	When is it a reference?
Hydrological/Ecological	
Water Body	➢ Characterisation of water status (*Annex II*); ➢ Further characterisation for those bodies at risk of failing environmental objectives (*Annex II*); ➢ Determination of environmental objectives (based on cost and benefit assessment) if derogation (*Article 4*); ➢ Justification of deadlines extension (*Article 4*).
Group of water bodies (grouping based on bio-physical & ecological criteria)	➢ Initial characterisation of River Basins (*Annex II*); ➢ Possible detailed programmes and management plans for water types (*Article 13.5).*
Protected Areas	➢ Designation of protected areas (*Article 6, Annex IV*).
River Basin	➢ Characterising, analysing, defining and implementing programmes of measures; ➢ Carrying out cost-effectiveness analysis (*Annex III*) for the identification of the programme of measures (*Article 11*).
River Basin District	➢ Carrying out and reporting economic analysis (*Article 5 and Annex III*); ➢ Evaluating pricing policies (*Article 9 and Annex III*).
Sub-basin	➢ Developing management plans (e.g. for national parts of international river basins, see below and *Article 13*).
Socio-Economic	
Water services	➢ Assessment of cost-recovery for water services (*Article 9*).
Economic sector	➢ Estimate the contribution to cost recovery by key water uses: household, industry and agriculture (*Article 9*); ➢ Possible detailed programmes and management plans for economic sectors (*Article 13.5).*
Water uses	➢ Economic analysis of water uses (*Article 5*); ➢ Adequate contribution of water uses to the costs of water services (*Article 9*).
Administrative	
State/Regional	➢ All activities linked to implementation (Member State's responsibility, e.g. reporting obligations); ➢ Plans for national portion of international river basins.
European	➢ Various reporting obligations from the Commission at the EU scale (*Article 18*); ➢ Cost-benefit assessment of the Directive at the EU scale (Commission's statement added to the Directive's text at the time of adoption).

3. At what scale should the economic analysis of water uses be conducted?

Reporting on the economic analysis of water uses (both the description of the existing situation and the analysis of the trends/baseline in key indicators and variables) has to be made at the river basin district scale (disaggregated into national portions of transboundary river basins whenever required).

However, lower spatial scales may be investigated according to:

- ➢ The scale at which **significant pressures and water uses** take place (e.g. a sub-region of the river basin or a specific sub-economic sector);

- The **decision making** scale, e.g. at which scales and for which decisions is the analysis used. For example, if some measures are applied at specific disaggregated scales (e.g. a specific watershed or a given economic sector), providing information on the economic importance of water uses at that scales may be appropriate; and
- The scale required for **information, consultation and participation**. It is important to ensure key indicators are computed at scales that are relevant to consultation and participation. Such scales are likely to be lower (e.g. a watershed or specific economic sector) than the river basin or river basin district.

Illustrations 1 to 3 of this information sheet (see below) provide some lessons on the definition of the adequate scale for analysis from testing and scoping exercises conducted during the preparation of this Guidance.

Illustration 1 – Defining the adequate scale of analysis by combining biophysical and economic information in the Scheldt river basin in Lille (France)

The WFD quantitative objective for groundwater is to balance abstraction and recharge. For the chalk aquifer around Lille, the relevant level of disaggregation for the economic analysis corresponds to a set of groundwater units for which:

- The recharge can be assessed for each individual unit;
- One abstraction is located in only one unit (no abstraction on boundaries);
- Abstractions in one unit have no (or limited) effect on the piezometry in other units.

If all these conditions are met, the physical system can be considered as a pool and economic information can be gathered for abstractions from this pool. With respect to pressures, it is important to consider both abstractions registered by national offices or water agencies and self-service abstractions. The second type of information will be more difficult to collect as it is rarely collected by water service operators or public agencies in charge of monitoring water services.

Source: G. Bouleau & A. Courtecuisse, Testing the WFD Guidance Document on groundwaters in the area of Lille. See Annex E.

Illustration 2 – Identifying coherent areas in the Rhône-Méditerranée-Corse basin (France)

A testing exercise in the Rhône-Méditerranée-Corse river basin in the South of France highlighted that defining the appropriate scale for the economic analysis has to take into account a variety of criteria:

- Economic activities (agriculture, industries, tourism);
- Hydrographic components;
- Social and land uses aspects;
- Availability of different data required.

As a result, the relevant scale for the socio-economic analysis, especially for large and heterogeneous river basins, is somewhere between the water body and the river basin levels. To subdivide the basin into coherent socio-economic areas, it was proposed to gather socio-economic, planning and land use information and adapt it from existing scales of analysis, such as hydrographic or administrative ones, to scales that meet the needs of the Water Framework Directive. One of the main interests of this approach is to integrate land planning and economic considerations into the analysis to facilitate information, consultation and participation of the public and stakeholders.

Source: P. Dupont & O. Gorin, Testing a pertinent scale for the economic analysis in the Rhône-Méditterrannée-Cors river basin. See Annex E.

Illustration 3 – Matching biophysical and economic information with administrative boundaries in the Vouga River Basin (Portugal)

The monitoring network in the Vouga River Basin in Portugal is not complete today for complying with the requirements of the Water Framework Directive. Thus, although it is possible to identify the existence of water quality problems and associated main pressures, the establishment of a clear link between pressures/discharges and water quality problems is not possible in most cases. The location of main polluting sources is known, but discharges are not fully characterized, and cause-effect relationships cannot be fully established. There is a need for the development and calibration of water quality models allowing for the establishment of such link, in the absence of a comprehensive monitoring network. This link is essential for the economic analysis, particularly for the cost effectiveness analysis of programmes of measures.

Different elements of economic information in Portugal are currently disaggregated into different administrative boundaries. At best, the scale is municipal, and in some cases it is regional (there are five regions in the mainland, which cut across river basins). Since regional and municipal boundaries do not coincide with river basin boundaries, the compatibility of scales is a relevant issue. As it is unlikely that all economic information will become available at a scale smaller than the municipal level, consistent criteria must be developed to partition municipal values between river basins (possibly using available GIS information to pinpoint clusters of users).

Source: P. Mendes. Scoping key elements of the economic analysis in the Vouga River Basin. See Annex E.

4. At which scale should we undertake the cost-effectiveness analysis?

From an economic point of view, and to account for the inter-connection between all water bodies of a given river basin, cost-effectiveness analysis is best performed at the scale of the **river basin**. But to undertake the analysis at lower scales is likely to be more manageable in cases of large numbers of water bodies, pressures and environmental problems within the river basin.

Identifying the scale at which environmental problems take place

The analysis of the pressures and impacts, along with the identification of significant water management issues, shows that specific scales can be attached to various environmental problems:

- Some pressures have an impact throughout the river basin, e.g. controlling flows in an upstream portion of a river basin will impact portions of downstream flows, while putting a dam downstream may stop migration of fish and thus impact the entire river’s ecology;
- Some pressures have a local impact, e.g. abstraction into a confined aquifer, or polluted discharge into a river that will then be naturally diluted; and
- Diffuse pressures often need to be accounted for at the river basin scale, as it is the addition of all pressures taking place within the river basin that is to be investigated.

Cost-effectiveness analysis should be performed at the scale at which environmental issues take place to ensure that the costs (especially other direct economic costs) and effectiveness of measures are fully accounted for in the analysis. In many river basins a range of environmental issues attached to different scales are likely be considered.

One pragmatic way to ensure some coherence between these analyses would be:

- **Step 1 -** To assess the scale at which environmental issues take place and classify these issues accordingly (from largest to lowest scale). This assessment is directly based on the analysis of pressures and impacts;
- **Step 2** – To undertake the cost-effectiveness analysis for the environmental issue that takes place at the river basin or largest scale considered, and select measures for solving this issue;
- **Step 3** – To assess the impact of these measures on other environmental issues, as it is likely that measures will impact on several issues. Identify the remaining environmental issues to be solved;
- **Step 4** – To undertake the cost-effectiveness analysis for the environmental issue that takes place at the next largest scale;
- The analysis continues as long as significant environmental issues remain. At the end of the process, add all the costs of the measures targeted to different environmental issues.

In some cases, cost-effectiveness analyses will be developed simultaneously for different environmental issues. It will be important then to ensure co-ordination and constant feedback between the different analyses undertaken.

Dealing with different sub-basins of the same river basin

For large river basins, sub-river basins may be proposed for undertaking the economic analysis. It is then recommended to adopt a stepped approach that follows the hydrological cycle/structure to ensure separate measures that are cost-effective for each sub-basin are also cost-effective at the river basin scale. A pragmatic approach is given below for a situation where pressures have a downstream impact on (surface) water status:

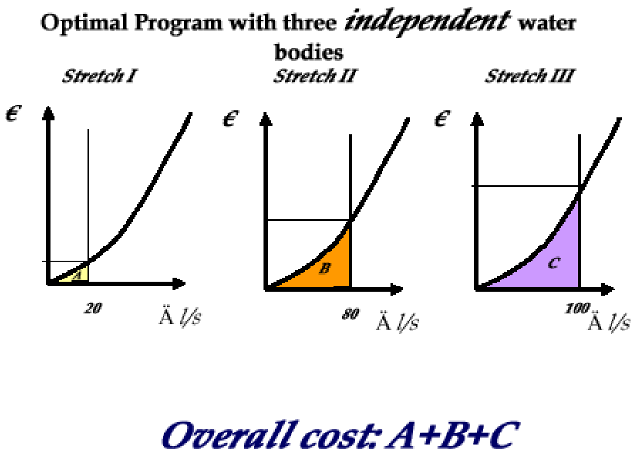
- **Step 1** – Start the analysis with the most upstream sub-basin. Identify cost-effective measures for this sub-basin along with their total costs and their impact on the status of water bodies;
- **Step 2** – Assess the impact (if any) of these measures on the status of water bodies of the next downstream sub-basin; and
- **Step 3 -** If the predicted water status for the downstream sub-basin is below good water status for some/all water bodies, cost effectiveness analysis is then performed at the scale of this downstream sub-basin to identify new measures, their impact, their costs.

The analysis continues then with these steps being systematically applied for all sub-basins while moving down to the most downstream sub-river basin. Clearly, there is a need to ensure the analysis moves regularly between different scales, i.e. the sub-basin, the basin, the country or group of countries, so measures that are relevant to different scales can be adequately considered and analysed (e.g. assessing the potential role of a tax on pollution discharges may require a direct analysis for all river basins of a given country if taxes are driven by national policies), as shown in *Illustration 4*. One may first investigate measures that apply at large scales to all sub-basins, and then move to measures that apply at lower scales and that can adjust/refine the broader effects of the large-scale measures. It may also be practical to develop separate cost-effectiveness analyses for individual environmental issues.

Illustration 4 – Cidacos (Spain): Investigating river basins and sub-basins

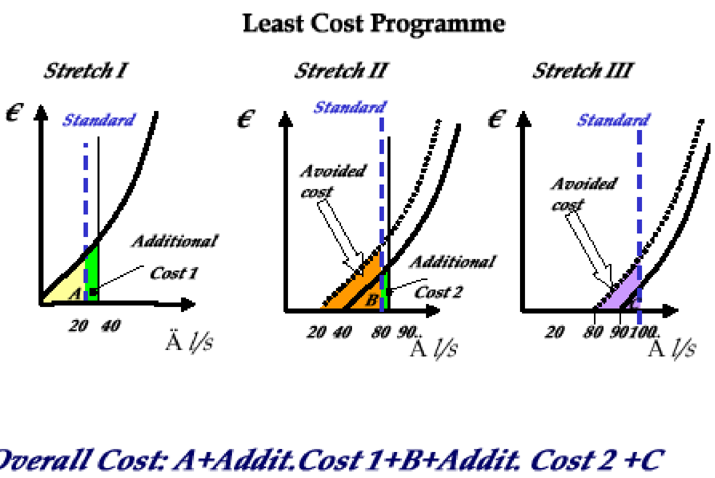
The Cidacos River is 44 km long, and drains a catchment of 500 km^2. Except for its initial part, the river runs through a plain, which is mainly agricultural (225 km^2). Animal farming is associated to farming with a total of 86 production facilities. Agricultural production is supplied with surface water and groundwater. The basin has 14 small population centres, with two small cities (Olite and Tafalla) and 17,000 domestic users. These are served by water from a small dam in the first stretch of the river, and also from two springs and some wells. These have water quality problems, from hard water and nitrates. The main industries are located in Olite and Tafalla, and industrial permits for water have been denied due to a shortage of good quality water supply.

The Cidacos scoping study distinguished between three water sub-basins or reaches: upstream, downstream and a middle stretch. In order to achieve good ecological quality (GEQ) an improvement to the water flow was considered, increasing flows by 20, 80 and 100 litres per second in the upper, middle and lower sub-basins respectively. The total costs of achieving the objective for each sub-basin *independently* can be obtained simply by aggregating the costs of the measures for the three areas (areas A, B and C in the diagram), i.e. the programme would cost € 1.2 million in total.



However, because the three sub-basins are connected, the cost of obtaining the GEQ in stretch II depends on the quantity of water it receives from the upstream basin (stretch I) and the cost of GEQ in the downstream basin (stretch III) depends on the ecological status of both stretches I and II. Therefore, the least cost programme of measures must take into account the externalities involved in the simultaneous improvement of the three interconnected sub-basins, as shown in the diagram below.

By improving the water flow above the minimum standard, it was shown that the marginal cost of achieving the required increase in the water flow in the middle and downstream sub-basins could be avoided. The (avoided) costs of the measures that would have been needed for stretches II and III were shown to be higher than the cost of increasing the water flow in stretch I. In Cidacos, the overall cost of the action plan obtained this way would be €0.56 million (or less than 50 per cent of the total cost of treating the three water bodies as independent).



Consequently, when considering the scale of the analysis the river basin as a whole must be used. The analysis cannot be done independently for each sub-basin, as it would exclude any shared benefits and costs of the programme of measures.

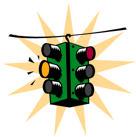
Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. See Annex E.

5. Which basic units should be considered in the cost-effectiveness analysis?

The cost-effectiveness analysis will not be able to deal with all measures targeted to individual users and related environmental impact. Thus, a certain level of aggregation is required for the analysis to remain pragmatic, and also to account for the scale at which some measures apply.

However, one cannot aggregate all information and analysis at the river basin scale as it eliminates the hydrological structure of the river basin and the links between uses, pressures, and water status of specific water bodies. Assessing the basic unit that should be investigated into the cost-effectiveness analysis requires considering:

- The scale of water bodies themselves;
- The scale at which pressures and impacts take place (which areas need to be targeted by measures so as to restore good water status); and
- The scale at which measures will be implemented/will take place (see point below).



Look out!

Some measures for improving water status have an inherent scale of application/implementation that need to be considered for the cost-effectiveness analysis (e.g. environmental taxes are often national-based instruments). In other cases, the analysis of existing uses, pressures and impacts will lead to the identification of smaller geographical areas (e.g. a given watershed within a river basin), sub-sectors (e.g. a given chemical sector) or sub-uses (e.g. large users of water with swimming pools) that will be targeted by measures (e.g. the restoration of a specific wetland, or a change in water pricing for a specific urban area or irrigation scheme).

6. At which scale should we assess cost-recovery?

Assessing spatial relevance *vis-a-vis* cost recovery appears rather straightforward:

- Information on pollution, uses, financial costs and existing prices are usually collected for water service (or combined water service) areas. This information needs then to be aggregated at the river basin scale that appears as adequate for discussing overall financial flows and recovery issues;
- Environmental and resource costs may relate to the sub-basin or entire river basin (e.g. if a pollution created in the upstream part of a river basin has negative impact in the estuary of the same river). Assessing these costs requires a good assessment of the scale at which environmental impact of existing water services and uses take place. Costs can then be computed for each water service at the scale of the river basin; and
- The assessment of the relative contribution to these costs of key water uses combines both water uses and related services aimed at removing environmental damages caused by these uses. The Water Framework Directive requests a minimum disaggregation into agriculture, households and industry. According to local circumstances and key water uses identified in the analysis of pressures and impacts, this disaggregation may be further refined.

7. At which scale should reporting of information be carried out?

Different aspects need to be considered here:

- Firstly, it is important to identify the geographical scale at which relevant information and expertise is available. The scale at which information is available today is likely to lead to the use of proxies, (statistical) extrapolation or interpolation techniques to obtain robust estimates of key variables at the desired scale. It will be important to ensure assumptions and approximation are made transparent and reported along with results of the analysis;
- Secondly, the scale at which information and results are to be reported for effective information and consultation of the public; and
- Thirdly, the scale for reporting to the EU: in such case, the coverage is clearly the river basin district, with the analysis being presented for key spatial and socio-economic/water uses aggregates.

In addition to the River Basin Management Plans developed for each district, Member States may produce more detailed plans for specific sectors, issues or water types (*Article 13*), providing ample opportunities to focus on specific aggregation levels lower than the river basin. Such detailed plans may be identified in the context of consultation and participation of interested parties or directly result from the analysis of pressures, impacts and significant water management issues.

8. A checklist for a summary

Table 2 summarises spatial and disaggregation scales that can be investigated at the different steps of the economic analysis.

Table 2 - Checklist

Steps	Analysis	Reporting
Characterisation of the river basin	➢ **Economic analysis of water uses** 1. Assessment at the scale of significant water uses as identified by Annex II => assess economic indicators at the same scale 2. Possible further disaggregation if very high socio-economic variability for given uses that are likely to lead to choosing different measures/having different impacts on proposed measures ➢ **Trend analysis and baseline development** 1. Assessment of trends in key drivers/variables at a scale consistent with the economic analysis of water uses ➢ **Assessment of cost-recovery** 1. Identify the scale at which water services (or combined services) take place => assessment of cost-recovery at that scale 2. Identify uses that are damaging the environment and cause specific water services to other uses => compare their relative participation to the recovery of the costs of water services at the scale of the water use/services linked to damage caused by water uses	➢ **Economic analysis of water uses** 1. Reporting at the river basin scale 2. Possible reporting for specific water uses ➢ **Trend analysis and baseline development** 1. Reporting at the river basin scale 2. Possible reporting for specific water uses ➢ **Assessment of cost-recovery** 1. Assessment of cost-recovery at the river basin district scale or for national portion of transboundary river basins 2. Assessment of the contribution of water uses to the costs of these services at the river basin scale
Assessing the gap/risk of non-compliance	➢ **Costs of basic measures** 1. Assess total costs of basic measures at the river basin scale ➢ **Likely costs and qualitative impact of potential measures** 1. Assess tentative costs per type of measures considered 2. Assess the impact of potential measures at the scale of the likely-affected water use(s)	➢ **Costs of basic measures** 1. Total costs of basic measures at the river basin scale ➢ **Likely costs and qualitative impact of potential measures** 1. Tentative costs per type of measures 2. Impact of potential measures at the scale of the likely-affected water use
Undertaking the cost-effectiveness analysis	➢ **Costs of measures** 1. For each individual measure proposed – assess costs at the spatial or disaggregation scale at which the measure will apply ➢ **Effectiveness of measures** 1. Assess the effectiveness of measures at the scale at which the concerned environmental issues take place – this depends on the pressures and impacts concerned and the type of measure considered (at which scale is the measure applied, and which part of pressures will be affected) => compute one effectiveness indicator for each measure ➢ **Cost-effectiveness analysis** 1. Cost-effectiveness analysis undertaken at the river basin scale => identify cost-effective programme and total costs 2. If cost-effectiveness undertaken separately for different environmental issues and sub-basins, ensure a logical step-wise approach (from upstream to downstream, from general environmental issues to local environmental issues) and constant feedback loops between analyses 3. Further levels of disaggregation are possible in the analysis linked to the assessment of significant water uses and the potential measures investigated	➢ **Costs of measures** 1. For each individual measure proposed – linked to the spatial or disaggregation scale at which the measure will apply ➢ **Effectiveness of measures** 1. Effectiveness for each measure ➢ **Cost-effectiveness analysis** 1. Chosen measures and total costs of cost-effective programme reported at the river basin scale 2. If cost-effectiveness undertaken separately for environmental issues and sub-basins, report on the results (chosen measures, costs) of each individual analyses and assess qualitatively possible inter-relations between different analyses 3. Possible level of disaggregation linked to the assessment of significant water uses and potential measures investigated

ESTIMATING COSTS (AND BENEFITS)

Directive references: *Articles 4, 5* and *9* and *Annex III*
3-Step Approach: this information sheet underlies all key steps of the approach
See other information sheets: *Reporting on Cost Recovery, Cost-effectiveness Analysis* and *Disproportionate Costs*

This information sheet helps you understand how to estimate costs and benefits, which are seen as avoided costs.

1. When to Estimate Costs?

Estimating costs is important for several parts of the economic analysis:

- Taking into account the principle of **recovery of costs** of water services, including environmental and resource costs, in order to ensure that an adequate contribution to the recovery of the costs of water services is made by the different water uses, disaggregated into at least industry, households and agriculture (*Article 9, Annex III*);
- Conducting a **cost-effectiveness analysis** of alternative policy measures or projects (*Article 5, Annex III*);
- Assessing the costs of alternative options in the **designation of heavily modified water bodies** (*Article 4*);
- Assessing the need for a derogation based on an economic appraisal of disproportionate costs (such as for the setting of **less stringent objectives or time derogation** – *Article 4*).

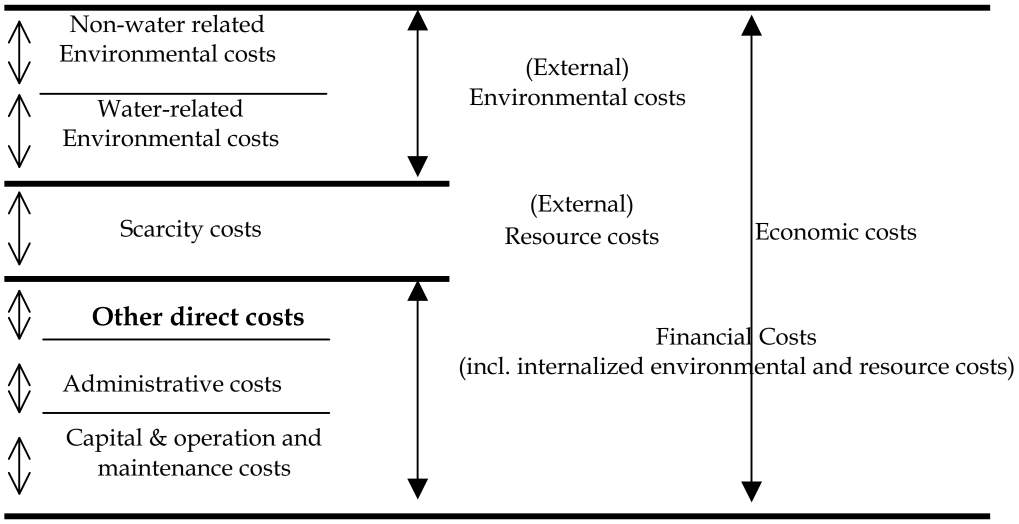
Note that the Directive defines costs as *economic costs*, which are the costs to society as a whole, as opposed to *financial costs*, which are the costs to particular economic agents. In the Directive (*Article 9*), economic costs are made up of three components (see also *Box 1*): financial costs, resource costs and environmental costs. This information sheet helps you analyse and estimate all of these cost categories.

2. Moving from Financial to Economic Costs

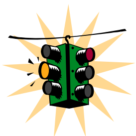
The Table below proposes an approach for moving from financial to economic costs.

Steps	Rationale
1. Estimate financial costs	Financial information is often more readily available than estimates of economic costs: as a result, they form a good basis for the analysis.
2. Make transfers (such as taxes and subsidies) explicit	Taxes only represent a transfer from society's point of view and should therefore be excluded from the economic analysis. However, environmentally related taxes might represent internalised environmental costs and should be accounted for as such.
3. In case of distorted markets and scarce resources: replace market prices by opportunity (or resource) costs	Because of distorted markets, market prices may not reflect the opportunity cost of the resource used, and therefore the benefits that could be achieved if the resource was assigned to its best available alternative use.
4. Include all non-priced environmental costs	For non-priced resources (and this is often the case for environmental resources), no price is paid as there is no market. To account for the total effect on welfare, these costs must be estimated and included.

Box 1 – What are the different types of costs mentioned in the Directive?



Source: Rogers *et al.* (1997)

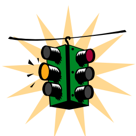


Look out! Treatment of indirect and induced costs

Direct costs (made up of mainly financial costs and administrative costs) are included in all components of the economic assessment for the purposes of the Directive. The treatment of indirect and induced costs is likely to vary according to the step of the economic assessment:

- *Indirect costs* are the economic costs for other sectors likely to result from the change in water status, such as a loss in productivity…;
- *Induced costs* are the costs resulting from second-order effects, such as the reduction in employment in the service sectors in rural areas resulting from a loss in employment in the agricultural sector due to water degradation.

Indirect costs may be considered when carrying out the cost-effectiveness analysis, but induced costs would only be taken into account (if possible) at the stage of the cost and benefit assessment for justifying derogation.



Look out! Focus on net costs

When estimating economic costs, you should focus on the *net costs*, including any savings or financial benefits, also known as 'negative costs'. An example of negative costs is income earned from selling sludge (fertiliser), which arises as a by-product of wastewater treatment. Since this activity brings in revenues, it should be subtracted from the costs of wastewater treatment.

Step 1 - Estimating Financial Costs

Financial costs in this context are the costs of providing and administering water services. They can be broken down in a number of cost elements, presented below. The Table gives the definition of each cost element and warns you about potential traps and difficulties.

Cost element	Definition	Look out!
Operating costs	All costs incurred to keep an environmental facility running (e.g. material and staff costs).	***When projecting operating costs, make sure to take into account additional costs linked to new capital investments.***
Maintenance costs	Costs for maintaining existing (or new) assets in good functioning order till the end of their useful life.	***As many water and wastewater assets are long-lived and buried under ground, it will be difficult to estimate the appropriate level of maintenance needed for exploiting the assets without leading to their deterioration.***
Capital costs: ➢ ***New investments***	Cost of new investment expenditures and associated costs (e.g. site preparation costs, start-up costs, legal fees).	➢ ***Associated costs can be substantial. In the absence of data, it is better to try and estimate them rather than neglect them;*** ➢ ***For projections, costs of new capital costs should be spread over a number of years. For this, the Annual Equivalent Cost Method is recommended*** *(see Box 2 and Illustration 1)*
➢ ***Depreciation***	The depreciation allowance represents an annualised cost of replacing existing assets in future. Estimating depreciation requires defining the value of existing assets and a depreciation methodology.	➢ ***Several methods can be used to estimate the value of existing assets, mainly the historical value, the current value and the replacement value methods*** *(see Box 3);* ➢ ***Applying existing accounting rules for calculating depreciation may not necessarily lead to the estimation of "economic" depreciation – they may need to be adjusted to reflect economic reality, i.e. that the value of assets declines faster towards the end of their life.***
➢ ***Cost of capital***	It is the opportunity cost of capital, i.e. an estimate of the rate of return that can be earned on alternative investments. The cost of capital applied to the asset base (new and existing) gives you the returns that investors are expecting to earn on their investments.	➢ ***The expected rate of return is likely to be different for public and private investors but no capital is ever "free", as there are always alternative investments;*** ➢ ***Estimating the cost of capital is likely to be difficult and contentious, as it depends on the return of alternative investments;*** ➢ ***Capital subsidies provided to private investors will need to be taken into account when calculating the amount of returns that they are allowed to earn.***
Administrative costs	Administrative costs related to water resource management.	➢ ***Examples include: costs of administering a charging system or monitoring costs.***
Other direct costs	This mainly consists of the costs of productivity losses dues to restrictive measures.	➢ ***Example: loss of agricultural production resulting from the creation of a retention area;*** ➢ ***Question: over which horizon should these costs be accounted for?***

Box 2 - The Annual Equivalent Cost (AEC) method

The Annual Equivalent Cost (AEC) method allows you to convert the Net Present Value (NPV) of a new capital expenditure into an annuity (or rental) which has the same value. This can be done as follows:

1. List all capital expenditures and when they are incurred;
2. Calculate the net present value of expenditures, using the chosen discount rate;
3. Convert this net present value into an "annual equivalent cost" (AEC) based on:

$$AEC = \frac{NPV * DiscountRate}{(1-(1+DiscountRate)^{-lifetime})}$$

AEC = annual equivalent cost
NPV = net present value of investment
Discount rate = chosen discount rate (the same as used to calculate the NPV)
Lifetime = lifetime of the capital equipment

Box 3 - Valuation of capital assets: Current vs. replacement value

Depending on the accounting system in use, it is possible to use various types of valuation methods for existing capital assets:

- The **historical value** is the value of the assets at the price they were originally purchased. Because of inflation, this value often bears no relation with what it would actually cost today to replace those assets – therefore, it is not the best measure for estimating economic costs;

- The **current value** is the historical value multiplied by an inflation index. Calculating this value raises a number of issues: 1. Estimating the inflation index may be open to interpretation (should the general inflation index or the construction (consumer?) price index be used?); 2. This method does not take account of technical progress: a water treatment plant that cost a given amount 10 years ago might cost half today thanks to technical progress. However, this method is relatively easy to apply and is more appropriate than the first one;

- The **replacement value** method estimates the present value of an asset from the current cost of replacing it for an identical service level. The advantage of this method is that it allows taking into account technical progress. However, it might be difficult, costly and time-consuming to apply to all the capital stock. In addition, the water sector being relatively less dynamic than, say, the telecommunications sector, the current value method may be sufficient for the purposes of estimating economic costs.

Illustration 1 - Deriving financial costs for the appraisal of measures in the Cidacos river basin

Cidacos is located in the region of Navarra, in Northern Spain, and is a tributary to the Aragon River. When conducting an economic analysis, deriving financial costs was necessary to determine the costs and benefits of achieving different objectives for water status (good vs. moderate), measures such as demand management, increased efficiency and water imports were considered.

The study calculated the annual equivalent costs (AEC) of each measure considered, assuming a discount rate of 2% and a time horizon of 30 years. This assumes that the costs of measures having a lifetime of more than 30 years have a lower effect on the AEC. The costs considered for the AEC calculation for each measure include:

- Investments costs
- Operation and Maintenance (O&M) costs
- Economic opportunity costs or benefits (when available)
- Environmental costs:
  - External avoided costs of measures (when available).
  - Other environmental benefits associated to the measure (apart from those deriving from the achievement of WFD objectives).

To derive financial costs, capital and O&M costs were expressed in relation to a physical measure, such as per Sq Km, per Ha, per Litre and per m3. This provided a uniform scale through which different costs and measures could be analysed and compared effectively. An issue that emerged in this exercise was the increasing marginal costs of some measures relative to others over time. As the cost analysis progressed, the increasing marginal costs of some measures emerged, through expanded service coverage or possible marginal efficiency gains, such as those aimed at improving efficiency in water use; or with the constant costs of other measures (e.g., water transfers). This point has important implications for ranking measures and choosing a cost-effective combination of measures. It should also be noted that the cost-effectiveness of a measure is not constant over time in some cases. Some measures have increasing marginal costs as technical efficiency improves (as we reach the maximum potential of the measure). This is relevant since assuming constant costs may lead to an inefficient programme of measures.

Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. *See Annex E.*

Step 2 - Making Transfers Explicit

As mentioned above, taxes and subsidies should usually be treated as transfers within society and should therefore be excluded from the estimation of economic costs. However, it is important to distinguish between general taxes and environmental taxes and subsidies:

- General taxes need to be deducted from financial costs;
- Environmental taxes and subsidies may represent internalised environmental costs and, as such, should not be deducted from financial costs.

Step 3 - Taking Account of Resource Costs

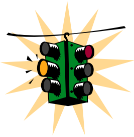
Resource costs represent the costs of foregone opportunities that other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. costs related to groundwater over-abstraction). These users can be either those of today, or those of tomorrow, who will also suffer if water resources are depleted in the future.

If markets function well, the opportunity costs of resources are reflected in the financial costs of resources. However, for environmental resources, these costs are often not included in market prices. Opportunity costs, the scarcity value of under-priced environmental resources like water, should therefore be included when estimating economic costs (see *Box 4*).

Step 4 - Including All Non-priced Environmental Costs

Environmental costs represent the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (for example, a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils). This loss in welfare may encompass lost production or consumption opportunities as well as non-use values (such as the value produced by contemplating a clean lake at dusk), which are harder to quantify. Environmental costs are not commonly estimated – steps and alternative methodologies for carrying out this estimation are therefore highlighted below.

In addition, as environmental costs can be seen as negative benefits and avoided costs (see *Illustration 2*), the following Section also discusses the estimation of environmental benefits, which will be useful for the cost and benefit assessment necessary to justifying derogation (see Information Sheet - *Disproportionate Costs*).



Look out! Before estimating environmental costs, it is necessary to know the environmental impacts of the measures used to reach the objectives.

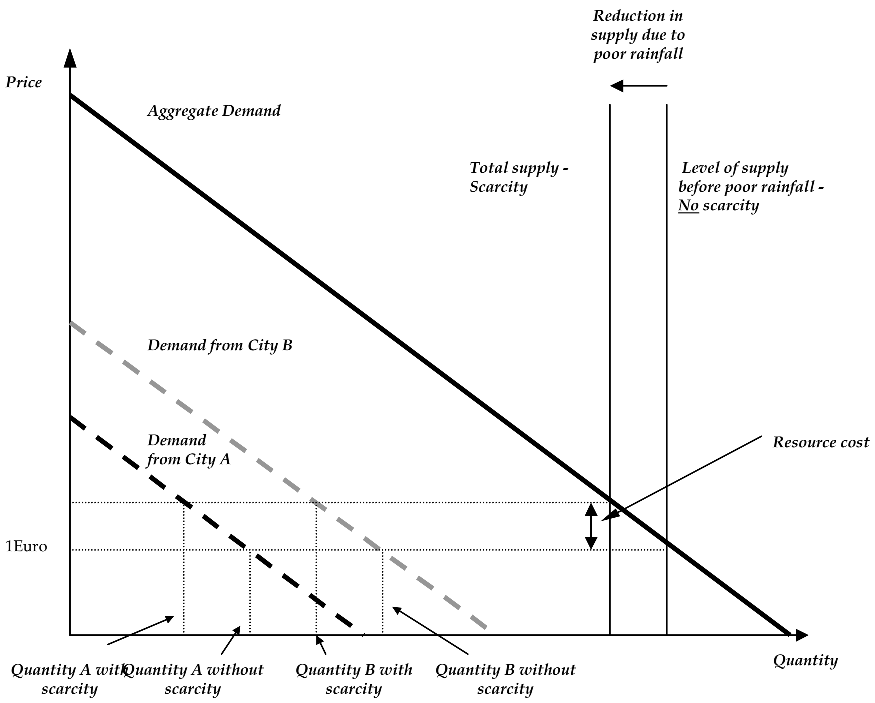
This information will be available from the work carried out by other technical experts (such as experts investigating impacts and pressures - see *Annex A* for contact details) – and environmental modelling might be required. When looking at environmental impacts, it is important to realise that measures taken to reach the objectives in one area will potentially have impacts downstream or on other parts of a river basin. In other words, linkages within a river basin district must be fully understood. Only once the magnitude of change in environmental quality has been measured, is it possible to link it to unitary costs and benefits estimated through different techniques or with the assessment of measures that would be required to prevent and mitigate etc.

Box 4 - Calculating resource costs

There are no well-established methods for estimating resource costs, although some attempts have been made at estimating them. As resource costs are seldom incorporated into market prices, it will be necessarily to rely on estimates of foregone demands and economic values.

The following example illustrates potential methods that would need to be developed:

- Two users (City A and City B) are competing for the use of the same water. It is possible to estimate the demand curve for each of them;
- If there is sufficient water available to satisfy both demands, there is no scarcity and the resource cost of water is zero;
- Suppose that due to poor rainfall in a given season, there is only a limited amount of water available (supply with scarcity). Due to this scarcity, there will be a resource cost, which can be calculated by finding the price for which total demand is exactly to the supply with scarcity. The difference between that price and the normal price is the resource cost, as shown in the Figure below.



What are environmental costs and benefits?

Society derives benefits (or costs, which are foregone benefits) from improved environmental quality in water bodies, which would arise from achieving the environmental objectives contained in the Directive. This value is made up of both 'use' and 'non-use' values (see *Box 5* for examples and below for an explanation). Other and broader benefits may need to be assessed in some instances, such as an assessment of the broader economic benefits for example, for conducting the required analysis for proposed new modifications. These are not explicitly dealt with here, however.

What are use and non-use values/benefits?

Use values/benefits. 'Use values' refers to the fact that economic agents currently use the environmental goods in question, either directly (by sailing on a lake for example) or indirectly (by watching a video of someone else sailing on that lake). Direct use values are the easiest ones to estimate, as they usually stem from products that can be traded in a market as entrants into a production process or final products (for example, water for food processing or fish).

Non-use values/benefits. Some benefits are not associated with any direct use, so called non-use values, but exist because individuals value an ecological resource without using or possibly even intending to use it, for example water quality and biodiversity in a lake.

Box 5 - Types of Environmental Benefits / Avoided costs

Benefit Class	Benefit Category	Types of benefits and examples
Use values	Direct use	Market (Commercial: fishing, navigation, tourism) Non-market (Recreational: water skiing, fishing, swimming, boating, photography)
	Indirect use	Amenity value derived from a nice environment Benefit extracted from someone else using the environmental good (e.g. Reading a fishing magazine) General ecosystem support (preserving the food chain to support fishing)
	Option value	Value derived from preserving potential direct or indirect use values in future, which depends on uncertainty over future demand and supply
Non-use values	Existence Bequest	Biodiversity, heritage and cultural values Preservation of water quality for family and future generations

Sources: *OECD (1999) and Timothy M. Swanson and Edward B. Barbier (1992).*

Illustration 2 - Benefits defined as avoided costs: *The Artois-Picardie basin*

Tourism is one of the main economic activities in the Artois-Picardie basin in the North of France. In particular, the 'Opal Coast' benefits from beach-oriented tourism, which provides 40 percent of the basin's turnover (around € 1 billion per year). Access to the region's beaches and the sea are critical factors for maintaining tourism. Hence, if the quality of water was 'sufficiently' bad, the beaches of this coastal stretch would have to be closed for bathing activities: users would either go elsewhere, or not take part in bathing activities at all.

Two studies were carried out by the Artois-Picardie Water Agency to assess the potential economic loss linked with such a scenario. The studies showed that between 30 to 50 percent of visitors to the area would cancel their trips, leading to economic losses ranging between € 300 million and € 500 million per year. These values can be seen as the benefits of providing bathing and other recreational facilities that are dependent on water quality. As a way of comparison, the money invested in sewage treatment for the basin totalled € 150 million over the last 10 last years. The magnitude of the benefits gained from good quality alone provides a compelling reason for continued investment in sewage treatment to avoid the potential cost of pollution.

Source: Agence de l'Eau Artois-Picardie (1997), 'Qualité de l'eau, tourisme et activités récréatives: la recherche d'un développement durable'.

Methodologies for Estimating Environmental Values

Various techniques exist for the valuation of environmental costs and benefits, which are more or less practical, time-consuming and have different cost implications. Below, we outline four possible methodologies for estimating those costs. A rough guide to choosing between these methodologies is presented in *Box 6* and an example of how stakeholders may be involved in the process is given in *Illustration 3*.

Method	Definition	Overall assessment
Market Methods	These methods use values from prevailing prices for goods and services traded in markets. Values of goods in direct markets are revealed by actual market transactions and reflect changes in environmental quality: for example, lower water quality affects the quality of shellfish negatively and hence its price in the market.	***Good method if market data exist but limited to direct use values for goods traded on a market. Since this is often not the case, other methods must be used.***
Cost-based valuation methods	This method is based on the assumption that the cost of maintaining an environmental benefit is a reasonable estimate of its value. References for this type of valuation include the costs of preventative and/or mitigation measures. This assumption is not necessarily correct: all mitigation may not be possible, in which case actual mitigation costs would be an underestimate of true environmental costs. By contrast, mitigation measures might not be cost-effective and those costs might be an over-estimate of the environmental costs. A distinction needs to be made between: ➢ The costs of measures already adopted, which are theoretically already included in financial costs. These costs should be reported as a distinct financial cost category. Counting them as environmental costs would be double counting; and ➢ The costs of measures that would need to be taken to prevent environmental damages up to a certain point, such as the Directive's objectives. These costs can be a good estimate of what society is willing to forego.	***Practical and relatively easy - a good starting point, although the costs of the environmental damage itself tends to be underestimated with this method.***

Method	Definition	Overall assessment
Revealed preference methods	The underlying assumption is that the value of goods in a market reflects a set of environmental costs and benefits and that it is possible to isolate the value of the relevant environmental values. These methods include recreational demand models, hedonic pricing models and averting behaviour models (see *Box 7* for a description).	***This set of techniques tends to be time-consuming and costly to use. The use of such techniques could be reserved to particular environmental issues that raise specific problems***
Stated preference methods	These methods are based on measures of willingness to pay through directly eliciting consumer preferences (i.e. asking them!) on either hypothetical or experimental markets. For hypothetical markets, data are drawn from surveys presenting a hypothetical scenario to the respondents. The respondent makes a hypothetical choice, used to derive consumer preferences and values. Methods include contingent valuation (see *Box 7*) and contingent ranking. It is also possible to construct experimental markets where money changes hand, e.g. using simulated market models. In the questionnaire, it is possible to ask respondents how much they would pay for avoiding an environmental cost or how much they value a given environmental benefit.	***As above***

Box 6 – A Rough Issues To Choosing a Methodology for Estimating Environmental Costs

Checkpoints	**Choice of method**			
	Direct market method	Cost-based valuation	Revealed preferences	Stated preferences
Are you measuring the value of the environmental cost before or after the environmental change?	After	Before or After	Before	Before
Is the market for the environmental value you want to estimate hypothetical or real?	Real	Real	Real	Hypothetical
Are markets directly or indirectly related to the environmental value you want to estimate?	Directly related	Directly Related	Indirectly related	Directly related
Is it important that you can estimate demand/supply elasticity?	Yes	No	Yes	Yes
Are (estimated) non-use values likely to be significant?	No	No	Yes	Yes
Does the method require significant time and financial resources?	No	No	Not necessarily	Yes

Some benefits will not be quantifiable, either because of technical reasons (e.g. all impacts of achieving the environmental objectives cannot be foreseen, it is not possible to quantify all the benefits of improved water quality in a river stretch etc.) or lacking resources (e.g. there is insufficient time to carry out quantitative studies before the RBMP in 2009 or it is too costly). In these situations, benefits should be assessed and described qualitatively.

The Use of Value Transfer

An alternative option to direct valuation of environmental costs is the use of *Value Transfer* (more commonly known as benefit transfer in the case of benefits). This method uses information on environmental costs or benefits from existing studies and uses this information for the analysis in the river basin under consideration. As a result, a data set that has been developed for a unique purpose is being used in an application for a different purpose, i.e. it transfers values from a *study site* to a *policy site,* i.e. from the site where the study has been conducted to the site where the results are used.
Above all, benefit transfer is suitable when technical, financial or time resources are scarce.

However, amongst other problems, it is important to note that since benefits have been estimated in a different context they are unlikely to be as accurate as primary research (see also *Look out!*). A step-wise approach should be developed in order to ensure that the transfer of values derived in other contexts can minimise the potential for estimation errors.

Box 7 – Examples of Revealed and Stated Preference Methods

Revealed Preference Methods

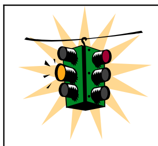
Hedonic Pricing. "Hedonic pricing methods explain variations in price [in the price of goods] using information on [qualitative and quantitative] attributes". They are used in the context of the water to value how environmental attributes and changes affect property prices. In addition to structural features of the property, determinants of property prices may include proximity to, for example, a river or lake. The change in property price corresponding to an environmental degradation, for example the pollution of a river or lake, is the cost of this degradation.

Averting Behaviour. This method derives values from observations of how people change defensive behaviour – adapt coping mechanisms - in response to changes in environmental quality. Defensive behaviour can be defined as measures taken to reduce the risk of suffering environmental damages and actions taken to mitigate the impact of environmental damages. An example of the former is the additional cost of having to filter or boil bad quality water before drinking it. The costs of mitigating the impact may entail expenditures on medical care needed as a consequence of drinking poor quality water. The expenditures produce a value of the risk associated with the environmental damage.

Recreation Demand Models (RDM). Improvements or deterioration in the water quality may enhance or reduce recreation opportunities, for example swimming, in one or more sites in a region. However, markets rarely exist to measure the value of these changes. RDM focus on the choice of trips or visits to sites for recreational purposes and look specifically at the level of satisfaction, time and money spent in relation to the activity. By assuming that the consumer weighs time and money as if he/she were purchasing access to the goods, for example a river stretch, patterns of travel to particular sites can be used to analyse how individuals value the site and, for example, the water quality of the river stretch. Reductions in trips to a river stretch due to a deterioration in water quality, and associated changes in expenditures, reveal the cost of this deterioration.

Stated Preference Methods

Contingent Valuation. Contingent Valuation is based on survey results. A scenario including the good that would be delivered and how it would be paid for (e.g. through an increase of the water bill) is presented to the respondent. Respondents are asked for their willingness to pay (WTP) for the specified good, e.g. improvements to the groundwater status. The mean willingness to pay is calculated to give an estimated value of the good, in this case improved groundwater status, and these means can then be aggregated to establish the value to the relevant population. However, note that one of the difficulties with this approach lies in ensuring that respondents adequately understand the environmental change that is being valued, for example going from poor to good water status.



Look out! When using Benefit Transfer, you must…

- Assess the quality studies to be used;
- Compare assumptions, baseline conditions, target population and policy measures etc. to ensure that the policy settings are similar; and
- Address uncertainty.

The methods used for transferring benefits include *Meta-analysis, Benefit function, Bayesian techniques* and *Point estimate*. To facilitate benefit transfers during the implementation of the Directive, it might be appropriate to build a trans-European database with references on benefits and costs.

Illustration 3 - Integrating stakeholder analysis in non-market valuation of environmental assets: estimating the value of a wetland area in Kalloni Bay on Lesvos island (Greece)

The study reviewed here sought to investigate the economic values placed on a wetland surrounding Kalloni Bay on the island of Lesvos and employed two types of methodology:

(1) Local people and visitors to the area were surveyed via a questionnaire: each respondent was asked to rate four possible development scenario for the wetland and were asked about their willingness to pay for their preferred scenario;

(2) Opinions from important local stakeholders such as fishermen, elected representatives, construction companies, and hotel owners about their priorities for both conservation and development were gathered through stakeholder focus groups. The stakeholder analysis was designed for: (i) identifying conflicting uses of environmental assets, (ii) conceptualising conflicts on the basis of property right allocations among social groups, regions and nations, and, last but not least, (iii) understanding the institutional mechanisms by which costs and benefits are appropriated.

Dynamics of the stakeholder focus groups
Individual based methods are often criticised for failing to account for institutional structures. As a result, it appeared important to reflect the institutional and social structure of the island through the focus group method. The focus groups revealed important differences in the social constructions made by different stakeholders about the wetlands and its place in the culture and economy of the Kalloni area. The issue of local people having rights over local resources was an important theme, and participants thought that problems and conflicts should be resolved locally. However, different stakeholders were reluctant to enter into discussions with each other. There was, in general, a belief that all of the different activities involving the wetlands such as tourism, agriculture and fishing could co-exist: many local people combine occupations (e.g. being simultaneously farmers and hotel owners). However, the links between the consequences of different activities were not always accepted. For example, farmers refused to make the connection between their use of fertilisers and pesticides and pollution of the bay. The uncertainty over property rights and responsibility was also a major area of concern, and inappropriate uses of land on one property were acknowledged as having detrimental effects on adjacent properties.

Economic valuation of the wetlands

The study yielded interesting results in terms of economic valuation of the wetlands. First, it made clear that the local population is capable of expressing a variety of preferences for extension or reduction of the wetland in terms of economic values, which can be captured by contingent valuation. Further, the stakeholder groups discussed different options for the future based on their needs, hopes and fears as particular interest groups, which informed the development of the scenarios and the choice of payment vehicle. By using these scenarios and from the focus group discussions with relevant stakeholders, a rich diversity in the motivations of different individuals and groups was encountered. For example, the local mayors valued the wetlands as a tourist potential that should be managed as a 'park', with strictly defined boundaries and distinct uses. On the other hand, for construction companies, the wetland was a nuisance that hindered their plans for development. However, the latter recognised that to some extent, they might benefit from an increase in tourism from the well-managed wetlands so their position was not so clear-cut. It resulted that because of the highly complex social constructs, stakeholder participation is essential to address conflicting interests, power-and-equity issues, and the tension between local and more global needs (e.g., tourism).

This study concluded that local people are quite capable of functioning as both citizens and consumers. As citizens, they feel responsible for their environment, though this is often expressed in very different ways, as the stakeholder focus groups demonstrated. However, they also feel responsible to themselves, as consumers of the wetland's economic potential. The conflicting issues that emerged through this study demonstrate the need for stakeholder communications in economic analysis, not only to characterize the social and political issues but also to establish a process through which participation by stakeholders creates ownership and self-determination for meeting environmental and economic objectives.

Source: Skourtos, M.S., Kontogianni, A., Langford I.H., Bateman I.J. and S. Georgiou (2000).

3. Reporting on Cost Issues

The calculation of full economic costs requires that assumptions be made about the lifetime of investments, about discount rates, depreciation methods, costing methods, valuation methods etc. Besides, in adjusting financial cost data for taxes and subsidies and in estimating the environmental and resource costs of ensuring sustainable water use, assumptions will need to be made as well.

To ensure the cost analyses of the member states are comparable, all assumptions and costing methods used should be made explicit, stating clearly how the presented cost information has been derived.

Though different Member States apply different standards for estimating economic costs it would be desirable to resemble as much as possible the methods and standards used in the international guidelines of for example the European Commission or the European Environmental Agency (see *Box 8)*, especially when international analyses are performed, for example in case of an international cost-effectiveness analysis. These guidelines may also help decide on issues such as which parameters and methods to include.

The general guideline is that when reporting on economic costs, all assumptions and costing methods should be clearly reported. Depending on the use of economic cost information, other requirements might apply. This is further elaborated in the information sheets *Cost-effectiveness Analysis*, *Reporting on Cost-recovery* and *Disproportionate Costs*.

Box 8 - Suggestions for Reporting on Cost Issues

Minimum requirements for the presentation of cost information according to EEA (1999)

1.It is essential that reported costs are properly defined. As a minimum, the total *investment expenditure* and total annual *operating/maintenance costs* should be reported separately.

2. As far as possible, it is recommended that all cost data should be documented in full in the year in which the actual expenditure is incurred, even if the data are subsequently adjusted to take account of time (such as by using *discount rate*s).

3. All costs in should be measured in relation to an alternative. The alternative most commonly employed is a projection of the existing situation, i.e. the situation in which the *environmental protection measure* has not been installed. Therefore, only *additional costs* actually incurred relative to the *'base cas*e' should be included in the reported cost data.

4. Where the costs associated with an *environmental protection measure* have been apportioned between two or more controlled pollutants, the method of apportionment should be described.

5. The reported cost data should only relate to *direct cost*s; *indirect costs* should be excluded from the cost data.

6. Where *environmental protection measures* produce non-environmental benefits, *revenues* or *avoided cost*s, these should be reported separately from *investment expenditures* and *operating and maintenance cost*s.

7. It should be remembered that costs and prices are not fixed forever. For example, the unit price of a measure often falls as it changes from an experimental measure to a mass-produced measure. Therefore it is recommended to use the most recent valid data available.

8. It should be remembered that old equipment can sometimes have a lower *efficiency* and higher maintenance costs than new equipment.

9. As a minimum, any *discount rate* used should be recorded.

10. If cost data are adjusted for inflation or changes in price through time, then the method used should be recorded and any index used should be recorded and referenced.

11. If determining annual cost data, the approach that has been used to derive the annual costs should be recorded, along with all underlying assumptions.

Note that this does not necessarily apply directly to the economic assessment required for the Directive – these are guidelines from the EEA only. For example, whereas the EEA recommends to only incorporate direct costs (and not indirect costs), the incorporation of indirect costs in the economic assessment for the Directive would depend on the stage of that assessment, as specified above.

REPORTING ON COST RECOVERY

Directive references: *Article 9* and *Annex III*
3-Step Approach: *Step 1.3* and *Step 3.3*
See other information sheets: *Estimating costs, Defining water services and uses, Baseline Scenarios, Pricing as an Economic Instrument*

This Information Sheet helps you understand what and how you should report on the recovery of costs of water services by types of water users.

1. Why is it necessary to report on cost recovery?

Article 9.1 of the Directive states that: "Member states shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis according to Annex III, and in accordance with the Polluter pays principle".

This information sheet is a guide for reporting on cost recovery and is relevant for:

- Implementing the **recovery of costs of water services** and ensuring an **adequate contribution of the different water uses** to the recovery of costs of water services; (*Article 9*);
- Creating **water pricing policies** to provide adequate incentives for users to use the resources efficiently (*Article 9*); and
- Making the relevant calculations necessary for taking into account the principle of cost recovery in the **economic analysis** (*Annex III*) and making a first assessment of whether the cost-recovery objective of the Directive are currently met.

However; the information sheet focuses on the latter point (*Annex III*). A key objective of this initial analysis will be to improve **transparency** in order to understand which water services are actually paid for, to which extent, by whom and how. More specifically, this will entail identifying whether some external subsidies are provided to the water sector, or whether some cross-subsidies are paid between categories of water uses.

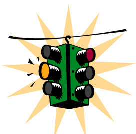
Finally, note that the objective of the Directive is not necessarily to move to "full cost recovery" but to move to a situation where the "polluter pays " principle is adequately applied. The Directive allows Member States to take into account the social, environmental and economic effects of cost recovery. But it is only with maximum transparency that the extent of these secondary effects of cost-recovery can be understood.

2. Approach to Analysing and Reporting on Cost Recovery

The approach that is proposed here for analysing and reporting on cost recovery and assessing the extent to which polluters pay can be broken down into a number of tasks, as shown in *Figure 1* of this information sheet. It is important to stress that this approach may need to be adapted to local and national situations and institutional setup for cost recovery.

Figure 1 – Tasks and Key Questions in Analysing and Reporting on Cost-Recovery

Key Tasks	…And Questions
1. Define the water services	What is the scale for the analysis? What are the differences in scale between water uses and water services? How can they be reconciled? What is the overall scope of the analysis
2. Identify providers, users and polluters	Who generates the costs of the water services? Do they receive a service or are they self-serviced?
3. Calculate financial costs of the water services	What are the financial costs of the water services?
4. Identify and estimate the environmental and resource costs of the water services	What are the environmental and resource costs? Can they be identified and estimated at least in qualitative terms?
5. Identify the cost –recovery mechanism	How are costs currently recovered: through prices, charges or through other institutional mechanisms of cost recovery?
6. Identify the cost –recovery mechanism	What level of costs do water users recover? What is the level of financial costs recovered? What is the amount of external subsidies to the sector? Where do these external subsidies come from and how are they financed?
6. Identify the cost –recovery mechanism	How can costs be allocated to water uses? What proportion of the total costs do water uses cover, and is that in accordance with their actual use?



Look out!

The suggested steps to report on cost recovery do not include investigating issues dealing with price incentives (Article 9). This is treated as a separate issue in a different information sheet (see *Pricing as an Economic Instrument*).

Task 1 - Define the Water Services

The first task is to define water services (see *Water Uses and Services* Information sheet) and to determine the scale of the analysis (see *Scale Issues* Information Sheet). Particular attention should be paid to the geographical scope of the analysis (local, regional, river basin, national, international). Subject to data availability, the definition of water services may have to be at the administrative rather than the geographical level. *Illustration 1* of this information sheet demonstrates how data were collated and adapted to RBD level in the Middle Rhine, however, in some cases, for lack of more disaggregated data, cost-recovery might need to be analysed at the national level (see *Illustration 2* for an example).

Illustration 1 – Cost recovery and data availability in the Middle Rhine, Germany

The principal water services in the Middle Rhine are public water supply and local authority sewage disposal, and both types are highly decentralised with a large number of companies. In general, the existence of consistent data may be a problem for the assessment of cost-recovery levels and, potentially, a decentralised structure could complicate data collection further. However, in the Middle Rhine, statistics is collated and categorised so that information based on administrative area definitions can be related to geographical definitions based on river basins. As a result, the Middle-Rhine scoping study shows that *existing secondary* data can provide enough information for a good first assessment of the level of cost recovery.

In order to assess the level of cost recovery of water services in the Middle Rhine, structural and output data were collated and processed. Essentially, the data collection was carried out in two stages (see Table 1):

Table 1

Type of data	Data sources
Stage 1. Collection and evaluation of generally available data: information on the structure of water uses and water services and related economic characteristics (e.g. charges, subsidies, financial costs of water supply and sewage disposal)	The Federal Statistical Office (censuses of all water supply companies, excluding publicly owned enterprises), regional statistical offices (environmental statistics form censuses of *all* water companies), and data and information from the technical and financial authorities of the Länder.
Stage 2. Collection and evaluation of third party data to supplement Stage 1.	The Federal Gas and Water Management Association, joint authorities/associations surveys on public sewage disposal, and evaluation of special surveys and expert reports.

Surveys to collect *primary* data were planned for a third stage but were not undertaken as *Stages 1* to *2* provided sufficient data to derive the current level of cost recovery. As an example, Table 3 contains a summary of data collected for *public water supply* in the region of Hessen. Table 2 (below) outlines the main results (financial statistics) for public water supply:

Table 2

Water service	Rate of cost recovery
Public water supply Cost recovery from revenue excluding allocations and subsidies Cost recovery from revenue including allocations and subsidies	 83% 90%
Internalised environmental and resource costs (groundwater charge) are approximately DM 52.6 million in total, which significantly exceeds the sum of total subsidies (DM 3.4 million) and the cost recovery shortfall (DM 19.7 million).	

It was found that the ability to adapt official statistics of the Federal Government and the Länder (administrative districts) to river basin district level (as required by the Directive) greatly improved the reliability of the estimates. In addition, to ensure the efficiency of supply, detection and evaluation of data, as well as comparability of the results, a central data pool will be set up to facilitate the availability and access to economic data.

Illustration 1 (Continued)

Table 3

Revenue/Income and Cost/Expenditure	**Amount (DM)**	
Number of companies	132	
TOTAL Revenue/income	**280,365,486**	
Fees/proceeds from sales	**244,471,830**	
Allocations and subsidies for on-going purposes of which:	**3,404,471**	
Federal Government		0
State of Hesse		1,073,277
Local Authorities		2,296,070
Other private sectors		35,124
Other operating receipts	12,235,053	
Contributions	8,773,279	
Investment allocations and subsidies of which:	**10,952,929**	
Federal Government		0
State of Hesse		10,538,653
Local Authorities		52,624
Private companies		110,813
Other (private) sectors		250,839
Other income	527,924	
TOTAL Cost/expenditures	**302,370,508**	
Personnel expenditures	32,954,151	
Imputed costs	78,275,119	
Interest		29,383,892
Depreciation		48,891,227
Operating expenditures	149,450,933	
Groundwater charges		52,621,451
Other operating expenditures		96,829,482
Aquisition of assets	3,342,563	
Structural measures	35,854,654	
Other expenditures	2,493,088	
Profits/Losses	**-22,005,022**	
Public investment allocations and subsidies	**10,702,090**	

Illustration 2 – Issue of Data Availability in the Netherlands

- In the Netherlands, data on the costs of wastewater treatment are available at the administrative level of the Regional Water Boards. The information supplied by the Water Boards includes other costs than those for wastewater treatment alone, and assumptions need to be made regarding their share of the total costs.
- Data are available both at the national and regional level. As the regional level does not yet correspond to the geographical level of the river basin, at this moment aggregated national data needs to be used for the analysis of the cost recovery.

In addition, the scale at which the costs of water services are incurred might be different from one category of costs to the other (financial costs would usually be collected at the water service level, whilst environmental and resource costs would be at the level of the river basin, the scale at which water uses can be analysed). Ways to reconcile these different scales and to combine data should therefore be sought during that first task. This might require co-ordination between different administrations (for example, the economic regulator of water services who would normally have access to data on the financial costs of water services and the environmental regulator, who may have data on the environmental and resource costs in general, although not necessarily allocated to water services).

Task 2 - Identify the Providers, Users and Polluters

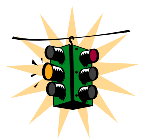
This task involves the identification of the actors involved in the generation of financial, resource and environmental costs. Water services are provided in different ways, e.g. on a communal or individual basis, by a public or a private company. The geographical scope of the analysis is determined by the level at which the responsible authority and the provider of the water service operate and the scale of the market served (see *Illustrations 1* and *2* of this information sheet).

Normally, little information is available for individually provided water services (agricultural groundwater abstraction, industrial waste water treatment, septic tanks of households etc.) - see the *Look out!* Box below. Should this be the case, an *estimation* of the extent to which water services are provided on an individual basis, for example the percentage of households with septic tanks or percentage of industry not connected to the sewerage system, can be attempted. It is only where there are significant environmental problems linked to self-services (such as mining of an underground aquifer due to too many private wells) that an appropriate estimate of all costs related to self-provided services is key to transparency and better decision-making.

A specific case is that of diffuse pollution, which can be created by agricultural pollution but also industrial or household uses (such as urban run-off). Even though diffuse pollution is not a water service, the costs resulting from diffuse pollution, in so far as they have an impact on the costs of water services (through an increase in water treatment costs for example), should be covered by those who have generated this pollution. With the Water Framework Directive (Article 9) requiring *an adequate contribution of the different water uses … to the recovery of the costs of water services*, it is important to ensure links can be made between water uses and related water services and costs.

Task 3 - Calculate the Financial Costs of the Water Service

To calculate the financial costs (see *Estimating Costs* Information Sheet), extensive information is needed regarding the various cost items involved in providing the water service. Typically, this type of information can be collected from the provider's annual production account or balance sheet or, if there is more than one provider, from their aggregated production accounts or balance sheets (see *Illustration 3* of this information sheet). Depending upon the relevant scale of analysis and the number of providers involved, this can be done at a local, regional, river basin or national level. *Illustration 4* of this information sheet presents an easy-to use methodology for estimating financial costs.



Look out! Cost-recovery of self-provided water services
Water services can be provided either by third parties (e.g. communal water services) or on an individual basis (e.g. water treatment facilities of industry, agricultural water abstraction, septic tanks of households etc.). For the latter, the financial costs of water services are covered as the user will usually have financed these investments. Nevertheless, they can be included in the analysis, in order to fully account for the polluter pays principle. In addition, the environmental and resource costs for these services should also be estimated.

Illustration 3 – Estimating cost-recovery in the Netherlands

Table 1 below shows the aggregated costs water quality (and quantity) management, including both financial, internalised environmental, and remaining environmental costs. This is the case because the costs of mitigation measures to compensate for water pollution (e.g. cleaning of polluted river beds and water soils, monitoring of the water quality) are included in the financial costs and paid for by the users through the wastewater treatment charge. Also, since the wastewater charge paid is related to the pollution caused, the polluter pays principle applies. In total, costs add up EURO 1,030 million.

Total revenues for water quality management amount to EURO 1,035 million. Revenues include financial returns on assets and the revenues received from the wastewater pollution charge. This charge is set to recover the costs of wastewater treatment and mitigation measures. From these revenues, the subsidies received for operating the wastewater treatment installation need to be subtracted, resulting in a total of 1,021 million.

The cost-recovery rate can therefore be estimated as:

$$\frac{\text{Total revenues-subsidies}}{\text{Total costs:}} = \frac{1021}{1030} = 99\%$$

Table 1 - Aggregated Balance Sheet of Water Boards in the Netherlands

Costs and revenues *(in million euro)*	**Water quantity management**	**Water quality management**
Total costs	668	1,030
Total revenues		
A received interest	37	85
B received waste water treatment charges		
C received apportionments for water quantity management	514	
D sales, rents and other taxes	14	17
E investment adjustments	9	5
F subsidies	46	14
G other income received from third parties	18	5
H internal adjustments	23	9
Total revenues	661	1,035
Net revenues -/-costs	-/-7	5

Illustration 4 – Estimating Financial Cost Recovery in the French West Indies

Two of the main features specific to water supply schemes are: (i) they incorporate assets with service lives of varying lengths, often extending beyond the life of the loans subscribed to finance them; and (ii) corresponding maintenance costs grow over time and are not easy to estimate.

In the French West Indies, a large, multi-purpose water scheme supplying raw water mainly for agriculture (52%) and domestic purposes (40%) provides the basis for a simplified case study on financial cost recovery to illustrate how these features should be taken into account. The scheme is publicly-owned (and as such, investments were funded by various local authorities from 1977 to 2000) but privately managed. From the scheme, 16.8 hm^3 of raw water are sold every year and nearly 10,000 ha are irrigated.

Given the asset lives and a discount rate estimated at 3%, the annual capital costs were calculated to estimate whether the scheme's financial costs are fully recovered. To calculate maintenance costs, an intermediate step in was made to estimate a maintenance rate for each type of asset, taking into account that these costs increase over time, and using lower and upper bound values derived from past experience (see Table 1 below).

Table 1: Capital and maintenance annual costs calculation (€ 2000)

Asset life	Maintenance rate	Total investment per type of asset	Annual capital cost	Total maintenance cost	Annual maintenance cost
100 years	1-2%	504,184	12,092	148,883	4,712
100 years	0.3-1%	11,588,767	298,198	1,311,909	41,518
75 years	0.3-1%	132,573,805	3,586,153	14,776,679	495,893
50 years	1.5-5%	1,640,445	58,292	193,798	7,532
50 years	1.5-5%	210,592	6,124	101,797	3,956
40 years	1.5-5%	7,495,407	244,879	3,264,663	141,237
30 years	1.5-5%	561,173	22,856	234,025	11,940
25 years	1.5-5%	274,366	12,811	105,158	6,039
20 years	1.5-5%	34,811	1,903	11,584	779
10 years	1.5-5%	58,533	4,871	10,111	1,185
Total		173,827,944	4,789,921	20,158,607	714,790

The total financial cost was then calculated by adding this table's intermediate (total) costs to operation costs. These were derived from existing data provided by the private operator.

Table 2: Total financial annual costs and its components per cubic meter (€ 2000)

Type of costs	Total value	Value per m^3
Capital costs	4,789,922	0.285
Maintenance costs	714,790	0.043
Operation costs	1,084,522	0.064
TOTAL	6,589,234	0.392

These total costs can be allocated between the different water users (irrigators and others) and compared with the price of water charged to those users. However, there are some clear limits to this approach: average costs calculated over a long period (75 years for some assets) are compared with fees charged in a given year. Thus, a comparison between average annual costs and current prices to estimate cost recovery only gives a rough estimate and should be interpreted with caution. In this case, water used for domestic purposes represented 40% of total volume used and 57% of total fees received, due to the lower price of irrigation water and to a different water pricing structure. For raw water, operation and maintenance costs were fully covered by users through tariffs but a large part of capital costs were covered through subsidies from the public authorities.

Based on several case studies conducted in France, this method for estimating financial costs appears relatively robust as it provides the means to estimate costs with assets of varying asset lifes. It can also be applied to external costs whenever it is possible to identify stakeholders who are affected by externalities and who have incurred expenses to avoid them or to remedy their effects. So far, however, this method has been applied solely to estimating financial costs.

Source: T. Rieu (2002, forthcoming).

Task 4 – Identify and Estimate the Environmental and Resource Costs of Water Services

According to the Directive's definition, environmental and resource costs should also be considered in order to take account of the principle of cost recovery. As mentioned in *Estimating Costs (and Benefits)*, the estimation of environmental costs and resources might be difficult, due to methodology issues. Some environmental and resource costs are already internalised and as such, are included in the financial costs (see *Illustration 5*). Non-internalised environmental costs will prove most difficult to quantify and incorporate in the cost-recovery equation. For those, and for the sake of improving transparency, it might be sufficient to identify the costs and estimate them in a first instance.

Illustration 5 – Introducing a Natural Resource Tax (NRT) in Latvia

The Natural Resource Tax (NRT) was introduced in Latvia in September 1995 as a means to incorporate environmental externalities into the cost of water and wastewater services. Groundwater and surface water abstractions are charged, together with discharges.

The NRT rates vary according to the type of water abstracted and the type of pollutants. The following table shows the NRT rates for both water extraction (ground or surface) and water pollution:

	Unit	NRT-rate
Ground water extraction	€ / 1000 m^3	17.7
Surface water extraction	€ / 1000 m^3	3.5
Water pollution with SS	€ / tonne	17.7
Water pollution with COD, P and N	€ / tonne	53.1

Source: Latvian Law on Natural Resource Tax adopted on 14 September 1995.

In the following table, the Latvian NRT rates for groundwater extraction and pollution with P and N are compared with NRT rates in other Central and Eastern European Countries and some EU Member States.

	Ground water extraction (€ /1000 m3)	Water pollution (P) (€ / tonne)	Water pollution (N) (€ / tonne)
Latvia	**17.7**	**53.6**	**53.6**
Lithuania	10 – 24	404.3	118.9
Romania	7.3 – 8.4	43.6	43.6
Slovenia	30	5783	694
Estonia	16 – 48	216.6	130.3
Czech Republic	56	1960	1120
Poland	92.3		
The Netherlands	150 (1998)		
Denmark	670 (1998)	14,620	2,660
Germany		46,000	1,900

Source: REC (October, 2001)

This table shows that the NRT rate for groundwater extraction is generally lower in Latvia compared to other Central and Eastern Europe countries, and substantially lower than in EU Member States (it should be noted that GDP per capita in Latvia is only 29% of the average in the EU).

In addition to this relatively low NRT rate, it appears that the tax on water extraction and water pollution does not achieve its intended goal to achieve full cost-recovery while protecting the environment. The rates are relatively low and have remained unchanged since 1996, whilst the inflation between 1996-2001 was 43%. As such, the NRT rates probably do not cover environmental costs, at least from pollution (with respect to abstraction, given abundant groundwater resources and relatively low extraction rates, resource costs are close to zero). In order to prevent social problems, however, and given that water and sewerage tariffs are already relatively high, the NRT rates could only be increased in line with the expected economic growth in Latvia. Many small businesses have difficulties paying even the relatively small NRT and have little incentive to do so given that the monitoring mechanisms are deficient. From this case, it transpires that the NRT currently in place in Latvia largely represents a compromise between social, economic and environmental goals rather than a fully-blown economic instrument for recovering environmental costs.

Source: I. Kirhensteine (2000, forthcoming).

Task 5 - Identify the Cost Recovery Mechanism

This task involves identifying the mechanism currently used for recovering the costs of water services by water users. This would generally involve payment by users (through prices, charges, taxes) or alternative institutional mechanisms for recovering costs. This task should pay specific attention to the institutional mechanisms that are used in order to recover costs going beyond the mere pricing mechanisms. As shown in *Illustration 6* below, water users may sign a specific agreement between themselves in order to share the costs of an improvement in water status, which might reflect more closely the way in which they are sharing the benefits than through relying on an administrative pricing mechanism.

If prices and charges are the main cost-recovery mechanism, it would be important to collect data on the tariff structure, including the price per unit of water service used (for instance, EURO per m^3 or fixed charge per household etc.). If more than one user group is involved, the unit price may be aggregated and averaged across one or more user groups.

Illustration 6 – Institutional mechanisms for cost recovery in Tarragona (Spain)

In Spain, as in other semi-arid regions around the Mediterranean, increasing pressures on available water resources requires improving the efficiency of existing water uses. A water user association in Tarragona came up with an innovative negotiated arrangement in order to increase its available water resources by financing improvements in irrigation water uses.

Background. In Spain, irrigation is a key factor for agricultural production and the Government has played an important role in irrigation development. As a result, irrigated agriculture is by far the largest water consumer. Many irrigators have historical water rights and enjoy large water allotments, but they are faced with low guarantee levels, as allocation rules in times of scarcity give priority to urban uses. To regulate highly variable rainfall patterns, the Government invested in water system regulation infrastructure, with the construction of large water storage reservoirs. Growing water demand together with declining responsibilities for further reservoir building has resulted in increased resource scarcity and mounting competition amongst water users, focusing the debate in the water sector on conservation and reform.

Financing the modernisation of irrigation systems. In some old irrigation districts, technological improvements on the irrigation networks could allow for water savings, especially in areas where possibilities for further reservoir building are limited. Irrigation modernisation programmes can be beneficial for farmers but also for domestic users and the environment, through the resulting water savings. In the region of Tarragona in the Ebro river basin in Spain, where beneficiaries were well defined and third party effects insignificant, private negotiation led to the implementation of irrigation modernisation programmes. A water user society (municipal and urban water users) agreed to pay for modernisation investment in two irrigation districts in the Ebro river basin. In turn, these irrigation districts agreed to reduce their water entitlements (by the amount of water saved through distribution system modernisation) in favour of the water user society. This direct negotiation between water users appears as an alternative to the use of pricing mechanisms for reaching the cost-recovery objectives. In practice, urban users agreed to pay the costs of additional supplies through the financing of irrigation improvements. However, the circumstances in which this kind of institutional solution can be used are relatively limited. In most cases beneficiaries include a large number of downstream users including the environment and public price setting and subsidy transfer would play a key role to give incentives for the adoption of water conservation measures in irrigation districts.

Source: M. Blanco (2002, forthcoming).

Task 6 - Calculate the Recovery Rate of the Economic Costs of Water Services

The next task involves calculating whether, at an aggregated level, the cost of water services is globally recovered via revenues from users of this water service. This will need to be carried out water service by water service. In order to do so, it will be important to assess the revenues received by the water service and to assess whether any external subsidies are paid in order to finance the costs of this water service.

As highlighted in *Box 1* below, subsidies can be paid either directly or indirectly. In addition, they can be paid continuously or have been paid in the past (for example, a capital grant paid in the past to finance investments, or a write-off of capital asset value when transferring some assets in the private sector, as it was done in the United Kingdom at the time of privatisation). Therefore, it will be important to define clearly what is considered to be an external subsidy and when it was granted. An example of cost recovery and identification of subsidies in Hungary is given in *Illustration 7*.

Box 1 – Cost recovery: The issue of subsidies

The polluter pays principle (PPP) requires that users pay according to the costs they generate. However, subsidies reduce users' contribution to the full cost of water services and disable price incentives to use resources in a sustainable manner – both important objectives of Article 9.

Subsidies are allocated to either providers, users or polluters in different ways. They can be paid **directly** by the (central or local) government:

- to the provider of water services in the form of investment subsidies. *(capital subsidies, lowering fixed costs)*;
- to the provider of water services in order to co-finance the operation of the infrastructure *(operational subsidies, lowering variable costs);*
- to water users *(income transfers, lowering the price/charges paid by the user).*

In addition, subsidies can be paid **indirectly** by:

- users/polluters paying the costs of other users/polluters. ross subsidisation may arise between different users (households, agriculture, industry), different regions (dry and wet, populated or less populated) and/or different types of users (rich or poor, small or large users etc.).

When user groups pay only part of the costs of a water service, the rest of the costs will have to be paid or subsidised by others. These others can be the public at large contributing through general taxation (tax revenues being used by the central government to subsidise the supply of water services in ways described above) or other user groups that pay a larger fraction of the total costs (including resource and environmental costs) than they generate.

Once the external subsidies have been identified, the general formula for calculating the cost recovery rate for water services can be calculated as follows:

$$CRR = \frac{TR - Subsidy}{TC} * 100\% ,$$

where CRR is the Cost Recovery Rate, TR the total revenues (depending on the cost recovery mechanism this figure could be based on either fixed or variable charges in EURO/year), Subsidy the total amount of subsidies paid to the water service, and TC the economic costs (in EURO/year) of the water service provided.

If the water service is provided free of charge, the CRR equals zero. The problem with assessing the full extent to which the PPP holds is that external resource and environmental costs must be calculated and added to the financial cost. This may be difficult due to data availability (e.g. cause and effect are not always clear and environmental costs are often incurred at a scale that is larger than the scale of analysis). In such a case, to make an estimation of the extent to which environmental and resource costs are recovered, aggregated data on the quantity of water used by the different sectors and the amount of pollution caused by water services may at least be sufficient to inform a general assessment of the most important pressures and pollutants. In combination with information on environmental charges and levies, they can provide sufficient information to give a qualitative estimation of the extent to which the polluter pays principle has been applied.

In addition, due to the difficulties of identifying and allocating environmental and resource costs, it is important to distinguish between financial cost-recovery and overall cost-recovery. Financial cost-recovery should be analysed in the first instance as a minimum, and then overall cost-recovery could be estimated on top of this, bearing in mind the difficulties of doing so.

Illustration 7 - Cost recovery in Hungary and the need to identify subsidies

To meet EU accession requirements, Hungary must comply with EU regulations concerning wastewater collection and treatment by 2015. As a result of accession negotiations, total wastewater collected must be 79.5%, and the level of treated sewage must be 90% (from 38.5% in 2002). The investment costs for this undertaking will total € 820 millions. Most of the necessary investments will be financed by State and EU subsidies, although the present level of these subsidies is already high with over 1/3 of the water services companies having negative earnings.

An assessment of cost-recovery in Hungary remains difficult: the water services sector is highly fragmented with companies using different accounting systems; data gathering and processing is costly, due to the number of companies and claims of data confidentiality; economic valuation of environmental costs is lacking.

An overhaul of the water services sector in 1990 led to increased decentralisation, with local control transferred to local and regional companies (with public ownership of assets), and the establishment of 5 regional, fully state-owned companies that handle bulk production and some supply. Regulatory responsibilities and ability to set prices for water and sewage were also transferred to local water authorities (except for the regional companies, whose prices are set by the Ministry of Transport, Telecommunication and Water Management – MoTTW). Local control over pricing means varied costs relative to production costs – areas with higher production costs must charge more for water than areas with lower production costs. Along with the transfer and loss of centralized control, the central government also decided to reduce subsidies for operation costs in the water sector, claiming that local water charges should recover the water sector operating costs. However, as illustrated in the following table, this is a difficult task.

Table 1: Characterisation of the Water Services Sector in Hungary

Agriculture	Industry	Household Use
"Free price" system, where control over pricing is exerted via the tender process.	Systematic economic change since 1988 led to declines in industrial production and use of less polluting production.	Water/sewerage pricing a political decision, with responsibility in the hands of local officials.
Prices vary based on use of gravity or pump, distance to carry water, required pressure, economies of scale, whether there is infrastructure to be maintained, etc.	Decrease in demand due to price increases and bankruptcy of production companies.	High prices relative to disposable income, along with unwillingness (or ability) to pay has led to 10% consumer debt to companies. Even if the charges per unit of consumption = the costs per unit, actual revenues from charges will still not fully recover costs.
Prices usually cover operation and maintenance costs only	Revenues (industry and households combined) cover only operating costs, not depreciation or development. Amortisation isn't used as a practice, so future costs are undervalued.	Revenues (households and industry combined) only cover operating costs, not depreciation or development. Amortisation isn't used as a practice, so future costs are undervalued.
Water use rights by application and last for 3 years, except for a large regional water supply company that also operates irrigation objects in a 25-year concession.	Large industrial users mostly extract water individually. The prices of water purchased are not centrally regulated, which means diverse pricing structures.	Due to legal/technical constraints, it is impossible to shut down water services for non-payment to households.
Prices not available to the public. No official requirement to collect price data; data that is collected is generally considered confidential.	Revenues from industry are used to cross-subsidise household use.	Benefits from cross-subsidy from industrial sector.

The subsidies that are provided by the central government are the responsibility of the MoTTW. Each year, the MoTTW sets threshold values for water and sewage unit costs and municipalities (local governments) with higher costs receive the difference as a subsidy. The charges paid by the household consumers in the subsidised settlements are then equal to the threshold level of costs.

In practice, the Ministry first decides on the aggregate amount of transfers in each year, and then determines threshold values. In 1998, 1999 and 2000, total subsidies amounted t to CHF 3.4, 3.8 and 4.1 billion (at current price) respectively. For 1998, this is less than 0,5% of the total costs of water and sewage services provided for households in the country. More than one third of the settlements in Hungary (usually smaller villages) receive this kind of subsidy.

With a relatively low level of forecasted household incomes, simply raising the water charges will not result in an improved water sector. Further, increased investments from the EU and the state alone will also not result in an improved water sector. Given the state of the sector, and the need for further investments and reform to meet the EU accession goals, a closer look at how the subsidy system operates, how these are implemented, and how they are measured to meet overall policy goals may be necessary. The situation in Hungary may also be relevant to accession countries facing similar challenges, and to some Member States.
Source: P. Krajner (2002, forthcoming).

Task 7 - Identify the Allocation of Costs to Users and Polluters

The allocation of costs to water users will require determining a number of cost drivers, which are proxy indicators for estimating the amount of costs that they generate. These cost drivers are likely to differ according to the type of costs that are at stake. For example, in the case of the provision of a water distribution service, "volume of water used" might be an adequate driver for allocating operating costs whereas "required pipe capacity" may be a more appropriate driver for allocating investment costs. Cost drivers for environmental costs might be linked to the quality of the water discharged into the environment or into the sewer.

Specific attention should be paid to the potential existence of cross-subsidies between users of the water services (see *Box 1* of this information sheet). The availability of data will largely determine to what extend those cross-subsidies can be made explicit. Typically, the allocation of costs to different categories of water users can be a difficult exercise.

3. Reporting on Cost Recovery

It follows from the tasks outlined above that information is needed on the specific water services involved, their costs (including possible environmental and resource costs) and the way they are paid for (or not), providers, users/polluters and possible subsidies/transfers is required to estimate the rate of cost recovery (see *Illustration 8* of this information sheet for an example on how this may be achieved).

This information can usefully be compiled in a matrix, as shown in *Table 1* of this information sheet. This structure makes the interactions between the economic system and the water basin explicit and combines all the necessary information in one general accounting matrix. In this structure, a distinction is made between the different water users (households, industry and agriculture) and providers of water services (communal and individual). A similar structure is currently used by the National Accounting Matrices, Water Accounts (NAMWA)[10].

[10] This structure has been elaborated in the NAMEA (National Accounting Matrices-Environmental Accounts) and NAMWA (National Accounting Matrices- Water Accounts) by the Netherlands Statistical Bureau (CBS), and is now being reproduced in most EU member states and further elaborated by Eurostat.

Illustration 8 – Observatory for household water pricing (France)

Since the middle of the 1990s, increased attention has been paid to water pricing for households in France, with the launching of observatories in different Ministries and within the river basin water agencies. Originally, these observatories were developed to determine the average price per cubic meter of water (including water supply and waste water treatment). Already from the beginning, some attempts were made to identify the different components of the price (investment, maintenance, subsidies, etc.). However, the results of these studies were highly variable from one region to the other. In 1999, the Ministry of Environment and the water agencies decided to create a national observatory of domestic water prices at the National Institute for Environmental Statistics (IFEN). This observatory is based on information collected from 5000 municipalities, which are interviewed every three years. A great deal of technical and economic information is collected, such as:

- Price per cubic meter;
- Status of infrastructures;
- Forecasted investments;
- Information on subsidies…

While still in its start-up phase, it is expected that the data from this new national observatory will stimulate more work in the field of cost-recovery for household-related water services that will be of direct use for implementing the economic-related articles of the Water Framework Directive.

Source: A. Courtecuisse – Artois Picardie River Basin Agency – See also:
http://www.ifen.fr/pages/4eaulit.htm#65

Table 1 - General structure of information requirements with respect to reporting on cost recovery

Water service	Provider	User/Polluter	Financial costs	Resource costs	Environmental costs	Possible cost recover mechanisms	subsidies/transfers involved
Supply of (drinking) water	communal/ individual (agriculture, industry, household)	Households Agriculture Industry	Annual costs of water infrastructure, maintenance and operation costs	Opportunity costs of alternative water uses	Environmental damages due to abstraction, storage, impoundment etc.	Utility charges, market prices, abstraction taxes/charges paid by households, industry and agriculture etc.	Subsidies to low-income households, capital subsidies on investments in water supply infrastructure
Irrigation	communal/ individual (agriculture)	Agriculture	Annual costs of irrigation system, maintenance and operation costs	Opportunity costs of alternative water uses	Environmental damages due to abstraction, storage, impoundment etc.	Abstraction charges and/or charges paid for the use of the irrigation system by agriculture etc.	Subsidies on agricultural water use, capital subsidies on investments in irrigation system.
Hydro power	communal	Industry Households	Annual costs of investment, maintenance and operation costs	Opportunity costs of alternative water uses	Environmental damages of impoundment, dehydration of nature		Subsidies on industrial electricity use, capital subsidies on hydropower dam construction.
Drainage	communal/ individual (agriculture)	Households Agriculture	Annual costs of investment, maintenance and operation costs	Opportunity costs of loss of wetlands	Environmental damage to wetlands, dehydration of nature	Water management charges paid by households, agriculture, industry	Financing of large scale drainage out of general means, other subsidies
Sewerage	communal/ individual (industry)	Households Agriculture Industry	Annual costs of sewerage system, maintenance and operation costs		Environmental damage of (residual) water pollution	Sewerage and pollution charges paid by households, industry, agriculture	Capital subsidies on investments in the sewerage system, financing of sewerage out of general means
Waste water treatment	communal/ individual	Households Agriculture Industry	Annual costs of waste water treatment, operation and maintenance costs		Environmental damage of (residual) water pollution	Waste water treatment and pollution charges paid for by households, industry, agriculture	Capital subsidies on investments in waste water treatment, subsidies to users of waste water treatment.

BASELINE SCENARIO

Directive references: Article 5, *Article 9* and *Annex III*, also implicit in *Annex II*
3-Step Approach: *Task 1.2*, *Task 2, Task 1.3 and 3.3*.
Information sheets: *Recovery of Costs* and *Cost-effectiveness Analysis*

This information sheet will help you develop one or several alternative baseline scenarios (or "business-as-usual" (BAU) scenarios), and proposes an optional approach to complement the forecasting analysis (to define the BAU scenarios) with prospective analysis.

1. Objective

Article 5 requires that each Member State shall ensure that "an economic analysis of water use is undertaken for each River Basin District" and Annex III further specifies that this analysis should "take account of the long term forecasts of supply and demand for water in the RBD and where necessary: estimates of the volume, prices and costs associated with water services and estimates of relevant investment including forecasts of such investments".

The construction of long-term forecasts (what is referred to as *business-as-usual* scenarios) during *Step 1.2* of the 3-step economic approach is needed for:

- Identifying whether there is a gap in water status between the projected situation and the Directive's objectives by 2015 (*Step 2* – as illustrated in Figure 1 of this information sheet);
- Identifying potential measures to bridge that gap (if there is one) and construct a cost-effective programme of measures (*Step 3.1 and 3.2*);
- Making the relevant calculations necessary for taking into account the principle of cost recovery of water services, taking into account long-term forecasts of supply and demand for water in the River Basin District (*Step 1.3 and 3.3*).

Note that the *business as usual* scenario will only integrate what would happen in a given river basin district without the Water Framework Directive, due to changes in population, technologies, the implementation of water policies resulting from previous European directives, other sector policies, climate change, etc. During *Step 1.2* of the economic assessment, it will be important to focus on the forecasting of pressures and of key socio-economic drivers that are likely to affect those pressures. It is only during *Step 2* of the overall approach that these forecasts are translated into an assessment of their impact on water status.

2. Key Issues

Given the use of the baseline scenario, it is important to broaden the scope of the forecasting analysis suggested in Annex III in order to:

- Forecast not only investments but other key parameters and drivers influencing water supply and demand (or more generally all significant pressures), since a failure to do so would undermine the definition of the programme of measures;
- Not rely too much on a mere projection of past trends, as such forecasting method tends to produce misleading results: forecasts need to integrate predictable changes in

past trends based on a series of assumptions concerning these changes;

- Identify (and distinguish) variables that can be derived with a high degree of confidence and those that are uncertain. This distinction should be made for 'physical' parameters as well as for economic and policy-based drivers; and
- Build a series of alternative scenarios using alternative assumptions, particularly with respect to policy options. This will allow stressing the main (significant water management) issues in the river basin district, and discussing policy options by simulating their consistency and their long-term significance (e.g. it can be useful to compare two distinct scenarios, one where water prices and charges are kept stable and one where they increase: both assumptions are realistic, but stem from different policy options).

In order to build the baseline scenario, it will be necessary to forecast a set of variables before assessing the impact that these changes will have in terms of pressures and water status. It will be important to distinguish between three types of variables as presented in Table 1 below.

1. Trend variables: underlying (exogenous) trends, on which water policy has no direct influence;
2. Critical uncertainties: variables which are particularly difficult to predict, and might have a significant impact on the final result;
3. Water policy variables (see *Table 1* below): variables linked to the underlying water policies, independently from the implementation of the Water Framework Directive (as the focus is on building a "business as usual scenario")

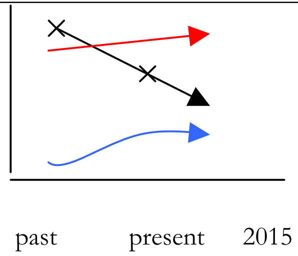
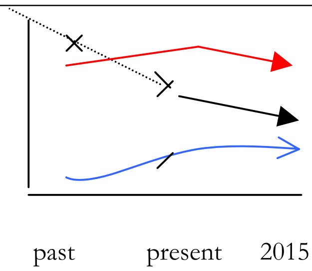
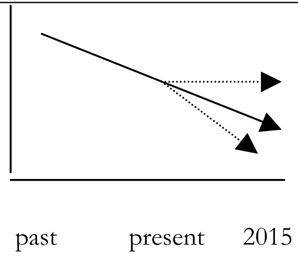
Table 1 – Categories of variables to be examined for the business as usual scenario

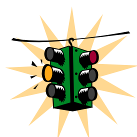
Categories of variables	**Examples**
Trend variables	• Changes in demographic factors, e.g. population growth in specific urban areas; • Economic growth and changes in economic activity composition, e.g. growth of the relative importance of services; • Changes in land planning, e.g. new areas dedicated to specific economic activities, land management in the catchment for reducing erosion.
Critical uncertainties	• Changes in social values and policy drivers (e.g. globalisation / regionalisation; policies relying on economics, technology vs. on values and lifestyles); • Changes in natural conditions, e.g. climate change; • Changes in non-water sector policies, e.g. changes in agricultural policy or industrial policy that will affect economic sectors.
Water policy variables	• Planned investments in the water sector, e.g. for developing water services or for restoring the natural environment/mitigating for damaging caused by given water uses; • Development of new technologies likely to impact on water use for industrial production and related pressures.

3. Practical Tasks for deriving the Baseline (*Business-as-Usual*) Scenario

The proposed approach for developing the Baseline Scenario is outlined in three tasks, as shown in *Box 1* of this information sheet. This box serves as a visual aid throughout the process outlined below.

Box 1 – Illustration of the General Method

Task	Output	Visual illustration
1. Assess current trends in *trend* variables, including physical parameters and socio-economic drivers	Short-term projections of trend variables based on existing trends	 *Variables are projected based on current trends over a short-term horizon*
2. Project certain changes in water policy variables	Longer-term projections of variables incorporating changes in current trends	 *Variables are projected over a longer-term horizon, incorporating certain changes in water policies*
3. Integrate changes in "critical uncertainties" and derive one or several realistic business-as-usual scenarios	Build several baseline or *Business-as-usual* scenarios	 *Alternative BAU scenarios are constructed, out of several combinations of assumptions on trend variables, water policy variables and critical uncertainties*



Look out! Developing the baseline is an iterative process

The first baseline scenarios developed for supporting the development of river basin management plans are likely to build on existing knowledge of trends in key variables and lack robustness and to incorporate many uncertainties. As the assessment of significant water management issues evolves, it will be possible to identify areas where further work is needed to improve the baseline scenarios. To enable revisions, it would be important to keep a log of:

- The overall reasoning process: assumptions, choices of variables, range of variation, priorities in analysis;
- Calculations made with respect to key variables, physical parameters and formulas (and ideally provide a schematic description of calculations);
- Databases used for calculations; and
- Perceived limitations in the analysis and suggested future work.

Task 1 - Assess current trends in "trend" variables (including physical parameters and socio-economic drivers)

The output of this task is a survey of past observations, historical data and a forecast of ongoing trends over a relatively short-term horizon. This work will be partly based on physical and ecological characterisation of the river basin and will build on technical and data handling/statistical expertise. The analysis of past evolution of water resources and physical parameters will mostly rely on technical expertise and on the analysis of trends in pressures, water uses, water services and impacts. The data to be gathered are summarised in Table 2 below.

The methodology for this task will be based on a comparison between the past and present status of *trend* variables in the river basin (including water uses, water services and physical parameters -as per Annex V of the Directive). This should enable:

- *Pointing to significant changes in the river basin district*: e.g. major degradations and improvements: what quality and quantity parameters have deteriorated or conversely improved, and what were the most apparent causes?
- *Gathering knowledge on the evolution of the human and technical context*: population and its location, economic activity components, equipment and water works;
- *Assessing the rate of policy implementation* and especially, the pace of water investments over the recent period;
- *Evaluating the likelihood of the above trends to be prolonged over the mid-term future*: are there good any reasons for assuming that the worsening /improving parameters will stop worsening / improving?
- *Compiling a first identification of the main pressures likely to cause a future gap* between the Directive's objectives and the possible future situations, and thus help identifying key driving forces and drivers linked to these pressures.

Table 2 - Data to be gathered in Task 1

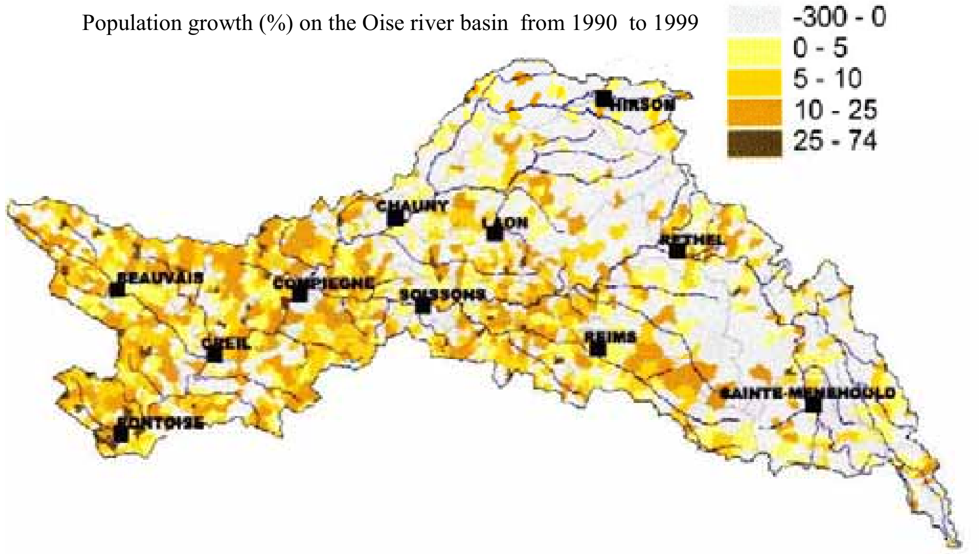
TASK 1	Key points	Output
Identify Trends in Physical parameters	Map evolution of: • Trends in water status over the past relevant period (e.g. evolution of pollution and ecological quality)	Overview of general trends in the hydrological system in the RBD.
Identify Trends in socio-economic drivers influencing water uses and, water services and impacts	Map evolution of: • Equipment (e.g. water distribution and sewage, rates of households and industries connected to public network) • Pricing (e.g. pricing policies, average prices) • Uses (e.g. hydropower, navigation, angling, etc.) and related impacts (e.g. power produced, transportation volumes, number of angling people, etc.)	Overview of general trends in water uses and services in the RBD.
Identify Trends in Water Policies and Regulations	• List past and existing national water policies • State the level of compliance with water-related environmental directives (e.g. habitats directive) and describe past investments and efforts • Describe trends in rates of a. Equipment in water distribution treatment and in sewage treatment capacities; b. Agri-environmental policies implementation; c. Industrial compliance.	Overview of general trends in the implementation of present water policies and regulations.

Illustration 1 - Oise river basin (France): case study of deriving a baseline scenario

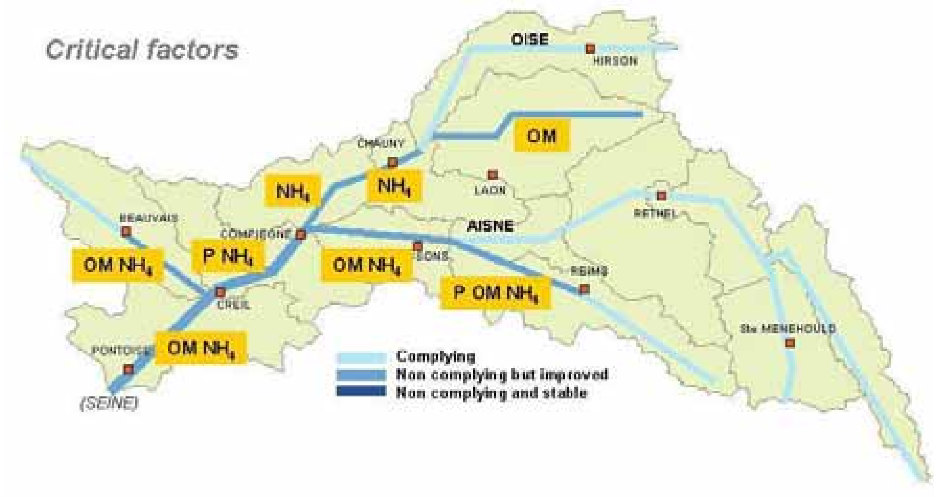
As part of the Seine River District in France, the Oise River Basin suffers from high diffuse pollution from agricultural runoff, high urban water intensity, dense industrial concentration on main and smaller rivers, and overall poor water quality in the main river and some of its smaller tributaries. By identifying past trends and the present state of water policy, surface water quality and pollution (including sewage equipment and discharges), a baseline scenario was formulated to provide insight to policy makers for addressing present and future water resources management. The following maps highlight some of the study's results:

Task 1 - Evaluation of major past trends
Evolution of polluting activities 1990-1999:
+2.7% population increase (+0.3%/year)
+11% industry production growth (+1.3%/year)

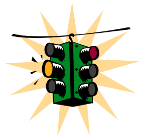
Population growth (%) on the Oise river basin from 1990 to 1999



Task 2 - Baseline projections
In a second phase, the effects of the development of future activities and planned policies and programmes (sewage works) in the Oise river basin were simulated and critical factors that limit compliance with good quality (chemical) status were identified. The baseline scenario highlighted major difficulties for achieving surface water quality objectives, including durable nitrate pollution involving groundwater and incompatibility between the "good" status definition and some natural processes (e.g., suspended matter standards versus erosion). While the baseline scenario has a useful purpose, there is an extreme uncertainty about the future level of economic activities in the region, particularly for industry and agriculture. The availability of data for this study was a great asset that allowed for scenario building, and the study provided useful results about the risk of non-compliance with the good status objectives of 2015, and allowed for a wider vision than recent planning preparation (up to 2006).



Source: Agence de l'Eau Seine-Normandie, 2002 (provisional assessment).



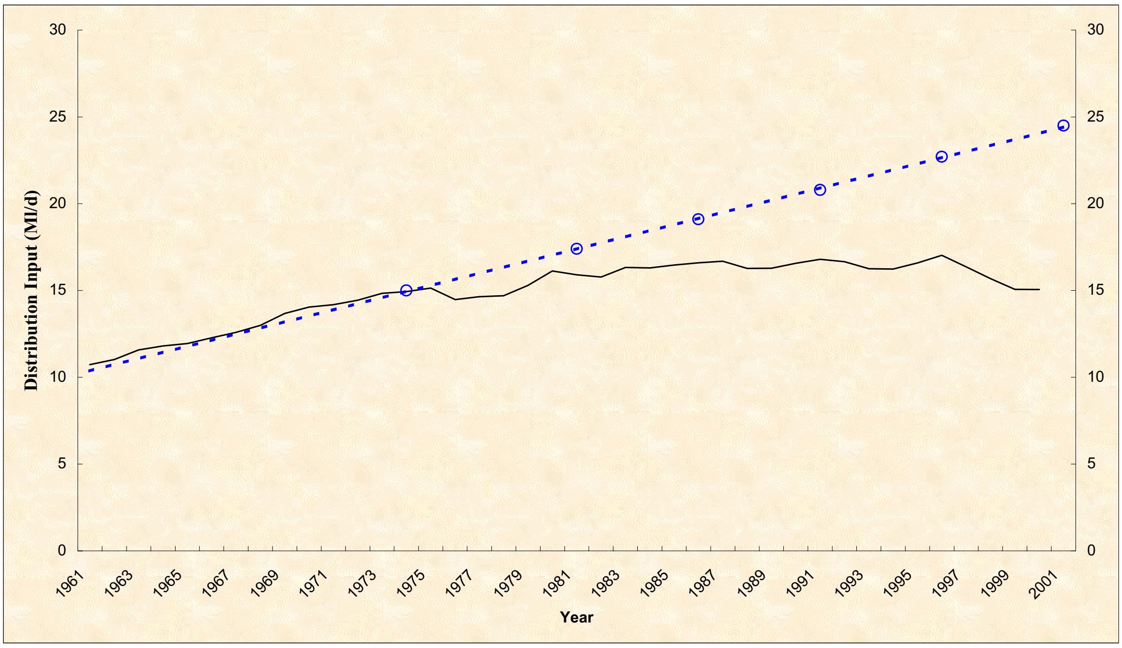
Look out! Do not rely too much on past projections and examine alternative scenarios, rather than an unique one

Reviews of existing past projections have shown that long-term projections in the water sector usually proved false when evaluated afterwards. Accordingly, it would be dangerous to suggest that an adequate image of the future can be the result of a mere projection of past trends. In addition, it will be important to avoid presenting one "image of the future" as a baseline scenario. A plurality of images, from a series of combination of variables, will be preferred.

Illustration 2 – Issues with trend extrapolation: "The past is not necessarily a good indicator of the future" (England and Wales)

In England and Wales, water demand rose steadily from 1960 to 1975. Applying an assumption that "the past is a good indicator of the future", it would have been logical to apply a simple linear relationship to demand from 1975 onwards. However, a simple non-causal relationship ignores the real drivers affecting water use. It is therefore not surprising that this extrapolation technique often fails, as it would have done in this hypothetical example (see Figure 1).

Figure 1 Water supply in England and Wales, 1961-2000



For short-term forecasting a more refined approach using a multiple linear regression form of extrapolation of trends might be suitable. This might be dependent on variables such as temperature and rainfall but it is likely to be more effective if applied to specific elements of water demand rather than *total* water demand. Indeed, the problem with overall trend forecasting is that it fails to analyse causal relationships and as a result, lacks transparency. Therefore, a more disaggregated approach to demand forecasting might be preferable (see *Illustration 3* of this information sheet).

Using simple trend projections might have benefits, as it is a low cost method and that it is quick and simple to derive a trend line. However such method has also many disadvantages, in the sense that it produces low quality forecasts and that it is reliant on good quality time series from which to derive statistical relationships. In sum, the past is not a reliable indicator of the future for anything other than possibly short-term forecasting.

Illustration 3 – A disaggregated approach to demand forecasting (England and Wales)

A preferred approach to trend projection and an important building block of any demand forecasting exercise requires adopting a disaggregated approach to demand forecasting, in order to identify the key drivers of demand and in particular, the key sectors having an impact on demand. This illustration draws on water demand forecasting activity undertaken to develop a water resources strategy for England and Wales. Its purpose is to demonstrate the level of detail necessary to reasonably apply assumptions about future water use brought about by changes to the key drivers of demand. The approach is valid for different sized areas although in small river basins there may be local issues relating to robustness of sample sizes and data availability.

The causalities of short-term changes in water demand are likely to be different to those affecting the longer-term. In the case of the former, it may be sufficient to examine recent history to establish how existing pressures are likely to translate into total water demand. Since water demand within a river basin will fluctuate over the longer-term (+5 years) as individual water uses grow and/or decline, it is logical to estimate how total water demand may change by examining the drivers of demand and the consequences for *each use*. Table 1 summarises the breakdown of total water demand used in the case study referred to above.

Table 1 Elements of water use by sector

Sector of demand	Component of demand	Micro-components of demand
4 no. sectors:		
• Household	8 no. components eg Toilet use, personal washing, clothes and dish washing, garden watering.	14 no. micro-components eg various WC, bath, shower, hand basin, washing machine, washing by hand, garden sprinkler.
• Industrial and commercial	18 no. components eg Chemicals, food & drink, textiles, retail, hotels.	Not applicable.
• Agricultural spray irrigation	23 no. crop types relating to three different soil types and seven agro-climatic zones.	Not applicable.
• Leakage	Reported and unreported leakage on trunk / distribution mains and on service connections to customers.	Not applicable.

A similar level of disaggregation to that described is recommended as good practice in order to introduce sufficient confidence into the supply-demand balance assessments that are key to establishing a baseline water use estimation.

The benefits of such detailed disaggregation include:
- Improved robustness of forecasts by reducing the uncertainty inherent in use of generic assumptions;
- Transparent forecasts of total water demand where the key sectors for growth / decline can be described explicitly – provides a clear platform on which to engage stakeholder debate;
- Application of specific assumptions can be restricted to just the relevant sectors;
- Facilitates development of sector-based scenarios of political, economic, social and environmental futures; Facilitates application of "*what if …?*" tests to forecasts, such as impacts of water management policies, technology etc.

The disadvantages of such disaggregation include:
- Availability and costs of obtaining econometric and water use data at such a detailed level;
- Cost effectiveness may be questionable for very short-term forecasting (year on year) particularly in regions where there are considerable surplus resources and robustness of forecast is less critical.

Source: UK Water Industry Research Ltd / Environment Agency (1997). For enquiries relating to demand forecasting email: rob.westcott@environment-agency.gov.uk

Summary of the key drivers of demand for each sector

Drivers / Sectors	Household demand	Leakage	Industrial and commercial demand	Spray irrigation demand
Economic drivers				
• Personal affluence	✓			✓
• Level of production/output		✓	✓	✓
• Level of employment				
Water policy drivers				
• Abstraction licensing		✓	✓	✓
• Water price	✓	✓	✓	✓
• Water Regulations/Regulatory framework	✓	✓		
• Metering	✓			
• Leakage targets				✓
• Levels of service		✓	✓	
• Water efficiency duty			✓	
Technology drivers				
• White goods	✓			
• Power showers	✓			
• Acoustic loggers		✓		
• Industrial reuse and recycling equipment			✓	
• Irrigation scheduling systems				✓
• Trickle irrigation				✓
Sector-specific drivers				
• Common Agricultural Policy (CAP)				✓
• Supermarket produce quality criteria				✓
• Organic production				✓
• Drought tolerant crop varieties				✓
• Personal water use preferences/behaviour, eg washing and garden watering	✓			
• Resource stress				
• Rate of uptake of water-use minimisation measures by industry and commerce			✓	

Task 2 – Project certain changes in water policy variables and derive longer-term projections

Based on the previous task, key driving forces and drivers related to water and water policy (be they hydrological, socio-economic or policy/regulatory related) should be identified and analysed. In this task, it is proposed to concentrate on changes that are more certain and for these certain changes:

- To make reasonable assumptions about the future dynamics of the analysed drivers;
- To assess the impact of changes in these drivers on pressures; and
- To estimate the resulting impacts and thus water status.

Above all, this task is intended to assess the outcomes that can be awaited from the implementation of other water and environmental Directives, and notably their results in terms of water pollution abatement investments, taking into account the future capacities that are effectively planned for the next years.

Task 1 will have given an estimation of the future increase in raw pollution from human activities (pressures analysis). This task will try to answer the following questions:

- What additional quantities of pollution will be abated in the future (e.g. following the construction of additional sewage treatment works)?
- What will be the effects of planned policies on water availability for the water services and uses (e.g. regulation policies, storage equipment policies…)?

This task is central to the Water Framework Directive process and thus has to be steered by the district authority at high decision-making level. A "strategic co-ordination group" will probably be needed to incorporate all expertise and interdisciplinary inputs in the process. Again, on these matters, it is recommended not to strive for describing one unique image of the future if not possible. When choices among different values are necessary for some variables (e.g. activities growth rates, technological changes, policy implementation rates…), a series of alternative baseline scenarios can be prepared. The table below summarises the approach in Task 2.

TASK 2	**Key Points**	**Output**
Make assumptions about the future dynamics of trend variables identified in Task 1	• Determine whether parameters have stabilised (e.g. household connections to public networks, tax levels); • Determine the supposed effect of proposed future policy measures on the water status (e.g. new investment programmes, new national regulations, already planned institutional changes and public equipment policies such as energy, transportation, etc.: what possible effect on water quality and availability?).	Assumptions on the future dynamics of trends
Make projections based on certain trends	• Derive the projected values of the different parameters for 2015; • Check the general consistency of the different trends, explain the apparent inconsistencies (e.g. how can we explain a forecast of growing investments along with a supposed decrease in river quality? Because of a rise in general pollution flows out from economic growth). Propose one or several combinations of assumptions on trends	Baseline or Business-as-usual projections of the RBD in 2015

Illustration 4 - A methodology for scenario building developed for the region of Sfax (Tunisia)

Relevant experiences of scenario-building used in the policy debate are few and far between, which is why it is interesting to introduce an approach developed in Tunisia, in the context of acute water pressures. While Tunisia may not be representative of European contexts at large, the approach taken was usefully applied despite the lack of means and data, and it proposed some simple tools to build scenarios, based on "re-using" the technical forecasts that generally exist in water planning institutions.

In Tunisia, the scenario-building exercise was conducted to feed the debate on strategies related to water demand management, as the approach still tends to focus on supply-side solutions without examining the links between water resource management, land use planning and economic development. For instance, irrigation demands are often considered as an input into the projections rather than something that can be acted upon independently.

As such, the scenario-building exercise followed a four-step process:

Step 1: Use technical planning forecasts as a foundation, and analyse the underlying assumptions in detail;
Step 2: Build scenarios using basic assumptions combined into contrasted scenarios, and make an explicit representation of the water uses/resource system to quantify the water balance with the assumptions;
Step 3: Choose a range of combinations for the assumptions (e.g., one combination is the backbone of one scenario), and then calculate the water balance over time that corresponds to the combination;
Step 4: Based on these elements, imagine a plot that tells the story of the system from now until 2030, giving consistency to the assumptions and water balance curves.

The region of Sfax's demographic projections demonstrates this four-step process.

For **Step 1**, three alternative choices were considered to forecast the region's demography:
- The first considered three possibilities of evolution for the agglomeration of Sfax's population;
- The second concerned two possibilities of evolution for the demography of other cities in the region;
- The third considered two possible evolutions of the rural population.

Data was technical and derived use per use. For every use, more or less simple trends analyses of past evolutions were used to derive projections of, for example, population, unitary domestic consumption, or irrigated area (see Fig.1). This simple framework was used as a basic representation of the water uses/water resources system.

Figure 1: Example of assumptions formulation on the demographic evolution of the Sfax region

	2000	2005	2010	2015	2020	2025	2030	
Population du Grand Sfax								
x 1000 hab								
- hypothèse de désaffection D1a	492,0	548,6	611,6	675,3	745,5	823,1	908,8	(+2,2% jusqu'à 2010, et +2% après)
- hypothèse de mise en valeur progressive D1b	492	543,2	599,7	678,6	767,7	868,6	982,8	(+2% jusqu'à 2010, puis +2,5% après)
- hypothèse de non migration D1c	492	556,7	629,8	712,6	806,2	912,1	1032,0	(+2,5% sur toute la période)
								Hypothèses du PAC de Sfax
Population Communale hors Grand Sfax								
Taux de croissance annuel de 1984 à 1994 : 10,65 %/an								Incertitude sur ces données indirectes
Taux de croissance annuel de 1994 à 2000 : 16,58 %/an								Incertitude sur ces données indirectes
- hypothèse de développement d'autres centres urbains D2a : +5%/an								
x 1000 hab	58,0	74,0	94,5	120,6	153,9	196,4	250,7	
- hypothèse de non développement des autres villes D2b: +4%/an jusqu'à 2010, +2% après								
x 1000 hab	58	70,6	85,9	94,8	104,7	115,5	127,6	
Population rurale du gouvernorat								
Taux de croissance annuel de 1984 à 1994 : 1,58 %/an								Incertitude sur ces données indirectes
Taux de croissance annuel de 1994 à 2000 : 2,06 %/an								Incertitude sur ces données indirectes
- hypothèse de maintien de l'activité rurale D3a : +2%/an	315,4	348,2	384,5	424,5	468,7	517,4	571,3	
- hypothèse d'exode rural D3b: +1%/an jusqu'à 2010, puis +0,5%/an après	315,4	331,5	348,4	357,2	366,2	375,5	384,9	

Step 2 requires a check on the global consistency of a combination of assumptions. In the Sfax region, the following critical queries were posed: (i) what are the underlying assumptions for each growth curve (population, leakages)? Is it an exponential, linear or logistic curve? What is the growth rate?; and (ii) What is the statute of the variable: is this a trend that can be extrapolated, a critical uncertainty (depending on external uncertainties) or is it a project variable (which is subject to decisions by stakeholders)? (iii) What is the anticipated water resources supply/demand balance and is the sum of water uses below the maximum available resources? Also, the political and social context of the scenarios must be considered in conjunction with the technical assumptions that form their foundation.

Step 3 requires combining basic assumptions to develop alternative scenarios by reducing a set of basic assumptions, explaining qualitatively the process of evolution and quantifying the assumptions on future evolutions. In Sfax, the alternatives developed were land use planning, spontaneous development, and the baseline scenario. To represent the scenarios, it was important that they were consistent in format with a structured list of assumptions to ensure transparency (for discussion with stakeholders); a quantitative evaluation of the resources/demand balance; a narrative illustrating the causal paths, major issues, and transitions that could occur; and, if possible, a geographic representation of the spatial distribution of resources and uses. It is important to stress that *transparency of the scenario construction*, methods and use of the data sources is *as important as the reliability of the data* underlying the assumptions.

The water resource/uses water balance, modeled in Step 2, combined with the set of assumptions for the land use planning scenario resulted in a situation where the forecasted solicitation of the deep aquifer from planned development became greater than the threshold for aquifer renewal. It was therefore necessary to imagine other ways to generate water supply, particularly concerning agricultural use of groundwater.

Step 4 requires imagining a plot and a narrative. The following was imagined for the land-use planning scenario:

"A very dynamic land use planning policy is being implemented. Local development stakeholders are negotiating subsidies and some autonomy from the state in a way that natural water resources limitation cannot be taken into account. Finally, the development model for which a lot of money has been invested is put into question because of excessive water use."

Then, this scenario was imagined for the spontaneous development scenario:

"*The city of Sfax continues growing without implementation of land use planning policies. Because of water scarcity and of the Euro Mediterranean free trade zone, agricultural employment in the region decreases drastically. Sfax must incorporate this new population and labour force, which accelerates water supply problems in the city. Thanks to its political weight, the city manages to have a bigger allocation from the national water resources network, but national solidarity and water resources sharing becomes a problematic national political issue."*

This last example shows why social and political elements must be added to the technical forms of the baseline scenario. While the techical plans indicate a growing and intensifying irrigation sector, the sector's future is in fact more uncertain. Both for regional and national policies, the impact of external factors on water scarcity are important to at least acknowledge, even if they are not quantifiable.

The scenario approach presented here is possible to implement without important efforts and even with little data. It exemplifies that the baseline scenario necessitated by the Water Framework Directive can be built as one particular combination of assumptions, for instance the one based on land use planning and other existing plans. The other possible combinations are also plausible and are necessary counter examples to the baseline scenario. It is therefore necessary to put into discussion the scenarios that are built, and to ensure that the construction method is transparent enough for any stakeholder to be able to participate in the discussion.

Source: Treyer, S. (2002, forthcoming).

Illustration 5 - Example output from a scenario building exercise in the Ribble (England)

The case study identified seven pressures on the water status of the Ribble basin, of which water industry discharges (STW), the presence of dangerous substances, agricultural and diffuse pollution and abstraction were found to be significant. The Table below illustrates how the outputs of a characterisation and risk assessment can be presented, drawing on experience in the Ribble river basin. Though the Ribble case study analysed pressures quantitatively and qualitatively, the results below are presented in a qualitative form: the arrows denote whether the pressures are likely to fall, rise or remain at current levels whilst H, M and L describe the likely magnitude of risk of failure to achieve a given water status (good, moderate or poor). The Table shows that there is a high risk of failing to achieve good status in 2015, 2021 and 2027 on account of STW discharges and diffuse pollution from agriculture and that abstraction could contribute significantly to the risks of failing to achieve good water status in 2027.

		Likely Development in Pressure			**Likelihood of limiting achievement of quality states in future plan periods**								
Ribble	Significant?	2000 to 2015	2015 to 2021	2021 to 2027	2015			2021			2027		
					G	M	B	G	M	B	G	M	B
Water Industry STW discharges	Yes	↓	→	→	H	M	L	H	M	L	H	M	L
Landfill	No	↓	↓	↓	L	L	L	L	L	L	L	L	L
Land drainage	No	→	↓	↓	M	L	L	L	L	L	L	L	L
Dangerous substances	Yes	→	→	→	L	L	L	M	M	L	M	M	L
Agricultural diffuse pollution	Yes	↑	↑	↑	H	H	L	H	H	L	H	H	L
Abstraction	Yes	→	→	↑	L	L	L	L	L	L	H	M	L
Overall (inc. synergies/cumulative effects)					H	H	L	H	H	L	H	H	L

G-Good, M-Moderate, B-Poor Status. H-High (75%), M-Medium (50%), L-Low (25%) risk of failure

Source: Integrated appraisal for river basin management plans. Environment Agency

Source: Integrated appraisal for river basin management plans. Environment Agency, Andrews et al(ii), extract: the Ribble case.

Task 3 - Integrate Changes in Uncertain Parameters (integration of critical uncertainties)

In this task, more uncertain changes that are likely to have significant impacts on the pressures and water status are integrated into the analysis for developing the final business-as-usual scenarios to be used for identifying the gap in water status.

At this stage, the possibility of uncertain events or "what-if scenarios" will therefore be integrated into the "business-as-usual" scenario with questions such as:

- What if the river basin district goes through a technology or water consumption shift?
- What if a series of severe droughts or flooding events occur during the next 10 years?
- What if agriculture common policy is radically changed? etc.

Of course, possibilities for such variations are infinite. However the first two tasks will have helped designating the key parameters on which uncertainty analysis is necessary (e.g. if diffuse pollution appear as a major issue in a district, analysis of uncertainty in that field is worthwhile, through the analysis of alternative agricultural policies for example). The Table below summarises the key issues that could be examined during that Task. Taking into account such changes will produce the Baseline scenarios for the district.

Task 3	Key points	Output
Identify changes to the parameters that are uncertain and could have significant impacts on the water policy	Pay special attention to: • Increase in magnitude and frequency of uncertain events (policy and technological shifts, meteorological events such as floods and droughts occurrence) • Possible reactions and feedbacks from the environment: acceleration of water quality improvement due to enhancing of auto-purification by the water environment; apparition of new quality parameters previously hidden (again recommended use of modelling) • Possible social changes having significant impacts on the water system: consumption habits (housing, land planning, …), institutional design of water policy • Possible economic changes having significant impacts on the water system: economic growth cycles, investment flows, employment, economic policy, taxing system, etc. • Associate and merge analyses of "demand" and of "supply" of water. Baseline scenarios are particularly necessary for preventing the dissociation of supply policies and demand-side management, "putting offer and demand in the same image".	Alternative baseline scenarios

Illustration 6 – The incorporation of critical uncertainties in the development of a Water Resources Strategy (England and Wales)

The only certainty surrounding long-term forecasts is that they are likely to be wrong! Any best estimate forecast contains uncertainties. One way of dealing with some of these uncertainties is to define scenarios, or story lines, within which the key drivers of demand evolve on a justified basis. The use of scenarios enables us to test not only "*what if…?*" scenarios but it also provides an indication of the sensitivity of components to particular assumptions.

The Agency's case study referred to above (see *Illustration 3* of this information sheet) used a demand-forecasting approach based on the projection of disaggregated demands. In order to assess the key uncertainties related to these forecasts, the possible impacts of different socio-economic and political pressures on the key drivers of demand were examined using the *Foresight* tool, developed by the UK Government to project alternative Environmental Futures scenarios over a period of several years. Note that the process used in developing this Foresight generic tool involved drawing on national and global future scenarios for the state of the environment as a whole (without focusing particularly on water), which were then developed and reviewed by business, government and academia. This produced a tool that others can use to explore possible futures.

Scenario development

In the study, four future scenarios for water use were developed for the period 2010 and 2025, which reflected different permutations of regionalisation versus globalisation and communitarian versus individualistic traits.

Key lessons

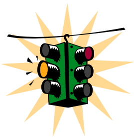
The areas of greatest residual uncertainty in this process were in relation to the pace at which policies might be applied and their relative success. Expert advice drawn from stakeholders in business, trade associations, economists, government and the water industry helped to minimise such concerns. Wherever possible these judgements were reinforced by practical examples and real experiences. One weakness that emerged from the use of scenarios, however, is if the forecast relies on unsubstantiated key judgements about demand changes.

The benefit of this approach is to acknowledge that the future cannot be reliably predicted, however, it is possible to identify the circumstances under which significant demand changes might realistically occur. As well as facilitating a means of testing combinations of assumptions and their relative effects / sensitivity, this method permits an examination of the robustness of management options to a range of demands. Also it facilitates debate on the potential acceptability of various options under certain socio-economic conditions.

Source: Environment Agency for England and Wales (August, 2001).

4. The role of public participation in scenario-building

The choice of assumptions made while developing a *business as usual* scenario will require discussions with the public and stakeholders, and input from economists and technical experts.



Look out! Participation in scenario building can take many forms

Participation in scenario building can take many forms. Most past experiences demonstrate that public participation should be placed as much "upstream" in the process as possible. At least 3 modes of participation are possible:

- *Participation by collective building of scenarios*: involve the public in the process in the choice of assumptions and their values;
- *Participation by checking coherence of the proposed scenarios*: check consistency of assumptions and of scenarios with the various visions that are shared or distributed among social groups;
- *Participation by asking the public to question the main "statements" in water policy*: scenarios illustrate and somehow caricaturise the most common policy statements, helping the public to input into decision-making and fostering transparency in the process.

The use of scenario building for public participation

One particular method of involving the public is to use scenario building (or foresight methodologies). This may usefully complement forecasting (i.e. the derivation of the business-as-usual scenarios) in order to structure policy discussion and public participation, and identifying key water management issues. Scenario building as an exercise is not so much carried out to produce one single image of the future, but it intends to foster the debate on present and immediate future policy options by exploring their possible future consequences. Prospective scenarios can provide colourful illustrations of the main issues for water management, give extended view of the ongoing policy debate on water (e.g. supply- or demand- management), illustrate the *pros* and *cons* of the possible solutions, reveal possible factors of change, and offer a possibility of a wide but formalised interdisciplinary discussion. Prospective scenario building is proved to be much less "data-demanding" than forecasting a baseline.

Optional additional task	Key points	Output
Combine various combinations of possible changes in parameters, using futures studies methodology	Design several contrasted scenarios in order to allow for uncertainties surrounding the key parameters Organise and give effective result of stakeholders and public participation	Exploratory scenarios

Methods and practical tasks in this field are very diverse, with respect to:

- The spatial scale: world perspective, river basin / regional scale, local scale.
- The time horizon: preferably long-term horizons (25 to 100 years);
- The type of "input variables": either in qualitative or quantitative terms;
- The type of output: contrasted "visions", possible statements on water status, qualitative and/or quantitative scenarios, …

The role of public participation in scenario building at river basin district level: A summary

Task	Role of public participation	
Task 1	System analysis and choice of determinant assumptions In-depth interviews with main stakeholders, experts and institutions of the district, aimed at: • Defining the key variables that determinate the water system in the district according to the interlocutors; • Proposing a hierarchy for these variables (more or less determinant); • Describing their range of variation	Overview of general trends in key variables – Short-term projections
Task 2	Scenario building based on task 1 inputs and participation from stakeholders, experts, representatives, scientists through working groups, thematic workshops, etc …	Baseline scenario without uncertainty
Task 3	Large-scale debate on the proposed scenarios: presentation at various policy levels, large communication, and collection of opinions from the public. The list of assumptions that underlie the scenarios should be delivered as clearly as possible to allow transparency and possibilities for criticism and reformulating, etc.	Alternative baseline scenarios incorporating uncertainty
Task 4 (optional)	Amendment of scenarios, and quantification refinement: based on previous tasks, derive and calculate the precise significance of scenarios for their systems and instruments: investment and subsidising system, pricing, technical actions, policy organisation, etc. Organisation of large scale publication and participative discussions.	Exploratory scenarios

Illustration 7 - The role of participation in four long-term thinking exercises in the field of water

	World Water Vision	**Globesight**	**WaterGAP**	**WEAP**
Approach	Participatory Vision Development based on reference scenarios	Human in the Loop Systems Dynamics Simulations	Simulation of Resources Dynamics	Policy analysis
Spatial scale	World, Region (river basin, socio-economic region, or territorial region), and Sector	River basin	World/region on a 0.5-0.5° scale, using river basins as smallest output entity. 4000 river basins in total.	Municipal, agricultural systems, single sub-basins or complex river systems. GIS based.
Time scale	Up to 2025	Calibrated on historical data. Time horizon flexible.	Up to 2100 (historical data is used for calibration)	Time horizon flexible.
Inputs	Demography Economy Technology Society Governance Environment Hydrology (through the use of quantitative models)	Demography Energy Economy Agriculture Hydrology	Land cover Climate Population Income Technology	policies costs demand factors pollution supply hydrology
Nature of inputs	Qualitative	Quantitative	Quantitative	Semi-quantitative
Output	Visions and scenarios, which have become independent. The overall synthesis is largely built on the preferences elaborated in the scenarios.	Water balance between water demand and water supply	Water availability Water Withdrawals Water stress indication	Water sufficiency costs and benefits Compatibility with environmental targets Sensitivity to key variables
Nature of output	Qualitative, with quantification	Quantitative	Quantitative	Quantitative
Socio-economic driving forces	Demography Technology Society Governance Economy Environment	Demography Energy Economy (GDP) Agriculture	Population Income Electricity Water Intensity Agricultural intensity Water use efficiency	Policies Costs Demand factors Pollution Supply
Scenario use	Value-laden reference scenarios being used to fuel debates and visioning exercises, as well as direct input to the final vision.	Different scenarios can be run, either through data changes or through different interventions by the human element.	Scenarios are used as input for the model. Water use scenarios (technological change and structural change) and climate scenarios are used.	What-if policy scenarios
Participation	Large scale consultations among stakeholders through contributions and feedback to intermediate versions of documents and through workshops. Decentralisation of the exercise in order to foster appropriation and legitimisation.	Cybernetical view of participation. Human beings are seen as submodel. The goal-seeking behaviour of algorithms is replaced by the goal-seeking behaviour of human 'models'.	Scientists-based model which does not include participation. However, WaterGAP can handle participation upstream (in defining socio-economic scenarios) and downstream.	Decision support system in which the (individual) user can assess different scenario possibilities. No citizen participation is included in the concept.

Source: Van der Helm, R. & Kroll, A (2002, forthcoming).

5. Summary

The development of baseline or *business-as-usual* scenarios require a range of economic and technical expertise to account for, and investigate, trends and evolutions of a wide range of hydrological, technical, socio-economic and regulatory parameters. Methods that need to be mobilised include:

- Statistical analysis of past data;
- Economic and environmental modelling, e.g. to asses the impact of changes in sectoral policy drivers on key pressures;
- Review of existing planning documents that develop scenarios for key socio-economic sectors; and
- Interaction with, or participation of, key stakeholders.

The development of the baseline scenarios investigates drivers and parameters at different scales:

- For parameters and drivers linked to **local changes**, input into the analysis of potential changes in these parameters and validation of key assumptions with stakeholders and the public is likely to enhance acceptance of results of the analysis and the selected baseline; and

- For **global changes** (e.g. climate change) and EU/national sector policies, interaction and feedback will be required between river basins and between countries to ensure coherent assumptions are made for foreseen changes in key drivers.

COST-EFFECTIVENESS ANALYSIS

Directive references: *Articles 4* & *5* and *Annex III*
3-Step Approach: *Step 3.2*
See other information sheets: *Baseline Scenario*, *Estimating Costs* and *Disproportionate Costs*

This information sheet will help you carrying out a Cost-effectiveness Analysis (CEA). The CEA is used for assessing the cost-effectiveness of potential measures for achieving the environmental objectives set out by the Directive and construct a cost-effective Programme of Measures.

1. Objective

Cost-effectiveness analysis (CEA) is an appraisal technique that provides a ranking of alternative measures on the basis of their costs and effectiveness, where the most cost-effective has the highest ranking. The CEA proposed here takes an *economic* view of cost-effectiveness (see *Estimating Costs* Information Sheet for a definition of the term).

The CEA is used for assessing the cost-effectiveness of potential measures for achieving the environmental objectives set out in the Directive, and in particular for:

- Making judgements about the most cost effective **programme of measures** which could be implemented in order to bridge a potential gap in water status between the baseline scenario and the Directive's objectives (*Annex III*) (see also *Baseline Scenario* Information Sheet); and

- Assessing the cost-effectiveness of **alternative measures** in order to estimate whether those programmes of measures are disproportionately costly or expensive (*Article 4*) (see also *Disproportionate Costs* Information Sheet).

The focus of this information sheet is on the first component of this analysis. The sheet outlines issues relevant to estimating the effectiveness, costs and economic impacts of water improvement measures as well as the key tasks of the CEA.

2. What are the Key Issues?

Key issues to look out for when conducting the cost-effectiveness analysis include:

- Provide value added information to aid decision-makers;
- Be practical and proportionate, allowing for the costs of carrying out the analysis and the availability of data and the importance of the effects and costs in question;
- Cover fully the costs and economic impacts of measures for the different sectors, whilst avoiding double counting;
- Be applicable to a wide range of measures in a RBMP (see *Box 1* of this information sheet), including specific control and abatement measures for both water quality and water resources (e.g. abstractions);
- Be able to cover measures that incur costs and achieve effectiveness in different periods;
- Be readily applicable in practice and capable of generating summary cost estimates in and across basins, sectors and measures in order to aid decision-making on measures that could be taken at national level and subsequently included in the RBMPs.

Box 1 - Possible measures for implementing the Water Framework Directive

Possible Measure/sector	**Decision-making body**	**Level of decision**	**Level of Implementation**
1. Requirements for water industry to implement measures to reduce abstraction	National Relevant Ministry	National	River Basin District
2. Controls on other Direct dischargers	Environment Agency National ministries re control measures for other sectors	RBMP & also In line with National/Agency policy on sector	River Basin District
3. Controls on other abstractors	Environment Agency	RBMP	River Basin District
4 Best practice controls on pollution and abstraction at farms	Agency in charge of environment (but, in a clear national policy context)	RBMP & also In line with National/Agency policy on sector	River Basin District
5. Controls on other indirect dischargers (e.g. run off from traffic on roads)	National Ministry	Highways Agency, Local Authorities	Highways Agency, Local Authorities/basins
6. Agri-Environment programmes (financial and technical assistance and advice to go beyond good practice)	National agriculture + finance ministries in response to Ministry submissions	National	Regional/basins
7. Economic instruments	National agriculture + finance ministries In response to Ministry submissions	National	National taxes (but pollution charges and tradable permits are local)
8. Morphological measures	River Basin Agency	RBMP	River Basin District

3. What are the Practical Tasks?

The key components of the CEA are the costs and effects on water of the measures. These and other tasks are outlined below. At times, this will save you doing the job twice, since most of the cost analysis for the cost and benefit assessment will have already been performed for the cost-effectiveness analysis. Some other key points to consider throughout the process include:

- The cost-effectiveness analysis should be used to refine the programme of measures by focusing on the largest cost components and the major determinants of the effectiveness of measures. The analysis should then be used to develop packages of the most cost-effective measures for achieving alternative water status;
- Some measures have differing uncertainties concerning their effectiveness and costs. To allow for this, it would be desirable to use ranges of costs instead of point estimates;
- It is costly to undertake a CEA. Therefore, the focus of the analysis should be on the limited number of water bodies requiring actions to achieve good status. Consider only those measures that are likely to be worthwhile for achieving this aim.

The analysis of cost-effectiveness can be broken down in five basic tasks and one optional (see *Figure 1* of this information sheet).

Figure 1 – Tasks and Key Questions in Analysing and Reporting on Cost-Recovery

Key Tasks	…And Questions
1. Define Scale of the Analysis	Where are the most significant pressures causing the failures located? At which scale do the measures under consideration for addressing the gap have an impact?
2. Define Time Horizons	What measures can be implemented in the first RBMP (2009-2015) period? If the objectives cannot be met by 2015, which measures can be implemented in later periods? What are the major cost elements that could be reduced by an extended deadline?
3. Determine the Effects of Measures on Water	What is the technical feasibility and applicability of specific control measures? How should the effectiveness of measures be assessed and on the basis of which parameters? How do the measures affect the risk of an incident taking place?
4. Estimate the Costs of Proposed Measures	What are the direct costs of measures and environmental costs (or benefits) non linked to water? How are these costs allocated between different sectors and who pay for the measures? Are any of these costs likely to be disproportionate for a particular group?
5. Assess Cost Effectiveness	What is the cost-effectiveness of each measure? How can the most cost-effective programme of measure be constructed? How can alternative programmes of measures to meet an objective be compared?
6. Optional – Assess wider economic impacts	What is the overall cost impact of the programme of measures particularly on the Exchequer costs? What are the wider economic impacts of the cost-effective programme of measures?

Task 1 - Define the Scale of the Analysis

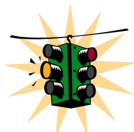
Sub-task	Key points	Look out! 
Define the spatial scale	• Define the spatial scale according to the level identified by the IMPRESS Working Group for the location of the significant pressures that cause the failures (see *Illustration 1* of this information sheet). • Extend the scope of the cost-effectiveness analysis depending on the scope of the environmental and economic impacts of the main measures under consideration.	Data can be aggregated to identify key environmental and sectoral problems and appraise the cost-effectiveness of measures at RBD level.

Illustration 1 – Determination of scale based on information in Cidacos (Spain)

The analysis of pressures in the Cidacos river has played three roles for the cost-effectiveness analysis:

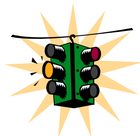
1. To define water bodies for the analysis on the basis of homogeneity of pressures/human activities;
2. To design programmes of measures that help to reduce key pressures;
3. To understand factors behind existing pressures and their likely evolution in order to make projections about the likely status of water quality in 2009 and 2015.

In Cidacos, information about emissions exists (for point pollution) or in some cases it is possible to rely on estimates (for diffuse pollution). For example, estimates of leachate of nutrients from farms are based on estimates empirically tested elsewhere (elaborated by the National Plan of Irrigation) applied to the existing information for Cidacos. This depends on the types of soil, types of crops and productivity, irrigated areas, use of water and monthly distribution, irrigation techniques and efficiency of irrigation systems. This information exists in the Cidacos river ordered by irrigation co-operative and by total number of hectares.

The identification of the water bodies for the analysis was done on the basis of types of pressures and in such a way that it would be possible to monitor improvements of water status resulting from the programme of measures. Control stations helped defining the limits of the water bodies used for the Cidacos study.

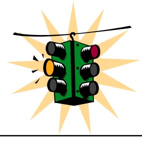
Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. See ***Annex E.***

Task 2 - Define Time Horizons

Sub-task	**Key points**	**Look out!** 
Identify the relevant time periods for the analysis	• Focus, firstly, on measures to be implemented in the first RBMP period 2009 – 2015; • Look at later RBMP periods (2015 – 2021 and 2021 – 2027) if the measures cannot achieve cost-effectively good status by 2015; • Look at later RBMP periods if there are uncertainties about the costs and effectiveness of the measures applicable in the first RBMP and scope for increasing effectiveness and reducing costs. • Identify the major cost elements that could be reduced by an extended deadline and an actual start in developing and applying more efficient control measures (started in the period 2009 - 2015 although the measures would come into effect in a later period). This will require a clear signal to the sectors concerned so as to prompt such an actual start to the development and application of more efficient control measures. In addition, it is necessary to examine scope for this increasing the effectiveness of measures (especially in respect of development and application of technological changes).	Distinguish between: • Long run ongoing costs in 2027. (opportunity costs of the resources used for achieving good status instead of alternative uses); • Short run dislocation costs and economic impacts of measures to achieve good water status by 2015 and 2021.

Task 3 - Determine the Effects of Measures on Water

CEA requires comparable and if possible, quantitative information on the effects of measures.

Sub-tasks	**Key points**	**Look out!** 
Assess technical feasibility and applicability of specific control measures for each RBD	Base the analysis on: • Analysis of the current and future pressures on water in the basin, which should characterise these pressures into main segments of the key sectors that cause most of the problems to identify and develop measures effectively targeted at them; • Views of stakeholders involved in the practical implementation of the measures to address the specific pressures (e.g. water industry, non-water industry, agriculture). • Studies and reviews of available technologies (e.g. BREF notes, BAT reviews) and prospects for the development and application of technical changes.	
Assess effectiveness (see Illustration 2 for an example).	• Clarify how (risks of) failure to achieve the good status target will be defined and interpreted in practice; • Effectiveness needs to be assessed in terms of reductions in the risks of pollution incidents arising (e.g. slurry run off, leaks) as well as reductions in continuous discharges and abstractions; • How to assess the likely effects on discharges and abstractions and correspondingly the effects on biological water quality of specific measures, especially where measures focus on achieving behavioural and more qualitative changes (e.g. changes in farm practices); • How to assess and allow for any time lags before a measure could become fully effective? Would this extend over a number of planning periods? The problem of time lags may be addressed by setting interim targets and periodic reviews of their achievement; • How to allow for the complex synergistic effects of policy measures that may have a nation or region-wide scope and serve multiple objectives or have multiple effects. • Prospects for the development and application of technical changes that could increase the effectiveness of measures for achieving good quality if such changes were embarked upon over an extended deadline.	Multi Criteria Analysis based on scientific advice may serve to combines these various effects into a weighted composite index so that the relative effectiveness of the measure can be assessed on a consistent basis. Consider how long before a measure can be • in place and operational; • fully effective; • will impact on the water body so that it recovers to a higher status

Key issues to address include:

- ➢ How to choose and combine criteria for determining the relevant effects? Effects on water are diverse (e.g. effects on emissions of dangerous substances; water flows; water pollution levels, biological quality of the water body; and groundwater etc); and
- ➢ Should failing one criteria mean failing to meet the objective (fail one fail all) or should the fact that different measures may have different effects on different metrics be taken into account?

To make it easier, it would be important to identify the effect of the measures on each parameter as clearly as possible (see *Illustration 3* of this information sheet).

Illustration 2 (below) demonstrates how the effectiveness of measures was assessed for the Ribble basin.

Illustration 2 – Assessing the effectiveness of measures in the Ribble (UK)

This example illustrates how effectiveness of measures was assessed in the Ribble basin. It is assumed that an aggregate 50 percent reduction in nutrient levels would be needed to achieve the necessary reduction in the risks of not achieving good water status. However, it should be noted that, depending on the outcome of other research on the appropriate compliance assessment model, different formats for presenting risk reduction information might be more appropriate. In addition, precise estimates of the risk reduction may not be the most appropriate format for presentation. Broader categories of risk reduction (High-Medium-Low, or ranges) may be better. However, in order to make the analysis tractable, point estimates are used here.

The table presents estimates of the effectiveness of number of measures for the River Ribble. For example, STW optimisation may be judged to deliver a 20% risk reduction (+/- 5%, i.e. 15% to 25%). The measure can become operational immediately (i.e. no specific time lag). This might be contrasted to the agricultural general binding rule measure, which might deliver the risk reduction, but entails considerable uncertainty about its effectiveness and would require a significant lead time. Full effectiveness of this measure would not be expected until the 2021 planning date. In addition, this measure is not currently available, as it would need to be negotiated at a national level.

Aggregate risk reduction required			Risk reduction delivered			Feasibility	Expected km delivered in 2015		
2021	2027	Measures	2015	2021	2027	Uncertainty range	2015	2021	2027
Elevated Nutrient Levels									
50%	50%	STW Management optimisation	20%	20%	20%	5%	5	5	5
		STW Opex scheme	50%	50%	50%	10%	14	14	14
		STW Capex scheme	50%	50%	50%	10%	14	14	14
		Agri surveillance/enforcement	2%	2%	2%	1%	1	1	1
		Agri General binding rule	10%	50%	70%	25%	3	14	19
		Agri Nutrient surplus charge	15%	30%	50%	25%	4	8	14
Land drainage									
0%	0%	Risk acceptable, do nothing	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Dangerous substances									
25%	25%	Monitor + R&D	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Abstraction									
0%	50%	Monitor + R&D	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: J. Fisher. Integrated appraisal for river basin management plans. See Annex E.

Illustration 3 – Issues in conducting the cost-effectiveness analysis in Cidacos (Spain)

In Cidacos, information for determining water quality status was drawn from the control stations in the river that measure a number of quality parameters and other stations that measure quantity of water, pluviometry and estimate runoff. There are also two stations that monitor biological indexes along the river all year long, allowing for the identification of the current status of key parameters in winter and in summer.

Selecting quality parameters
From an initial assessment, a few key parameters were selected for the Cost Effectiveness Analysis, including water quality and hydromorphological parameters that need to improve to achieve the objectives (as defined in the existing quality plan).

The criteria for selecting those parameters were the following:

- Those parameters where there is a gap or which are closer to thresholds;
- Those parameters that may be sensitive to further expected pressures;
- Those parameters that may be sensitive to the introduction of measures aimed at improving other parameters.

The hydromorphological parameters chosen were: water flow, and improvements of river borders and river vegetation. Others such as the existence of barriers, bridges, etc., were not considered for the purpose of this study since it was difficult to assess the effectiveness of the measures when the inter-relations between physico-chemical and hydromorphological parameters with the biological parameters have not been characterized.

Examining the effects of measures on combined sets of parameters
From the study, it became clear that it is important to identify and characterize the inter-relations between the different “selected” parameters in order to assess with some accuracy the effectiveness of measures. Some simple examples are: an improvement of water flow affects dilution of pollutants and hence has a positive effect on physico-chemical parameters. However the objective of water flow is not affected by the water quality parameters. By contrast, water flow would be negatively affected by the improvements of river border vegetation (that demands water). It is important also because it helps identify those parameters (often those with key synergies) on which it could be most effective to intervene.

Analysing the effectiveness of measures
The analysis of the effectiveness of the measures for the Cidacos river were based on:

- Empirical information on the impact of measures on pollution emissions;
- Empirical information about the water saving potential of measures and how this translates into increased water flow;
- Expert judgement about how these will lead to an improvement in the specific parameters.

The effectiveness of the measures was estimated on the basis of actual data for the Cidacos River. For example, the estimation of the effectiveness of measures aimed at improving water flow (such as improvement of irrigation, canals, substitution of pipes, or changes to low pressure water distribution systems) varies according to water use and density of irrigation networks. This information applied to the real data on the Cidacos (on density and number of hectares with different water applications) leading to estimates of ***total maximum water saving potential for each individual measure***.

In the case of agriculture, 27 measures were analysed in terms of their maximum potential for water savings or reduction of Nitrites, Nitrates, and BOD5. These have been expressed in absolute numbers or expressed either as a percentage reduction of pollution or percentage increases in water savings in relation to the base line indicators. The main problem was how to measure the improvement of water quality resulting from a certain reduction in pollution. Another problem was to identify how much each user contributes to the water status of the river.

This information used in relation to agriculture had been collected to prepare the National Irrigation Plan. The available information for urban areas came from empirical evidence of demand management programmes, management of urban water, inspection reports to companies and commercial water uses and the reports on measurements on pollution from wastewater treatment plant outlets.

Source: Ministerio de Medio Ambiente, Gobierno de Navarra, ‘Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River’. *See Annex E.*

Task 4 - Estimate the Costs of Proposed Measures

Analysing the costs and economic impacts consistently for distinctly different sectors is a major challenge. All costs should be measured in comparison with the business as usual situation that would arise in the absence of the option. Also, who pays for measures that have significant effects on particular parties (e.g. water customers in respect of water bills) and the scale of any such payments should be identified. Therefore the allocation of costs of the proposed measures is a key element of the analysis.

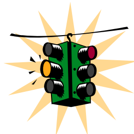
Sub-tasks	**Key points**	**Look out!** 
Determine costs of measures	• Estimate costs of measures (including direct costs, financial and administrative) and environmental costs not linked to water (see below). *Illustration 5* and *Annex I* of this information sheet give an example of such costs from the Ribble basin; • Examine how to review and validate the cost estimates (and note that costs are dynamic – they change as a result of developments in sectors); • The links between costs and the business-as-usual case need to be considered as implementation of current legislation will affect additional measures needed and also change the prevailing prices and incentives structures for agriculture; • Allocate the costs of measures to water users (see *Illustration 4* of this information sheet), and identify winners and losers, in order to potentially feed into the analysis of disproportionate costs to justify derogation – This would also determine the institutional viability of proposed measures.	Formats should be developed for different types of sectors and measures. These need to build on the existing costing conventions currently used in each sector (see *Annex I* of this information sheet).
Determine costs of other policy measures	• Estimate the costs of control measures such as economic instruments, water pricing measures, cost recovery charging levels and technical and financial assistance measures (e.g. agri-environment measures, waste minimisation programmes) to encourage behavioural changes (e.g. changes in farm practices).	
Estimate non-water environmental impacts from the control measures	• Focus only on the external elements and determine the scale and significance of such external impacts (materiality) as any direct costs of measures are included in the financial costs, e.g. impacts on natural habitats of particular measures; environmental impacts from combustion and extraction of the energy and raw materials used in some control measures, nuisance from sewage treatment works and impacts from transport of sewage sludge.	The CEA does not value the water related benefits of measures. Benefits are included in the appraisal of derogations, see *Disproportionate Costs* Information Sheet.

Illustration 4 – Allocating costs of measures to water users in Cidacos (Spain)

In the Cidacos case study, the most cost-effective measures require many actions in the irrigation communities located upstream of the river and no action in those located downstream. The cost reduction gains that result from this approach far outweigh other more symmetric alternatives. However, the drawback is that measures must be funded and the target farmers' cannot finance the programmes of measures by themselves. Therefore, they must rely on other farmers' contributions, especially those whose irrigation districts will not be modernised or rehabilitated**.**

The consideration of institutional issues means that the costs and benefits for the six irrigation communities of the Cidacos River would have the following effects:

Stretch Irrigation community	Net margins variation (in % with respect to the present situation)
Stretch I	
▪ **CR Barasoain**	27.4
▪ **CR Pueyo**	11.5
Stretch II	
▪ **CR Olite**	-18.8
▪ **CR Tafalla**	-12.4

The numbers in the Table gives an idea of the winners and losers from the proposed programme of measures, which may stir conflicts amongst usually quite united stakeholders. Thus, measures will need to be taken to enhance the persuasiveness to gain the support for a cost- effective set of measures. While in the Cidacos project, it is assumed that all irrigators will be charged equal water rates, the net margins variation found in the study might support the option to implement differential rate schemes.

Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. See Annex E.

Task 5 – Assess Cost-effectiveness

The unit-cost effectiveness estimates from above analyses should form the main element of the appraisal of costs of measures. Cost-effectiveness can be presented in two ways: (i) costs divided by the effect, or (ii) effect divided by costs. For the selection of measures in the framework of the Directive, the former is used:

Costs per effect:

KEm = Km/BEm

KEm - cost-effectiveness of measure m (Euro/m3)
Km - economic costs of measure m (Euro)
BEm - the water quality improvement (= the effect) of the measure (say in km or m3 of improved water body)

The cost-effectiveness analysis itself can be broken down into a number of tasks:

- Analyse the costs of individual measures;
- Produce ranking of measures based on their cost-effectiveness (see *Illustration 5* of this information sheet);
- Produce proposed programme of measures to achieve given objective; and
- Rank alternative programme of measures to achieve a given objective based on their overall effectiveness.

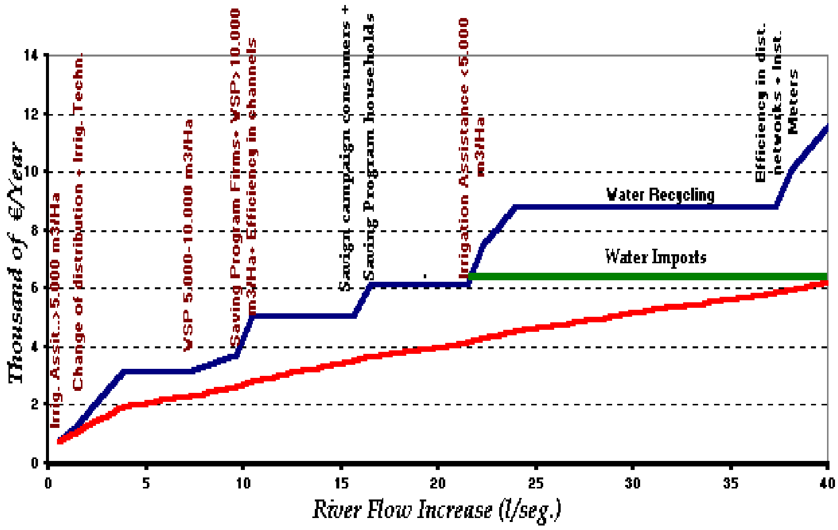
A summary of the cost-effectiveness analysis in the Ribble is given in *Illustration 6* of this information sheet.

Illustration 5 – Ranking measures based on their cost-effectiveness

Different measures can be implemented to achieve an improvement in the water status for a specific parameter. In order to select an appropriate set of measures, these can be ranked according to technical efficiency (ability to obtain an X reduction of pollutants or increase in river flow) and associated costs.

In the Cidacos scoping study, a total of 26 policy measures for improving the water flow were identified initially. These measures involved reducing pressures on water abstraction by reducing the water demand, increasing the efficiency of the water distribution networks in urban and the rural areas, and importing water from another basin through existing infrastructure, and each of them was appraised according to effectiveness and cost. As shown in the diagram below, the cost and efficiency of each measure can be represented by marginal cost curves (see blue and green curves), indicating the cost in euro per unit of achieved flow increase (litre per second) and so provide a ranking. (The red curve shows the average cost of the resulting policy package.)

In the Cidacos river, an increase in the water flow of 50 litres per second is required to meet the objectives of the Directive. Following the ranking of measures (as shown in the diagram), it was shown that the most effective measure (i.e. the measure that could achieve the greatest increase in water flow at the lowest cost) was the implementation of a water saving programmes (WSP) in the agricultural sector (achieving 20% of the requirement, or 10 litres per second), mainly by reducing the demand and changing irrigation techniques for farms using more than 6.000 m3 per Ha, followed by WSP designed to reduce the demand in households and firms (urban uses), which achieved another 15 percent (or 7.5 litres per second) of the required flow increase.



However, note that the cost effectiveness (and ranking) of a measure is not always constant. For some measures, the marginal cost increases with the level of efficiency (see water recycling, blue curve). It is therefore important to carefully look into the behaviour of costs: assuming that costs are constant may lead to an inefficient selection of measures.

Illustration 6 – Estimating the cost-effectiveness of proposed measures in the Ribble (UK)

This illustration demonstrates how costs of measures were reported and used to calculate the cost-effectiveness of measures in the Ribble river basin.

Annex I (to this information sheet) illustrates a worked example of proformas for recording and presenting the ranges of costs of individual measures. The example used is that of the Ribble STW Capex scheme. Capital and operating costs were recorded separately. In capital costs, a distinction is made between the costs of the pollution control equipment and installation. In operating costs, a distinction was made between changes in operating costs and changes in revenues or receivables. These were then used with information on the economic life of the investment (30 years in this example) and the discount rate (6%) to estimate the present value of costs and the equivalent annual value of costs. Recorded costs were reported in a common unit – Annual Equivalent Cost (AEC).

The reported (financial) costs (see Annex I to this information sheet) were used together with the appraisal of the other impacts and the assessment of the effectiveness of the option to calculate cost-effectiveness. Table 1 below presents an illustrative assessment of the costs and effectiveness of options for the Ribble. Cost-effectiveness is measured here in terms of the annual equivalent costs of the measures divided by the km of river delivered to good status. This is a fairly simplistic statistic, which may not be appropriate in all circumstances. It is of great importance that the calculated CE variable should show explicitly the uncertainties, regarding both the costs as well as the effectiveness of some measures. This can only be resolved through the judicious use of ranges of cost and CE calculations.

The key points in Table 1 are highlighted in bold. This shows that Sewage Treatment Works (STW) optimisation is most cost-effective (EAV= Euros1,852/km/yr) but is insufficient alone to achieve the target status. It would achieve 20% of the required 50% risk reduction.

For 2015, the STW Capex scheme is the next most cost-effective measure, followed by the General Binding Rule (GBR) with agriculture and the STW opex scheme. The GBR measure, however, is more cost-effective in the long run because of the long time-to-effect lag due to the lags in implementation of the measure and the slow environmental response to this measure.

Once the cost effectiveness is assessed, strategies involving packages of options can be defined on the basis of meeting the different targets at different points in time. If the objective is G2015, the best strategy would be STW optimisation, GBR + opex scheme; then monitor to see how effective the GBR is and turn off the op ex scheme, if/once the full effect is felt. This flexibility would not be possible if the initially cheaper Capex solution was chosen. If target is moderate status in 2015, followed by achieving good status in 2021, however, the op ex scheme would not be necessary and this would reduce significantly the costs.

Source: J. Fisher, 'Integrated appraisal for river basin management plans'. See Annex E.

Illustration 6 (continued): Table 1 - Illustrative results for the option appraisal (costs and cost effectiveness) – Ribble

Aggregate risk reduction required				Risk reduction delivered			Feasibility	Expected km delivered in 2015			Cost (Euros)	Cost per km delivered (Euros)			
2015	2021	2027	Measures	2015	2021	2027	Uncertainty range	2015	2021	2027	EAV of future costs	2015	2021	2027	Other relevant (measures specific) ancillary impacts
Elevated Nutrient Levels															
50%	**50%**	**50%**	**STW Management optimisation**	**20%**	**20%**	**20%**	**5%**	5	5	5	10,000	**1,852**	1,852	1,852	Impacts on water prices; Environmental impacts of energy consumed at STW
			STW Opex scheme	50%	50%	50%	10%	14	14	14	300,000	22,222	22,222	22,222	
			STW Capex scheme	50%	50%	50%	10%	14	14	14	200,000	**14,815**	**14,815**	**14,815**	
			Agri: tight specific surveillance/enforcement	2%	2%	2%	1%	0.6	0.6	0.6	100,000	185,185	185,185	185,185	Economic impacts on agriculture; Wildlife + natural habitat + soil protection benefits of buffer strips
			Agri General binding rule	**10%**	**50%**	**70%**	**25%**	3	14	19	60,000	22,222	**4,444**	**3,175**	
			Agri Nutrient surplus charge	15%	30%	50%	25%	4	8	14	250,000	61,728	30,864	18,519	
Land drainage															
0%	0%	0%	Risk acceptable, do nothing	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Dangerous substances															
0%	25%	25%	Monitor + R&D	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Abstraction															
0%	0%	50%	Monitor + R&D	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	

A key element will be to take into account uncertainty in all elements of the analysis, as it can significantly affect the results (see *Illustration 7*).

Illustration 7 - Addressing uncertainty in cost-effectiveness analysis: an example from the Scheldt estuary

A cost-effective analysis of the Scheldt estuary's morphological measures involved three different types of uncertainty: The effectiveness of the measures; the costs of the measures; and the assumptions made in the baseline scenario.

To address the first uncertainty, experts were asked to estimate the probability of measures reaching their ecological objective. If the probability was below 100%, additional measures were defined until the ecological objectives were reached. This means to address the measures' effectiveness within the CEA was then formulated by summing the probability of reaching the ecological objective times the costs of the additional measures to reach the objective.

The cost of the measures was accounted for by including ranges of costs instead of point estimates. The uncertainty surrounding the loss of added value through reduced navigation in the Scheldt estuary was considered especially large, and for the calculation of these costs large assumptions were made. This uncertainty was expressed in the CEA by including the probability of the actual costs being lower, and using expected cost figures instead of point estimates in the analysis.

To address the uncertainty surrounding assumptions made in the baseline scenario, experts were asked to judge the probability that the assumptions were correct. This involved asking experts whether they thought the baseline would succeed in maintaining the natural dynamics of the estuary. Experts judged the probability of this being true as 80%, leaving a 20% change that additional measures would be required. As this finding revealed major savings for the first alternative and major costs for the second, including the uncertainty of assumptions in the baseline scenario made quite a difference.

In average annual costs (million EUR/YR)	Option 1 De-poldering	Option 2 No further deepening
Uncertainty not included	7.3	38
Most extreme, with uncertainty	11	- 45.4
Expected outcome, with uncertainty	8.4	11.9

By including uncertainty into the expected costs of measures in the cost-effectiveness analysis, the outcome of the assessment changed considerably. Besides, it made the range of costs explicit, a range that turned out to be much larger for the one option then it was for the other. As this is important information for decision makers, uncertainty should always be included when performing a cost-effectiveness analysis.

Task 6 (Optional) – Estimate the Economic Impact of Measures

In addition to this process, it may be useful to estimate the economic impact of the proposed measures, although this would go strictly outside of the cost-effectiveness exercise. In addition to direct costs, such an analysis would account for induced costs (i.e. the costs on other economic sectors) and the environmental costs not linked to water (see *Illustration 8* for an example).

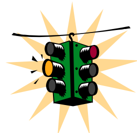
Sub-tasks	**Key points**	**Look out!** 
Estimate the exchequer (net) costs	The net impacts on public expenditures and revenues may be important because of the impacts on the economy of a change in net exchequer costs. This primarily includes the impacts of expenditures for agri-environment schemes and net impacts on revenues of economic instruments and, in countries with publicly owned water services, the impacts of changes in the prices charged for water services.	Includes primarily the impacts on expenditures for agri-environment schemes, revenues of economic instruments and impacts of changes in the prices charged for publicly owned water services.
Estimating wider economic and social impacts	• Include, for example, significant changes in patterns of employment, economic impacts on upstream suppliers or downstream customer industries and impacts on local economic development from changes in the price of water supply and discharges and changes in water quality; • Include effects of changes in water bills on the retail price index (RPI) and inflation.	Consider these only where there are particular concerns about economic and social impacts, e.g. dislocation costs and frictional unemployment impacts in a sector.

Illustration 8 – Impact of the incorporation of the economic impact of measures on the ranking of measures in Cidacos river basin (Spain)

Any change in the economic conditions affecting irrigated farms can potentially have other direct costs and also indirect costs. Costs that would need to be taken into account are those that affect land dedicated to agriculture and water consumption. "Other direct costs" are likely to be small if farmers keep the same practices or cropping patterns that they used prior to the implementation of a given measure. But if farmers' consumption is expected to fall, their output will change and their labour demand will also fall.

The Cidacos study considered (as in the Spanish Ministry Agriculture National Irrigation Plan) that 1 € of output produces 0.319 € of further added value. This is one measure of other direct costs (or benefits). The other is the impact in the labour market. The Cidacos case study makes the assumption that the loss of one hectare of irrigated land eliminates about 40 € of wages in addition to the losses of farmers' income.

An application is shown for the measure "restoration of the riverine forest".

	Net margin (including subsidies, €)	Subsidies €	Lost wages €	Indirect economic effects, €	Flow increases in litres/s
1 Ha in CR – A	775	189	26	255	0.06
1 Ha in CR- B	1096	153	54	360	0.07
Average	935	171	40	308	0.06
15 Ha	14,029	2,567	593	4,616	0.96

In addition, wider costs in the irrigation sector may be associated with those costs that are borne by stakeholders beyond the gates of the farms. In the Cidacos case study, it was assumed that attention should be given to those sectors linked to the agricultural sector, such as farm input suppliers and food processors. In addition, irrigated agriculture hires workers to perform various tasks, generating labour rents that are important in many agricultural areas. Impacts on the rural economy are thus integrated to the study, evaluating the other direct costs and labour market effects.

The Table below reports the selected programme of measures' costs in terms of Euros per increased unit of river flow. The reported evaluations indicate that incorporating wider costs in the analyses provides a different picture than excluding them. These differences are amplified when the costs reported in the table are brought to the basin-wide analysis, where other sectors and the spatial dimensions of the measures are fully integrated. For instance, if a measure applied in a non-agricultural sector has a cost of 5000 Euros for each litre/second of additional flow, many measures will not be desirable if all costs are included, and others would be more cost-effective if those costs are not included.

Measures' costs (expressed in Euros per increased flow of 1 litre per second)

	Indirect and labour effects included			Only direct effects included		
Measures	Water Body I	Water Body II	Water Body III	Water Body I	Water Body II	Water Body III
A	672	2846	2522	672	2356	2522
B	2576	6466	5892	2103	4865	4433
C	3567	6366	7652	2684	4790	5758
D	4301	6845	9667	3236	5151	7274
E	5552	12624	12320	4177	9499	9270
F	6440	12887	15828	4846	9697	11910

Water body I = upstream; Water body II = middle stream; Water body III = downstream

As a general rule, if cost differences are not very significant, an evaluation focused on direct costs may provide a valid starting point. However, if wider costs are thought to be important and sensitive to the regional or local economies, then they should be taken into account at least in the sensitivity analysis.

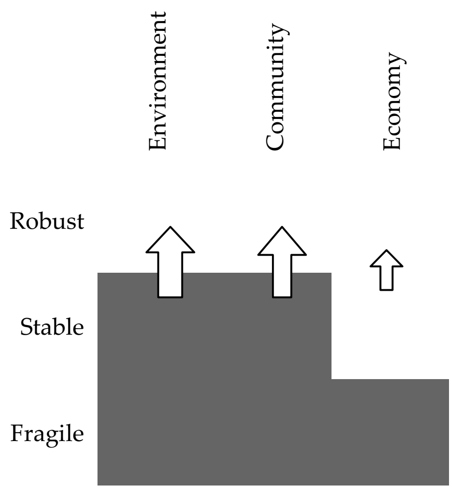
Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. See Annex E.

Illustration 9 – Analysis of Alternative Agricultural Measures: the Wise Use of Floodplains Project in the Erne Catchment (Ireland)

In order to engage stakeholders in thinking about local sustainability and the effectiveness of alternative measures to reach quality objectives, the Wise Use of Floodplains project in the Erne Catchment in Ireland used a simple model for public participation entitled the Local Sustainability Model (LSM).

The basic model can be supported with more detailed analysis or sub-models on specific issues. The participative process of establishing the baseline and discussing predicted impacts is as valuable as the result itself. The model is a simple three by three matrix. The columns represent three aspects of local sustainability: the natural environment, the community and its culture, and the economy. These are ranked as being Robust, Stable or Fragile. Communities can use this framework to assess how their area performs, shading in the model to provide a "picture" that local people can recognise.

THE LOCAL SUSTAINABILITY MODEL



Example of the local sustainability models use. Newtonbutler, Erne Catchment, February 2001.

1. Baseline conditions in the Catchment are represented by the shaded boxes.
2. Arrows show the predicted impacts of the measure being considered: a proposal to establish a single integrated cross-border Erne catchment management body.

The process of establishing the model leads a community through discussions on these three aspects using local knowledge and professional expertise. The example on the right shows an area which has a stable natural environment and community, but where the local economy is fragile. For potential catchment management options, or measures, arrows are drawn on the matrix reflecting the expected impacts. The model allows locals and professionals to share this qualitative impact assessment without the domination of one or the other.

Based on participatory work using tools such as the LSM, the Erne Wise Use of Floodplains Project developed options to restore water quality in the Erne catchment. An impact assessment study enabled comparison of their cost-effectiveness. Participatory work by the Erne project identified land management options and environmental impact criteria that were key to water quality in the catchment. These options included co-ordinated catchment-level changes to agricultural practices in the Erne, such as:

- Whole-scale buy-in to agri-environment schemes;
- Whole-scale adoption of mixed/organic farming methods; and
- Introduction of buffer strips on the most polluted rivers.

The economic, social and environmental impacts of these measures where analysed in a consultant's study that used a set of financial indicators, and ten weighted environmental and social criteria. The effectiveness scores were inevitably subjective, and encountered problems of double counting. Practitioners can be wary of these issues, and should develop and verify effectiveness scores with as wide a range of stakeholders as possible.

The management option's socio-environmental scores were compared to their predicted additional costs to taxpayers. The study revealed the current financial support for agriculture in the Erne catchment, and could be used to design more cost-effective policy modifications. The methodology developed in this project is interesting in the sense that it allows identification of cost-effective policies in relation to social and environmental objectives.

Source: I. Dickie (2002, forthcoming). See also the Royal Society for the Protection of Birds, www.rspb.org/economics/water

4. What are the Requirements for the Cost-effectiveness Analysis?

A broad-brush qualitative assessment provides a good foundation for the CEA. It can be used to identify the relevant costs, economic impacts and non-water environmental impacts of measures (see *Tasks 4* and *5* – see also the illustration on the methodology used in the Erne catchment in Ireland). However, a quantitative analysis is necessary on top of this, looking at (ranges of) estimates for the effects on water quality, and the financial costs of the main measures.

Where relevant, there should be a qualitative description of impacts over and above the direct costs already estimated. They may include:

- The nature, scale and significance of other considerations such as any wider economic and social impacts;
- Any distributional issues regarding who pays the costs;
- The ability of the sector to pay (or likelihood to pass on) the costs;
- Non-water environmental impacts of the measures; and
- The (administrative) costs of designing and implementing the measures.

As an option, the analysis can be taken further through the inclusion of the following actions:

- ***Developing nation-wide guidelines to assess cost-effectiveness.*** These guidelines should be developed in collaboration with the other regulators and representatives of the major stakeholders;

- ***Developing Guidance, drawing on practical experiences of the effectiveness of main measures.*** This would again probably be at national level and based on commonly applicable measures;

- ***Developing tailored formats for the estimation and presentation of cost estimates for the main types of measures for the major sectors.*** Costs should be presented in terms of changes in the cost elements arising from the proposed measures as compared with a business as usual baseline scenario. The appropriate expert and regulatory bodies should review carefully the estimates in relation to (ranges for) benchmark cost estimates for standard cost items. These benchmark estimates could be based on expert review of available estimates for each standard cost item. Ranges for the cost estimates should be presented, clearly and explicitly so that these can form the basis for discussions with the main stakeholders concerned. The segments of the sector to which the estimates relate, and key assumptions and factors behind uncertainties surrounding the estimates should be set out. This would allow subsequent improvements, as better information is obtained through increasing experience in applying the control measures;

- ***In the middle of the following RBMP period (i.e. around 2013), there should be an evaluation to check the costs and effectiveness of the measures in the first agreed RBMP.*** This will provide a better basis for assessing the cost effectiveness of measures for the next RBMP. It will also offer opportunities for increased feedback and system learning.

Annex I (of this Information Sheet) – Illustration of Format for Presenting Costs

1. CAPITAL COSTS			
Cost component	Cost (euro)		
	Low estimate	Medium estimate	High estimate
Pollution control equipment costs			
Primary pollution control equipment	450,000	600,000	750,000
Auxiliary equipment	112,500	150,000	187,500
Instrumentation	150,000	200,000	250,000
Modifications to existing equipment	157,500	210,000	262,500
Other (please specify)			
Total pollution control equipment costs	870,000	1,160,000	1,450,000
Installation costs			
Land costs	37,500	50,000	62,500
General site preparation	15,000	20,000	25,000
Buildings and civil works (eg foundations/ supports, electrical, piping, insulation etc)	225,000	300,000	375,000
Labour and materials (engineering, construction and field expenses)	157,500	210,000	262,500
Other (please specify)			
Total Installation costs	435,000	580,000	725,000
Other capital costs			
Project definition, design and planning	75,000	100,000	125,000
Testing and start-up costs	15,000	20,000	25,000
Contingency	22,500	30,000	37,500
Working capital	15,000	20,000	25,000
End of life clean up costs	30,000	40,000	50,000
Miscellaneous	37,500	50,000	62,500
Total other capital costs	195,000	260,000	325,000
Total capital costs	1,500,000	2,000,000	2,500,000

***Note:** Present Value of costs =Capex + (opex * discount multiplier). Equivalent annual cost = NPV/discount rate multiplier. Discount multiplier = 14.59 for a 30 year investment at 6%.*

2. CHANGE IN OPERATING COSTS (INC. REVENUE CHANGES)			
Cost component	Annual costs (Euro p.a.)		
	Low estimate	Medium estimate	High estimate
Change in operating costs			
Additional labour for operation and maintenance	15,000	20,000	25,000
Water/sewerage			
Fuel/energy costs	12,000	12,000	12,000
(specify energy/fuel type)	Grid	Grid	Grid
Reagent costs			
Waste treatment and disposal	22,190	32,920	43,650
Other materials and parts			
Change in operating costs of any additional pollution abatement equipment operation			
Insurance			
Taxes on property			
Environmental tax/charge			
Other general overheads (please specify)			
Total additional operating costs	49,190	64,920	80,650
Change in revenues			
By-products recovered/sold	2,000	2,000	2,000
Other (please specify)			
Total revenues			
Net change in operating costs	47,190	62,920	78,650

3. TOTAL COSTS – PRESENT VALUE or EQUIVALENT ANNUAL COST (Euro)			
Cost component	Low estimate	Medium estimate	High estimate
Total capital costs	1,500,000	2,000,000	2,500,000
Net change in operating costs	47,190	62,920	78,650
Economic assumptions			
Economic life of equipment		3	
Discount rate			
Net present value	2,188,500	2,918,000	3,647,500
Equivalent annual cost	150,000	200,000	250,000

Source: Fisher, JCD, Holt, A, (2001).

PRICING AS AN ECONOMIC INSTRUMENT

Directive references: *Article 9*
3-Step Approach: *Step 1.3 and 3.1*, and potentially *Step 3.2*
See other information sheets: *Estimating Costs, Reporting on Cost Recovery*

This information sheet helps you assess the effectiveness of pricing as a measure to achieve the environmental objectives of the Directive.

1. Objective

The Directive recognises water charges and prices as basic measures for achieving its environmental objectives. This information sheet proposes and illustrates a range of methods for assessing whether pricing policies (actual or proposed) provide appropriate incentives for users to reduce their water uses and pollution. This is particularly relevant for two main purposes:

- Assessing the incentive properties of current pricing policies (*Step 1.3*) and preparing the basis for the introduction of pricing policies that provide adequate incentives for users to use water resources efficiently (*Step 3.4* and *Article 9*);
- Reporting on the tasks and measures proposed for ensuring that pricing plays its due role in enhancing the protection of water resources (*Articles 9 & 13 and Annex VII*).

2. How does pricing impact water consumption and discharge?

The price of water is an important variable that influences the amount of water used by users or the amount of pollution they discharge. As such, it can be a useful measure to introduce (amongst others) in order to meet the objectives of the Directive:

- Pricing policies can help make users more efficient in their use of water resources by giving them financial incentives to shift to technologies and practices that ensure a better use of available resources or act to reduce leakage; and
- Similarly, on the dirty water side, pricing can incentivise users to shift to less polluting input or processes, eliminate highly polluting production lines and practices, or install treatment facilities to treat polluted water before discharging it into the environment.

To yield such effects, however, pricing policies must be designed so that a reduction in the quantity of water used or pollution discharged would lead to a simultaneous reduction in the total bill for the particular user. ***This means that the price of water should be proportional to the quantity of water used or the pollution generated*** (see *Box 1* of this Information Sheet).

Incentive-based pricing can be more or less effective depending on its design…

- **Seasonal tariff variations** can be very effective to provide higher incentives for saving water in periods with high scarcity only (e.g. increase *a* - see *Box 1* - in the summer);
- **Increasing-block tariffs,** with dissuasive charges above a certain level, can be an effective way of reducing demand from users with very high demands;
- **High fixed charges** (F in *Box 1*) and low volumetric charges might reduce tariffs' incentive properties on demand.

Box 1 – Tariffs with a volumetric element are key to introducing incentives

To introduce incentives, tariffs should incorporate a volumetric element, such as:

$P = F + a.Q + b.Y$, *where,*

P = total price for water services (e.g. supply of water, treatment);
F = a component of the price related to fixed costs (e.g. overheads);
a = the charge per unit of water extracted from the environment and used, linked to variable costs (e.g. pumping costs);
Q = the total quantity of water used;
b = the charge per unit of pollution produced and emitted to the environment, linked to variable costs (e.g. variables costs of treatment, emission charges etc; and
Y = the total volume of pollution emitted.

… and on user demand characteristics – for example, the impact of volumetric tariffs on demand might be negligible:

- If the total bill represents a small portion of a user's production costs or income;
- If the water user has no alternative (due to technical, social or economic constraints).

An important measure of whether or not pricing policies are likely to have an impact on water demand is the price elasticity of demand (see *Box 2* of this Information Sheet).

Box 2 – Estimating the Price Elasticity of Demand

How responsive the demand for water is to a change in price is usually captured by the notion of "price elasticity of demand". This parameter is defined as the percentage change in quantity demanded when the price changes, divided by the percentage change in price (see Box 3 for an illustration). For example, suppose that a 10 percent increase in price reduces the water demand by 5 percent, then the price elasticity of demand is -5/10 = -0.5. The higher the price elasticity in absolute terms, the more responsive the demand will be to changes in prices. The price elasticity of pollution discharge can be computed in a similar way.

- ***It is important to note that elasticity can vary through time as well as across different levels of consumption along the demand curve.***

To develop efficient incentive pricing policies and to assess the impact of these policies on water uses and pollution and on the state of the environment, it is important to answer the following questions:

1. Are prices paid proportional to water used or amount of pollution discharged (see *Illustration 1* of this Information Sheet for an example of water pricing structures)?
2. How do changes in prices (for different starting points) lead to changes in the demand for water or the pollution discharged, i.e. depending on the price elasticity of demand?
3. How do changes in demand affect water status, in order to understand the effectiveness of pricing as a measure for reaching the environmental objectives of the Directive?

In addition, it is important to take into account other policies than those strictly related to water might affect demand (see *Illustration 3* of this Information Sheet). The second point represents the main challenge from an economic point of view and is illustrated in *Box 3* of this Information Sheet.

Illustration 1 – Current water pricing in the Vouga river basin (Portugal)

In the Vouga River Basin, information on water pricing was sought during a scoping exercise for the implementation of the WFD. It was found that this information was available for only 18 out of 32 municipalities and for the two existing public irrigation facilities. The outstanding feature of the data was the wide disparity both in tariff structures and in actual tariff levels.

For the irrigation facilities, the users' payments are unrelated to actual water consumption (in one case there are per ha charges and in another case per hour) so pricing has no incentive impact whatsoever.

As with municipal systems, all require a monthly fixed payment (which varies with the requested capacity) as well as a variable (per m^3) charge. However, there are great disparities in the rates and in the structure of the variable part.

- For similar capacity, the monthly fixed payment can be very different; for instance, for 30 mm it varies between 1.05€ and 9.5€;
- Only three municipalities have seasonal rates (higher in the summer, mainly for larger consumption);
- The majority of municipalities charge different rates for domestic, industrial, agricultural, and other users; only two apply the same rates to all users;
- Some municipalities charge a constant price per m^3 for the industrial and commercial sectors. Otherwise, increasing block rates are applied but in two distinctive ways: for one group (e.g Mira) the price charged on all water consumed is defined by the block where total consumption falls (average price equals the block rate), whereas in the other group (e.g. Castro Daire) the price charged for each m^3 is the price of the block where that m^3 is (average price equals a weighted average of block rates). The first scheme is meant to discourage excessive consumption, although it implies highly irregular marginal prices as shown below:

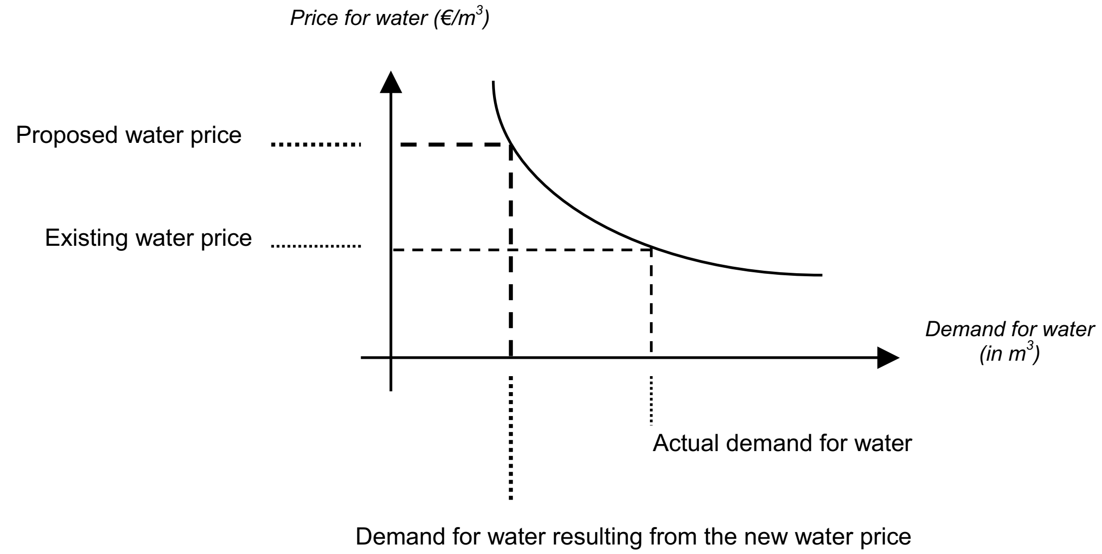
Municipality	**Block structure and prices**				**Marginal Price for 5th m³**	**Marginal Price for 6th m³**	**Marginal Price for 7th m³**
Mira	**Block**	**0-5 m³**	**0-10 m³**	**0-15 m³**			
	€/m³	0.22	0.30	0.37	0.22	0.70	0.30
Castro Daire	**Block**	**0-5 m³**	**6-10 m³**	**11-20m³**			
	€/m³	0.17	0.30	0.55	0.17	0.30	0.30

Such disparity is especially odd considering that many municipalities are connected to the same bulk supplier, who charges all municipalities the same price per m^3. Moreover, there are a few cases where the rates charged by municipalities are lower than this bulk rate.

Source: P. Mendes. Scoping key elements of the economic analysis in the Vouga River Basin. See Annex E.

Box 3 – The impact of price on demand

The approach promoted by the Directive in the use of pricing as an instrument (or as a measure) consists of defining an environmental goal and calculating the total amount to be paid by users (the tariff), by category of user, in order to achieve this goal. However, given that pricing is only one measure amongst a package of measures, this might be difficult.



3. Possible Approaches for Assessing the Relation Water Prices/Water Demands

Several approaches can be used to assess the relation between water prices and water demand/pollution discharged, as follows:

Interviewing key experts/stakeholders: ask people "what if?" questions in order to assess how they would react to a proposed change in the tariff structure or level.

Reviewing existing literature. Several types of literature reviews can be performed:

- Review of analysis already carried out in the river basin of interest. If this analysis is not out-dated and no significant changes in key variables and policies have taken place since it was carried out, then it can potentially provide useful information;
- Review of analysis carried out for the same uses under the same hydrological and socio-economic conditions;
- General literature review, although this is likely to yield only very general results (such as agriculture is more responsive to price changes than households) that have no direct practical use in performing economic analysis for the Directive.

Developing statistical models for specific sectors. Two types of statistical models can be developed:

- *Cross-sectional models* can be developed for comparing responses to price changes of user groups that face different price regimes at a given point in time; and
- *Time-series models* can be developed for comparing responses to price changes of a user group across a period of time.

The simplest statistical approach may consist of comparing two (or more) groups of users that face two (or more) different price regimes (e.g. an irrigation district paying a flat rate for its water versus an irrigation district where volumetric charges are applied). However, extrapolating the results of such comparisons to other situations is very delicate.

Such models have mostly been developed for analysing price incentive issues for the household sector, as information on the volumes used and prices tends to be more readily available (see *Illustration 2* of this Information sheet).

Developing behavioural models for specific sectors. Optimisation models can be developed for the various economic sectors to estimate the relationship between the price for water and the water demand/pollution discharged. Such models are formed by combinations of mathematical equations that attempt to reproduce real decision-making processes that aim at achieving given objectives (e.g. maximising the total income of a firm) taking account of key technical, legal and economic constraints faced by given economic sectors. Key tasks for carrying out behavioural modelling are outlined in *Box 4*, and an application is shown in *Illustration 4* of this Information sheet.

Behavioural models can be built for an entire sector, i.e. accounting for all farmers of a given irrigation scheme, if the different users of this sector are homogeneous in terms of objectives, constraints, conditions. However, if different users in the sector face a wide variety of strategies and constraints, it is more appropriate to identify key types of users and develop models for each user type.

Illustration 2 – An application of time series modelling: Did water pricing play a role in reducing household water consumption in Athens, Greece?

Severe droughts at the end of the 1980s and beginning of the 1990s have resulted in significant changes in the price of water in the region of Athens. Such price changes have taken place in a policy context where the need for demand management beside efforts to discover and tap additional water resources is increasingly recognised.

To assess the role water pricing can play to reduce the water consumption in the domestic and small commercial sector supplied by the Athens Water Utility Company (EYDAP), a statistical analysis of past price and water consumption information was undertaken to estimate the price elasticity of water demand. The information used for this statistical analysis included (i) the quarterly water consumption (in m^3) for an eleven-year period (1989 to 1999) for a sample of 1000 consumers, and (ii) price levels for the same period.

It is to be expected that consumers with different levels of water consumption will react differently to water price changes. Therefore, a statistical cluster analysis has been performed to identify five groups of consumers based on their quarterly consumption levels: (i) lower than 15 m^3; (ii) between 15 and 30 m^3; (iii) between 30 and 45 m^3; (iv) between 45 and 60 m^3; (v) above 60 m^3.

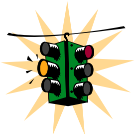
The analysis of the consumption information showed that the dramatic price increase that took place in the third quarter of 1992 led to a significant reduction in the demand for water. This was the case for all the groups of consumers except for the group with the lowest water consumption (lower than 15 m^3), which did not alter its consumption.

On the basis of the quarterly water consumption and (deflated/constant) price levels, a statistical time series model was developed to estimate the long-term price elasticity of the water consumption for each consumer group. To validate the model, all variables were tested and found to be statistically significant.

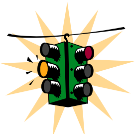
The results show that the long-term price elasticity of demand for the different consumer groups range from -0.58 for the low consumption group (i.e. quarterly consumption lower than 15 m^3) to -0.87 for the very large consumption group (i.e. quarterly consumption above 60 m^3). These elasticity values show that water pricing (combined with active information and awareness campaign) can be used as a major measure for controlling water consumption in the Athens area, and that price changes are likely to have a greater impact on the water consumption of large water consumers as compared to small water consumers.

Box 4 - Key Tasks for developing behavioural models

1. Define key relationships between input and output variables and basic assumptions. Make sure you characterise the relationships between price and demand for water;
2. Using a first set of information from a real-life situation, estimate the parameters of these relationships through calibration of the model to ensure that the model adequately reproduces the conditions of this real life situation;
3. Using a second set of information from a real-life a situation (e.g. a different year), validate the model by ensuring that it can also predict adequately the second situation;
4. Run simulations with the validated model, e.g. change the parameter 'water price' in the model and run the model so that it estimates the related demand for water, and repeat this operation as many times as required;
5. Use the results from several simulations, to build the water demand curve and estimate the price elasticity of demand for different price levels.



Look out! Models can be useful tools to organise participation
Models can be very useful tools to support discussion between experts and stakeholders about various water pricing measures. This element of assistance to the discussion is sometimes more important than its exact predictions.



Look out! Reality is often more complicated than simple models

Many countries in Central and Eastern Europe have witnessed significant changes in water consumptions since the early 1990s. Such changes were as much related to changes in water prices (following a cut in subsidies to the water sector) than to overall economic changes, which resulted in a drop in economic activity. Therefore, to account for changes in non-water related variables in time series models would be particularly important when analysing changes in water demand and tariffs in Central & Eastern Europe.

Illustration 3 – Taking account of broader policies to estimate the incentive properties of pricing policies: the impact of the CAP in Cidacos (Spain)

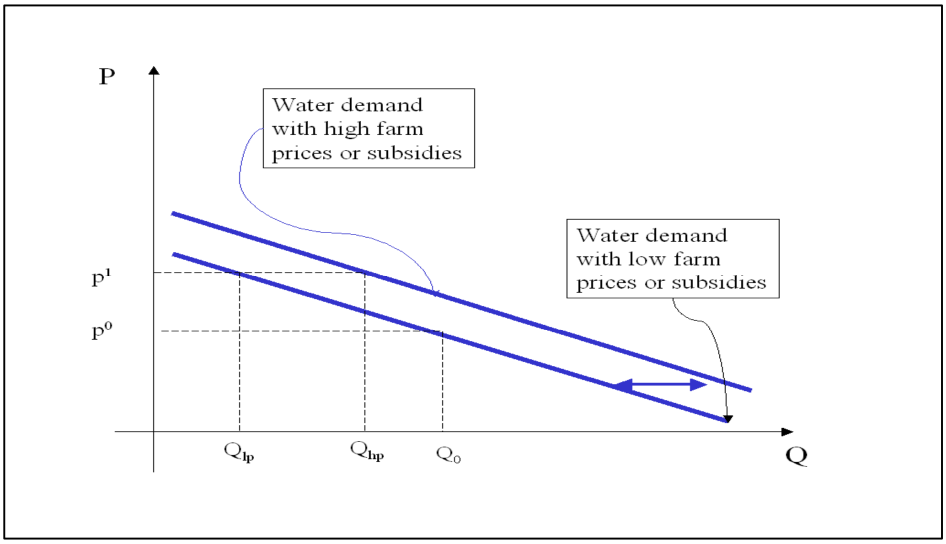
That the Common Agricultural Policy (CAP) programmes affect farmers' water demand has been thoroughly documented across many European countries and regions. This implies that water-pricing policies will, in principle, have different effects depending on the Agricultural policy scenario considered.

In general, those CAP programmes that provide measures of income support decoupled from production would not affect irrigators' water demand. By contrast, those other programmes based on production subsidies will have a significant impact on farmers' water demand. In the latter case, farmers' responses to pricing policies will be sensitive to the agricultural policy scenario. The way to ascertain the effects of a change of policy in farmers' water demand is to simulate farmers' behaviour. In the absence of calibrated models, relevant to the area of study, one can formulate several policy scenarios and carry out simple sensitivity analysis.

In the Cidacos case study, the following scenarios were proposed:

A key implication of assuming one or another CAP scenario is that irrigation water demand will shift as the economic conditions improve or get worse. This implies that farmers' demand response to water pricing will change as agricultural prices or product subsidies change. This is reflected in the following graph:

		Correcting factors	
Scenario	*Costs*	*Prices*	*CAP - subsidies*
Business-as-usual	1	1	1
Agrarian	0.9	1.2	1
WTO - liberalisation	1	0.8	0.7



Source: Ministerio de Medio Ambiente, Gobierno de Navarra, 'Virtual Scoping Study of the Cost Effectiveness Analysis in the Cidacos River'. See Annex E.

Illustration 4 – An application of behavioural modelling: Demand for irrigation water in Tarquinia (Lazio, Italy)

Water uses in the Marta River are characterised by a high number of users and a high degree of pollution. Keeping the river water flow above a minimum vital level is seen as a key target for both water management and sanitary authorities. However, this requires lower demand from some economic sectors during periods of significant water shortages. Therefore, to assess the role water pricing could play to reduce water demand from agriculture, an economic linear programming model was developed for the entire irrigation system.

Following a detailed analysis of the irrigation and farming systems, the model was developed as an aggregation of sub-models representative of the conditions faced by different farm types (facing a variety of land, labour, financial constraints) and for different districts of the irrigation systems with different water availability and distribution systems. The objective of the linear programming model was to maximise the gross income from agricultural activities, taking account of the key constraints faced by farmers in terms of labour availability, access to hired labour, land constraints, crop rotation constraints, and water availability. Built with a series of equations (equalities or inequalities) that link input (fertiliser, labour, water) and output (yield, gross margin) variables, and for a variety of crops, the model identifies the combination of crops that yields the highest farm income within the limits of the constraints set. By comparing the cropping pattern estimated by the model with real cropping pattern information for two different years, the model was calibrated and validated.

The model was then used to assess the changes in cropping patterns, farm income and water consumption that would result from changes in the price of irrigation water. The model was run several times with different price levels, and the water consumption resulting from each price level and computed by the model were recorded.

The results obtained from different model simulations, i.e. the water demand and the price elasticity of the water demand for different price levels, are presented in the table.

	Actual water demand	**Proposed water price increase**			
		+5%	**+15%**	**+25%**	**+50%**
Water demand (1000 m^3)	9,212	8,851	8,733	8,479	8,116
Price elasticity of demand		-0.78	-0.35	-0.32	-0.24

Note that the estimated values of water demand and elasticity are valid for conditions close to actual agricultural policies. Significant changes in these policies, for example a change in subsidies and agricultural product price support, would change the opportunities and constraints faced by farmers, and therefore also their responses to changes in the price level.

4. What is the most appropriate approach, depending on circumstances?

Each approach set out above has its strengths and weaknesses and is more or less suitable according to circumstances, as presented in the Table below.

Approach	***Strengths***	***Weaknesses***	***When is it suited?***
Interviewing experts and key stakeholders	➢ Fits participatory approaches to water management	➢ Rough estimates ➢ Difficult to evaluate robustness of the information	➢ Local level with a limited number of users (e.g. one specific industrial plant in a sub-basin) ➢ Comparing limited number of very significant tariff changes
Reviewing existing literature	➢ Can be useful as a first proxy ➢ Potentially less costly than other approaches	➢ Limited amounts of literature available (mostly on household uses – little on pollution)	➢ Analysis in the first instance to define the type of measures
Developing statistical models	➢ Can have strong predictive powers in a given area	➢ Difficult to extrapolate the results	➢ More complex, multi-variate models might sometimes be needed
Developing behavioural models	➢ Attempts to reproduce real-decision making processes on the part of users	➢ Mostly accurate for ranges of parameters not too far from real life conditions	➢ To model behaviour for an entire sector, particularly if users are rather homogeneous in terms of strategies and constraints

The approach chosen to assess the relationship between the price and water use will also depend on the information, human and time resources available. For example, undertaking a literature review and discussing pricing policy changes with key stakeholders may be the only short-term possibility. However, in the long run, it is important to ensure that more robust and accurate results are achieved. It is also important to ensure that the analysis and level of details are appropriate for the issues of the river basin considered.

Clearly, the incentive dimension of pricing policies is key, but not the only measure to achieve the WFD objectives. The definition of new pricing policies also needs to consider cost recovery issues, as specified in Article 9 (see *Reporting on Cost Recovery* Information Sheet). In addition, other social, environmental and economic effects of proposed changes in water pricing policies must be taken into account when designing these new policies.

DISPROPORTIONATE COSTS

Directive references: *Article 4* (Paragraphs 3-5 and 7)
3-Step Approach: *Step 3.3*
See other information sheets: *Estimating Costs*, *Cost-effectiveness Analysis*

This information sheet will help you assess whether the costs of the Programme of Measures are disproportionate and whether derogation from the Directive's objectives could be justified following an assessment of costs and benefits.

1. When is it Necessary to Assess Disproportionate Costs?

This information sheet presents an approach for determining whether the total costs of the programme of measures are disproportionately costly or expensive and is relevant for justifying derogation. In particular, this approach is relevant for:

- **Designating heavily modified water bodies (HMWB)** when the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons including **disproportionate costs**, reasonably be achieved by other means, which are a significantly better environmental option (*Article 4.3*, see *Illustration 1* of this information sheet for further explanation);

- **Time derogation** when completing the improvements in the status of water bodies within the time scale would be **disproportionately expensive** (*Article 4.4*, see *Illustration 2* of this information sheet for further explanation);

- **Less stringent environmental objectives** when the achievement of these objectives would be infeasible or **disproportionately expensive** and the environmental and socio-economic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing **disproportionate costs** (*Article 4.5*); and

- Failure to achieve good status or failure to prevent deterioration as a result of **new modifications** to the water body when the beneficial objectives served by those modifications or alterations of the water body cannot for reasons including **disproportionate costs** be achieved by other means, which are a significantly better environmental option (*Article 4.7*).

The analysis of whether costs are disproportionate or not will need to be initiated relatively early in the process, around 2006, in order to ensure that the public can be consulted on such a key element of the economic assessment (by 2008) and that work can be co-ordinated with other expertise, as this process will require a combination of technical and economic expertise. The precise tasks of the analysis are described in *Box 5* at the end of this information sheet. If achievement of good quality status is only possible after 2015, an interim lower objective can be set for 2015 and a time derogation be registered in the RBMP. If in 2009 it is considered that good status cannot be achieved by 2027, less stringent objectives should be registered in the plan.

Illustration 1 - Disproportionate costs in the designation of Heavily Modified Water Bodies: An example from the Netherlands

For the designation of Heavily Modified Water Bodies (according to *Article 4.3*), alternatives for the beneficial objectives of a water body must be presented. These alternatives must be: 1) technically feasible, 2) a better environmental option and 3) not cause disproportionate costs. In the EU Heavily Modified Waters working group, four typical Dutch water bodies* were tested for designation as HMWB. A summary of the alternatives to maintain the beneficial objectives and the costs involved is presented in the table below.

This table shows that although the absolute costs (A) may seem high for the 1st case (1000 millions €), the relative costs as expressed per km^2 of restored water body (B) show a different picture. There, the costs are still the highest for the first case (6000 €/km^2), but they are much more of a similar order of magnitude than in the other cases. Another criteria presented is to scale the costs to the size of the catchment (C), which in this example reverses the conclusion drawn from approach A: now the costs for case 1 are the lowest (5 €/km^2). The exercise presented illustrates how such 'benchmarking' can present a framework to assess the disproportionality of costs. It should be kept in mind that in the final conclusion, issues such as the ability to pay and the (intrinsic) value of the type of ecosystem restored should also be considered.

Designation task	**Dammed estuary (1)**	**Lowland brook (2)**	**Shallow lakes (3)**
Measures to achieve GES	Destruction of dam	Land reclamation for restoration of stream morphology	Land reclamation for restoration lake hydrology
Define beneficial objectives?	Safety, fresh water supply	Safety, agriculture	Safety, fresh water supply, recreation
Define alternative for beneficial objective?	Higher dikes to maintain safety and relocate fresh water intake points	Create retention areas; buy alternative land for agriculture; mitigate costs of yield losses	Displace the present habitation (no cost estimate); use surface water for drinking water
A: Costs of alternative	1000 millions €	1.5 million € + 2.5 million € /y	PM + 9.24 million €/year
B: Costs per km^2 (restored) water body	6000 K€/km^2	3600 K€/km^2	PM+3900 K€/km^2
C: Costs per km^2 catchment	5 K€/km^2	500 K€/km^2	PM+2000 K€/km^2

* *The waterbodies studied were: The Haringvliet Estuary (Dammed estuary; 1); the Hagmolenbeek (Lowland brook ; 2) and the Veluwerandmeren & Loosdrechtse Plassen (Shallow lakes; 3)*

Source: M. van Wijngaarden (2002, forthcoming).

Illustration 2 - Considerations for time derogation in the Alsace (France)

In the Southwestern part of the Alsace region (France), the potash mining activity has generated an intense pollution of the Rhine valley alluvial aquifer. The pollution originates from huge waste dumps containing salt (sodium chloride) that have accumulated since the early 1900s and have been leached by rainfall. The polluted water has progressively extended over time following the aquifer's flow lines. Different measures aimed at reducing the salt emission, increasing salt elimination and accelerating dilution through artificial aquifer recharge have been implemented, resulting in a significant reduction of pressure over the last 10 years. However, these measures are unlikely to be sufficient to restore the quality of the aquifer by 2015.

A hydrodynamic model was used to test current measures' effectiveness. The results indicate that if the measures already implemented are maintained from 2002-2027, the salt concentration of water will fall below 250 mg/l in the whole aquifer (to drinking standard) and approximately 96% of the salt present in the aquifer in 2002 will be removed. From this model it can be concluded that the current measures are sufficient to achieve the objective of good status in 2027, and that a time derogation can be defined if the more intensive, alternative programs of measures are disproportionately expensive. This scenario corresponds to the "third best" option in the Figures 1 and 2 below.

Two more intensive alternatives were defined to meet the 2015 objective. The first (or "second best") option consists of constructing more lines of pumping wells to prevent migration of the pollution plume, to meet the environmental objective in 2021. The "first best" option consists of constructing hydraulic barriers plus a line of pumping wells and a pipeline to evacuate the pumped water, and will meet the environmental objectives by 2015. Costs for these options are still being studied. The following charts show the three options according to their ability to meet the quality and time objectives.

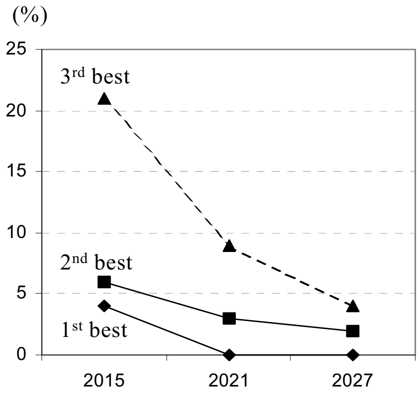


Figure 1: Quantity of salt remaining in the aquifer as a percentage of the initial stock (2002) for the three scenarios

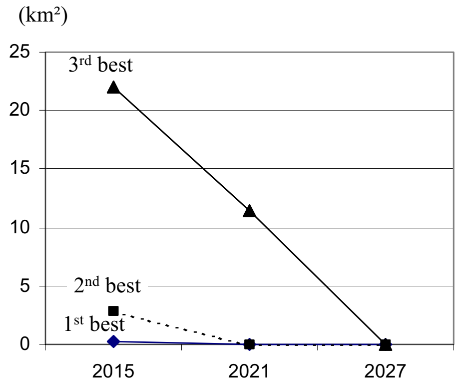


Figure 2: Area where the salt concentration is higher than 250 mg/l for the three scenario (in km²)

A preliminary analysis shows that the benefits of the first best option likely to accrue to direct uses (agriculture, industry, drinking water) are not likely to be significant in either monetary value or through employment or economic development. However, the benefits for *future* uses (avoided costs of treating polluted drinking water; gains from future industrial/economic development; etc.) may be more significant.

The work presented is ongoing and does not yet answer the question of the type of derogation needed for the Alsace aquifer. Part of the discussion concerns the choice of simulation model to determine the effectiveness of the alternative programmes of measures. In this case, the comparison of technical effectiveness of various programmes of measures has been undertaken using a simple hydrodynamic model. The major difficulty here was choosing the level of detail for the model, which determines the accuracy of results and the confidence stakeholders may have in the analysis. The choice of model also raises the question about how uncertainty should be considered in the logical argument to justify a derogation. Should the Member State petition for a derogation when the models say that the gap between the simulated quality of water and the objectives is expected to be close to 20% with a possible error of plus or minus 25%? Or should the error be expressed in number of years (the objective will be reached in 2015 plus or minus 5 years)?

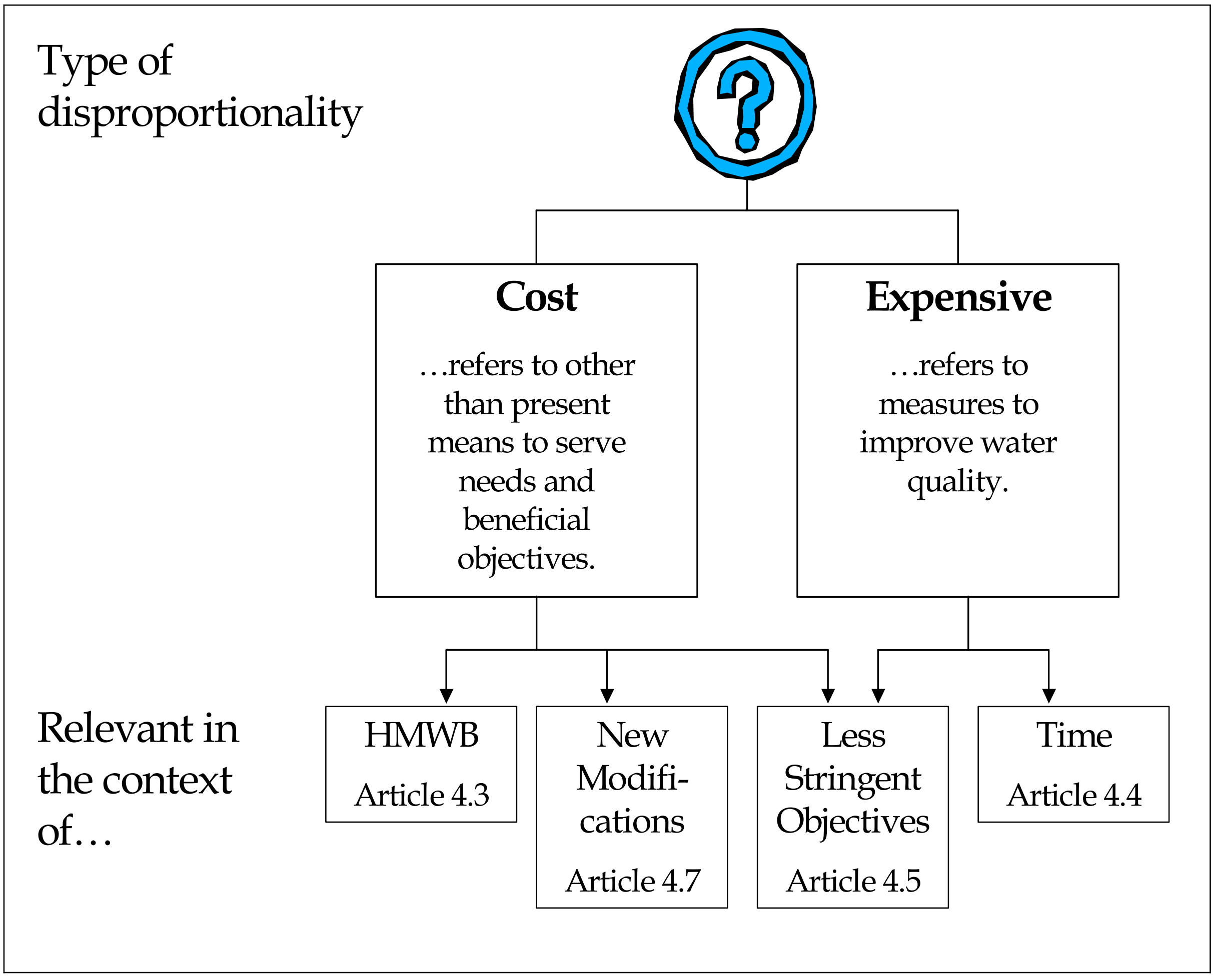
Source: J.D. Rinaudo and C. Pelouin. Assessing disproportionate costs in the Alscae aquifer. See Annex E.

2. What are the Key Issues?

'Disproportionate cost' refers to 'beneficial objectives being achieved by other means' in the context of designations, derogations and new modifications. 'Disproportionately expensive' refers to measures for improving water quality (see *Box 1* of this information sheet). This has two implications:

- Extended time or less stringent objectives can be justified on the grounds of **disproportionately expensive** measures (Articles 4.4 and 4.5); and
- Designation of heavily modified water bodies, new modifications and (again) less stringent objectives can be justified when the current needs and socio-economic benefits accruing from this activity cannot be achieved by other means not entailing **disproportionate costs**.

Box 1 – Disproportionality and Derogation



Note that Annex D.2b of this Guidance Document goes into more details for explaining the procedure to follow for designating Heavily Modified Water Bodies (Article 4.3) and justifying a derogation based on Article 4.7 following new modification/activity.

Look out! Estimating all benefits to society…
One source of identification of impacts of qualitative benefits is the consultation required under *Article 14.1* of the Directive. However, note that benefits that may accrue to 'interested parties' are not the only source of benefits. The analysis should attempt to fully incorporate all possible impacts so that the total economic value to society as a whole is established.

How Should Alternatives be Compared?

When derogation relates to heavily modified water bodies, new modifications or less stringent environmental objectives, it must be ensured that the human activity affecting these waters, and the environmental and socio-economic benefits accruing from this activity cannot be achieved by other means not entailing disproportionate costs. If there is an alternative option to achieving the objectives, its costs must be assessed so that they are not disproportionate. Importantly, alternative means should be a significantly better environmental option, not restricted simply to water quality. 'Significant' implies that the benefits from the alternative means should be appreciable compared to the original means.

What is Disproportionate?

Illustration 3 of this information sheet demonstrates in a simplified way what 'disproportionate cost' means. Whether an improvement is found to be disproportionately expensive or 'other means' disproportionately costly will be decided by individual Member States on a case-by-case basis (see *Illustration 4* of this information sheet for an example on decision making). Ultimately, disproportionality is a political judgement informed by economic information. Given the uncertainty around estimates of costs and benefits, bear in mind that:

- Disproportionality should not begin at the point where measured costs simply exceed quantifiable benefits;
- The assessment of costs and benefits will have to include qualitative costs and benefits as well as quantitative;
- The margin by which costs exceed benefits should be appreciable and have a high level of confidence;
- In the context of disproportionality the decision-maker may also want to take into consideration the ability to pay of those affected by the measures and some information on this may be required. This analysis might need to be disaggregated to the level of separate socio-economic groups and sectors, especially if ability-to-pay is an issue for a particular group within the basin. Whether and where this information is available depends on the scale or geographical area for which costs and benefits are considered (see *Box 2* of this information sheet).

Illustration 3 – The interpretation of the Directive on disproportionate costs

A sewage treatment works is discharging effluents into a watercourse (a small stream), which is a tributary and flows 1km down from the discharge into a much larger water body (a large river). The water quality of the tributary is of moderate status whilst the river is of good status. The tributary runs under roads and through an industrial estate.

The costs of possible measures, modifications to the works and a higher level of treatment for the effluent are high. The quantifiable benefits of improving the water quality on the tributary are appraised using benefits transfer techniques and a check is made to see if there would be any regeneration benefits. The measured benefits are low; in addition there are qualitative benefits from improving the ecology but there is little possibility of improved recreational use or angling. It is decided for the 2009-2015 River Basin Management Plan that the costs of reaching the environmental objectives of the tributary significantly exceed the benefits and the measures are judged to be disproportionately expensive. A lower quality objective, moderate, is recorded in the RBMP for this particular water body.

For the less stringent objectives to be set, the 'environmental and socio-economic needs served by such human activity cannot be achieved by other means which are a significantly better environmental option not entailing *disproportionate costs*'. The need served by the human activity is the disposal of sewage effluent.

In accordance with the Directive, an alternative option to higher levels of treatment, which meets the need, is explored with the water company. It is possible to build a pipeline from the treatment plant directly to the river and thus bypassing the tributary. Due to large dilution factors, this measure would have no negative impact on the water quality status of the river and is a better environmental option because the tributary is cleaner than under the first option.

The cost and benefits of each of each option are compared but it is found that the pipeline option would be disproportionately costly, as it would entail much higher costs but only a slight increase in benefits. Having explored other means of meeting the needs of achieving the human activity and rejected them, the less stringent objective for the water body is set.

Source: J. Fisher. Integrated appraisal for river basin management plans. See Annex E.

Illustration 4 - Using an expert panel to assess disproportionate costs in the Scheldt estuary

The Scheldt estuary, located in part in the Netherlands and Belgium, is an important source of economic land use and navigation. However, increased socio-economic pressure has directly affected the estuary's morphology, and resulted in a reduction of the system's natural dynamics. After developing a base case scenario and trend line to project future impacts, an expert panel representing both countries was convened to assess whether the costs of measures to reach the desired ecological objectives were disproportionate.

The panel first assessed the broader socio-economic effects of two alternative scenarios: either reducing the navigation channel by not allowing further deepening, or to reduce economic land use by de-poldering agricultural land. For these, a distinction was made between significant effects with associated costs, non-significant effects and effects that were significant but not quantifiable. The first category of effects was introduced to the cost-effectiveness analysis, and included increased salinity, yielding extra drinking water costs; increased scarcity of land, impacting land prices; and effects on recreation in the region, yielding either a loss or gain of added value. Because these broader effects were included, the outcome of the original cost-effectiveness analysis changed, and the option for no further deepening became the most cost-effective.

Non-significant effects were then disregarded, while the third category of effects was left for the final stage of preparing the river basin management plan, the assessment of the financial implication, organisation and instrumentation of the plan. These included the effect of the chosen option on political relations between the Netherlands and Belgium, societal support for the option, and the effect on regional employment.

To judge whether the no further deepening option posed disproportionate costs, the panel used the following criteria:

- Ability to pay;
- Cost comparison;
- Cost-benefit assessment.

Because public funds are sufficient to finance the proposed measures and the relative costs for private sector are relatively low (maximum 38 million Eur/yr, with an added value of 16 billion Eur/yr), ability to pay was not deemed disproportionate. A more extensive analysis would include the use of indicators, the effect on the sector's competitiveness, or on the financial solvability of the private sector company.

Cost comparison was also not considered disproportionate. A similar project in the Netherlands was sited as having relatively higher costs to reach comparable ecological gains. For a more extensive cost comparison, the panel proposed to use the indicator of costs per ha of comparable nature quality created in another domestic project.

An analysis of functional impacts demonstrated a difficulty in quantifying ecological objectives and societal benefits for the purposes of a cost-benefit assessment. As the other criteria showed that the costs of reaching ecological objectives in the Scheldt estuary were not disproportionate, the panel decided not to assess the relative value of costs and benefits.

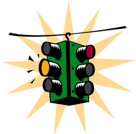
Source: Beckers et al., Scheldt International River Basin: Testing elements of the 3-step approach. See Annex E.

Box 2 – Issues to consider when assessing ability to pay

- Do we consider ability to pay of certain sectors separately, i.e. households, agriculture and industry? Are cross subsidies possible for the financing of measures, say between agriculture and industry?
- At what administrative level do we consider ability to pay? At the level of the river basin, at regional or national levels?
- Are state subsidies possible?
- How do ability to pay and cost recovery levels interact?
- How far do we look for costs and benefits accruing from a measure? Only within the river basin?
- How do we treat costs and benefits of a measure that occur upstream or downstream and affect other water bodies?

3. What are the Practical Tasks for Assessing Disproportionality?

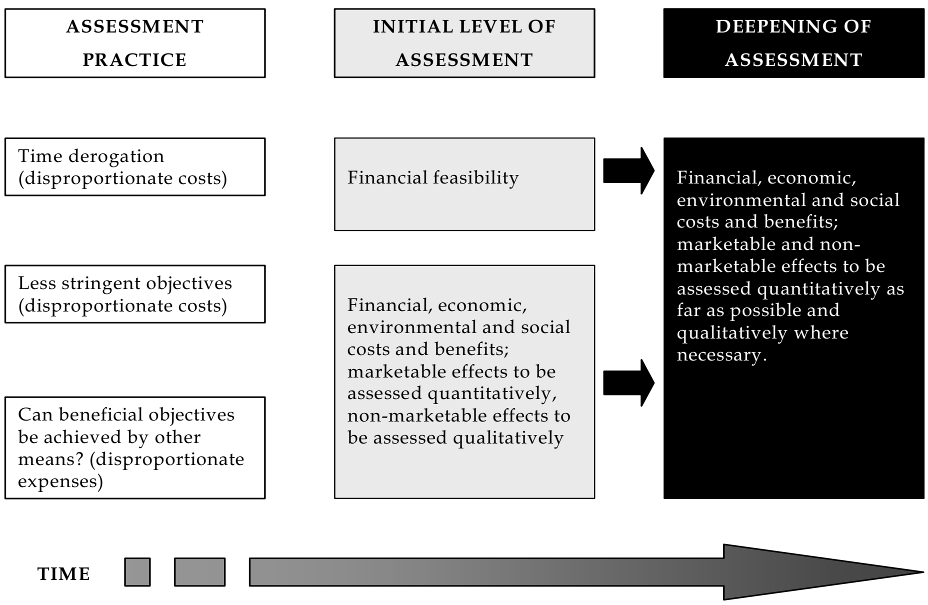
The analysis required for justifying derogation from the environmental objectives of the Directive is directly related to methodologies used for carrying out cost and benefit assessments. However, the approach proposed here is substantially different and reflects the requirements of the Directive.



Look out! Traditional cost-benefit analysis
The traditional Cost Benefit *Analysis* (CBA) estimates the *net benefit* (or cost) of an activity, policy or project in monetary terms (often for a country). The valuations are based on "the willingness to pay of the potential gainers for the benefits they will receive as a result of the [activities], and on the willingness of potential losers to accept compensation for the losses they will incur[11]. In layman terms, this means comparing variations of quantifiable costs and benefits, caused by the activities, for people affected by the policy under consideration.

The overall process for assessing disproportionality is presented in Box 3 below, showing a gradual deepening in the level of assessment.

Box 3 – Assessing Disproportionality



[11] The Department for Transport, Local Government and the Regions (DTLR) in the UK (2001), 'Multi Criteria Analysis: A Manual'

Assessing disproportionality

As shown in *Box 3*, the assessment may be largely qualitative at the initial stages. Costs and benefits of the alternative programmes of measures for achieving different water quality states should be identified and listed, though not necessarily fully valued. The extent to which costs and benefits are valued will depend on the type of derogation:

- For derogation on the basis of less stringent objectives and for the assessment of 'other means' (HMWB and new modifications), a fully quantified valuation may be undertaken for market costs and benefits and described in qualitative terms for non-market cost and benefit items (see *Box 4* for an example of a checklist);

- For time derogations, simple financial criteria may suffice to prove disproportionality as this is only a temporary measure. Over time, and as more robust quantitative data are collected, a deepening of the assessment could include a more extensive identification and quantification of costs and benefits, including financial, economic, environmental and social costs and benefits.

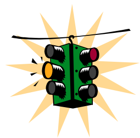
Box 4 – Example of AST Checklist

Option Definition and description

Option / BUC		Option Description	Problem	EAV of costs £/yr
Option	**Ribble nutrient strategy**	Undertake STW optimization, operational P removal and negotiated agreement with Dairy farmers	Excessive input of nutrient which limits the achievement of good status	370,000
BUC:	B2015-->M2021-->M2027			
Option	G2015-->G2021-->G2027			

Objectives, criteria and impacts		Qualitative measure	Quantitative measure	Assessment
Environment				
Ecology of waterbody				
Diverse Ecology	a	Adequate reduction in the risk of meeting good status so that good status should be achieved by 2015	Risk of not meeting good status reduced from 55% to 5% delivering 27km of water to good status	+ve
River bank habitat	a	Factors not limiting at present, but improved structure of riparian zone	No quantitative measure	*[BT value = £8,000/yr]*
Water quality	a	Water quality (nutrient status limiting) this limit is removed.	Reduction in nutrient loading from 150% of capacity to 80%	+ve
Local Air Quality	b	No impact	No quantitative measure	n.a.
Regional Air Quality	c	No impact	No quantitative measure	n.a.
Global Air Quality	d	Reduced methane emissions from dairy farming	Reduction of approximately 300 tonnes of CO_2 equivalents	BT value = £1,500/yr
Landscape	e	No impact	No quantitative measure	n.a.
Townscape	e	No impact	No quantitative measure	n.a.
Heritage of historic resources	e	No impact	No quantitative measure	n.a.
Economic value of water (priced) uses	f			
Public water supply		No impact	No quantitative measure	n.a.
Industrial water use		No impact	No quantitative measure	n.a.
Agricultural water use		No impact	No quantitative measure	n.a.
Commercial fisheries/shellfisheries		No impact	No quantitative measure	n.a.
Economic value of water (unpriced) uses	g			
Informal recreation		Improved recreation opportunities from moderate to good	15km of improved bankside habitat involving 1000 visits per year	BT value = 25,000/yr
Angling		Improved fishery quality from T2 to T1	Delivers 8km of improved fishery involving 250 angling visits per year	BT value = 40,000/yr
Other in-stream uses		None	No quantitative measure	n.a.
Residential amenity		No impact	No quantitative measure	n.a.
Commercial amenity		No impact	No quantitative measure	n.a.
Wider economic impacts	h			
Employment		No impact	No quantitative measure	n.a.
Regeneration		Rural economic diversification	No quantitative measure	+ve
Competitiveness		No impact	No quantitative measure	n.a.
Social	I			
Social inclusion/cohesion		No impact	No quantitative measure	n.a.
Distribution of costs and benefits		Improvement	Index of cost recovery improves from 0.90 to 0.95	+ve
Policy Integration	j			
Land-use policy		Consistent with land use policies	No quantitative measure	+ve
Other government policies		Generally supportive of other government policies	No quantitative measure	+ve

However, it is often very difficult to obtain (reliable) quantitative estimates for all costs and benefits, which are necessary for conducting a CBA. Therefore, the proposed disproportionality assessment should use quantified costs and benefits where possible, **but it strongly emphasises the need to incorporate qualitative measures where quantitative ones are unavailable.** The final output should look at developing a table where qualitative, quantitative and monetary information is presented so that trade-offs are transparent, e.g. when justifying derogation for a specific water body (see *Illustration 5* of this information sheet).



Look out! There is a link between the disproportionate cost analysis and the cost-effectiveness analysis: don't do it twice!
In terms of process, it is important to bear in mind that the evaluation of costs and benefits for the purpose of the disproportionality assessment will take place after having conducted a cost-effectiveness analysis for the construction of a programme of measures. As a result, it will not be necessary to estimate again the costs (and potentially, benefits) that will have been estimated for the cost-effectiveness analysis. For the measures that are part of the programme of measures, the cost-effectiveness analysis will have estimated:

- The direct or financial costs (including administrative costs);
- The non-water related environmental costs;
- The resource costs;
- The indirect costs (i.e. related losses in economic production).

In addition to this, and for the measures in the Programme, the disproportionality assessment will require estimating the induced costs (i.e. costs for other sectors of the economy) and the water-related environmental costs. However, in some cases, the induced costs might have been estimated as part as a follow-up to the cost. For measures outside of the programme, all these cost categories will need to be estimated. A fully quantified cost benefit analysis is not required for each assessment, however costs and benefits should be quantified wherever possible – in particular where markets exist.

Illustration 5 – Assessing disproportionate costs in the Ribble (United Kingdom)

This illustration outlines the procedure carried out for assessing disproportionate costs of measures in the Ribble basin. Drawing on potential impacts (identified by the stakeholder consultation processes at the earlier Objective specification stage), a matrix of costs and benefits for two identified measures was developed (see tables). The first (high cost) Option 1 achieves good status by 2015. The second (lower cost) Option 2 achieves good status by 2021. An important prior consideration here is the extent to which costs can be reduced by extending the time scales for the measures.

Given the potentially large number of water bodies for which more detailed assessments may be needed, it will not be possible to carry out original research and surveys in each and every case. Consequently, some form of 'benefits transfer' (BT) analysis may be needed, which would apply valuations derived from other studies of similar cases.

The results of the application of the BT exercise are shown in the tables, where monetarised benefits of £74,500/yr (Option 1) and £51,000/yr (Option 2) are estimated.

Given the high incremental cost of Option 1 (£300,000/yr), the results of the benefits transfer exercise are taken as evidence that a timing derogation, allowing good status in 2021 (Option 2) to be the objective, may be an appropriate strategy. In this case, however, it is assumed that there is sufficient uncertainty about whether the BT exercise fully captures the important differences between the options – particularly in terms of the incremental ecological improvements, which are not measured well in the existing benefits transfer information, and the rural economic diversification benefits. It is decided, therefore, that this water body should be passed on for further stakeholder consultation.

However, in-depth stakeholder consultation can only cover a small number of people. In addition, the consultation raises the issue of how to value some types of benefits – those that accrue to relatively affluent sections of the population, who may not reside within the basin but may bring in tourist revenues. These are issues that require a more broad-based assessment, using a more representative sample of affected people. Consequently, the conclusion of the assessment is, that this water body should be one of those, on which further stated preference analysis would be undertaken.

Analysis of the data (through modelling) reveals an implicit valuation of the benefits of Option 1 at £40,000/yr.

This information would then be incorporated into the revised AST to facilitate the overall decision making by DEFRA (Department of Environment, Food and Rural Affairs). This final decision-making would be done on the basis of all the evidence – quantitative, qualitative and indicator (monetary and non-monetary). In this case, the implication would be that the goal of good water status in 2015 would involve disproportionate costs.

Source: J. Fisher. Integrated appraisal for river basin management plans. See Annex E.

Option 1 – Undertaking STW Optimisation, Operational P Removal and Negotiated Agreement with Dairy Farmers

Option Definition and description

Option	Ribble nutrient strategy	Option Description	Problem	EAV of costs £/yr
BUC:	B2015-->M2021-->M2027			370,000
Option	G2015-->G2021-->G2027	Undertake STW optimization, operational P removal and negotiated agreement with Dairy farmers	Excessive input of nutrient which limits the achievement of good status	

Objectives, criteria and impacts	Note	Qualitative measure	Quantitative measure	Assessment
Environment				
Ecology of Wate-body				
Diverse Ecology	a	Adequate reduction in the risk of meeting good status so that good status should be achieved by 2015	Risk of not meeting good status reduced from 55% to 5% delivering 27km of water to good status	+ve
River bank habitat	a	Factors not limiting at present, but improved structure of riparian zone	No quantitative measure	*[BT value = £8,000/yr]*
Water quality	a	Water quality (nutrient status limiting) this limit is removed.	Reduction in nutrient loading from 150% of capacity to 80%	+ve
Local Air Quality	b	No impact	No quantitative measure	n.a.
Regional Air Quality	c	No impact	No quantitative measure	n.a.
Greenhouse gasses/climate change	d	Reduced methane emissions from dairy farming	Reduction of approximately 300 tonnes of CO_2 equivalents	BT value = £1,500/yr
Landscape	e	No impact	No quantitative measure	n.a.
Townscape	e	No impact	No quantitative measure	n.a.
Heritage of historic resources	e	No impact	No quantitative measure	n.a.
Economic value of water (priced) uses	f			
Public water supply		No impact	No quantitative measure	n.a.
Industrial water use		No impact	No quantitative measure	n.a.
Agricultural water use		No impact	No quantitative measure	n.a.
Commercial fisheries/shellfisheries		No impact	No quantitative measure	n.a.
Economic value of water (unpriced) uses	g			
Informal recreation		Improved recreation opportunities from moderate to good	15km of improved bankside habitat involving 1000 visits per year	BT value = 25,000/yr
Angling		Improved fishery quality from T2 to T1	Delivers 8km of improved fishery involving 250 angling visits per year	BT value = 40,000/yr
Other in-stream uses		None	No quantitative measure	n.a.
Residential amenity		No impact	No quantitative measure	n.a.
Commercial amenity		No impact	No quantitative measure	n.a.
Wider economic impacts	h			
Employment		No impact	No quantitative measure	n.a.
Regeneration		Rural economic diversification	No quantitative measure	+ve
Competitiveness		No impact	No quantitative measure	n.a.
Social	I			
Social inclusion/cohesion		No impact	No quantitative measure	n.a.
Distribution of costs and benefits		Improvement	Index of cost recovery improves from 0.90 to 0.95	+ve
Policy Integration	j			
Land-use policy		Consistent with land use policies	No quantitative measure	+ve
Other government policies		Generally supportive of other government policies	No quantitative measure	+ve

Option 2 – Undertaking Operational P Removal and Negotiated Agreement with Dairy Farmers

Option Definition and description

Option / BUC		Option Description	Problem	EAV of costs £/yr
Option Ribble nutrient strategy **BUC:** B2015-->M2021-->M2027 **Option** M2015-->G2021-->G2027		Operational P removal and negotiated agreement with Dairy farmers	Excessive input of nutrient which limits the achievement of good status	70,000
Objectives, criteria and impacts				
Environment				
Ecology of waterbody	Note	**Qualitative measure**	**Quantitative measure**	**Assessment**
Diverse Ecology	a	Adequate reduction in the risk of meeting good status so that good status should be achieved by 2021	Risk of not meeting good status reduced from 55% to 5% delivering 27km of water to good status in 2021	+ve
River bank habitat	a	Factors not limiting at present, but improved structure of riparian zone	No quantitative measure	*[BT value = 5,000/yr]*
Water quality	a	Water quality (nutrient status limiting) this limit is removed.	Reduction in nutrient loading from 150% of capacity to 80%	+ve
Local Air Quality	b	No impact	No quantitative measure	n.a.
Regional Air Quality	c	No impact	No quantitative measure	n.a.
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Policy Integration	j			
Land-use policy		Consistent with land use policies	No quantitative measure	+ve
Other government policies		Generally supportive of other government policies	No quantitative measure	+ve

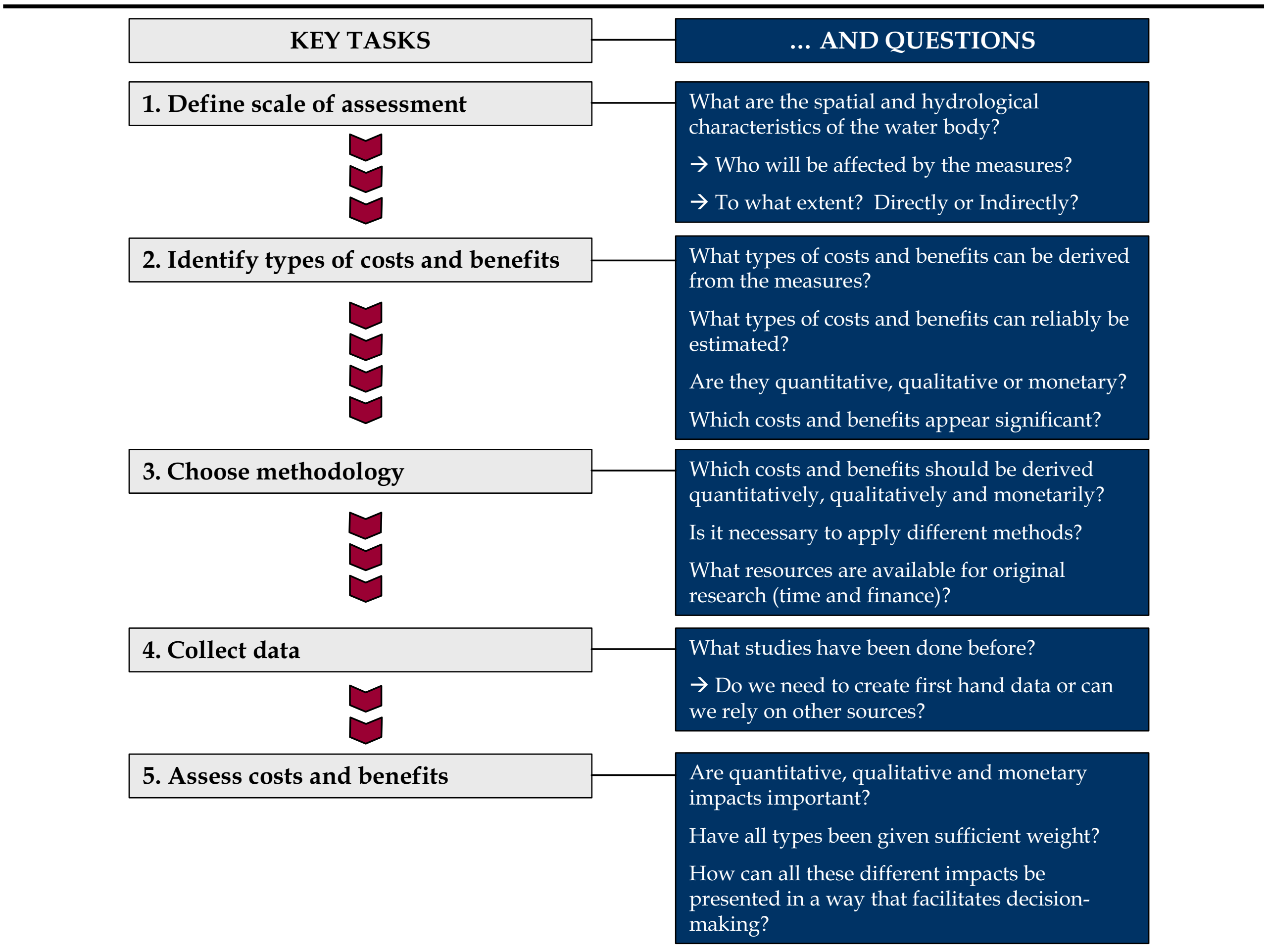
3. What are Practical Tasks for Comparing Costs and Benefits?

The rest of this information sheet deals in more details with the process for carrying out the estimation of costs and benefits. Attempting to measure the net benefits for the whole economy would often prove impossible. For the assessment of costs and benefits, the assessment would therefore need to be limited to the parties *directly* concerned with the policy measures.

In fact, a derogation would often be sought for failing to meet the Directive's objectives at the level of a particular water body and the definition of the appropriate scale of analysis would also have to do with the spatial and hydrological characteristics of the water body. For example, in order to reach the environmental objectives for a small, acidified lake, you may consider implementing a liming scheme. When looking at the costs and benefits you may want to restrict the impact assessment to the population of the one village immediately adjacent to that lake. However, if you are dealing with pollution of a complex groundwater system, the scale of impacts may necessitate the inclusion of neighbouring villages.

Tasks for assessing costs and benefits of reaching the environmental objectives of the Directive are presented in *Figure 1* below and explained in the following Sections.

Figure 1 – A Process for Assessing Costs and Benefits



Task 1 - Define the Key Groups Potentially Affected by the Measures Aimed at Achieving Good Water Status

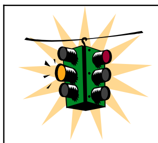
Achieving the environmental objectives set out in the Directive will have varying impact on a large number of parties. However, all these groups will not be affected directly and, as mentioned above, it might be difficult to assess the induced costs and benefits and unnecessary or too difficult to assess the tertiary impacts. Remember that every assessment has finite resources. It is therefore important to concentrate on groups that are most affected.

Task 2 – Identify the Types of Costs and Benefits Arising from the Measures and Focus on the Significant Ones

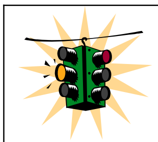
Once the user groups have been identified, the types of costs and benefits that are likely to arise must be determined. In *Task 3.2* of the Guidance, the most cost-effective measures will need to be identified (see *Estimating Costs* Information Sheet and Task 4 of the *Cost Effectiveness Analysis* Information Sheet). Following this task, the direct and non-water related environmental costs of the programme of measures will be known.

It is important to evaluate and focus on the costs and benefits likely to have an important impact, for example those that appear to have a significant effect compared with the baseline (see *Baseline Scenario* Information Sheet) and, within them, identify the different types of benefits (requiring different methods of measurements).

As an option, a matrix can usefully be created to map and rank the different types and significance of benefits arising from achieving the objectives. This matrix/list should include both qualitative and quantitative benefits and address issues such as magnitude of benefits, importance in relation to decision-making and other criteria for selecting or deselecting different benefits.



Look out! …for double counting when estimating costs and benefits!
The use of multiple methods may be important to compare different measures of costs and benefits, however it is important to avoid *double counting*. Double counting may arise because the same benefits have been 'picked up' several times (either as benefits or avoided costs) within the same study or separate studies when adding values across and will overstate the expected benefits.



… and don't forget to take into account uncertainty of the estimates!
It is important to describe the sources of estimates and confidence for all sources of cost and benefit estimates. This is important since all estimations of benefits, whether qualitative or quantitative, can be more or less certain. In particular, when using benefits transfer, using estimates in a context that they were not derived in may induce a high degree of uncertainty.

Task 3 – Choose Methodology for Estimating Costs and Benefits and Collect Data

Estimating Costs Information Sheet outlines the many ways of measuring environmental costs and benefits. Different methods can be used to estimate different types of benefits and are appropriate in different contexts. For example, direct market methods are applicable when environmental goods are factor inputs and changes in availability or quality affects production costs and a qualitative description is useful under some circumstances. *Box 6* in *Estimating Costs* Information Sheet, which gives some guidance on when to choose what methodology.

Task 4 - Carry Out the Assessment of Costs and Benefits

It is important to assess *all* costs and benefits, including qualitative and quantitative (biophysical and monetary) items. By now, you will have estimated the cost of the measures (see *Task 3.1* of the Guidance). Similarly, you will have assessed environmental impacts of the programmes of measures. You should describe these clearly.

If unit costs have been derived and will be applied to the environmental impacts, the number of units and cost or benefit per unit must be presented. This will facilitate the estimation of total effects: for unitary measures the unit environmental cost or benefits should be multiplied by the quantified biophysical impact.

- ***Note that technical expertise (e.g. from experts working on the analysis of pressures and impacts) is necessary for producing such estimates. There is a need to integrate economic and biophysical impacts in the Cost Benefit Assessment.***

Where qualitative values are minor, these shall at least be listed alongside the quantitative estimates of net benefits to support/contradict them. However, it is likely that qualitative values will play an important role. Look at each sector for costs and benefits, and present these in a way that aids decision-making. A tool could usefully be developed to achieve an efficient presentation. A rough example of such a presentation for reducing anthropogenic pressures (mainly nitrates) in agriculture is given in *Illustration 6* of this information sheet.

Like the Cost Effectiveness Analysis, the Cost Benefit Assessment may be incremental. In initial stages, a large part of the assessment may be qualitative, this will help single out the key issues. Quantitative estimates (both monetary and biophysical) may be added over time and as more research is complete and data are available.

Neither point estimates nor simple qualitative descriptions will alone give the decision maker information on how changes to different variables may affect the results of the assessment. It is therefore important to address uncertainty in the information presented, whether quantitative or qualitative (see *Illustration 6 - Figure 1* of this information sheet), to guard for different outcomes. Focus on the variables that are likely to have the greatest impact, and define how much these may change and would have to change in order to change the outcome of the whole assessment.

Illustration 6 - Improving the quality of water by reducing pressures from intensive agriculture by application of the proposed cost and benefit assessment methodology: An example

Objective: to improve the quality of water by reducing pressures from intensive agriculture. The assessment looks at the costs of investments and measures needed to improve water quality (and reduce the level of nitrates) and the expected benefits from these measures.

Task 1 – Define the Key Groups for the Assessment. Intensive agriculture over a limited area gives rise to a high anthropogenic pressure on the natural environment. This pressure may manifest itself in a deteriorating quality of surface waters, and may have negative economic impacts on a wide range of users, the most significant impacts being on the immediate geographical area on agriculture, industry, households, shellfish fishery and some recreational activities.

Task 2 – Identify the Types of Costs and Benefits. The programme of measures to restore water quality will affect users in the following ways:

Types of Costs

Agriculture	Restoring water quality entails investments and preventive measures and charging (a tax) on pollutants (an internalised environmental cost that can be treated as a financial cost). For curative measures, the storage and application of slurry have to be improved. This has different cost implications depending on animals. Preventive measures mainly involve the creation of grass strips, on 1 to 3 percent of the useful agricultural area. There is also a tax on every kilo of excess nitrogen.
Local Authorities and Households	To improve water quality, there has to be investment in municipal wastewater disposal systems. This involves investment and operating costs.
Industry	Industry has to invest in wastewater disposal to preserve water quality and will also increase the operating costs. Costs will have a negative effect on the unit production cost of businesses.

Types of Benefits

Local Authorities and Households	In effect, local authorities are choosing between investing in measures to protect the drinking water supply, or to bear greater health risks. An improvement in water quality makes it possible to avoid these costs (generate benefits).
Recreational Activities	Households use surface and coastal water resources for recreational activities (bathing, sport, walks, fishing). Deterioration in the quality will lead to either less use or greater health risks, all of which entail a cost.
Effect on Shellfish Culture	Water quality has a significant effect on the selling price of shellfish and the volume produced: where quality is good, it permits direct sales, giving bigger margins and a higher value added (packaging, dispatch, sale).

Task 3 - Choose Methodology and Collect Data. Once the types of benefits and costs have been identified, it is possible to select the appropriate methodologies for collecting data on benefits. Note that the costs will need to be assessed in the cost-effectiveness analysis required by *Task 3.2*. In this particular case, different methodologies are chosen for different benefit components.

Task 4 – Assess Costs and Benefits. Quantitative estimates of costs and benefits are aggregated and qualitative estimates are listed alongside.

Choice of Methods

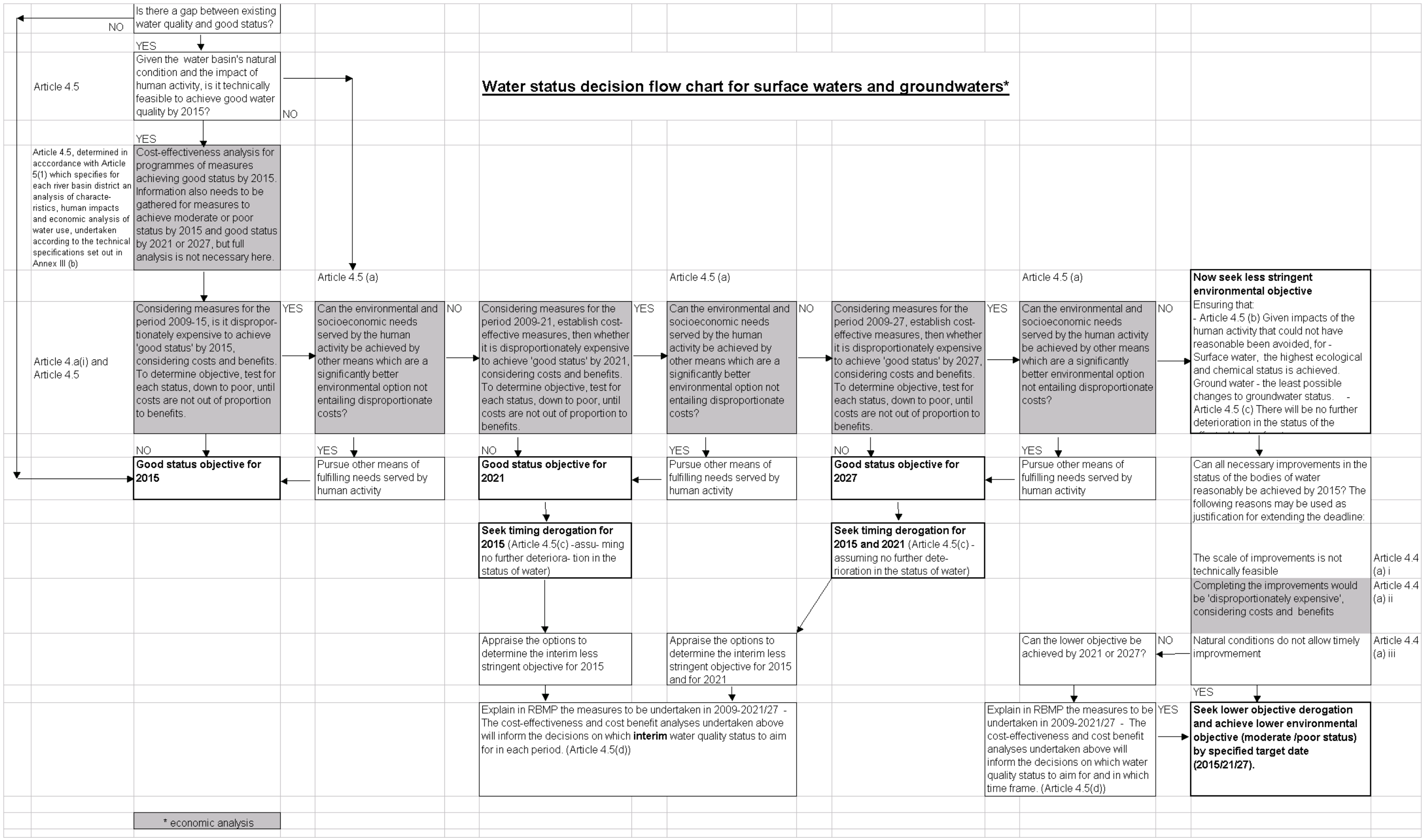
Local Authorities and Households	The costs of protection stem from the setting up of de-nitration or de-nitrification plants, changes in agricultural practices and the search for alternative sources of supply. Benefits are measured through the costs of mitigation.
Recreational Activities	Contingent valuations have been used to show households' willingness to pay to preserve these recreational uses (on top of their current water bills). These figures correspond to the user gain linked to bathing and to the value attributed to catching certain species of fish.
Effect on Shellfish Culture.	The economic loss for shellfish culture is reflected in the loss of production and profits for businesses located in the polluted area. Direct market methods were therefore used to elicit the values.

(Illustration 6 continued)

Figure 1- Assessing Costs and Benefits: ***Reducing the Anthropogenic Pressures (Mainly Nitrates) of Agriculture***

SECTOR	ITEMS	ASSESSMENT TYPE		
		Qualitative	**Quantitative** (Biophysical impacts)	**Quantitative** (Monetary impacts)
	Costs	-	-	(€)
Agriculture	Pollution control (slurry) of stock farming			
	Changing farming practices			
	Grass strips creation (preventative measure)			
Industry	*All industry* Wastewater disposal improvements: Investment costs Operating cost			
	Shellfish industry Investments in purification system			
Households	Effects of more costly wastewater disposal			
	Benefits	-	-	(€)
Agriculture	-			
Households	Avoided health costs from improved drinking water			
	Costs avoided for treatment of drinking water (de-nitration and de-nitrification plants)			
Industry	*Agri-business* Costs avoided for de-nitrification			
Recreation	Improved recreational quality			

Box 5 – Decision Flowchart



Annex D2 Analysis of derogation for New Modifications/Activities (Article 4.7) and for Designating Heavily Modified Water Bodies (Article 4.3)

INTRODUCTION

This Annex (separated into Annex D2a and Annex D2b) presents two methodological notes dealing with issues and options for integrating economics into:

- The justification for derogation that may be obtained for new modifications and activities that lead to a deterioration in water body status, following the provisions of Article 4.7 of the Water Framework Directive;
- The designation process for heavily modified water bodies as specified in Article 4.3 of the Water Framework Directive.

Both elements of the Directive have been combined in this Annex because of similarities between the role economics can play in both processes. As they stand, these notes intend to provide *food for thought* for experts that will be involved in such processes.

The note on the designation of heavily modified water bodies has been developed by the working group dealing specifically with heavily modified water bodies in the Common Implementation Strategy (see Annex A1), with input from the WATECO working group. It will be further modified, refined and integrated into the final guidance that will be developed by the heavily modified water bodies working group.

ANNEX D2a Economic Assessment of New Modifications/Activities Entailing a Deterioration in Water Status

The Directive recognises the need for integrating economic, social and operational concerns in the development of a programme of measures and integrated river basin management plans. Consequently, it allows Member States to derogate from the Directive's environmental objectives, either through the setting of a longer time frame or lower environmental objectives.

This Annex focuses on derogation that may be obtained for new modifications and activities that lead to a deterioration in water body status, following the provisions of *Article 4.7* of the Directive. It suggests a possible approach in seven steps for carrying out the analysis aimed at supporting decisions on derogation, based on a close analysis of the text of the Directive. **Figure D2a.1** summarises this approach and suggests that a number of conditions must be fulfilled in order to justify obtaining a derogation on the basis of Article 4.7.

Box D2a.1 – Summary provisions of Articles 4.7 and 4.8 of the Directive

Member States will not be in breach of the Directive when:

- Failure to achieve good groundwater status, good ecological status or, where relevant, good ecological potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of **new modifications** to the physical characteristics of a surface water body or **alterations** to the level of bodies of groundwater, or
- Failure to prevent deterioration from high status to good status of a body of surface water is the result of **new sustainable development activities**.

The conditions in which such derogation can be obtained are restricted in the following sections of Article 4.7, which provides that Member States have to ensure that:

(a) **All practical steps** are taken to **mitigate** the adverse impact on the status of the water body;

(c) The reasons for those modifications or alterations are of **overriding public interest and/or the benefits to the environment and to society** of achieving the objectives [of the Directive] are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development;

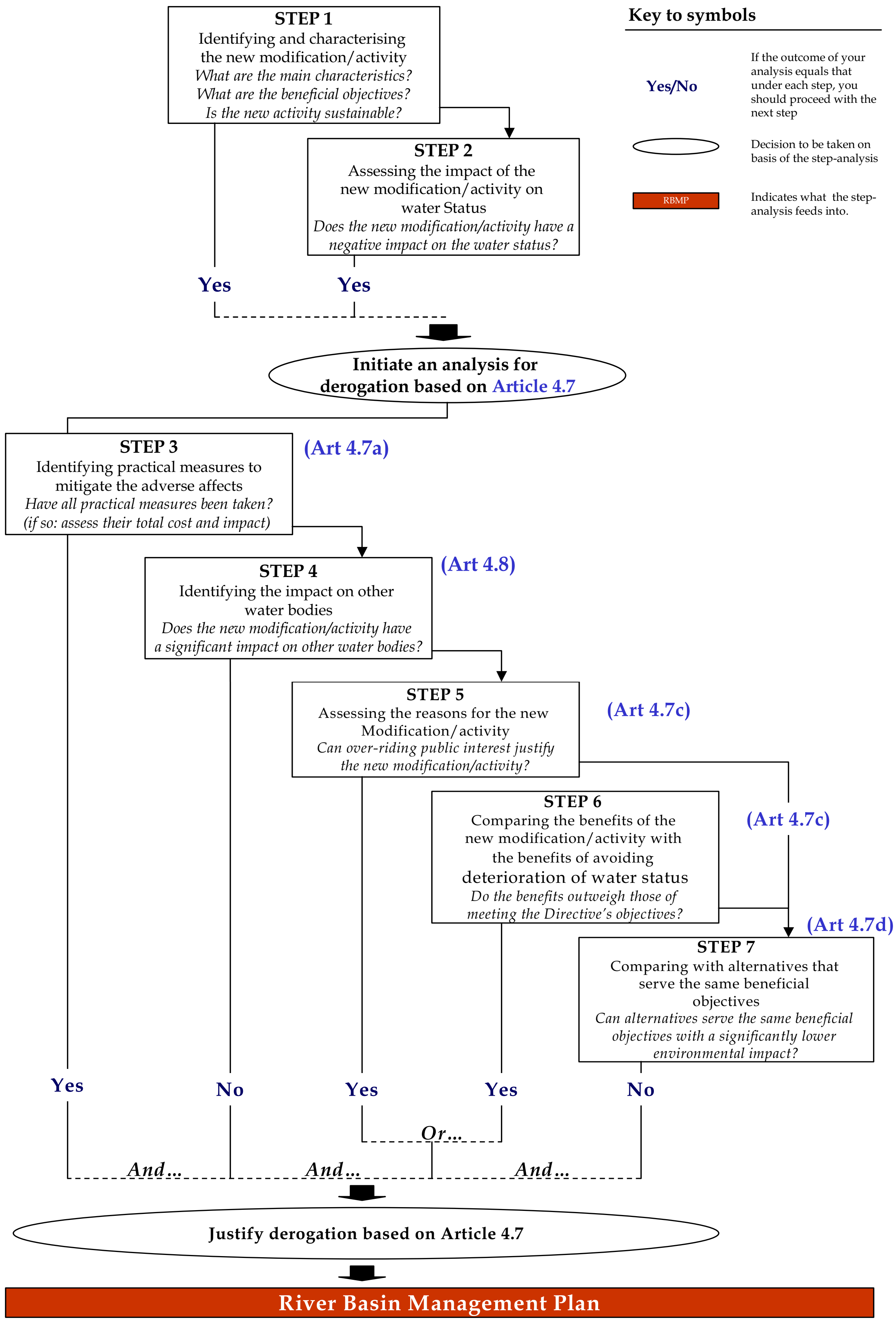
(d) The **beneficial objectives** served by those modifications or alterations of the water body **cannot for reasons of technical feasibility or disproportionate costs be achieved by other means**, which are a significantly better environmental option.

Finally, Article 4.8 sets some conditions for the use of Article 4.7 by stating:

- When applying paragraph… 7 [of Article 4], a Member State shall ensure that the application **does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water** within the same river basin district and is consistent with the implementation of other Community environmental legislation.

The rest of this document sets out a possible approach for making Article 4.7 operational. Note that this analysis could either take place in isolation when a new modification/activity emerges (for example, a new cropping pattern or a new industrial activity) or within the context of the application of the 3-Step Approach used for implementing the economic aspects of the Directive as a whole. In fact, many of the steps described below closely resemble some of the steps of the 3-Step Approach.

Figure D2a.1 – Economic Assessment of New Modifications and Activities



The analysis below will be used as a tool for estimating the need for derogation, which ultimately, is likely to be a political decision. Key decisions will follow from the following steps of the analysis:

1. *Step 1 – Identifying and characterising the new modification/activity;*
2. *Step 2 – Assessing the impact of the new modification/activity on water status:*
   - ***Decide whether to initiate the analysis for obtaining an Article 4.7 derogation.***

3. *Step 3 – Identifying practical measures to mitigate the adverse effects;*
4. *Step 4 – Identifying the broader impact on other water bodies;*
5. *Step 5 – Assessing the reasons for the new modification/activity;*
6. *Step 6 – Comparing the benefits of the new modification/activity with the benefits of avoiding deterioration;*
7. *Step 7 – Comparing the benefits of the new modification/activity with alternatives that serve the same beneficial objectives:*
   - ***Assess whether a derogation based on Article 4.7 can be justified. This can only be justified if all of the conditions for each Step 3 to 7 are fulfilled, as per Figure D2a.1.***

Step 1 – Identifying and characterising the new modification/activity

What defines a new modification or new activity?
There are two categories of "modifications" that may give rise to a derogation:

- ***A modification to the physical characteristics of the water body***, such as straightening a river or modifying the level of groundwater bodies, but without modifying the chemical and ecological dimensions of good water status (below: **new modification)**;
- ***A modification resulting from new sustainable development activities,*** although this can only be used for obtaining a derogation when surface waters go from high to good status (below: **new activity**).

The most complex issue here will be how to define *new sustainable development activity,* which mirrors the difficulties in defining the concept of *sustainability*, which integrates:

- Economic, social and environmental aspects;
- A temporal dimension (e.g. future generations) and potentially, a global dimension.

As a result, discussing the sustainability of a single economic activity or physical alteration must be put into the context of wide society objectives and goals. Box D2a.2 gives a summary of the issues linked to the definition of sustainable development and sustainability.

Practical implementation will need to be done by answering key questions:

1. What are the main characteristics of the modification or new activity?

First, it is required to identify the issue. This will be done through collecting information on the modification or activity such as:
Dimension and capacity of a dam, length of river modified, production capacity of a new industrial plant, employment linked to the development of this new industrial plant, total turnover, discharge and total volume of water potentially abstracted by a pump, total irrigated area and cropping pattern and number and type of water users involved.

Box D2a.2 – Sustainable Development and Sustainability - Selected References and Issues

The profile of sustainability and sustainable development issues has constantly increased since the early Brundtland Commission report. Along with this increasing interest, a wide number of definitions have been proposed for this highly complex issue. For example:

- Looking at sustainability from a very global point of view like the World Commission on Environment and Development (1987): *Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* The minimalist interpretation of this definition implies that future generations should not be left worse off than current generations;

- In 1992, the UNCED (United Nations Conference on Environment and Development) "Earth Summit" meeting in Rio De Janeiro, agreed prescriptions for achieving sustainable development. These prescriptions recognised that the "integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future.";

- Looking at sustainability with an increased environmental focus like the European Environment Agency (1995): … *Linked to this is the concept of the 'carrying capacity' understood as the maximum impact that a given ecosystem can sustain without permanently impairing the integrity and productivity of the ecosystem.* This clearly does not mean natural resources cannot be used; it is possible to use resources (even depletable ones) as long as the interest of future generations can be protected. The question remains on the sharing of natural resources between present and future generations and what form should this sharing take;

Thus, alternative interpretations of sustainability include (T. Tietenberg, 1996*):

- Sustainability as non-declining well-being: resources used by previous generations would not exceed a level which would prevent future generations from achieving a level of well being just as great. Thus, the value of individual components of capital stock (human, social and natural) can decline as long as the remaining elements increase to compensate this decline. This definition assumes a good substitution between natural capital and human and social capital;

- Sustainability as non-declining value of natural capital stock: the total value of natural capital should not decrease. Key to this definition is the recognition of the limited substitution between natural capital and man made capital. One form of natural capital could be decreased if it can be compensated by the increase of another natural capital (e.g. reduction of the value of fisheries compensated by an increase in the value of forests);

- Sustainability as non-declining physical service flows from selected resources. This definition stresses the physical dimension of the natural resources as opposed to their value as in the previous definitions. In the presence of critical thresholds for some resources, the cost of further degradation may escalate rapidly, calling for policies that maintain the quality and resilience of these resources. In the case of resources where critical thresholds can be defined, sustainability constraints are likely to be more binding.

The types of capital that sustain well-being including man-made, natural, human and social capital and their "adequacy" to support well-being depends on the interaction among them, as well as on the size of the population, its characteristics and preferences. The different types of capital also provide one of the main mechanisms through which generations are connected to each other – as the stocks are influenced by current investment decisions, but human lives span several generations.

To assess the sustainability of patterns of economic development, the level of demand of natural resources and the transformation processes required by human activities should then be considered. The trade-offs between different types of capital may need to be evaluated empirically for their substitutability (a rather controversial and difficult issue), describing the acceptable trade-offs. The social components and impact of policies has to be simultaneously considered. As summarised in the recent European Union strategy for sustainable development (2001), *in the long term, economic growth, social cohesion and environmental protection must go hand in hand*.

In the context of Europe, the recognition of the importance of sustainable development has led to the promotion of new instruments of analysis and planning. This includes the preparation of sustainable strategies at national, regional and local level, the preparation of Local Agenda 21 after the Aalborg Charter. At the European Union level, key policy elements include the preparation of the new Spatial Development Perspective, the Vienna Framework for Action for sustainable development, and the above-mentioned recent European Union Strategy for Sustainable Development. Regions across the European Union are currently preparing and proposing strategies and measures towards a more sustainable future.

**Source: T. Tietenberg (1996), 'Environmental and Resource Economics', 4th edition, Harper Collins*

2. ***What are the beneficial objectives served by the modification or new activity?***

   Second, it is necessary to understand the beneficial objectives of this new activity or modification. This will be based on a comparative analysis whereby the proposed activity should be compared with alternative options from an environmental and economic point of view. Examples of beneficial objectives include:
   - *Supply of specific water services to consumers or specific users, power generation and supply of electricity, employment or rural development.*

3. ***Is the new activity sustainable?***

   As mentioned above, the issue of sustainability is a complex one. To determine whether the activity is sustainable, a comprehensive assessment of its implications from an economic, social and environmental perspective will be required, such as:
   - *Economic impact: turnover, income and production patterns;*
   - *Environmental impact: water, air, soil, biodiversity, landscape, overall resource use, waste arising and renewability of resources;*
   - *Social impact: employment at both the local and the regional or national level of unemployment, social exclusion, etc.*

4. ***What is the coherence between the proposed modification/activity and existing sustainable plans and strategies?***

   Assessing the coherence between proposed modification or activity and existing local, regional, national and European sustainable development plans and strategies will ensure that the modification or activity is put into a more long-term sustainability perspective and that its contribution to broader objectives are assessed. Also, this will ensure that the interpretation of "sustainable development" is in coherence with the environmental impact assessment or strategic environmental assessment criteria that will be used prior to authorising this new activity or modification to go ahead.

Step 2 – Assessing the impact of the new modification/activity on water status

Why is it important to assess the impact on water status?
- To determine whether you need to carry out the analysis in the first place: it is only if the new modification/activity has an impact on water status that a derogation is needed;

Practical implementation can be done in two stages:

- Assess the new pressures related to the new modification/activity, especially the impact on water abstraction and pollution;
- Assess impact of these pressures in terms of likely changes in the ecological quality or quantity of water (e.g. when looking at alterations to the level of groundwater bodies).

➢ ***As mentioned above, the analysis carried out as part of Steps 1 and 2 will enable decision makers to assess whether the procedure for obtaining derogation based on Article 4.7 should be initiated. A procedure should be initiated if the proposed new modification/activity has a negative impact on water status and if the new activity is sustainable. The steps that follow include all the tests that will need to be carried out in order to justify a derogation based on Article 4.7.***

Step 3 – Identifying practical measures to mitigate the adverse effects

Why consider whether practical measures can be taken to mitigate the adverse effects?
Article 4 (a) specifies that Member States should ensure that all practical steps are taken to mitigate the adverse impact on water body status. Whether those steps (or measures) are practical or not will depend on them being both technically and financially feasible.

Practical implementation of this step will include:

- Define a range of practical mitigation measures based on their:
    - Technical feasibility within the timeframe considered (e.g. 6 years or 12 years if one time derogation is used);
    - Financial feasibility, based on their costs vs. available financial resources.
- Analyse the likely impact of these mitigation measures on the status of the concerned water body (quantity, quality, ecology);
- Assess the total costs of mitigation measures.

➢ ***An Article 4.7 derogation can only be justified if all practical mitigation measures have been taken. In addition, this Step will contribute to predicting the water status of the water body following the introduction of practical mitigation measures and assessing their total costs, so that they can be incorporated into the river basin management plan.***

Step 4 – Identifying the broader impacts on other water bodies

Why identify the impact on other water bodies?
Article 4.8 requires Member States to ensure that the new modification/activity does not permanently exclude or compromise the achievements of the Directive's objectives in other water bodies. Analysing the likely impact on other water bodies may be more difficult than analysing the impact on the local water body (as per ***Step 2***), as it requires a good understanding of the functioning of the hydrological cycle within the river basins and the biophysical relationships between water bodies. For example, it will require understanding the impact of installing a dam supplying water to an urban area in the upstream part of a river on the water status of the river's estuary, 50 kilometres downstream.

Practical implementation of this step will require:

- Assessing the likely impact of the new modification/alteration/activity on the status of other water bodies within the same river basin district before mitigation measures;
- Assessing the likely impact of the new modification/activity with mitigation measures.

➢ ***If the new modification/activity is likely to have a significant impact on other water bodies even if mitigation measures are implemented, then Article 4.7 cannot apply and the modification or new activity cannot be implemented. The contrary leads to continuing the analysis and applying the following tests.***

Step 5 – Assessing the reasons for the new modification/activity

Can over-riding public interest be invoked as a reason for the new modification/activity?
Article 4.7(c)) refers to modifications that are of over-riding public interest. However, this concept is not defined in the Directive. Similarly to what is specified in the Habitats Directive, it may cover issues of human health and human safety or other imperative reasons of social or economic nature. Making the concept of over-riding public interest practical is difficult. Key elements that may be considered for doing so include:

- Ensuring that the new modification/activity is primarily to fulfil public interests, i.e. not solely in the interest of private companies or individuals;
- The interest must be over-riding, i.e. not all types of public interest can apply. In this context, it is reasonable to assume that it must be a long-term interest. This time issue is coherent with Article 4(8) that stresses the need to ensure that improvements in the status of other water bodies cannot be permanently compromised.
- The proposed new modification/activity aims at protecting fundamental values for citizens' lives and society (e.g. health, safety), within the framework of fundamental policies for the State and society.

Practical implementation of this step will require analysing the following:

- Assessing whether the new modification/activity fulfils a public service obligation;
- Assessing whether the new modification/activity is in society's long-term interest;
- Assessing whether it aims at protecting fundamental values for citizens and society.

Note that for the analysis of the long-term interest, prospective analysis similar to what is performed for the development of the base line scenario may be undertaken. Clearly, the analysis will need to be in proportion with the importance of the new modification/activity in terms of its economic impact, its impact on the quality of waters and of the environment and on sustainable development.

➢ ***If the new modification/activity is not justified by over-riding public interest, then Article 4.7 cannot applied except if the benefits of achieving the Directive's objectives are outweighed by the benefits of the new modification/activity to human health, human safety or sustainable development (as per analysis in Step 6 below).***

Step 6 – Comparing the benefits of the new modification/activity with the benefits of avoiding deterioration of water status

Do the benefits of the new modification/ activity outweigh those of meeting the water quality objectives of the Directive?
Article 4.7(c) specifies that even if the new modification/activity is not of over-riding public interest, a derogation based on Article 4.7 could still be obtained if the benefits of the new modification/activity in terms of human health, human safety or sustainable development outweigh the benefits of achieving the objectives of the Directive in terms of water status.

Practical implementation of this step will require:

- *Investigating issues similar to those considered in analysing the "sustainability status" of new activities* as per ***Step 1*** of this analysis. These include: improvement in human health, improvements in human safety (e.g. in the case of flood protection projects), increase in economic activity or production.

- *Assessing the foregone benefits resulting from the failure to achieve the environmental objectives of the Directive*, based on the evaluation of the environmental, economic and social water-related benefits. In both cases, it should be attempted to quantify and express benefits or foregone benefits in monetary terms so as to make both parts of the analysis comparable. In many cases, however, it will be difficult to express all benefits or foregone benefits in monetary terms. Thus, the different benefits and impacts should be presented, whether in monetary terms, quantified or assessed qualitatively, in a multi-dimensional table.

  - ***If the benefits of the new modification/activity outweigh the foregone benefits from improved water status, then an Article 4.7 derogation can be invoked.***

Step 7 – Comparing with alternatives that serve the same beneficial objectives

Can alternatives serve the same beneficial objectives with a significantly lower environmental impact?
Article 4.7(d) sets as a condition that a derogation can only be obtained if the beneficial objectives to be obtained by the new modification cannot be achieved by other means with a significantly lower environmental impact, due to reasons of technical feasibility or disproportionate costs. This analysis will be similar to that carried out for designating heavily modified water bodies.

Practical implementation of this step will require:

- *Identifying the alternative options that provide the same beneficial objectives.* These may include local alternatives (e.g. pumping groundwater from an adjacent aquifer instead of building a dam on a river for supplying water to an urban area), or regional and national options (e.g. supplying electricity from a wind power station in other parts of the country instead of building an hydro-power plant on a river). A wide range of cost-effective options should be considered, and not only infrastructure development that may be easier to analyse;
- *Comparing the environmental impact of the new modification with that of alternatives.* As a first step, a qualitative assessment of the main environmental issues is required. A simple table may be prepared comparing the new modification and the proposed alternatives from the point of view of their environmental impact on water, air, soils, biodiversity, landscape, etc. In some cases, it may be possible to quantify the physical impacts on specific media, and to transform them into monetary (thus comparable) values;
- *Estimating the costs of the new modification versus that of alternative options.* These costs include investment costs, operation and maintenance costs, and any foregone benefit that may result from changes in economic activities linked to the alternatives or proposed modification. As the lifetime of the activity and proposed alternatives are likely to vary, all costs need to be annualised and computed in net present values.

  - ***If the new modification has no alternative with significantly lower environmental impact, then a derogation based on Article 4.7 can be sought.***

Information and Approaches to Undertaking the Steps

The different steps presented above require a wide range of information, expertise and knowledge on the biophysical (e.g. assessing the impact of the new activity on the status of the concerned water body), economic (e.g. assessing costs and impact on economic sectors) and social issues. Although one may attempt to quantify as much as possible the different elements to be investigated, this will often not be possible and most of the tests and questions presented above therefore needs to aggregate a wide range of quantitative and qualitative information. Approaches that can be used to gather this information include:

- *Qualitative description of the situation or impact*. In cases where it is difficult to quantify specific variables (e.g. a change in landscape), a qualitative description of a change is adequate;
- *Assessment of functional impacts (changes in services provided or functions linked to water bodies)*. Changes in services provided or functions linked to water bodies can serve as good proxy to changes in benefits or foregone benefits linked to a modification or new activity;
- *Consultative Forum*. Involving stakeholders for providing information and their assessment of various alternatives and options. This approach, that takes account of social issues and cultural/local perceptions, is clearly in line with the encouragement to involve all interested parties as spelled out in Article 14 of the Water Framework Directive;
- *Expert Group Panels*. Involving a (subjective but well-justified and transparent) technical assessment of alternative options by a multi-disciplinary team of experts; and
- *Economic assessments*. Good for comparing the costs of different alternatives for delivering the beneficial objectives considered, for comparing the benefits and foregone environmental benefits linked to new activities, for comparing (when monetary valuation possible) the environmental impact of different options.

The involvement of stakeholders and of experts panel groups is particularly important to assess issues that are multi-dimensional and that cannot be summarised into a single variable or figure. This is particularly true for assessing:

- Existing trade-offs between social, economic and environmental issues and deciding whether a new activity is sustainable (***Step 1***);
- Whether the modification or new activity can be justified on over-riding public interest grounds (***Step 5***);
- Whether the benefits from the proposed modification or activity are higher (or better valued) than the degradation to water bodies (***Step 6***); and
- Whether the proposed modification or new activity is indeed better than possible alternatives (***Step 7***), i.e. how to interpret the notions of *significantly better environmental option* and *disproportionate* costs.

Table D2a.2 summarises the general types of information required for the different steps of the analysis supporting the use of Article 4.7 and Article 4.8. The table stresses the multi-disciplinary approach required for assessing whether the use of derogation under these articles is indeed justified.

Table D2a.2 – Information Needed for Undertaking the Steps

Steps in the assessment		**Type of information**			
		Environment	Economic	Social	Technical
Describe the modification or new activity and its impact	Describe modification or activity				
	Assess sustainability				
	Assess impact on water status				
Identify mitigation measures and their impact	Define mitigation measures				
	Assess impact of mitigation measures on water status				
Assess impact on inter-connected water bodies					
Justify the modification or new activity	Assess overriding public interest				
	Benefits of activity versus foregone benefits				
Compare the modification or new activity with alternative options for providing beneficial objectives	Identify technically feasible alternatives		instruments		
	Compare environmental impact		When monetary values available		
	Compare costs				

ANNEX D2b Consideration of the Possible Appraisal Techniques Involved in the Designation Process for Heavily Modified Water Bodies

1.0 Purpose

1.1 This paper is intended as guidance for the case studies being undertaken on Heavily Modified Waterbodies (HMW) (WFD CIS Guidance Document No. 4). It is anticipated that the experience gained from the case studies will inform the development of Common Implementation Strategy Guidance.

1.2 The designation of water bodies as heavily modified involves the use of tests specified in Article 4(3) of the Water Framework Directive. This paper considers some of the options available to inform this decision making process.

1.3 The paper has been produced by the representatives from the HMW and Economics working group. It has been discussed and approved by the HMW Working Group.

2.0 Introduction

2.1 The designation process of heavily modified water bodies starts with the identification of those water bodies, which are substantially changed in character as a result of physical alterations by human activity (see HMW paper 3 (strategy)). This identification step does not require the use of economic assessment.

2.2 Following this initial identification step, two tests are proposed in Article 4(3) for the designation of heavily modified water bodies.

- Firstly, it is necessary to assess whether there are significant adverse effects on specified uses, which would result from the necessary mitigation measures required to achieve good ecological status for the water bodies considered;

- Secondly, if uses are significantly affected, then a review of other better options for providing the specified use should be undertaken by investigating issues of technical feasibility, environmental impact (better environmental options) and costs (disproportionate costs) of these options.

2.3 In practical terms, a very large number of water bodies will have to be assessed for possible designation as HMW over the period until 2009[12]. It will therefore be important to ensure that the methods used for the designation process are simple and pragmatic. Moreover, it is important to develop appropriate options so that the complexity of the assessment methodology can be made proportionate to the circumstances.

2.4 There are different appraisal techniques, which could help in the designation process by providing a systematic way of analysing and reporting designation decisions. Examples of techniques that may be chosen (independently or combined) include:

- **Qualitative description of the situation** - appropriate for circumstances where the situation is clear cut (refer to HMW paper 5 "pressures and physical alterations", No 11 negative list;

[12] How to identify water bodies (based on which criteria, which scale, etc) still needs to be discussed and agreed in the context of the Common Implementation Strategy activities. The chosen approach is likely to influence the total number of water bodies within a river basin, and thus the total number of heavily modified water bodies to be designated.

- **Consultative forum** - involving a participatory approach to identifying whether foreseen impact on uses is indeed considered as significant. This approach, that takes account of social issues and cultural/local perceptions, is clearly in line with the encouragement to involve all interested parties spelled out in Article 14 of the Directive;

- **Expert group panels -** involving a (subjective but well-justified and transparent) technical assessment of the options by a multi-disciplinary team of experts;

- **Assessment of the functional impacts** - providing an assessment of the impact upon the "use(s)" in terms of changes in services provided or functions linked to the water body;

- **Economic assessments** - by comparing costs of different alternatives for delivering the beneficial objectives considered, or by comparing costs and benefits of options.

3.0 HMW Designation test "Significant Adverse effects upon specified uses" - Article 4(3)(a) (ii - v)

> ***Article 4(3)(a)***
> *the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on: …….[specified uses]*

3.1 This test requires consideration of the context and scale of the effects on the listed activities (uses) which would result from necessary changes to achieve good status. There is no obvious way in which a single value could be considered significant. The assessment of significance will, by necessity, be based on the context and scale of the modification to the water body.

3.2 Simple qualitative descriptive methods would be appropriate where:

- The adverse effects on uses are relatively small in relation to the specified use (clearly not significant); or

- The adverse effects on uses are large and clearly prejudice their viability (clearly significant). This is particularly relevant when necessary changes to achieve good status imply the cessation of specific uses, functions and related human activities.

3.3 There may be a number of circumstances where the scale of adverse effect is more finely balanced. Under these circumstances, it is appropriate to undertake a quantitative assessment of the impacts to the use to justify their significance. Simple and consistent tools and approaches may therefore be required to assess the significance of impacts upon uses. This could include the following approaches.

- An assessment can be carried out of the change in use and function (e.g. the reduction in the quantity of hydro-power that can be generated from a hydro-power scheme). This can provide a first and robust quantification of the resulting change in use;

- It may be possible to assess the economic impact resulting from necessary changes to achieve good status. Thus, the economic benefits (in €) linked to the use of water under the present situation are compared with the economic benefits (in €) that would be obtained from the required change in use.

3.4 In both cases, relative values are preferred to absolute values for discussing the issue of significance. For example, a reduction of an irrigated area by 100 ha can be considered as significant as compared to a total irrigated area of 105 ha, but not significant as compared to a total area of 120,000 ha. This clearly makes the choice of the denominator of the relative value of particular importance (i.e. to identify the scale of the use to be considered). The information obtained can be fed to a consultative forum or group of experts for deciding whether changes are indeed considered as significant.

4.0 HMW designation test "Significant Adverse effects upon the wider environment" - Article 4(3)(a)(i)

> ***Article 4(3)(a)***
> *the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on: …….*
> *(i) the wider environment*

4.1 Changes in the hydro-morphological characteristics of a given water body may have significant impact on the wider environment, for example:

- The restoration of flood plains may threaten a specific landscape and biodiversity that has developed over the years as a result of the elimination of the floods in the riparian zones and former floodplains;

- The removal of a dam that may lead to the elimination of wetlands that have developed in connection to the water storage.

4.2 Where the modified waterbody could be designated under another Directive such as the Habitats Directive, it is assumed that the Directive with the highest standards will apply. If a HMW was designated under the Habitat and Species Directive, it would not be appropriate to consider mitigation measures required to achieve good status, if this compromised the reason for designation.

4.3 As for the previous test on the significance of adverse effects on uses, there may be a need to quantify such changes. However, to provide meaningful quantification of changes in values of landscape or biodiversity is likely to be difficult and a source of controversy (e.g. a reduction by 20% of the hedge rows of a given landscape clearly does not reduce the value of the landscape by 20%). Consequently, the qualitative assessment of changes is the preferred option. The information obtained could also be fed to a consultative forum or group of experts for deciding whether changes are indeed considered as significant.

5.0 Designation test: "Beneficial Objects" Article 4(3)(b)

the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.

5.1 This part of the article requires consideration of whether there are better environmental options for delivering the beneficial objectives served by the artificial/modified characteristics. However, identification of better environmental options is constrained by consideration of reasonableness that is made operational through two elements: technical feasibility and level of costs.

5.2 Thus, there are three aspects to this test. Alternative means to achieve the existing "water use" (or uses) must:

- be technically feasible;[13]
- achieve significantly better environmental option;
- not be disproportionately costly.

Significantly better environmental option

5.3 Reaching an agreed understanding of the meaning of significantly better environmental options has proved difficult. Two interpretations of the Directive's requirements have been proposed.

- The assessment should only consider local alternatives associated with the water environment. This may be consistent with the Water Framework Directive *per se*, but not with the overall issues of sustainability as promoted in EU and national sustainable development strategies;

- A wider interpretation requires consideration of local alternatives and regional/national alternatives that may provide the same service/function (e.g. replacing navigation with road or rail transport, replacing hydropower with nuclear or wind energy) and investigating the impact of these options on a wide range of environmental concerns.

5.4 The wider interpretation involves looking at not only water, but also air, soils, bio-diversity or landscape issues. This ensures alternative options are not better options from a purely water point of view leading to replacing water problems by other environmental problems (this may be the case for example if navigation is replaced by road transport). In the case of water, options have to account for the improvement in water quality resulting from the restoration to good ecological status in the heavily modified water body considered.

5.5 As a first approach, a qualitative assessment of the main environmental issues is required. A simple table may be prepared comparing the existing use and the proposed alternatives from the point of view of their environmental impact.

5.6 In some cases, the quantification of the physical impacts of the existing use and alternatives may be possible. Such impacts may be transformed into monetary (and thus comparable) values.

Disproportionate costs

5.7 Three possible approaches to assessing whether costs are disproportionate are described:

[13] Technical feasibility is put here as the first check, as assessing the environmental impact of options that are not technically feasible is clearly of no use.

- comparison of costs of alternatives;
- comparison of overall costs and benefits of modifications and alternatives; and
- costs versus ability to pay.

All three approaches could be considered in the case studies.

Comparison of cost alternative

5.8 The concept of disproportionate costs can be assessed by comparing the existing costs of delivering the use, service or beneficial objective, with the costs of alternative options. The main cost elements that are to be considered include:

- For the existing situation***:*** operation and maintenance costs, but also replacement costs (principal and interest payment);

- For each option/alternative**:** capital costs (principal and interest payment), operation and maintenance costs, and possible foregone benefits from changes in economic activities resulting from the option (e.g. reduction in agricultural production resulting from the development of a retention area as an alternative to dykes for preventing floods)

Costs versus ability to pay

5.9 Assessing costs of alternatives with ability to pay. Although ability to pay is not directly a designation process issue, it can be a useful way to assess different alternatives serving the same beneficial objectives.

Comparison of overall costs and benefits

5.10 Comparing the overall costs and benefits of the existing modification. This assessment ensures that the modification provides an overall net benefit to society, and is more consistent from an economic perspective than the two tests (comparing environmental impacts and the costs of alternatives separately) proposed above.

General considerations

5.11 The economic appraisal of the alternative modifications will need to consider in priority:

- The best practice techniques customarily used for each type of modification (e.g. flood defence, navigation etc.) to ensure environmental impacts of alternatives are properly compared;

- The most cost-effective alternatives, i.e. those that provide the same service at the lower costs.

5.12 In some situations, local cost information may be collected for comparing alternatives. In other situations (e.g. when comparing the costs of hydropower as compared to other energy sources), or as a first step/proxy, benchmark information available at regional, national or European scales can be used.

5.13 To ensure cost information between existing modifications and options can be compared, and because of the likely different life times and temporal distributions of costs, all costs have to be annualised using standard discounted cash flow analysis and appropriate discount rates.

Descriptive or quantitative methods

5.14 It is considered that in many circumstances the Article 4(3)(b) test can be addressed by describing the modification, its use and the consequences of its removal. Where such a descriptive analysis is insufficient to reach a determination, further quantification and assessment of economic variables analysis should be undertaken until a determination is possible.

5.15 It is clear that it will not be possible to define clearly where the boundaries between qualitative and quantitative assessment should be drawn. The application of the designation test to the case studies will provide a better understanding of the situations and conditions under which general and qualitative descriptions are considered sufficient. These decisions will also be a matter of local expert judgement. Consequently, it will be important to ensure that the decisions are made in a transparent and objective manner. The process of designation will be part of the River Basin Management Planning process. Designation decisions will consequently be subject to the Article 14 requirements for active involvement of all interested parties as well as the formal consultation requirements.

5.16 The information obtained on the environmental impact and costs of alternatives could be fed to a consultative forum or group of experts for deciding whether costs of alternatives are indeed considered as disproportionately high as compared to the costs of the existing means.

6.0 Timetable and River Basin Planning

6.1 HMW should be provisionally identified by 2004 as part of the characterisation of river basin districts required by Article 5. As specified above, this only requires the identification of those water bodies, which are substantially changed in character as a result of physical alterations by human activity. The identification step does not include any economic assessment and the designation tests should not be considered at this stage.

6.2 The designation tests should be considered as part of the River Basin Management Planning process to be completed by 2009. However, the logistics of the plan will require the consideration of the designation tests early during the planning process. Indeed, the designation tests must be complete in time to allow for the identification of the programmes of measures required to deliver good ecological potential in the most cost-effective way. The recommended date for the completion of the designation tests will build on the work of the *Economics* and the *Good Practice in River Basin Planning* working groups.

6.3 In the context of the preparation of the River Basin Management Plan, it is important to ensure compliance with Article 4.8. This requires Member States to ensure that the designation of specific water bodies as heavily modified *does not permanently exclude or compromise the achievement of the objectives of the Directive in other bodies of water within the same river basin district, and is consistent with the implementation of other Community environmental legislation*. Where failure to comply with Article 4.8 is predicted, then the body of water cannot be classified as heavily modified and should reach good ecological status.

7.0 Conclusions

7.1 A common appraisal framework for designating heavily modified water bodies across Europe is presented in Figure 1. Although the different steps of this framework are valid for all situations, the level of analysis and the need for quantification and economic assessment is likely to be variable, to take account of differences of the modification examined and its importance at the local and national scale.

7.2 The case studies within the HMW project offer the opportunity for Member States to test in a consistent manner the different steps of the designation process and to assess the level of quantification and economic assessment that may be required under specific situations. This will provide valuable examples of how the process of addressing the designation tests can be undertaken, and may allow the identification of types of analysis adapted to types of situations.

The following issues should be considered:

- Identification of methods and procedures to make decisions;
- Consideration and testing of relevant methods for evaluating the impact of changes to natural conditions in terms of changes in uses, functions, economic benefits;
- Assessment of disproportionate costs in terms of: (a) comparison of costs of alternatives; (b) comparison of overall costs and benefits of modifications and alternatives; (iii) costs versus ability to pay;
- Consideration of who should be involved (e.g. consultation forum, experts groups) during the designation process.

7.3 In many cases full scale economic assessment will not be necessary and descriptive methodologies may be sufficient for sound judgements to be made. The use of economic appraisal methodologies should themselves be proportionate, and used where such economic assessment is likely to improve decision-making. It will then be important to ensure adequate economic information is collected at the right spatial scale (i.e. linked to the beneficial objective and use) so the economic assessment can be performed in a timely manner.

7.4 Table 1 attempts to provide preliminary Guidance for the type of approach that may be required under different situations. However, Table 1 is to be taken cautiously for two reasons:

(i) the content of the table is to be refined and validated through the process of designating water bodies in the different case studies developed by the HWM group;

(ii) the designation of heavily modified water bodies can be part of an iterative process that alternate discussion with stakeholders and further analysis if required/no consensus is obtained on the answer to the specific tests that are part of the designation process.

7.5 To assist in the reporting of the case studies a standard format is provided (Table 2). This table lists the range of issues and information that may be considered through the designation process. Clearly, not every cell of the table needs to be completed. This is particularly the case for comparing the environmental impact of the modification with alternatives: some environmental impacts will be described qualitatively, while others will be quantified in terms of physical changes or in monetary terms.

Figure 1 - Flow chart summarising the steps required to address the Article 4.3 designation tests

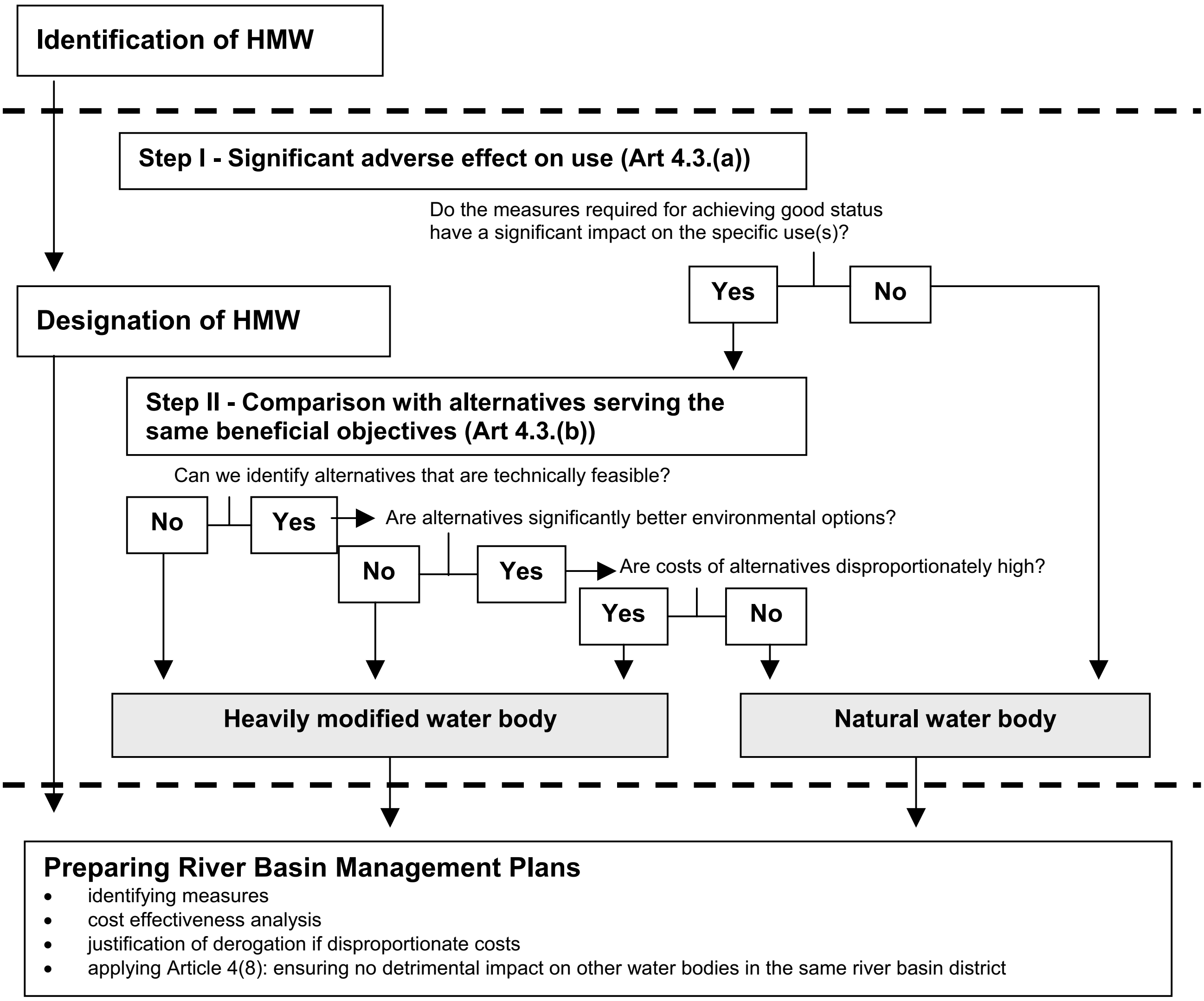


Table 1 - Preliminary Guidance on the use of descriptive and quantitative methods

Test	Qualitative assessment	Quantification of impact on use, function	Assessment of economic variables using benchmark information (costs, benefits)	Assessment of economic variables requiring specific methodology
Significant adverse effect	If abandonment of, or major change in, use/function/activity, or If very limited change in use	When partial change in use, function		Where significance of change in use uncertain
Better environmental options	Qualitative assessment for impact on different media as basis for analysis	If uncertain about which option is best		
Disproportionate costs	Description of scale of costs and also benefits if judgement / conclusion is clear	N.A.	National / Local scale benchmarking may provide sufficient clarity for good judgement	Where local situation significantly different from benchmark case or where other reasons for uncertainty exist

Table 2 - Reporting template for appraisal methods

Assessing the significance of the impact on use(s)

Assessing the significance of the impact on use(s)	Actual use				Foreseen use with good ecological status				Comparison actual versus good ecological status				Assessment
	Use (quantity, quality)	Production	Turn over, income	Employment	Use (quantity, quality)	Production	Turn over, income	Employment	Use (quantity, quality)	Production	Turn over, income	Employment	
Use 1													
Use 2													
Wider environment													
Significant impact on use(s) - Overall assessment													

Comparing existing modification with alternatives serving the same beneficial objectives

Environmental impact	Actual Use			Option 1			Option 2			Option 3			
	Qualitative	Physical	Monetary	Qualitative	Physical	Monetary	Qualitative	Physical	Monetary	Qualitative	Physical	Monetary	
Air													
Water													
Soil													
Landscape													
Environmental impact - Overall assessment													

Costs	Actual use	Option 1	Option 2	Option 3	
Investment costs					
Operation & Maintenance costs					
Possible foregone economic benefits					
Total annualised costs					

ANNEX D3 List of References

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http://eaufrance.tm.fr

All final reports from the different scoping and testing activities undertaken in the context of the development of the economics Guidance Document are available on this website.

http://www.ifen.fr/pages/4eaulit.htm#65 - The Artois Picardie River Basin Agency.

Annex E – Results of Scoping and Testing in Pilot River Basins

INTRODUCTION

This Annex presents the activities and projects undertaken by experts from different river basins and countries for testing specific elements of the economic approach proposed in the WFD CIS Guidance Document No. 1. These activities have been key in assessing the feasibility and practicality of this approach. Furthermore, they have provided opportunities in many countries for launching discussions between technical and economic experts, stakeholders and policy makers on the key elements of the economic analysis and more generally of integrated river basin planning.

The Annex provides:

- A summary table of the activities in terms of location and key issues investigated;
- An individual summary for each activity, presenting: (i) the key water management issues at stake in the river basin or sub-basin considered; (ii) the objectives of the study and activities undertaken; (iii) expertise, stakeholders and information mobilised; and (iv) results, lessons for success, problems and outstanding issues.

The case studies included, with their specific area of focus are:

1. **Alsace Plain Aquifer (France):** Estimating disproportionate costs;
2. **Bordeaux Aquifer (France):** Testing the cost-effectiveness analysis;
3. **CIDACOS River Basin (Spain):** Undertaking the cost effectiveness analysis;
4. **Corfu Island (Greece):** Carrying out the economic analysis of water uses;
5. **Middle-Rhine River Basin (Germany):** Assessing the recovery of the costs of water services;
6. **Motala River Basin (Sweden):** Scoping an integrated appraisal for river basin management plans;
7. **Oise River Basin (France):** Testing the development of baseline scenario;
8. **Ribble River Basin (England):** Integrated appraisal for river basin management plans;
9. **Rhone-Méditerranée-Corse River Basin (France):** Assessing the pertinent spatial scale for the economic analysis;
10. **Scheldt International River Basin (The Netherlands, France, three Belgium regions):** Testing elements of the three-step approach;
11. **Sèvre Nantaise River Basin (France):** Testing the chronological feasibility of the three step approach;
12. **Vouga River Basin (Portugal):** Scoping key elements of the economic analysis;

More information on the individual summaries can be obtained:

- On the Web site www.eaufrance.tm.fr, where the final reports of the different case studies are stored and are accessible to all; and

- Directly from the contact person(s) identified at the end of each individual summary. This contact person(s) will be able to further explain the activities developed and results obtained, and to provide you with the names of other experts that have undertaken the projects and the analyses.

River Basin (country)	Issues addressed	Key lessons learnt	Part of the 3-Step Analysis
Alsace plain aquifer (France)	Assessing disproportionate costs	Use of simulation models for baseline/effectiveness analysis/disproportionate cost analysis - Difficulty to find benefits in an aquifer (except drinking water)	Step 3 – Identifying measures and economic impact ➢ Assessing disproportionate costs (Costs Benefit Assessment)
Bordeaux aquifer (France)	Analysing the cost-effectiveness of measures	Importance of the scale of analysis in the results of cost effectiveness analysis	Step 3 – Identifying measures and economic impact ➢ Analysing the cost-effectiveness of measures, scale of analysis
Cidacos river basin (Spain)	Carrying out the full economic analysis, including the involvement of stakeholders – Specific focus on agriculture	Importance of linking water pricing/price elasticity with changes in sector policies – Key methodological issues for the cost-effectiveness analysis (scale, which costs, looking at impacts) – Importance of the financial feasibility of proposed measures	Main parts of the full 3-Step analysis ➢ Water uses and services, costs, cost-effectiveness ➢ Disproportionate cost analysis
Corfu Island (Greece)	Initial assessment of water uses, test of data availability and organisations	Low data availability	Step 1 – Characterising RBs ➢ Mainly water uses and services
Middle Rhine river basin (Germany)	Carrying out an economic audit of water uses - Assessing the recovery of costs for water services	Importance of data collection for the initial status – Role of existing statistics in assessing cost-recovery	Most of Step 1 – Characterising RBs ➢ Water uses and services ➢ Cost recovery
Motala river basin (Sweden)	Identifying information needs and gaps for the economic assessment and decision-making	Importance of data collection, link with stakeholders (public participation) and economics as a decision making tool – need to find coherence between data from wide range of organisations	Most of Step 1 – Characterising RBs
Oise river basin (France)	Building baseline and prospective scenarios	Need for building alternative scenarios	➢ Step 1 & 2 – Identifying significant water management issues - Baseline scenario
Ribble river basin (England)	Carrying out appraisal to construct efficient programme of measures to reach set objectives – integration between appraisal and consultation/participation – linking river basin planning and agriculture policy	Importance of common understanding and training process – Proposed approach considered feasible and applicable to other river basins	Main parts of the full 3-Step analysis ➢ Identifying water uses & services, estimating costs, analysing the cost-effectiveness of measures, disproportionate cost analysis
Rhône Méditerannée Corse river basin (France)	Identifying/Assessing criteria for the definition of the scale of the analysis	General approach linking economic, biophysical and planning/land use information for investigating scale issues, no specific economic methodology tested	Step 1 – Characterising RBs ➢ Defining the scale of the analysis

River Basin (country)	Issues addressed	Key lessons learnt	Part of the 3-Step Analysis
Scheldt International river basin (The Netherlands, France, Belgium regions)	Analysing water uses, initial identification of measures, cost-effectiveness analysis – Looking at water quality, groundwater abstraction and morphology	Importance of physical parameters (hydro morphology), in economic analysis (links with experts on pressures & impacts) – Use of expert panel for assessing disproportionate costs – Lack of coherence between different parts of an international river basin	Main parts of the full 3-Step analysis ➢ Water uses and services, costs, cost-effectiveness
Sèvre Nantaise river basin (France)	Testing of the feasibility of the 3-Step approach	Need to check data availability – Need to involve stakeholders Difficulty to find data on environmental benefits	Main parts of the full 3-Step analysis ➢ water uses and services, costs, cost-effectiveness
Vouga river basin (Portugal)	Identifying gaps in available data and creating links with stakeholders and other working groups	Low data availability Link with stakeholders (public participation) and other technical groups (e.g. dealing with Heavily Modified Water Bodies)	Most of Step 1 – Characterising River Basins

Alsace Plain Aquifer (France): Estimating disproportionate costs

Keywords	Cost effectiveness analysis, disproportionate costs, derogation, groundwater, pollution, hydrodynamic model, simulation
Location (river basin, country)	Alluvial aquifer of the upper Rhine valley, Alsace region, France
Key water management issues	• Groundwater pollution: since the 1910s, the potash mining industry has generated huge waste dumps with high salt contents (NaCl). These dumps have been leached by rainfall, resulting in significant contamination of one of the largest European aquifers; • Significant pollution control measures have already been implemented, leading to a progressive restoration of the aquifer. However, these measures might not be sufficient to reach the objective of "good status" by 2015. Additional measures may be needed to reach the objective but their cost is likely to be disproportionate with regard to the benefits and the financial capacity of actors.
Objective and the study's function in the overall analysis	• Estimate the risk of non-compliance using hydrodynamic simulation models; • Compare alternative programmes of measures through cost effectiveness analysis; • Define "disproportionate costs" using different approaches and implications. Develop a method to justify derogation on the basis of the disproportionate cost argument. Test this method on the case study; • Identification and evaluation of benefits (in case of groundwater quality restoration).
Planned activities and overall structure of the study	• Step 1: Development of a simple hydrodynamic model to simulate the impact of various programmes of measures. Key issue: choosing a model (trade-off between accuracy and cost); • Step 2: Simulation of the baseline scenario & identification of additional measures needed to reach the objective in 2015. Key issue: addressing uncertainties; • Step 3: Cost-effectiveness analysis of the alternative measures; • Step 4: Defining what is a disproportionate cost: (i) costs versus ability to pay; (ii) cost versus benefits; (iii) costs versus best alternative use of public finance; • Step 5: Identifying and assessing the value of benefits related to groundwater restoration.
Disciplines and expertise mobilised	• Economist & hydrologist from BRGM; • Consultative group (Rhine Meuse Water Agency, government administrations & regional authority): discussion of the method, assumptions and results; • Stakeholders (mining company, municipal water suppliers, farmers organisations, industrial water user association, scientists).
Key information source mobilised (reports, books, statistics…)	• Pollution monitoring data & geological information (to develop the model): annual pollution monitoring reports; • Interviews with stakeholders to identify and quantify benefits; • Scientific reports to cross check information from experts.

Alsace Plain Aquifer (France): Estimating disproportionate costs

<u>Stakeholders</u> involvement	• Experts of the consultative group involved in: (i) the definition of "disproportionate"; (ii) the identification of the programmes of measures; • Stakeholders consulted through interviews on: (i) the definition of benefits for current water users and (ii) the prospects of future water demand and potential benefits for future generations of aquifer restoration.
Highlights/Results/Successes	• Pointing at: ⇨ The need to use simple hydrodynamic models to simulate the baseline scenario and to assess the effectiveness of alternative programmes of measures; ⇨ The need to involve stakeholders in the identification of costs and benefits, and to cross check this information with experts/scientists/secondary data.
Key problems and potential solutions	• All costs and benefits cannot be assessed in monetary value. How can they be aggregated when expressed in different units (Euros, number of jobs, etc)? How can this difficulty be solved to calculate a cost-effectiveness ratio? To compare costs with benefits? • Some benefits, in particular those accruing to future generations, are uncertain. We suggest that the estimate of these benefits should be associated with a probability of occurrence. The total benefits should be expressed as the sum of the benefits weighted by their probability of occurrence.
Outstanding issues	• Three very different approaches can be used to define what is a "disproportionate cost". This choice determines the methodology to be adopted to justify a derogation: ⇨ Costs are reputed to be disproportionate if costs to be born by actors exceeds their financial ability to pay; or ⇨ If the overall costs exceed the overall benefits for the society as a whole (the State should only implement measures which lead to an improvement of the social welfare); or ⇨ If the rate of return over public investment needed to finance the measures (given the maximum amount that can be reasonably paid by other actors) is lower than any other water restoration programme in the river basin district that can be financed given the limited financial resources. It is important that one of these approaches be selected as a reference.
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Bordeaux Aquifer (France): Testing the cost effectiveness analysis

Keywords	Cost effectiveness analysis, scale issues, groundwater, economics and decision making.
Location (river basin, country)	Deep aquifers of Gironde (Bordeaux) department: Adour-Garonne district (southwest of France). A local master plan (SAGE) was adopted on the coastal zone of this geographic area.
Key water management issues	• Over-exploitation of these aquifers with 150 Mm^3 abstracted per year; • Important catchment for domestic uses mainly for the Bordeaux municipality and tourism along the coast; • Abstraction for irrigation (corn and vegetables); • Abstraction for industry and geothermics; • Risk of saline intrusion to the aquifer, and of decreased piezometric water levels.
Objective and the study's function in the overall analysis	• Testing the feasibility of the cost effectiveness analysis: ⇨ Determine the type and availability of needed data? ⇨ Determine the coherent scale of analysis; ⇨ Determine the analysis' level of certainty: which type of costs should be taken into account?
Planned activities and overall structure of the study	• Step 1: Comparison between baseline scenario and 2015 objectives; • Step 2: Defining technical and economic adjustment variables; • Step 3: Crossing these variables and using them to model the aquifer and define alternative scenarios; • Step 4: Identification and calculation of cost needs to be taken into account (using models for non-market costs); • Step 5: Comparison of alternative scenarios by actualisation of costs.
Disciplines and expertise mobilized	• Technical expertise: agency experts, BRGM for building the models of the aquifers, and a local co-ordinator for the master plan; • Economic expertise: economist from the university; support from the agency.
Key information source mobilised (reports, books, statistics…)	• Data collected for the master plan: data on abstraction (agency) and model of the aquifer (BRGM); • University studies on economic losses for users; • Estimation of experts on "water saving policies".
Stakeholders involvement	• The experts of the agency were involved in the technical analysis, but it was more difficult to involve them in the economic part; • The local co-ordinator of the master plan represented local decision makers.
Highlights/Results/Successes	• Pointing at the reliability and the interest of the cost effectiveness analysis at a local scale, particularly when the master plan only contained small elements of economic analysis.
Key problems and potential solutions	• Difficulties linked to data: insufficient data on water uses, water pricing, and "water saving policies"; • Difficulties linked to economic tools, particularly when transferring results from one or two other cases, or in making methods understandable to non-economists.

Bordeaux Aquifer (France): Testing the cost effectiveness analysis	
Outstanding issues	• Need to set precise limits for cost effectiveness analysis: it is impossible to compare the results of a global cost effectiveness analysis (at the scale of the whole aquifer) with the sum of cost effectiveness on separate, homogeneous part of the aquifer; • Need to develop a socio-economic database for water issues and water uses; • Need to develop links and common understanding between economists and decision makers.
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Cidacos River Basin (Spain): Undertaking the cost effectiveness analysis

Keywords	Cost-effectiveness, integration between economics and biophysical expertise.
Location (river basin, country)	Ebro River Basin (Spain)
Key water management issues	• High variability in water supply; • Water abstraction pressures; • Diffuse pollution from farms; • Water emergencies for domestic water supply; • Flooding problems during specific times of the year; • One of the main axis of economic development for the Navarra region; • Existence of plans in the region to conserve biodiversity, using rivers as ecological corridors.
Objective and the study's function in the overall analysis	• The study developed a step-by-step implementation of the cost effectiveness analysis proposed in the Guidance with special emphasis on measures affecting water flow. It addresses the implications of conducting the analysis at a river basin level (inter-related water bodies) versus water body by water body. Implications of analysing the inter-relation between measures affecting water quality and water quantity are detailed. The study also draws lessons for the planning processes.
Planned activities and overall structure of the study	• Step 1: Initial information collection on natural water regime, regime of abstractions in the river, water quality and information on biotic indexes; location of control stations and regularity and reliability of information of parameters. Assessment of additional information required by the Directive (mainly related to hydro-morphological indicators). Site visit. Preparation of characterisation initial report; • Step 2: Interview key stakeholders in the river basin for a first overview of significant water issues in the basin (key pressures today and for the future), for interpreting existing information; for defining objectives for the basin for each parameter and for establishing a first catalogue of measures. Analysis of gap. Selection of parameters where there is gap and control parameters; • Step 3: Collection of additional information on key pressures, cost of measures and effectiveness of measures for improving water status (focus on water flow and physico-chemical parameters). Calculation of cost effectiveness indicators (focus on agricultural measures and urban measures). Ranking of measures for improving water status as they affect individual parameters and considering reassessment of gap in linked water bodies and interrelations between parameters. Development of an ad-hoc model; • Step 4: Analysis of the economic impacts of the programmes of measures and the distributional implications of different financing plans. Analysis of environmental costs of programmes of measures (non water or in other basins). Analysis of sensitivity of changes in ranking of measures when incorporating environmental and economic impacts. • Step 5: Refinement of the analysis incorporating feedback in Workshops with EC experts; • Step 6: Workshop with key stakeholders for discussing and validating the preliminary results and comparing costs and benefits of achieving different levels of objectives. Stated preference survey; • Step 7: Write conclusions for a protocol for the economic analysis in RBP to facilitate implementation in the country;

Cidacos River Basin (Spain): Undertaking the cost effectiveness analysis	
Disciplines and expertise mobilised	• Combination of economic expertise, hydrologist, engineers, biologist, chemical engineers; • Input from water managers, agricultural organisations, local organisations, academics, regional and basin authority administrators, environmental concerns.
Key information source mobilised (reports, books, statistics…)	• Existing Planning documents and information from the ministries of agriculture, environment, from the river basin authority, the regional government, specialised water organisations (irrigation, domestic water supply and WWT); • Statistics from national organisations; • Monitoring information from monitoring stations; • Previous research on effectiveness of measures, elasticity of demand and behavioural models of water use behaviour when confronted with uncertainty.
Stakeholders involvement	• Key stakeholders from the river basin (environmental authorities and experts, water service suppliers, irrigation authorities, river basin authority and regional authorities, water users, beneficiaries of water improvements, majors of urban areas, local environmental groups, water supply companies); • Two workshops organised to share/discuss the results of the study, to take key decisions/collect information, evaluate environmental benefits and analyse disproportionate costs issues.
Highlights/Results/Successes	• Cost effectiveness analysis completed resulting in measures being ranked according to their cost effectiveness (including economic impacts and environmental costs). Preparation of river basin plans including a variety of measures affecting agricultural and urban users. Analysis of final costs of river basin plan when considering the linked effects of improvement in inter-related water bodies. Analysis dealing with uncertainty of quantitative value of environmental costs; • Analysis of the different financing alternatives of RBP and their impacts on prices paid by different users (and upstream and downstream). Analysis of institutional viability of measures and distributional effects of measures. Disproportionate costs analysis structure. Stated Preference survey for analysing environmental benefits; • The study used real information on the basin as much as possible.
Key problems and potential solutions	• Information for assessing environmental costs and benefits was not available. Different hypotheses on environmental costs were considered to analyse their impact on the relative desirability of different measures; • The effectiveness of measures was difficult to assess. Consequently, some assumptions were made; • Data on unit costs of measures exists in many cases but needed to be analysed in detail to ensure proper calculation of Annual Equivalent Cost.
Outstanding issues	• The contribution of different pressures to the actual status of water bodies remains a key priority to perform cost effectiveness analysis and to choose programmes of measures; • Analysis of effectiveness of measures and incorporating considerations of institutional viability of measures; • The analysis had concentrated on measures affecting water flow and physico-chemical parameters. Further analysis is required to analyse how these measures improve habitats and hence biological parameters. Measures affecting any one parameter will have “knock on” effects and this needs to be known; • Need to carry out further analysis of social impacts of implementing programmes of measures.

Cidacos River Basin (Spain): Undertaking the cost effectiveness analysis

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Corfu Island (Greece): Carrying out the economic analysis of water uses

Keywords	Integration between economics and biophysical expertise.
Location (river basin, country)	Island of Corfu (NW Greece). The island was considered as a River Basin on a pragmatic basis, given that Greece has a large amount of islands, each with many small river basins.
Key water management issues	• Water reserves are subject to very high pressures since a significant water deficit exists on the island. This leads to conflicts between water uses. Note that water for all uses on the island is of groundwater origin and that apart from the deficit, groundwater deterioration problems exist (presence of gypsum and saltwater intrusion due to over-exploitation). To highlight the magnitude of pressure on water resources, we have to take into account the high seasonal variability of water demand, which inevitably follows the tourism peak, condensed in the summer period. To illustrate the high priority of tourism and the magnitude of conflict among uses, it is interesting to observe that in the Ropa Valley where the main land use is agriculture, the only irrigated area is a golf course.
Objective and the study's function in the overall analysis	• The study aims at investigating the link between biophysical information and the economic analysis process; • It has been designed as a "non-virtual" exercise, to test the feasibility of the process of data collection/analysis and not to undertake the overall economic approach proposed in the Guidance Document. • A specific approach has been adopted based on the use of a GIS system to facilitate data storage, retrieval, processing/analysis and final data visualisation and map output; • This is considered necessary due to spatial (temporal) variability of water resources/demand characteristics, of water uses, economic activities, and pricing policies.
Planned activities and overall structure of the study	• Step 1: Initial literature review for assessing the information base; • Step 2: Interview key local water administrators (Region, Prefecture, Municipalities) for developing main assumptions for the analysis; • Step 3: Analysis of data collected and preparation of synthesis report; • Step 4: Refining the results, further elaboration; • Step 5: A Workshop with all target groups for discussing the results and raising awareness in all river basins in the country about the role of economics in the WFD is scheduled for late Summer 2002.
Disciplines and expertise mobilized	• Combination of economic expertise, hydrogeology (water quantity and quality characteristics), climatic data, land use.
Key information source mobilised (reports, books, statistics…)	• Planning documents from the Ministries of Agriculture and Interior; • Statistics on demographic data and activities by socio-economic sector; • Information collected by I.G.M.E. on water quality and quantity; • Information collected on costs of water services and water demand.
Stakeholders involvement	• Local water administrators, harbour authority, and water service suppliers were interviewed during the initial phase of the study.

Corfu Island (Greece): Carrying out the economic analysis of water uses	
Highlights/Results/Successes	• Some issues were not investigated due to the specifics of the pilot area. Thus, not all aspects of the Guidance Document were assessed; • Overall, readily available statistical information provided most of the information included in the study; • Lack of time hindered the development of a strategy for raising proper awareness, resulting in poor reporting from local authorities on data they are responsible to collect; • Data from more centralized sources were better organized and more easily obtained.
Key problems and potential solutions	• Information for assessing environmental costs was not available; • Difficulties with project financing; • The establishment of a "Water Agency" to operate as the sole organization for water management and to serve as the advisory and co-ordinating office for regional competent authorities may bring solutions for more coherent information collection and storage. Such establishment is currently being discussed in Greece.
Outstanding issues	• The allocation of costs to different uses was not performed, and the analysis remained at a very aggregated level. Further analysis will be required for assessing cost-recovery at the sectoral level; • The feasibility of applying the approach chosen in this study to all river basins in Greece remains to be assessed. Due to a potential lack of funding and time constraints, the collection of new data as performed in this study may pose significant problems. These issues need to be faced in a pragmatic way.
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Middle Rhine River Basin (Germany): Assessing the recovery of the costs of Water Services

Keywords	Cost recovery, economic assessment, data access
Location (river basin, country)	Middle Rhine, located in Germany
Key water management issues	• Cost recovery in the water services sector. •
Objective and the study's function in the overall analysis	• The study addresses the methodological and empirical issues associated with the collection and evaluation of economic characteristics relating to water services (water supply & sewage disposal). It was carried out to prepare for implementation of the provisions of the European Water Framework Directive (reporting; preparation of a Middle Rhine management plan); to consolidate the methodological concept for an economic analysis of water use (recovery of costs for water services, with due regard for economic and resource costs); and to develop an appropriate empirical concept to obtain necessary economic data and information to complete the analysis.
Planned activities and overall structure of the study	• Conduct a three-stage survey in the Lander of Hesse and Rhineland-Palatinate concerning economic characteristics of water services; • Stage 1: Collect and evaluate generally available, primary data from federal and regional statistical offices concerning manufacturing data and environmental, manufacturing, employment and investment costs, and financial data for water and energy companies. Local data included information on population, and environmental statistics, financial data on local water supply companies and sewage plants. Data and information from the technical and financial authorities of the Lander provided information about information systems on water services, land survey data, water and shipping authorities, various charges for water services, and on subsidies, measures for water protection, and sustainable use of resources. Any gaps in the data may be supplemented with third party data; • Stage 2: Collect and evaluate third party data and information, such as water statistics and water rates from the Federal Gas and Water Management Association (BGW), ATV-DVGW/BGW's joint survey on public sewage disposal, and also evaluate special surveys and expert reports; • Stage 3: Primary surveys within the context of implementing the Water Framework Directive. No primary surveys were implemented within the context of this pilot project, as the data available was enough to complete the analysis. Primary surveys should only be implemented in isolated cases where there are decisive information gaps. When carrying out primary surveys, collaboration with the relevant specialist organizations is advisable.
Disciplines and expertise mobilized	• Economics for the Hessian Ministry for the Environment, Agriculture and Forestry.

Middle Rhine River Basin (Germany): Assessing the recovery of the costs of Water

Key information source mobilised (reports, books, statistics…)

- Primary data was used from the Federal Statistical Office, regional statistical offices for local authority data, research from water authorities and environmental agencies. Other primary data from the technical and financial authorities of the Lander was used regarding information systems about water supply and sewage disposal, land survey information, data about water and shipping authorities, on subsidies for water management plants and measures for water protection, and on charges (wastewater, groundwater, etc.);
- This includes an evaluation and full census of all companies in the State of Hesse for 1998. These evaluations are annual and comparable in form by all Lander, constituting a comprehensive, reliable information base;
- Secondary data and information came from the Federal Gas and Water Management Association, ATV-DVGW/BGW's joint survey on public sewage disposal, and evaluation of special surveys and expert reports;
- Primary surveys in collaboration with specialist organizations.

Stakeholders involvement

- None.

Highlights/Results/Successes

- Principal findings of an analysis of the public water supply reveals that cost recovery from revenue (excluding allocations and subsidies) in Hesse is approximately 90%. Internalised environmental and resource costs (groundwater charges) significantly exceed the sum of total subsidies and the cost recovery shortfall;
- For sewage disposal in the Hesse, cost recovery from revenue (excluding allocations and subsidies) is approximately 80%. Cost recovery from revenue including allocations and subsidies is approximately 92%. Internalised environmental and resource costs (sewage charge) was significantly lower than the sum of total subsidies and the cost recovery shortfall.

Key problems and potential solutions

- Not all of the sources for third party information are generally available. The availability of results from special surveys and the requirements governing the adoption of such data should be reviewed in each individual case. Where data is adopted, agreements must be signed with the respective institutions and fees may be payable. It would appear expedient to aim for centralized solutions in this context;
- The abundance of data contributes to substantial time and efforts to provide an analysis, as it was necessary to combine fundamental data and information from various sources that were not necessarily compatible. Adapting the official statistics of the Federal Government and the Lander to the data requirements of the WFD may significantly improve overall reliability when determining economic characteristics;
- Further, the area-wide implementation of the proposed survey and requisite constant updating necessitate a suitable form of data processing and the supply of information to the specialist authorities, as well as advance clarification of accessibility for the various parties involved in sub-regional management plans. Setting up a central data pool from which the required data about river basins could be extracted would be beneficial for this purpose.

Outstanding issues

- Decentralised nature of the water services sector in the Middle Rhine River Basin (with 275 water supply companies and 562 sewage treatment plants) has major significance to the potential impacts of water use on the environment and for determining economic characteristics of the water supply;
- There are a number of small impoundments used for energy extraction that are of local significance and were not considered for this report.

Middle Rhine River Basin (Germany): Assessing the recovery of the costs of Water

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Motala River Basin (Sweden): Scoping an integrated appraisal for river basin management plans

Keywords	Water quality control and management, economic appraisal, river basin characterisation, staff resources, information gathering
Location (river basin, country)	Motala River Basin, Sweden.
Key water management issues	• Intensive agricultural pressure (cereal crops, meat production); • Diversified farming and forestry; • Coastal areas face decline in fisheries and increased tourism, leading to eutrophication in some water bodies; • Acidification on the fringes of lakes in the central plains; • Diversified economic sector in urban areas with IT industry and small metal industries; • Surface water used for drinking in urban areas; • Hydropower fully exploited between 1890-1918; energy production still important.
Objective and the study's function in the overall analysis	• This study aims to show what type of information is needed to inform decision-makers (at which level and for what decisions) on the various types of options available to meet the requirements of the WFD. Additionally, the study shows how different elements of the appraisal system could best generate this information, and how the information could be implemented into decision-making. Finally, key information gaps and specific research needs and priorities are identified.
Planned activities and overall structure of the study	• Step 1: Characterise and differentiate (parts of) water bodies to identify bodies of water where objectives must be set and measures both identified and appraised; • Step 2: Characterise various possible measures to achieve good quality status and the level at which these measures have to be implemented; • Step 3: Characterise the diverse parties affected positively or negatively by the impacts of these possible measures; • Step 4: Determine the best use of information provided by the existing appraisal system on the environmental, economic or social impacts of the possible measures, and identify key gaps in expertise and information to be addressed to undertake cost-effectiveness and cost-benefit analysis; • Step 5: Identify staff resources; • Step 6: Identify outstanding research issues.
Disciplines and expertise mobilized	• Environmental issues, economics; • Agencies involved in (general) river basin management: Municipal governments, Motala River Association for Water Care, the Lake Vätten Association for Water Care.
Key information source mobilised (reports, books, statistics…)	• Statistics Sweden (collects data for 119 main river basin); • Swedish Meteorological and Hydrological Institute (has a register where all Swedish river basins larger than 50 km^2 and all lakes larger than 1 ha are being mapped); • Swedish Waste and Wastewater Association (for data on costs for water use and wastewater disposal); • Regional and municipal government information; • Water-related associations (e.g., Swedish Board of Agriculture, Farmers Association, National Board of Fisheries, Swedish Environmental Protection Board).

Motala River Basin (Sweden): Scoping an integrated appraisal for river basin	
Stakeholders involvement	• None.
Highlights/Results/Successes	• Because of a long history of attention towards environmental quality issues, national and regional environmental strategy programmes are in place to address sustainable water management, to protect endemic marine species populations, to limit pollution in lakes and rivers, and to reduce water-borne emissions of nitrogen from human activities to the Baltic and its archipelago by half (between 1985-1995); • Scaling for basin-wide and sub-basin levels to achieve specific targets for phosphorus and nitrogen reduction was accomplished, and specific sectors were assigned the responsibility to meet each measure's objectives.
Key problems and potential solutions	• Despite ongoing programmes to meet targets, some sub-basins are not meeting the established environmental targets. Starting from an existing source apportionment that shows the contribution of polluters in the sub-basin, a cost-effective pollution abatement scheme should be made for the whole river basin and including the whole River Basin District, to achieve good quality status. Ideally, such a scheme would be based on marginal costs for pollution control, although required economic information is difficult to obtain and the criteria for the trade-off between sectoral needs and wants are not yet well developed; • The abatement level of point source emissions in Sweden is already high, particularly regarding phosphorus, due to the implementation of tertiary wastewater treatment in the 1970s and 1980s, and regulation of industrial emissions. This increases the marginal costs for further treatments, and may influence a cost-effectiveness analysis. In other sectors, for example in farming, where these are fewer technical fixes, reliable data on marginal pollution control costs are less distinct. Instead, actual data for selecting among measures are (i) efficiency (achievement of effects with little regard to costs), and (ii) the degree of acceptance from stakeholders.
Outstanding issues	• Need for further information about the link between pollution abatement costs in the most polluted water bodies, to investigate cost-effective solutions, including improvements such as wastewater treatment plants, costs of constructing wetlands and buffer zones, restore old industrial sites and waste deposit for heavy metals and other harmful substances; • Need to assess the costs/reduced profits for farmers that change their land use practices; • Need to research subject of valuing environmental public goods, possibly through contingent valuation methods adapted to include social learning and public participation in decision-making; • Need to research the extent to which environmental changes, in particular regarding water quality in Sweden, will be a consequence of endogenous socio-economic factors over the next 25 years.

Motala River Basin (Sweden): Scoping an integrated appraisal for river basin	
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Oise River Basin (France): Testing the development of Baseline Scenario

Keywords

Baseline projection, baseline scenarios, surface water, ground water, integration between economics and biophysical expertise, cost recovery

Location (river basin, country)

Oise river basin, part of the Seine river district (France)

Key water management issues

- High diffuse pollution from agriculture (mainly intensive cropping, high livestock density);
- Important urban areas, mainly downstream but also on some upstream areas;
- Dense industrial concentration on main and smaller rivers;
- Poor quality of Oise river and very poor quality of some smaller rivers;
- Existence of a master plan for the Seine river district.

Objective and the study's function in the overall analysis

- Assessment of data availability;
- Simple technical and socio-economic previsions testing: population, activity growth, population growth; pollution abatement equipment programmes and their effects on future discharge;
- Methodology testing and improvement for baseline projection and scenarios, focusing on surface water quality;
- Illustration of potential benefits of baseline scenarios for water policy settings.

Planned activities and overall structure of the study

- Step 1: Identify past trends and present state of water policy, surface water quality and pollution (including sewage equipment and discharges);
- Step 2: Establish baseline projection; assessment of the confidence of key data, methods and results (water quality, investment estimation); water quality evolution estimated by expert knowledge;
- Step 3: Baseline scenarios including cost recovery examination; water quality evolution estimated by model;
- Step 4: Insights for water policy-making: evaluation of the relevance of present policy, cost recovery issues, knowledge needs;
- Step 5: Insights on methodology: feasibility of global approach and of specific tools (e.g. environment response modelling), along with needed improvements.

Disciplines and expertise mobilised

- Biophysical expertise, engineering (sewage techniques and efficiency) and economics;
- Multi-disciplinary co-ordination and synthesis;
- Communication expertise for effective dissemination of study output.

Key information source mobilised (reports, books, statistics…)

- Detailed data on water pollution sources (raw pollution, treatment, discharge, main investment programme or needs proceeding from present water policy), water intakes and water quality;
- Expert knowledge on mean pollution ratios;
- Demographic data (past, present and future provisions);
- Regional planning documents.

Stakeholders involvement

- Main stakeholders involved in the study: water agency bureau for Oise river basin (manager, planning expert, investment support manager, water quality expert), water agency experts (economics, engineering and water quality), independent scientists (modelling environment response) and private consultancy (co-ordination and synthesis, communication);
- Associated stakeholders include regional representatives of Environment Ministry.

Oise River Basin (France): Testing the development of Baseline Scenario	
Highlights/Results/Successes	• Proved feasibility of methodology on Oise river basin scale; • Good confidence can be reached on assessment of pollution sources, discharges and equipment needs for industry and households; • Baseline scenario highlights major difficulties for achieving surface water quality objectives: durable nitrate pollution involving ground water, long improvement process for very poor quality sectors, incompatibility between good status definition and some natural processes (suspended matter standards towards erosion).
Key problems and potential solutions	• Main problems are related to groundwater: distribution of discharges (non connected households, breeding farms) between surface and ground water, magnitude and speed of contaminating and decontaminating mechanisms in soils and groundwater, pollution transfer from ground to surface water. There is a need for specific knowledge and for integrating surface and ground water; • Drastic uncertainty about future level of economic activities (industry and agriculture): scenarios are needed but not sufficient, perspective has to be used.
Outstanding issues	• Specific key expertise involved is not economics, but “economic approach”, i.e., multi-disciplinary co-ordination and synthesis plus uncertainty management; • Existing data allow baseline projection on surface water pollution and quality, highlighting needs for scenarios and for environment response models; • Methodology feasible at Oise river basin scale, projection relevant for 5 to 7 years (anticipated), scenarios and probably perspective necessary for a projection up to 15 years; • Study provides useful results about compliance defaults of present policy towards good status objective for 2015, allowing a wider vision than recent planning preparation (up to 2006).
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Ribble River Basin (England): Integrated appraisal for river basin management plans

Keywords System of measures; risk-based assessment, cost-effectiveness

Location (river basin, country) Ribble River basin, located in the Northwest of England.

Key water management issues

- Water abstraction pressures;
- Diffuse pollution from agricultural land, compounded with somewhat impermeable clay soils;
- Varied water quality in urban and rural reaches;
- Lack of wastewater treatment facilities;
- Pressures from tourism and economic development and regeneration.

Objective and the study's function in the overall analysis

- This hypothetical study uses existing data and assumptions for missing data. It charts the whole process of carrying out an integrated appraisal of measures – from choosing a system of measures and conducting a cost-effectiveness analysis to determining options for disproportionate costs - for achieving good water quality in the basin through a six-step process, rather than the three-step process suggested by the Guidance Document. Specific emphasis is paid to the Cost Effectiveness Analysis. The case also identifies and investigates the issues and problems that arose throughout this "virtual" process, and looks ahead to future requirements beyond the 2004 deadline.

Planned activities

- Use of expert interviews (both telephone and face-to-face) with key decision makers, stakeholders and experts, to gain perspectives on the appropriate processes for developing an integrated study, developing tools and information to perform the "virtual" study;
- Develop a background review and issue report that presented an illustrative, outline an approach for integrated assessment in six steps (detailed below), along with a range of worked examples to indicate how this assessment process could address some of the issues raised by stakeholders and decision makers;
- Host a two-day workshop to discuss findings and issues regarding practical implementation of this approach; identify strengths of the approach and prioritise future research needs.

Overall structure of the study

- Step 1: Objective specification, to produce an agreed and consistent programme of measures, which incorporates national, regional and local objectives related to water and other quality issues. Interview key decision-makers, stakeholders and experts to seek their views regarding the appraisal system, determine the information needed to aid decision-making and on the availability of data for this;
- Step 2: Assessment of pressures and risks of non-compliance under a business as usual case. This risk-based assessment maps the likelihood that water bodies will fail to achieve good water status in future planning periods without any additional policy measures;
- Step 3: Option screening. Identify feasible and cost-effective measures aimed at reducing the risk of not achieving good water status in different plan periods;
- Step 4: Option appraisal. Identify and appraise cost-effective measures for achieving various classes of water quality status, and an assessment of the costs and ancillary impacts of these measures. This aims to cover in an even-handed way all of the effective measures for the main sectors (e.g., water industry, non-water industry, agriculture, and other diffuse sources of water pollution).

Ribble River Basin (England): Integrated appraisal for river basin management	
	• Step 5: Objective refinement. To assess the most appropriate measures for particular water bodies given the feasibility of identified measures in achieving different classes of water status and their costs. This process focuses on examining whether the system of measures selected is disproportionately expensive, so as to inform the decision of whether derogations may be needed; • Step 6: Plan agreement. Develop an agreed set of actions for the Agency, its partners, sectors and specific geographic areas and involving national, regional and local stakeholder consultation.
Disciplines and expertise mobilized	• A range of experts with backgrounds including economics, policy, environmental data assessment, water quality, water resources, HMWB, agricultural specialists, local and regional authorities; • Experts in public consultation/participation; • Functional experience included the strategic, policy, and operational levels.
Key information source mobilised (reports, books, statistics…)	• Expert interviews with key decision-makers, stakeholders and experts; • Available data assisted with assumptions where data is unavailable; • The appraisal is a virtual study; no new empirical research was used, nor do the findings have any empirical status.
Stakeholders involvement	• Study was developed by the Environment Agency with WRc and Environment & Society Research Unit (ESRU, University College London); • Two-day workshop hosted 55 delegates, about half were from the Environment Agency, and the rest representing a wide range of organizations including the Department for Environment, Food and Rural Affairs (DEFRA) in England and Wales, European experts including EC DG Environment officials, OFWAT, academics, NGOs and expert stakeholders from the water industry, National Farmers Union, and the Royal Society for English Nature.
Highlights/Results/Successes	• Uses a six-step approach rather than the three-step approach suggested by the WFD. The study stresses that the six steps identified are not linear; there are numerous links and feedbacks required and inputs regarding consultation, the framework (Guidance) and tools that feed into all stages at different points; • Process-oriented study addresses how the different steps required to implement an integrated system of measures system might be considered, with clearly detailed responsibilities, inputs, outputs, relationship to the WFD deadlines, and relationship to WFD requirements, while identifying further issues for discussion; • Identifies the need to undertake a risk assessment of water bodies that may fail to achieve a good quality water state in future plan periods when developing the business as usual case. Addresses issues with developing the proper tools and methods to conduct a risk analysis where lack of data with different levels of certainty, and where qualitative data may; • Discuss the integration between sector policy (namely agricultural policy) and the process of developing integrated river basin management plans.
Key problems and potential solutions	• Simplistic worked examples demonstrate the need for more complicated analysis, modelling multiple outputs and indirect impacts of measures; • Use of “fail one fail all” for indicators projecting water quality status fails to capture the degrees of impact each indicator may have; • Study proposes using a weighting system to differentiate between levels of indicator.

Ribble River Basin (England): Integrated appraisal for river basin management	
Outstanding issues	• The overall process for integrated appraisal for RBMPs in the context of the direct needs of the WFD, and the capabilities of the Environment Agency to meet these needs; • Whether to assess impacts measure by measure, or strategy by strategy; • With the large number of water bodies and lack of resources to study each, developing a form of benefits transfer will be necessary to apply valuations derived from other studies of similar cases.
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Rhône Méditerranée Corse River Basin (France) : Assessing the pertinent scale for the economic analysis

Keywords Scale, agriculture, industry, tourism, local water management plans, redefining perimeters, detailed data on water use, public consultation.

Location (river basin, country) Rhône-Méditerranée-Corse Basin (France).

Key water management issues

- Population density with diversified spatial distribution;
- Heterogeneity of population with high demand and discharges in vulnerable zones;
- Desertification of mountainous zones;
- Importance of tourism with accompanying pressures on water supply;
- Intense agricultural region with cattle breeding;
- High industrial activity concentrated in five areas.

Objective and the study's function in the overall analysis The Rhône-Méditerranée-Corse (RMC) Agency investigated the basic territorial scale that could be used for an economic analysis. The main objective was to define operational ways (choice of criteria, indicators, cartographies) that would allow competent district authorities to define criteria suited to their river basin for identifying coherent and relevant geographic territories to undertake the economic analysis and to address the constraints raised by an analysis strictly limited to a water body scale.

Planned activities and overall structure of the study A preliminary study was carried out at the end of 2001. The objective of the study is not to give a "recipe" for all districts, every case being specific and presenting a specificity due to the natural environment and the socio-economic context. Rather, the aim is to propose a methodological approach based on an exhaustive research of criteria describing economic activities, while keeping in mind the need to adapt data, tools and geographic zones (hydrography or management entities) in each district.

Disciplines and expertise mobilised

- The study was undertaken by the RMC water agency;
- Multi-disciplinary consultation.

Key information source mobilised (reports, books, statistics…)

- Detailed data on water use sources (agriculture, tourism, industry, natural parks, population, etc.);
- Expert knowledge.

Stakeholders involvement No stakeholder involvement in the study.

Highlights/Results/Successes It was necessary to stay within a reasonable budget for data collection to define territorial scales for economic analysis. Consequently, comments relative to indicators and cartographies demonstrate that most of the time and for most basins, hydrographic territories close to the socio-economic areas can be defined based on the criteria for the study. In the RMC basin case, the "SDAGE territories" seem most relevant for adaptation to the model. In other basins, territories can be defined with assistance from geographic commissions, local water development and management plans (SAGE), or other local management areas.

The following stage consisted in redefining perimeters of SDAGE territories (in the case of RMC basin). As a result, the basin was cut in 18 large zones. The final division will be defined taking into account the water bodies' perimeters while taking care, if possible, not to divide the entities of local management (local water development and management plan, parks, etc.).

Rhône Méditerranée Corse River Basin (France) :	
Key problems and potential solutions	It is necessary to avoid as much as possible dividing a territory such as natural reserves, parks, or other entities and divide it between two entities. However, it is sometimes difficult to conciliate all of the existing divisions with the information brought by a study of socio economic criteria and hydrographic logics. The methodology used tried to identify successively relevant criteria and, if possible, to discriminate between economic activities. It was then a question of identifying all the hydrographic partitions to identify one that had closer information brought by the interpretation of the previously identified criteria. This method limits costs and offers a necessary qualitative approach that accounts for local and concrete characteristics. The methodology is based on a compromise between socio economic, hydrographic, territorial criteria, etc., and so contains some degree of interpretation.
Outstanding issues	The study began with significant efforts in terms of data collection and information research with data suppliers or with competent entities in the main economic fields of economic activities (agriculture, industry, tourism, etc). In the French case, it has to be underlined that the majority of information is available easily (at low cost) on the municipal scale even if certain sectors for confidentiality purposes provide their data only for larger scales, as is the case with the agricultural sector. It is thus a question of refining the initial division by including each local community in a single economic zone, and each water body in a single economic zone, following the text of the framework directive, which specifies that the economic analysis can be made by grouping water bodies.
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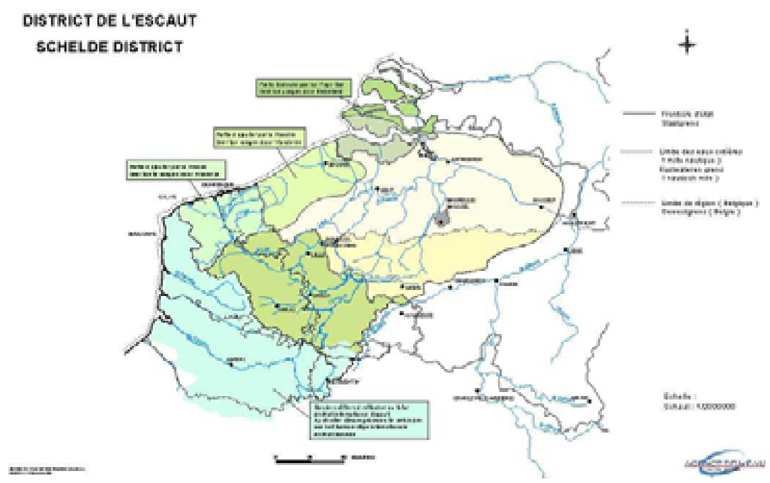
Scheldt International River Basin (The Netherlands, France, three Belgium regions): Testing elements of the three step-approach

Keywords

Characterisation, cost-effectiveness, integration between economics and biophysical expertise (Impact & Pressure), groundwater abstraction, surface water quality, morphology, International district, data availability

Location (river basin, country)

Scheldt International River Basin (France, Belgium[14] and The Netherlands)



Key water management issues

- **International context;**
- **High density of population and industry;**
- Rather bad quality of surface waters and Heavily Modified Water Bodies;
- Diffuse pollution from agriculture;
- Local stress on water resources (groundwater);
- Existence of master plans for some parts of the river basin and an international commission for the protection of the Scheldt.

Objective and the study's function in the overall analysis

- The study aims at applying the approach and some elements of the draft Guidance Document (baseline scenario, cost-effectiveness analysis) on three individual case studies: surface water quality, groundwater abstraction and morphology. The purpose of this work was to test the feasibility of the process and methods rather than to provide specific results, and to assess the availability and comparability of data between the five parties involved in the Scheldt International River Basin.

Planned activities and overall structure of the study

- Step 1 - initial literature review phase for assessing the information base in the five parties involved in the river basin considered;
- Step 2 – workshop in Amsterdam involving WATECO and IMPRESS working group experts (November 2001) – analytical process based on the Ribble scoping – identification of 3 sub-case studies (water quality, groundwater abstraction, morphology);
- Step 3 – Workshop in Brugges (February 2002) – report from each of the three case studies team;
- Step 4 – Presentation of the preliminary results at the "Lille 3" conference – March 2002;
- Step 5 – Writing of a synthesis and possible follow-up of the work started through the "Scaldit" project.

[14] including the 3 Belgian regions : Brussels, Flanders and Wallonia

Scheldt International River Basin (The Netherlands, France, three Belgium regions):

Disciplines and expertise mobilised	• Combination of economic expertise, impact and pressure, soil scientists; • Input from River 21 project for the characterisation and baseline scenario; • Support from the EC DG Environment, consultants (ERM) and academics (ENGREF) for the case study on groundwater abstraction; • Access to the data collected by the Secretariat of the International Commission for the Protection of the Scheldt.
Key information source mobilised (reports, books, statistics…)	• Planning documents and indicators from the water bodies and administration from the fives parties (mainly from the RIZA, VMM, Artois-Picardie Water Agency, IBGE and Ministry of Environment from Wallonia); • Data on water quality, groundwater abstraction.
Stakeholders involvement	• The involvement of stakeholders was limited (initially a workshop with stakeholders was proposed but had to be cancelled due to time constraint). However, the need for stakeholder' input has been clearly identified (data, expertise, discussion on potential measures...).
Highlights/Results/Successes	• The test of the process has allowed the clear identification of the working links required for integrating the economic analysis in the whole process of developing an integrated river basin management plan in an international river basin district; • All the steps of the economic approach (characterisation, risk assessment, cost-effectiveness analysis) performed for the morphology case; • Elaboration of a rough method to assess the impact of main water uses on water quality; • Analysis of the aquifer system of the entire river basin district and proposal of a simple model for applying the economic approach.
Key problems and potential solutions	• The monitoring system differs between countries/parties. A solution could be to harmonise these systems; this could be developed along activities aimed at modelling the entire district integrating sub-catchments to tackle upstream/downstream interdependencies; • The need to find the "right" scale to undertake the analysis. This generates preliminary work in order to understand the functioning of the district (e.g. relations between the different aquifers).
Outstanding issues	• The baseline scenario and the cost-effectiveness analysis were skimmed over as the data or the expertise were lacking or difficult to collect for a test in an international context; • Set up of an informal network of experts (mixing disciplines and countries) that could be a resource for the implementation of the WFD
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Sevres-Nantaise River Basin (France): Testing the chronological feasibility of the three step approach

Keywords	Cost effectiveness, cost benefits, baseline scenario, scenarios of investment, costs of programme of measures, cost recovery.
Location (river basin, country)	Sèvre Nantaise river basin – Loire Brittany district (centre of France). A local water master plan (SAGE) was adopted over this geographic area.
Key water management issues	• Lack of own water resources: 50% of the drinking water comes from other river basins; • Important tourism in the river basin; • Abstraction for irrigation (corn and vegetables); • Abstraction for industry (96 large industries in the river basin); • Important diffuse pollution (pig farming).
Objective and the study's function in the overall analysis	• Testing the chronological feasibility of the three-step approach; • Availability of data required (mainly for cost recovery); • Building of prospective scenarios; • Elaborating and evaluating programmes of measures based on cost effectiveness and cost benefit analysis; • Estimating the current level of cost recovery for the three main sectors (household, agriculture, industry).
Planned activities and overall structure of the study	• Collection of existing data and "proxy" to assess initial status; • Build a baseline scenario; • Build an alternative programme of measures, estimating costs and benefits; • Compare the alternative scenarios on the basis of cost effectiveness and cost benefit analysis; • Estimate the current level of cost recovery per sector.
Disciplines and expertise mobilised	• Technical expertise: agency experts and consultant. • Economic expertise: consultant with support from the agency and the Ministry.
Key information source mobilised (reports, books, statistics…)	• Data collected for the master plan: data on abstraction, water quality and economic activities, along with modelling of the impact of alternative investment programmes; • University studies on environmental benefits; • Estimation of experts on: investment costs, level of cost recovery.
Stakeholders involvement	• Agency experts were involved in the technical and economic aspects of the study; • No involvement of the actors of the master plan (local decision makers) was required, because they did not have to validate the proposed scenarios due to the short duration of the study, and the earlier stage of development of the master plan (initial status).
Highlights/Results/Successes	• Pointing at the reliability of the chronological link of each step of the 3-step process provided in the Guidance Document.

Sevres-Nantaise River Basin (France):	
Key problems and potential solutions	• Difficulties linked to the data: there is an important need for data (physical, economic, etc.), for each step. The availability has not been tested with this study, as data was collected or constructed from other, former studies; • Difficulties linked to economic tools: environmental costs and benefits are hard to quantify, and they are hard to transfer easily; • Difficulties linked to reporting cost recovery: it is possible to have data on cost recovery for households. For industry and agriculture, little data exists at each scale (local, regional, district, national).
Outstanding issues	• Need to involve stakeholders in future studies; • Need to develop an economic database in the field of environmental cost and benefits; • Need to develop knowledge about cost recovery in industry and agriculture.
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Vouga River Basin (Portugal): Scoping key elements of the economic analysis

Keywords	Linkage between economic and biophysical analysis, sources of information, stakeholder participation, cost recovery, current price structures.
Location (river basin, country)	Vouga river basin (Portugal).
Key water management issues	• Urban, industrial and agricultural pollution; • Institutional arrangement complexity; • Inappropriate management resources; • Implementation of the existing River Basin Plan and National Water Plan.
Objective and the study's function in the overall analysis	• The main goal was to perform a virtual economic analysis, along the lines of what will be required for 2004 (Art. 5 of the WFD).
Planned activities and overall structure of the study	• Step 1: Identification and characterisation of the main users; • Step 2: Collection and organisation of the existing information; identification of information gaps; • Step 3: Interviewing stakeholders; • Step 4: Analysis of price and cost structures; • Step 5: Analysis of cost recovery and incentive properties of pricing schemes; • Step 6: Initial analysis of gaps in water status in co-operation with other national working groups.
Disciplines and expertise mobilised	• Direct involvement of economists and environmental and water resource engineers; • Work developed by the economic group of INAG, the institution responsible for the WFD implementation in Portugal; • Universities and research centres were involved though protocols with INAG (UNL and ISCTE).
Key information source mobilised (reports, books, statistics…)	• Vouga River Basin Plan and National Water Plan; • Stakeholder interviews; • Other official statistics (INE).
Stakeholder involvement	• Development of specific questionnaires to fill the main economic information gaps; • Group visits to the river basin with direct stakeholder contact.

Vouga River Basin (Portugal): Scoping key elements of the economic analysis

Highlights/Results/Successes	• There is considerable variability in municipalities' price structures and there are no clear criteria in the definition of price schedules. The revenues of supply and wastewater systems are not usually enough to cover investment and operation costs. The only case where data was sufficient yielded estimates between 85% and 115% of operation cost recovery for water supply; • For agriculture, data is very poor. Infrastructure values are outdated, there are no organised records of exploration costs, and water volumes are not metered. Prices in public irrigation facilities are low and unrelated to actual water consumption. The managers of those facilities expressed a common opinion that no one would use the water if prices increased. For other types of irrigation systems, no information is available; • For industry, there is some data on consumption and costs for large industrial facilities, but information is missing for many plants, especially those that have self-services for water abstraction, treatment and wastewater discharges.
Key problems and potential solutions	• Available economic information is incomplete, piecemeal, unevenly spread in space and time and not always comparable. Existing information is not readily available since it is not organised in a way that would make it straightforward to use; • The situation should improve with the recent approval of a mandatory set of accounting standards for local authorities, and with the carrying out of planned national surveys of supply and wastewater systems as well as water uses in general; • Information on water quality is not complete, as the national monitoring network is in the process of being set up; • The group was unable to go very far into the identification of gaps in water status and subsequent selection of programmes of measures because the other working groups were just starting their activities; • Some information is, at most, disaggregated into municipalities. As municipal boundaries do not coincide with river basin boundaries, the compatibility of scales will be a relevant issue.
Outstanding issues	• Co-operation with the other working groups did not go as far as would be desired to perform the complete economic analysis; • Very limited approach to baseline scenario development; • Available information was insufficient for cost-effectiveness analysis.
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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 2

Identification of Water Bodies

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 2

Identification of Water Bodies

Produced by Working Group on Water Bodies

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (hereafter referred to as Common Implementation Strategy (CIS) for the Water Framework Directive (WFD)). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, the European Commission (Directorate General for Environment, Unit B.1) was invited to set up an informal process for drafting a horizontal Guidance on the application of the term "water body" which is defined in the Directive. This term is essential for several aspects of implementation, such as the typology, the reference conditions, the classification of the status and the monitoring.

A drafting group was established in March 2002 and a first draft was discussed on the Strategic Co-ordination Group meeting in April 2002 and the meeting of the Water Directors in June 2002. Following this meeting in Valencia, the members of the Strategic Co-ordination Group were invited to comment the draft paper in two rounds and revised versions were presented in each meeting of the group. In addition, the Expert Advisory Forum (EAF) on Groundwater discussed and contributed twice to the refinement of the groundwater Section in this document.

Due to the active and constructive contribution of all experts in the drafting group, the EAF Groundwater and the Strategic Co-ordination Group, it was possible to present the final draft of the horizontal Guidance Document on "water bodies" to the meeting in Copenhagen, where the Water Directors reached the following conclusions:

"We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders of the Directorate General for Environment of the European Commission for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation."

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1 Introduction

1.1 Background to Guidance

The Water Framework Directive (2000/60/EC) is a comprehensive piece of legislation that sets out, *inter alia*, clear quality objectives for all waters in Europe. In order to make the implementation of the Directive, and the compliance checking of its quality objectives, operational, the concept of "water bodies" has been introduced as the key units to which a number of the Directive's requirements are related.

Several of the working groups of the Common Implementation Strategy for the Water Framework Directive (2000/60/EC) have requested horizontal Guidance from the European Commission on the interpretation and application of the term water body. The working groups have asked for such Guidance in order to assist them in the preparation of their own Guidance on issues such as reference conditions (WFD CIS Guidance Document No. 10) and intercalibration (WFD CIS Guidance Document No. 6).

In addition, several Member States have contributed to discussions on the application of the term water body, and a number of documents have been produced. These are listed in the Annex to this paper, and are available on the WFD CIRCA system where electronic formats are available. These discussions have revealed that there are different views among Member States on the interpretation, and consequently practical application, of the term water body.

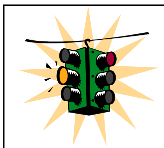
1.2 Purpose of Guidance

The purpose of this Guidance Document is to build on these discussions to develop a common understanding of the definition of water bodies and specific practical suggestions for the identification of water bodies under the Water Framework Directive.

1.3 Structure of Guidance

The following Section on the background includes general considerations applicable to surface and groundwater. However, the Directive's requirements for characterising, and its objectives for surface water bodies and bodies of groundwater are different. These differences affect the way the respective water bodies should be identified. Hence, the Guidance paper is therefore divided into two main sections. Section 3 provides guidance on the application of the term surface water body. Section 4 provides guidance on the application of the term body of groundwater.

Each Section is structured so that it describes the **principles** involved in, and a **hierarchical process** for, sub-dividing river basin districts into water bodies. The main steps in the proposed hierarchies are summarised in **Figure 7** and **Figure 11**.



Look out! The methodology from this Guidance Document must be adapted to regional and national circumstances
The Guidance Document proposes an overall pragmatic approach. Because of the diversity of circumstances within the European Union, Member States may apply this guidance in a flexible way in answer to problems that will vary from one river basin to the next. This proposed Guidance will therefore need to be tailored to specific circumstances.

Having said that, it should be clear that the identification of water bodies must be consistent and co-ordinated within a river basin district. In particular, international river basin districts need to develop common approaches for the whole river basin.

2 Background

2.1 Purpose of identifying "water bodies"

The Water Framework Directive covers **all** waters, including inland waters (surface water and groundwater) and transitional and coastal waters up to one sea mile (and for the chemical status also territorial waters which may extend up to 12 sea miles) from the territorial baseline of a Member State, independent of the size and the characteristics[1].

This totality of waters is, for the purpose of the implementation of the directive, attributed to geographical or administrative units, in particular the **river basin**, the **river basin district**, and the "**water body**"[2]. In addition, groundwaters and stretches of coastal waters must be associated with a river basin (district).

Whereas the river basin is the geographical area related to the hydrological system, the river basin district must be designated by the Member States in accordance to the directive as the "**main unit for management of river basins**"[3].

One key purpose of the Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems. The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of "water bodies". "Water bodies" are therefore the units that will be used for reporting and assessing compliance with the Directive's principal environmental objectives. However, it should be emphasised that the identification of a "water body" is a tool not an objective in itself.

The "water body" should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying "water bodies" is to enable the status to be accurately described and compared to environmental objectives[4].

It should be clear that the identification of water bodies is, first and foremost, based on geographical and hydrological determinants. However, the identification and subsequent classification of water bodies must provide for a sufficiently accurate description of this defined geographic area to enable an unambiguous comparison to objectives of the Directive. This is because the environmental objectives of the Directive, and the measures needed to achieve them, apply to "water bodies". A key descriptor in this context is the "status" of those bodies. If water bodies are identified that do not permit an accurate description of the status of aquatic ecosystems, Member States will be unable to apply the Directive's objectives correctly (Figure 1). At the same time, an endless sub-division of water bodies should be avoided in order to reduce administrative burden if it does not fulfil any purpose as regards the proper implementation of the Directive. In addition, the aggregation of water bodies may, under certain circumstances, also help to reduce meaningless administrative burden, in particular for smaller water bodies (cf. Chapter 5).

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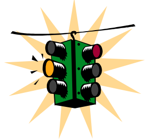
[1] *Articles 2 (1), (2) and (3)*

[2] *Articles 2 (13), (15), (10), and (12) respectively*

[3] *Article 2 (15)*

[4] *An estimate of the status of water bodies will be required to assess the likelihood that they will fail to meet the environmental quality objectives set for them under Article 4 [Article 5; Annex II 1.5 & 2]. The status of water bodies must be classified using information from the monitoring programmes [Article 8, Annex V 1.3, 2.2 & 2.4]. The status of water bodies must be reported in the river basin management plans [Article 13, Annex VII] and, where necessary, measures must be prepared [Article 11, Annex VI].*



Look out! **The Directive only requires sub-divisions of surface water and groundwater that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of surface water and groundwater into smaller and smaller water bodies that do not support this purpose should be avoided.**

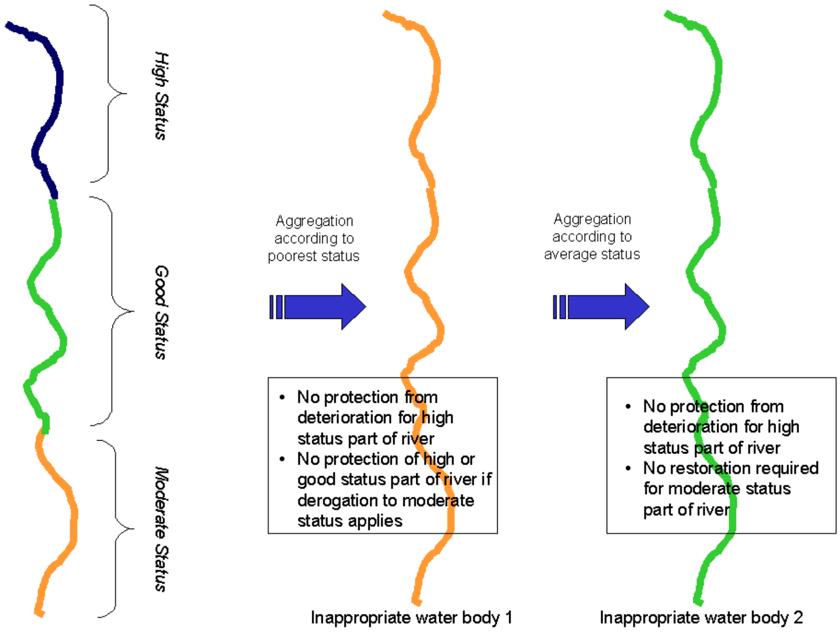


Figure 1: Illustration of the implications for the objectives of the Directive if "water bodies" do not provide for the accurate description of surface water status

2.2 Timetable and refinement for the identification of water bodies

The identification of water bodies should be an iterative and on-going process. The water bodies that Member States are required to identify by 22 December 2004[6] and report to the Commission by 22 March 2005[5] will be only a first step. Where necessary, water body identification should be verified and refined in the period before the publication of each river basin management plan.

The Directive requires Member States to identify "water bodies" as part of the analysis of the characteristics of the river basin districts[6]. The first such analysis must be complete by 22 December 2004. The analysis must be reviewed, and where necessary, updated by 22 December 2013 and then every six years.

However, identifying water bodies that will provide for an accurate description of the status of surface water and groundwater will require information from the Article 5 analyses and reviews, and the Article 8 monitoring programmes. Some of the necessary information will not be available before 2004. The information that is available is likely to be updated and improved in the period prior to the publication of each river basin management plan.

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[5] *Article 15.2*

[6] *Article 5, Annex II 1.1 & 2*

It is evident that for the first RBMP, all waters must be assigned to water bodies and their status must be described[7]. However, practical approaches may be required in particular for large numbers of pristine waters in remote areas where it can be demonstrated that no significant pressure exist (see also Section 5).

In conclusion, verification and refinement steps of water body identification should be foreseen in the implementation process.

[7] *cf. WFD CIS Guidance Document No 7.*

3 Specific Guidance on surface water bodies

3.1 Definition of body of surface water

Article 2.10 of the Directive provides the following definition of a body of surface water:

"Body of surface water" means a ***discrete and significant element*** *of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.*

The application of the definition requires the sub-division of surface water[8] in river basin (districts[9]) into "discrete and significant elements". Although examples of such elements are given ("such as a lake, a reservoir, a stream, river or canal "), the Directive does not provide explicit guidance on how to identify the elements that should be regarded as "discrete and significant", and hence "water bodies". For example, it does not specify how to identify **part** of a river, stream or canal that represents a "**discrete and significant element"**.

The use of the terms "discrete and significant" in the definition of "surface water body" means that "water bodies" are not arbitrary sub-divisions of river basin districts. Each water body should be identified on the basis of its "discreteness and significance" in the context of the Directive's purposes, objectives and provisions.

3.2 Technical interpretation of discrete and significant element

General considerations in relation to the definition and the characterisation requirements for surface water bodies[10] establish a number of specific requirements relevant to the identification of discrete and significant elements. These also present a certain hierarchy of definitions which should be in the identification process. They are summarised in the following paragraphs.

3.2.1 Discrete element

For a surface water body to be a discrete element of surface water, they must not overlap with each other or be composed of elements of surface water that are not contiguous.

It is evident that a water body must be discrete **and** significant at the same time, the element of discreteness is not sufficient on its own. In addition, the considerations regarding the aggregation of water bodies may be applied under certain circumstances, in particular for small "water bodies" (cf. Chapter 5).

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[8] *Article 2.1*

[9] *Article 3.1*

[10] *Annex II 1*

3.2.2 Surface water categories

A surface water body must not be split between different surface water categories (rivers[11], lakes[12], transitional waters[13] and coastal waters[14]). It must be of one category or another [15]. The boundary of a water body may be established where two different category "meet" (Figure 2).

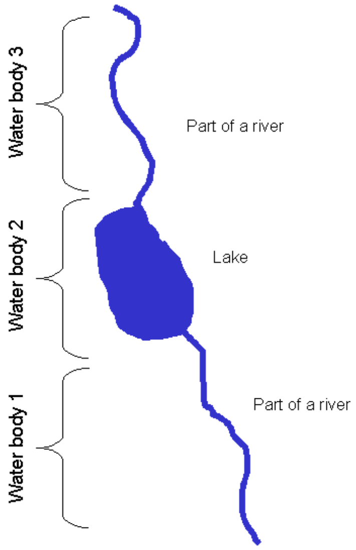

Figure 2: The boundaries to the categories of surface water create boundaries to water bodies

3.2.3 Typology[16]

A surface water body must not cross the boundaries between surface water body types. It must be of one type or another since one purpose of characterising surface water bodies is to differentiate them into types[17].

3.2.4 Physical characteristics delineating discrete and significant elements

Physical features (geographical or hydromorphological) that are likely to be significant in relation to the objectives of the Directive should be used to identify discrete elements of surface water.

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[11] *Article 2.4*

[12] *Article 2.5*

[13] *Article 2.6*

[14] *Article 2.7*

[15] *Annex II 1.1(i)*

[16] *CIS WGs 2.3 and 2.4 are developing Guidance on the application of typology systems (WFD CIS Guidance Document No. 10 and 5)*

[17] *Annex II 1.1 (ii)*

Geographical or hydromorphological features can significantly influence surface water ecosystems and their vulnerability to human activities. These features can also differentiate discrete elements of surface water. For example, the confluence of one part of a river with another could clearly demarcate a geographically and hydromorphologically distinct boundary to a water body (Figure 3).

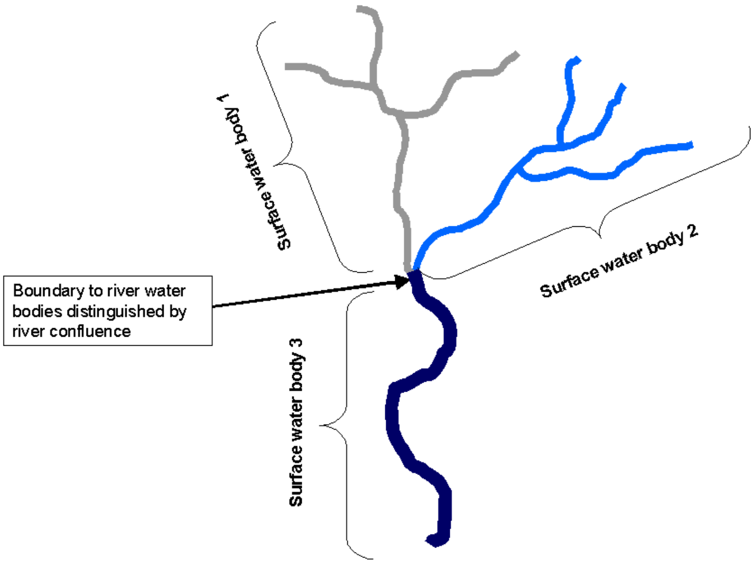

Figure 3: Example of the sub-division of a river on the basis of physical features – in this case a river confluence.

However, the Directive does not exclude other elements, such as a part of a lake or part of transitional water, from being considered as water bodies. For example, if part of a lake is of a different type to the rest of the lake, the lake must be sub-divided into more than one surface water body (Figure 4).

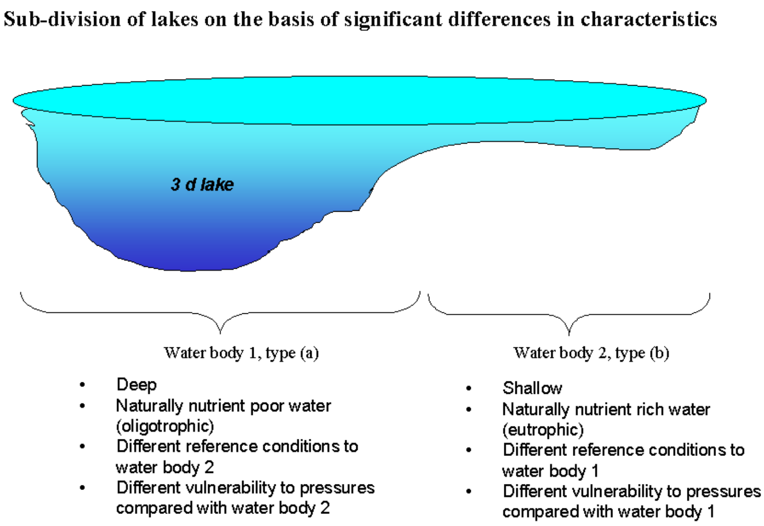

Figure 4: Sub-division of a lake on the basis of a type boundary

3.2.5 Heavily modified and artificial water bodies[18]

Heavily modified water bodies may be identified and designated where good ecological status is not being achieved because of impacts on the hydromorphological characteristics of a surface water resulting from physical alterations (Figure 5).

Heavily modified and artificial water bodies[19] must be (at least) provisionally identified during the characterisation of surface waters[20]. Their identification and designation should be finalised for the purposes of the first river basin planning cycle on publication of the river basin management plans in 2009. The designations must be reviewed every six years[21].

The identification of heavily modified water bodies must be based on the designation criteria set out in Article 4.3. In principle, the boundaries of heavily modified water bodies are primarily delineated by the extent of changes to the hydromorphological characteristics that (a) result from physical alterations by human activity and (b) prevent the achievement of good ecological status.

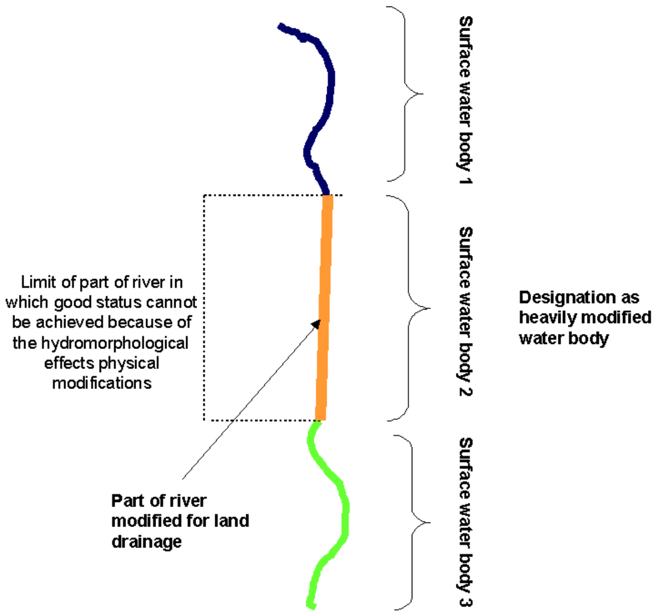

Figure 5: The establishment of water body boundaries through the identification and subsequent designation of heavily modified water bodies

3.2.6 Summary

The above-mentioned criteria can be directly drawn from the Directive. They represent a hierarchy of definitions that is already sufficient to enable a first identification of "water bodies" in the river basin (districts). As first step, the water category and the water body type

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[18] CIS Working Group 2.2 is developing detailed Guidance on the identification and designation of heavily modified water bodies (WFD CIS Guidance Document No. 4)

[19] Article 2.9

[20] Annex II 1.1(i)

[21] Article 4.3

should be used to draw the boundaries resulting in discrete "water bodies". In a subsequent step, geographical and hydromorphological elements could be considered. However, if such an approach does not lead to a meaningful delineation of "water bodies", other criteria could be used. These other criteria are described in the subsequent Section.

3.3 Other criteria for delineating surface water bodies

The Water Framework Directive provides for the above-mentioned criteria (cf. Section 3.2) to identify water bodies. However, there are other considerations or parameters which will help to improve the delineation of meaningful water body boundaries. One requirement that is implicit in the Directive is that the purpose of identifying "water bodies" is to enable the **status**[22] of surface waters to be accurately described. Related to this requirement, there are considerations regarding **pressures** and **impacts**. Furthermore, different **uses** (e.g. drinking waters) and existing or new **protected areas** (e.g. Natura 2000 sites) may be used in the refinement of the "water body" identification. The subsequent Sections will focus on aspects of status and protected areas. However, it should be noted that the questions of pressures, status and impacts are closely inter-linked. In the absence of sufficient information on the water status, the results of the pressure and impact analysis may be used for identifying meaningful water body boundaries (WFD CIS Guidance Document No. 3). This will mainly apply for the preparation of the first characterisation.

Member States may identify "surface water bodies" using additional criteria designed to take account of local circumstances and therefore assist in the river basin management planning process.

3.3.1 Status criteria

A discrete element of surface water should not contain significant elements of different status. A "water body" must be capable of being assigned to a single ecological status class with sufficient confidence and precision through the Directive's monitoring programmes[23].

Although effects of human activities will always vary no matter what the size of a water body, major changes in the status of surface water should be used to delineate surface water body boundaries as necessary to ensure that the identification of water bodies provides for an accurate description of surface water status (see Section 2 and Figure 6).

It is clearly possible to progressively subdivide waters into smaller and smaller units that would impose significant logistic burdens. However, it is not possible to define the scale below which subdivision is inappropriate. It will be necessary to balance the requirement to adequately describe water status with the need to avoid the fragmentation of surface waters into unmanageable numbers of water bodies. In addition, the aggregation of water bodies may be appropriate, under certain circumstances, to reduce meaningless administrative burden (cf. Chapter 5). In the end, it is a matter for Members States to decide on the basis of the characteristics of each River Basin District.

Initially, Member States will not have sufficient information to accurately define the status of waters. Consequently, especially during the period prior to the publication of the first River Basin Management Plan, it may be appropriate to use the analysis on pressures and impacts

[22] *respectively **potential** for artificial and heavily modified water bodies*

[23] *WFD CIS Guidance Document No.s 5 6, 7 and 10 provide Guidance on the classification of ecological status and monitoring.*

as a surrogate for status. As understanding of status improves, the boundaries of water bodies can be adjusted. Contiguous elements of surface water within a type that are of the same status may be recombined to avoid unnecessary sub-division of surface waters.

Finally, it is emphasised that the scale chosen for a particular "water body" will have influence on the management of the active involvement of stakeholders and the public (WFD CIS Guidance Document No. 8 provides guidance on Public Participation).

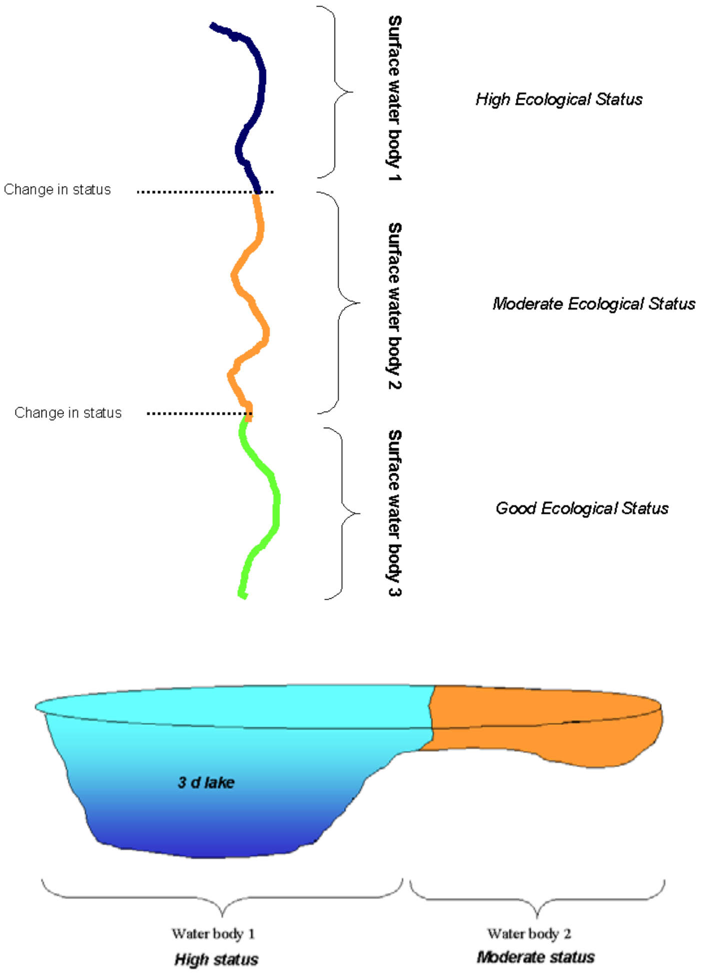

Figure 6: Identification of water bodies according to differences in status

3.3.2 Protected areas

Protected areas are identified under various pieces of legislation such as *inter alia* Natura 2000 sites designated under the Habitat Directive - (92/43/EC). Under the Water Framework Directive, all the protected areas must be considered for an integrated river basin management[24]. Specific objectives[25] were defined and various provisions specify more specific requirements for protected areas (e.g. monitoring[26]). In consequence, there are additional objectives to be considered for water bodies which are also fully part of a protected

[24] *Article 6, 7 and Annex IV*

[25] *Article 4 (1) c*

[26] *Annex V, point 1.3.5*

area. Hence, the existing boundaries of protected areas may be considered for the identification of water bodies under the Water Framework Directive.

The boundaries of water bodies and protected areas will, in most cases, not coincide because both geographical areas are being defined for different purposes on the basis of different criteria. In case a water body would not fully be inside or outside a protected area, it may be considered to sub-divide the water bodies into two parts so that the boundaries coincide.

3.4 Suggested process for the practical application of the term surface water body.

The principles described above for the identification of surface water bodies can be applied in a hierarchical process (see Figure 7).

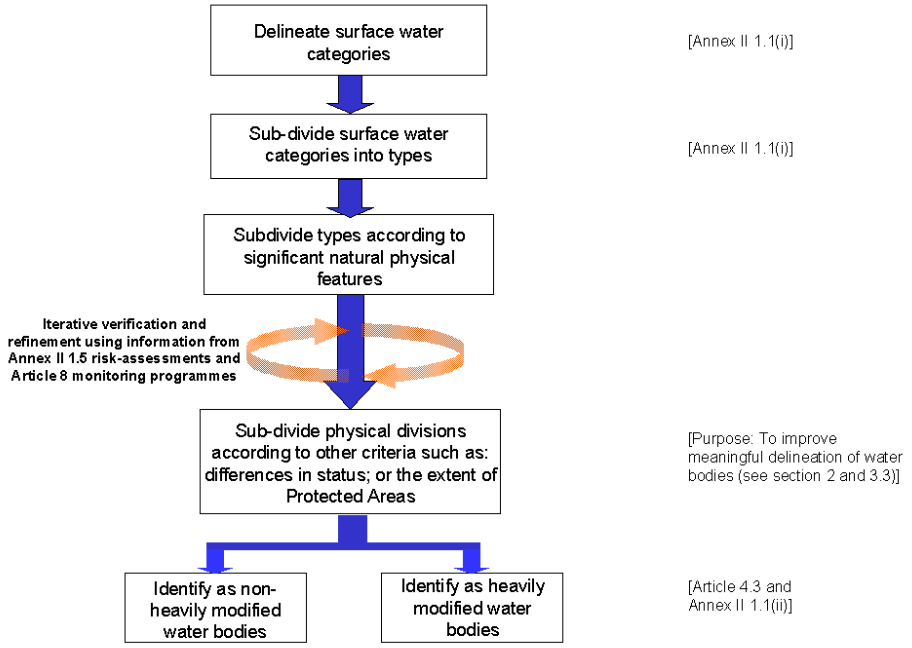

Figure 7: Summary of suggested hierarchical approach to the identification of surface water bodies

To ensure that water bodies do not cross the boundaries of surface water categories (Paragraph 3.2.2), the **suggested first step** in delineating surface water bodies is to identify the boundaries of the surface water categories.

To ensure that water bodies do not cross the boundaries of surface water types (Paragraph 3.2.3), the **suggested second step** in delineating surface water bodies is to identify the boundaries of the surface water types in each river basin district.

To ensure that water bodies represent discrete and significant elements of surface waters, the **suggested third step** in delineating them is to identify boundaries using distinct physical features (Paragraph 3.2.4) that are (a) likely to be significant in the context of aquatic ecosystem characteristics, and (b) are consistent with the examples of discrete and significant elements of surface water given in the Directive's definition (see Section 5.1).

In order to ensure that water bodies are identified in a meaningful way, the **suggested fourth step** in identifying surface water bodies is to identify boundaries on the basis of other relevant criteria (cf. Section 3.3). This approach is also necessary for the identification of heavily modified water bodies (see Section 3.2.5). Initially, in the case of absence of information on status, the pressure and impact assessment[27] procedure required under Article 5 will provide estimates of status changes (refer to WFD CIS Guidance Document No.3). The monitoring programmes[28] will provide the information necessary to confirm status-based boundaries. Hence, an iterative approach for identifying water bodies should be applied. At the same time, it is evident that the delineation of water bodies must be finally agreed at a certain point in time in order to enable the preparation of the river basin management plan. The competent authorities of a river basin district will have to ensure that a balance between an iterative identification and the final assignment of water bodies is achieved.

3.5 Small elements of surface water

The purpose of the Directive is to establish a framework for the protection of **all** waters including inland surface waters, transitional waters, coastal waters and groundwater[29]. Member States must ensure that the implementation of the Directive's provisions achieves this purpose. However, surface waters include a large number of very small waters for which the administrative burden for the management of these waters may be enormous. .

The Directive does not include a threshold for very small "water bodies". However, the Directive sets out two systems for differentiating water bodies into types[30], System A and System B. Only the System A typology specifies values for size descriptors for rivers and lakes. The smallest size range for a System A river type is 10 – 100 km^2 catchment area[31]. The smallest size range for a System A lake type is 0.5 – 1 km^2 surface area[32]. No sizes for small transitional and coastal waters are given. The application of system B must achieve, at least, the same level of differentiation as system A. It is therefore recommended to use the size of small rivers and lakes according to system A. However, it is recognised that in some regions where there are many small water bodies, this general approach will need to be adapted. Having said that, it may be appropriate to aggregate water bodies into groups for certain purposes as outlined in Chapter 5 in order to avoid unnecessary administrative burden.

However, there are still large numbers of discrete rivers and lakes that are smaller than these thresholds. A possible approach for the protection of these waters is outlined below.

Member States have flexibility to decide whether the purposes of the Directive, which apply to all surface waters, can be achieved without the identification of every minor but discrete and significant element of surface water as a water body.

[27] *Annex II 1.5*

[28] *Article 8*

[29] *Article 1*

[30] *Annex II 1.2*

[31] *Annex II 1.2.1*

[32] *Annex II 1.2.2*

A suggested approach (see Figure 8) is to:

- include small elements of surface water as part of a contiguous larger water body of the same surface water category and of the same type, where possible;
- where this is not possible, screen small elements of surface water for identification as water bodies according to their significance in the context of the Directive's purposes and provisions (e.g. ecological importance; importance to the objectives of a Protected Area, significant adverse impacts on other surface waters in the river basin district). In such a case, small elements; (1) belonging to the same category and type, (2) influenced by the same pressure category and level and (3) having an influence on another well-delimited water body, may be grouped for assessment and reporting purposes;
- for those small elements of surface water not identified as surface water bodies, protect, and where necessary improve them to the extent needed to achieve the Directive's objectives for water bodies to which they are directly or indirectly connected (i.e. apply the necessary basic control measures under Article 11)[33].

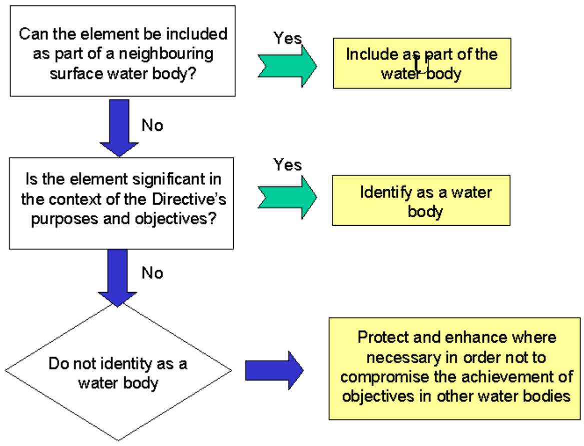

Figure 8: A suggested approach to ensuring appropriate protection of smallest surface waters

3.6 Components of a "surface water body" and wetlands

A "surface water body" comprises the quality elements described in the Directive for the classification of ecological status[34].

[33] *The Article 4.1(a)(iii) priority substances objectives apply to all surface waters regardless of whether they are identified as surface water bodies.*

[34] *Annex V 1.1 & Annex V 1.2*

In concrete terms this means that, e.g., a river water body comprises:

(a) the hydromorphological quality elements, which include the water flow, the bed of the channel, that part of the land adjacent to the channel that's structure and condition is directly relevant to the achievement of the values for the biological quality elements (i.e. the riparian zone); and

(b) the relevant biological elements.

In relation to wetlands, this means that those wetlands must be associated with a "water body", which are directly influencing the status of the related "water body". The boundaries of such wetlands must be identified in a pragmatic way in order to meet the requirement of a "discrete and significant" element.

The question of wetlands in the context of the Water Framework Directive will be subject to a separate Guidance Documents (currently in preparation) under the umbrella of the Common Implementation Strategy. It is recommended that this Guidance on wetlands, which will emerge in the first half of 2003, should develop the understanding of wetlands as a component of a surface water in more detail.

4 Specific Guidance on bodies of groundwater

4.1 Definitions

The application of the term body of groundwater must be understood in the context of the hierarchy of relevant definitions provided under Article 2 of the Directive.

- Article 2.2: ***Groundwater*** *means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil;*
- Article 2.11: ***Aquifer*** *means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater;*
- Article 2.12: ***Body of groundwater*** *means a distinct volume of groundwater within an aquifer or aquifers.*

A body of groundwater must be within an aquifer or aquifers. However, not all groundwater is necessarily within an aquifer.

The environmental objectives of preventing deterioration of[35],and protecting, enhancing and restoring[36] good groundwater status apply only to bodies of groundwater. However, all groundwater is subject to the objectives of preventing or limiting inputs of pollutants[37] and reversing any significant and sustained upward trend in the concentration of any pollutant[38].

4.2 Aquifers

As a consequence of the hierarchy of definitions (Section 4.1), the **suggested first step** in the identification of bodies of groundwater requires a general interpretation of the term aquifer, in respect what constitutes a significant flow of groundwater and what volume of abstraction would qualify as a significant quantity (see Figure 9).

4.2.1 Significant flow

The significance of groundwater flow should be understood in the context of the purpose and provisions of the Directive. Accordingly, a significant flow of groundwater is one that, were it from reaching an associated surface water body or a directly dependant terrestrial ecosystem, would result in a significant diminution in the ecological or chemical quality of that surface water body or significant damage to the directly dependent terrestrial ecosystems.

A key purpose of the Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems directly depending on aquatic ecosystems[39]. The objective of protecting and restoring good groundwater status[40] is designed to help achieve this purpose. It applies to all

[35] *Article 4.1(b)(i)*

[36] *Article 4.1(b)(ii)*

[37] *Article 4.1(b)(i)*

[38] *Article 4.1(b)(iii)*

[39] *Article 1(a)*

[40] *Annex V 2.1.2 & 2.3.2*

bodies of groundwater. Consequently, to ensure that the purpose of the Directive can be achieved, the definition of significant flow must encompass all groundwater flow that is important to aquatic and terrestrial ecosystems. Geological strata that permit such flow should therefore qualify as aquifers.

4.2.2 Abstraction of significant quantities of groundwater

Article 7 requires the identification of all groundwater bodies used, or intended to be used, for the abstraction of more than 10 m^3 of drinking water a day as an average. By implication, this volume could be regarded as a significant quantity of groundwater. Geological strata capable of permitting such levels of abstraction (even only locally) would therefore qualify as aquifers.

If either of the criteria described in Paragraphs 4.2.1 or 4.2.2 are satisfied, the geological strata should be regarded as an aquifer. Most geological strata would be expected to qualify as aquifers as most supply or are intended to supply 10 m^3 a day as an average or could serve 50 or more people.

However, it is clear that the requirements are different as regards those groundwater bodies which are being used or are intended to be used for drinking water abstraction (cf. Article 7) and those bodies where groundwater is abstracted for other uses (cf. Annex II 2.3). For the latter, not all groundwater bodies would be identified. The criteria in Annex II 2.3 specify, that only those groundwater bodies must be addressed "*which cross the boundary between two or more Member States or are identified [...] as being at risk of failing to meet the objectives set for each body under Article 4".*

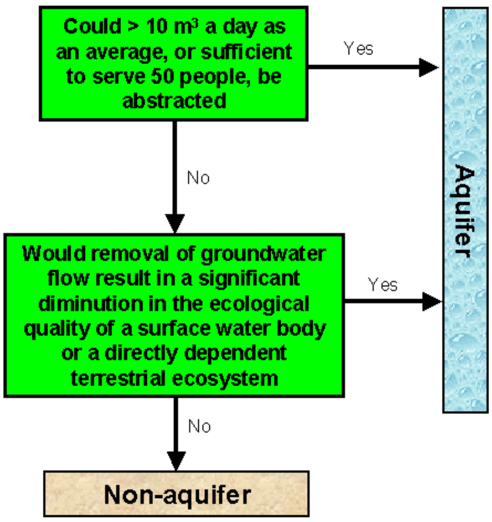

Figure 9: The Directive's definition of aquifer requires two criteria to be considered in determining whether geological strata qualify as aquifers. If either of the criteria is met, the strata will constitute an aquifer or aquifers. In practice, the criteria mean that nearly all groundwater in the Community would be expected to be within aquifers.

4.3 Delineation of bodies of groundwater

The Directive's definition of the term body of groundwater does not provide explicit Guidance on how bodies should be delineated.

The delineation of bodies of groundwater must ensure that the relevant objectives of the Directive can be achieved. This does not mean that a body of groundwater must be delineated so that it is homogeneous in terms of its natural characteristics, or the concentrations of pollutants or level alterations within it. However, bodies should be delineated in a way that enables an appropriate description of the quantitative and chemical status of groundwater.

The delineation of bodies of groundwater should ensure that groundwater quantitative status[41] can be reliably assessed. In some circumstances, quantitative status may be determined using long-term monitoring data. In other cases, an estimation of the available groundwater resource will require a water balance calculation (see WFD CIS Guidance Document No. 7- Chapter 4). Delineating bodies of groundwater in such a way that any groundwater flow from one groundwater body to another (a) is so minor that it can be ignored in water balance calculations; or (b) can be estimated with adequate precision will facilitate the assessment of quantitative status.

Member States will need to take into account the particular characteristics of their aquifers when delineating bodies of groundwater. For example, the flow characteristics of some geological strata, such as karst and fractured bedrock, are much more complex and difficult to predict than others. The delineation of water bodies should therefore be regarded as an iterative process, refined over time to the extent needed to adequately assess and manage risks to the achievement of the Directive's objectives.

It may also be the case that there is substantial flow between strata with very different characteristics (e.g. karst and sandstone). The properties of these different strata may mean that they require very different management approaches to achieve the objectives of the Directive. In such cases, Member States may wish to delineate water body boundaries that coincide with the boundaries between the strata. In doing so, Member States should ensure that their ability to adequately assess quantitative status is not compromised.

4.3.1 Geological boundaries

Bearing in mind the above, the starting point for identifying the geographical boundaries of a groundwater body should be geological boundaries to flow, unless the description of status and the effective achievement of the Directive's environmental objectives for groundwater require sub-division into smaller groundwater bodies.

4.3.2 Other hydraulic boundaries

Sub-divisions of an aquifer or aquifers that cannot be based on geological boundaries should be based initially on groundwater highs or, where necessary, on groundwater flow lines (Figure 10).

4.3.3 Taking account of differences in status

The objectives for bodies of groundwater, and the measures required to achieve them, depend on the existing status of the bodies. The bodies should be units of one chemical and one quantitative status that can be characterised and managed to allow the effective achievement of the Directive's objectives. Major changes in the status of groundwater should therefore be taken into account when delineating groundwater body boundaries to ensure that, as far as practical, water bodies provide for an accurate description of groundwater status. In doing so, Member States should bear in mind the need to ensure that groundwater quantitative status can be reliably assessed (see Section 2). Where status is consistent, large bodies of groundwater may be delineated. Where status differences are reduced during

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[41] Annex V 2.1.2. Quantitative status requires assessment of the available groundwater resource [Article 2.27]. This requires a water balance calculation.

a planning cycle, Member States may recombine subdivisions of groundwater of the same status for the purposes of subsequent planning cycles. **However, water bodies must at least be fixed for each plan period.**

Initially, Member States will not have sufficient information to accurately define the status of groundwater. Consequently, especially during the period prior to the publication of the first River Basin Management Plan, it may be appropriate to use the analysis of pressures and impacts[42] as an indicator of status. As understanding of status improves, the boundaries of groundwater bodies should be reviewed as part of the analyses required under Article 5 prior to the publication of each river basin management plan.

It is clearly possible to progressively subdivide the groundwater in aquifers into smaller and smaller units and thereby create significant logistical burdens. However, it is not possible to define a universally applicable scale below which subdivision is inappropriate.

The degree of subdivision of groundwater into bodies of groundwater is a matter for Members States to decide on the basis of the particular characteristics of their River Basin Districts. In making such decisions, it will be necessary for Member States to balance the requirement to adequately describe groundwater status with the need to avoid the fragmentation of aquifers into unmanageable numbers of water bodies.

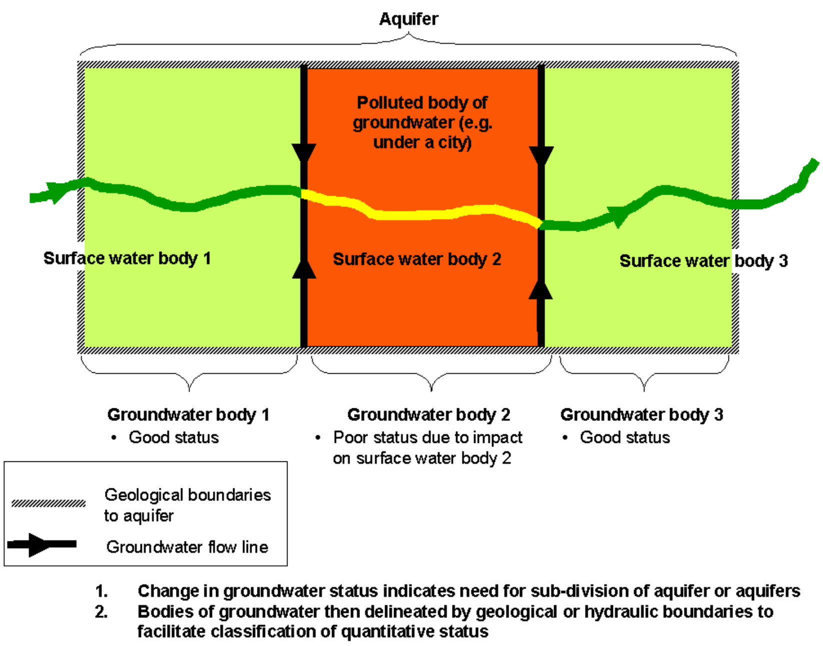

Figure 10: Sub-division of aquifers into bodies of groundwater using hydraulic boundaries

4.4 Upper and lower boundaries to bodies of groundwater

Groundwater bodies should be delineated in three dimensions[43].

The depth of groundwater within an aquifer or aquifers that needs to be protected and, where necessary, enhanced through its inclusion in a body of groundwater should depend on the risks to the Directive's objectives. This is a matter for Member States to decide based on

[42] *Article 5 and Annex II(2)*

[43] *e.g. Annex II 2.2*

their assessments of groundwater characteristics and the risks to the Directive's objectives[44]. It should be noted that all groundwater is subject to the 'prevent or limit' objective [Article 4.1(b)(i)] whether or not it is identified as being part of a body of groundwater.

Although most pressures will affect the relatively shallow component of a groundwater flow, groundwater flow at depth can still be important to surface ecosystems - even though this may be over an extended timescale. Human alterations to groundwater flow at depth can affect shallow groundwater and thus potentially the chemical and ecological quality of connected surface ecosystems. Deep groundwater may also be an important resource for drinking water or other uses. However, Member States would not be expected to identify deep groundwater as water bodies where that groundwater (a) could not adversely affect surface ecosystems; (b) are not used for groundwater abstraction; (c) was unsuitable for drinking water supply because of its natural qualities or because its abstraction would be technically unfeasible or disproportionately expensive; and (d) could not place the achievement any other relevant objectives at risk.

The Directive's definitions of aquifer and body of groundwater (see Section 4.1) permit groundwater bodies to be identified either (a) separately within different strata overlying each other in the vertical plane, or (b) as a single body of groundwater spanning the different strata. This flexibility enables Member States to adopt the most effective means of achieving the Directive's objectives given the characteristics of their aquifers and the pressures to which they are subjected. For example, where there are major differences in status of the groundwater in strata at different depths, it may be appropriate to identify different bodies of groundwater (i.e. one on top of another) to ensure the status of groundwater can be accurately described, and the Directive's objectives appropriately targeted.

Similar criteria should be applied in defining the upper and lower boundaries of the groundwater body as to the geographical boundaries (Section 4.3). In other words, to facilitate the estimation of quantitative status, the upper and lower boundaries should be based first on geological boundaries and then on other hydraulic boundaries such as flow lines.

4.5 Assignment to River Basin Districts

Groundwater bodies must be assigned to a River Basin District[45].

4.6 Targeting measures within bodies of groundwater

The analyses undertaken in accordance with Article 5 and Annex II of the Directive (see WFD CIS Guidance Document No. 3 - IMPRESS), and supplemented by information from the monitoring programmes established under Article 8 (see WFD CIS Guidance Document No. 7 - monitoring) will identify those bodies at risk of failing to achieve the Directive's objectives because of specific pressures. This information together with the identification of Protected Areas under Article 6 will enable Member States to target measures on the right pressures in the right parts of their bodies of groundwater. To assist this targeting, Member States may establish zones within which specific measures are required to achieve the Directive's objectives. For example, Article 7 indicates that Member States may establish safeguard zones to help protect water intended for human consumption[46].

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[44] *Article 5 and Annex II 2*

[45] *Article 3.1*

[46] *Article 7.3*

4.7 Suggested process for the practical application of the term body of groundwater

Figure 11 suggests an iterative, hierarchical process for identifying bodies of groundwater based on the principles described in this Guidance paper.

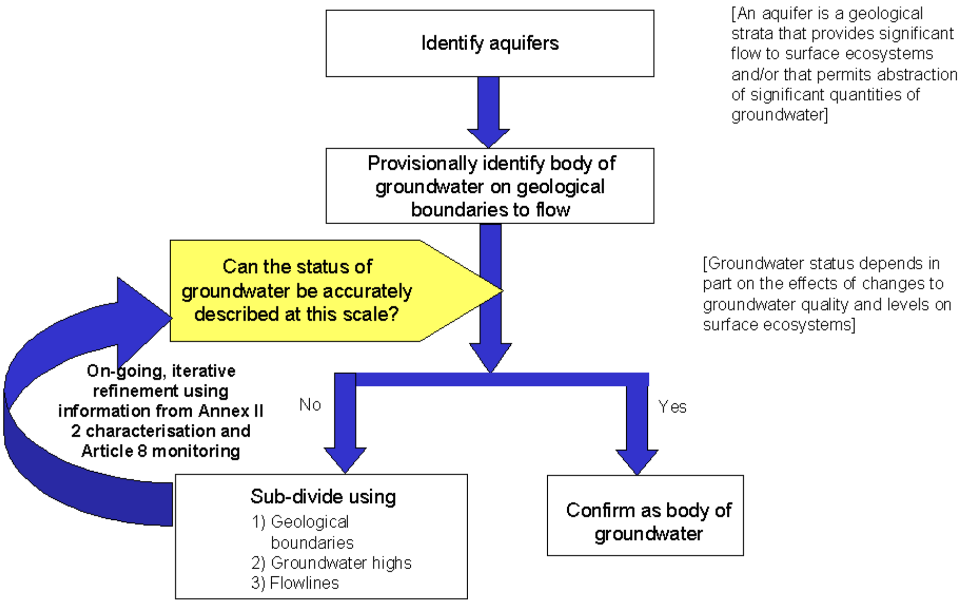

Figure 11: Summary of the suggested hierarchical approach to the identification of bodies of groundwater

5 Aggregation of water bodies

Surface water bodies or bodies of groundwater may each be grouped for the purposes of assessing the risk of failing to achieve the objectives set for them under Article 4 (pressures and impacts)(refer to WFD CIS Guidance Document No. 3)[47]. They may also be grouped for monitoring, reporting and management purposes where monitoring sufficient indicative or representative water bodies in the sub-groups of surface water or groundwater bodies provides for an acceptable level of confidence and precision in the results of monitoring, and in particular the classification of water body status refer to WFD CIS Guidance Document No. 7)[48].

It is clear that, for management purposes, it may be useful to aggregate water bodies. First practical indications suggest that such an aggregation will also be inevitable when it comes to reporting to the European Commission. At the same time, there are no criteria whether and when such an aggregation is acceptable.

Where contiguous elements of surface water within a type are of the same status, their combination in a single water body will provide for an accurate description of surface water status.

In addition, it will be necessary to apply this aggregation on the basis of clear criteria agreed on river basin district level and in a transparent way. Further details on whether and how aggregation of water bodies for the purpose of reporting is possible need to be discussed and elaborated in the context of the Expert Advisory Forum on Reporting. In the meantime it is recommended to focus particular attention on this issue when testing this Guidance Document, e.g. in the pilot river basins.

[47] *Annex II 1.5, 2.1 & 2.2.*

[48] *Annex V 1.3, 2.2 & 2.4.*

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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 3

Analysis of Pressures and Impacts

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 3

Analysis of Pressures and Impacts

Produced by Working Group 2.1 - IMPRESS

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, an informal working group dedicated to the identification of pressures and assessment of impacts within the characterisation of water bodies according to Article 5 of the Directive was set up in October 2001 and named IMPRESS. Germany and the United Kingdom have joint responsibility for the project management and secretariat of the working group, which is composed of technical experts from governmental and non-governmental organisations.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the IMPRESS group activities and discussions that have taken place since the official launch of IMPRESS in October 2001. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the process of Guidance development through meetings, workshops or electronic communication media, without binding them in any way to its content.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders, Isobel Austin and Volker Mohaupt, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

Table of contents

Overview / Executive Summary

WHAT IS THE PURPOSE OF THIS GUIDANCE DOCUMENT?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the analysis of pressures and impacts within the characterisation of water bodies according to Article 5 in the broader context of the development of integrated river basin management plans as required by the Directive.

TO WHOM IS THIS GUIDANCE DOCUMENT ADDRESSED?

If this is your task, we believe the Guidance will help you in doing the job, whether you are:

- Undertaking the pressures and impacts analysis yourself;
- Leading and managing experts undertaking the pressures and impacts analysis;
- Participating as a stakeholder in the assessment process;
- Using the results of the pressures and impacts analysis for aidimg decision making and supporting the development of river basin management plans; or
- Reporting on the pressures and impacts analysis to the European Commission as required by the Directive.

WHAT CAN YOU FIND IN THIS GUIDANCE DOCUMENT?

Common understanding about pressures and impacts in the Water Framework Directive (Chapter 2)

- What is the role of the analysis of pressures and impacts within the implementation process of the directive?
- How the analysis contributes to the characterisation of water bodies, which has to be fulfilled according to Article 5 of the Directive, and how this analysis feeds into the development of monitoring programmes, river basin management plans and programmes of measures;
- What are the key terms of the analysis (e.g. significant pressures, water bodies at risk of failing the Directive's objectives)?
- What are the Directives objectives?

General approach for the analysis of pressures and impacts (Chapter 3)

- What is the overall approach and what are the key working steps proposed to undertake the analysis?
- Which are the methods proposed for surface waters to:
    - Identify driving forces, pressures and significant pressures?
    - Assess susceptibility of water bodies to pressures and the severity of impacts?
    - Evaluate the risk of failing objectives?
- Which are the methods proposed for groundwater to:

- Undertake the initial characterisation?
- Undertake the further characterisation for 'at risk' groundwater bodies and bodies that cross the boundaries of member states?

The Toolbox (Chapter 4)

- Which specific tools, such as data, classification systems and models, are available to aid the analysis of pressures and impacts?

Sources of data and information (Chapter 5)

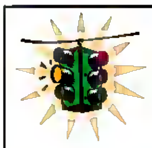
- Where do you find the information and data that will be required to undertake the analysis described in Section 3 or to support the tools mentioned in Section 4?

Examples of current practice (Chapter 6)

- What examples are available of current good practice in respect of at least one aspect of the analysis?

The methodology from this Guidance Document must be adapted to regional and national circumstances

The Guidance Document proposes an overall process and associated key steps. Due to the diversity of circumstances within the European Union, the way to undertake the analysis will vary from one river basin to the next. This proposed methodology will therefore need to be tailored to specific circumstances.



Look out!

What you will <u>not</u> find in this Guidance Document

The Guidance Document focuses on the "review of the impacts of human activity on the status of surface waters and on groundwater" according to Article 5 and Annex II (1.4, 1.5 and 2.). This then helps to develop River Basin Management Plans and Programmes of Measures. The Guidance focuses specifically on the 2004 requirements of the Directive. The Guidance does not focus on:

- How to designate heavily modified water bodies (see WFD CIS Guidance Document No 4 on Identification and Designation of Artificial and Heavily Modified Water Bodies);
- How to design monitoring programmes (see WFD CIS Guidance Document No 7 on Monitoring);
- How to develop any measure needed to achieve the objectives of the Directive (see WFD CIS Guidance Document No 9 on Best Practices in River Basin Planning).

1. Implementing the Directive: Setting the scene

This Section introduces the overall context for the implementation of the Water Framework Directive (WFD) and the initiatives that led to the production of this Guidance Document.

1.1 December 2000: A Milestone for Water Policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the WFD (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force.

The WFD is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the WFD.

1.2 The Water Framework Directive: new challenges in EU water policy

What is the purpose of the Directive?

The WFD establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which, according to Article 1:

- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

...and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);

- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (*Article 2 (22), Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the WFD cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).

Member States may not always be able to achieve good water status for all water bodies within a RBD by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions, which must be specifically explained in the relevant RBMP, the WFD offers the possibility to Member States to engage into two further six-year cycles of planning and implementation of measures (i.e. to 2027). Where failure to achieve objectives is constrained by natural conditions, the period may be extended beyond 2027.

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basim management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives,** combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources,** combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

1.3 What is being done to support implementation?

Activities to support the implementation of the WFD are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the WFD.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy (CIS).

The main objective of this strategy is to provide support to the implementation of the WFD by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance (see Annex I). A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision making body for the CIS.

The IMPRESS working group
In the context of this strategy, a working group dedicated to the identification of pressures and assessment of impacts within the characterisation of water bodies according to Article 5 of the Directive has been set up. The main (short-term) objective of this working group, launched in October 2001 and named IMPRESS, was the development of a non-legally binding and practical Guidance Document on this topic within the WFD. Germany and the United Kingdom have joint responsibility for the project management and secretariat of the working group, which is composed of technical experts from governmental and non-governmental organisations.

To ensure an adequate input and feedback during the Guidance development phase from a wider audience, and to evaluate earlier versions of the Guidance Document, the IMPRESS group has organised several discussions and feedback events such as meetings and workshops.

Developing the Guidance Document: an interactive process
Within a very short time period, a large number of experts and stakeholders have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- **Regular meetings** of the 40-plus experts and stakeholder members of IMPRESS;
- **Regular interactions** with experts from other working groups of the Common Implementation Strategy, mainly those dealing with economic

analysis, designation of heavily modified water bodies, reference conditions, and monitoring.

You can contact the experts involved in the IMPRESS activities
The list of IMPRESS members with full contact details can be found in Annex III of this guidance. If you need assistance with your own activities, contact a member from IMPRESS in your country.

2. Analysis of Pressures and Impacts in the Water Framework Directive – Common Understanding

2.1 Recall of WFD requirements

2.1.1 Requirements in relation to pressure and impact analysis

The previous Chapter has made clear the *purpose* of the WFD, and the importance of *integration* in achieving its objectives. The necessity to analyse pressures and impacts is stated in Article 5 of the WFD which requires, for each river basin district:

- An analysis of its characteristics;
- A review of the impact of human activity on the status of surface waters and groundwater; and.
- An economic analysis of water use.

This Guidance addresses the second of these requirements, but must be fully integrated with the economic analysis, for which Guidance has been prepared by the Economic Analysis working group (WATECO) (refer to WFD CIS Guidance Document No 1). The WFD requires the tasks specified under Article 5 to be completed by 2004. They will then be reviewed by 2013, and subsequently every 6 years (2019, 2025…). Given the overall purpose of the WFD, the analysis undertaken in 2004 must consider both the current condition for each water body, and a prognosis for the period to 2015. Thus the WFD is initiating an on-going process of assessment, iteration and refinement.

A specification for the impact review is contained in WFD Annex II Section 1 for surface waters, and Annex II Section 2 for groundwaters (Figure 2.1).

Surface waters
The review process is described in five parts corresponding to the sub-sections within WFD Annex II Section 1, namely:

1. Characterisation of surface water body types;
2. Ecoregions and surface water body types;
3. Establishment of type-specific reference conditions for surface water body types;
4. **Identification of Pressures;** and,
5. **Assessment of Impacts.**

This Guidance Document addresses the final two parts of this process, but clearly relates closely to both the characterisation and the establishment of reference conditions. There are two separate working groups of the CIS providing Guidance on Reference Conditions for Inland Surface Waters (REFCOND) and Typology and Classification Systems of Transitional and Coastal Waters (COAST) (refer to WFD CIS Guidance Document No.s 10 and 5, respectively).

The WFD requires information to be collected and maintained on the type and magnitude of significant anthropogenic pressures, and indicates a broad categorisation of the pressures into:

- Point sources of pollution;

- Diffuse sources of pollution;
- Effects of modifying the flow regime through abstraction or regulation; and,
- Morphological alterations.

Any other pressures, i.e. those not falling within these categories, must also be identified. In addition there is a requirement to consider land use patterns (e.g. urban, industrial, agricultural, forestry etc) as these may be useful to indicate areas in which specific pressures are located.

The impact assessment should use both information from the review of pressures, and any other information, for example environmental monitoring data, to determine the likelihood that the surface water body will fail to meet its environmental quality objectives. For bodies at risk of failing their specified objectives, it will be necessary to consider the implementation of additional monitoring and a programme of measures.

Groundwaters
A different process is described within WFD Annex II, Section 2, but this again has five parts (Figure 2.1), namely:

1. **Initial characterisation**, including identification of pressures and risk of failing to achieve objectives;
2. **Further characterisation** for at risk groundwater bodies;
3. **Review of the impact of human activity on groundwaters** for trans-boundary and at risk groundwater bodies;
4. **Review of the impact of changes in groundwater levels** for groundwater bodies for which lower objectives are to be set according to Article 4.5; and,
5. **Review of the impact of pollution on groundwater quality** for which lower objectives are to be set.

This Guidance addresses all parts of this process. The pressures identified in WFD Annex II, Sub-section 2.1 correspond to the first three of the categories identified for surface waters, namely:

- Point sources of pollution;
- Diffuse sources of pollution; and,
- Changes in water levels and flow caused by abstraction or recharge.

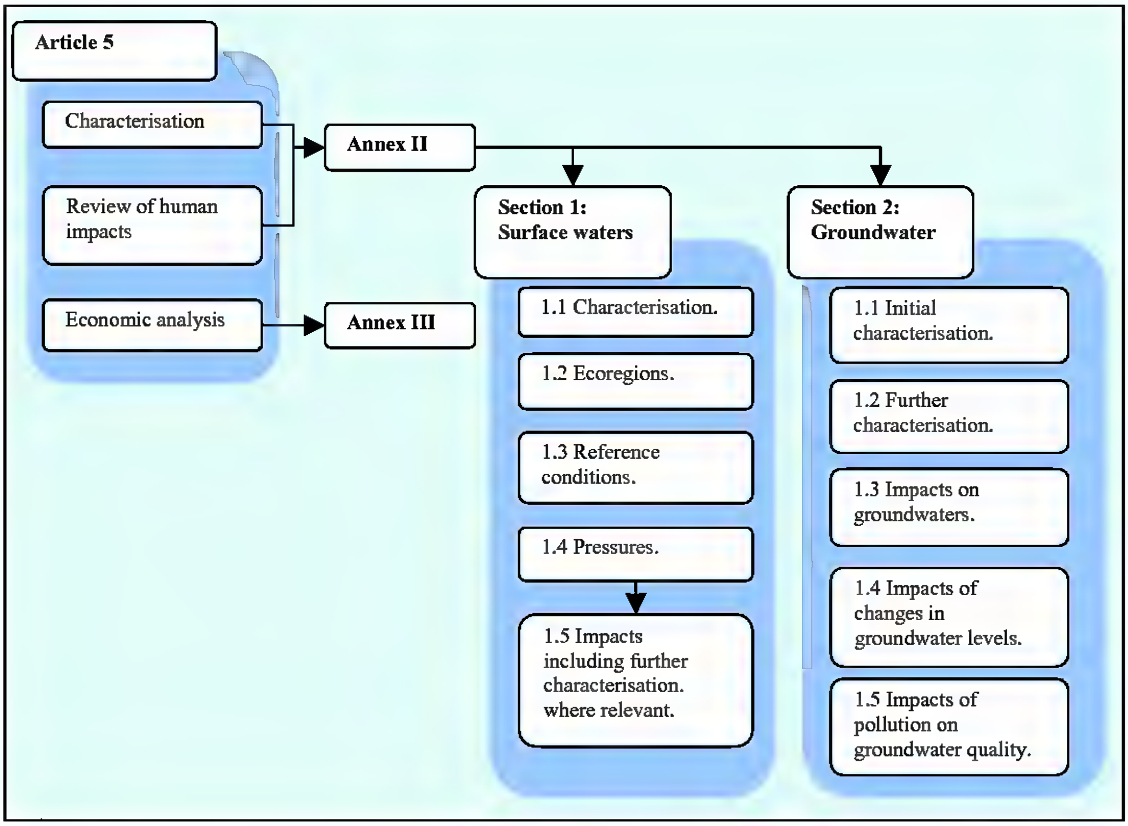


Figure 2.1 *The WFD specifies requirements for impact analysis separately, and differently, for surface and groundwaters.*

2.1.2 Links to other relevant requirements and related timescale

The review of pressures and impacts is only one element of the planning process, with other elements feeding into the review, or dependent on its outcome (Figure 2.2).

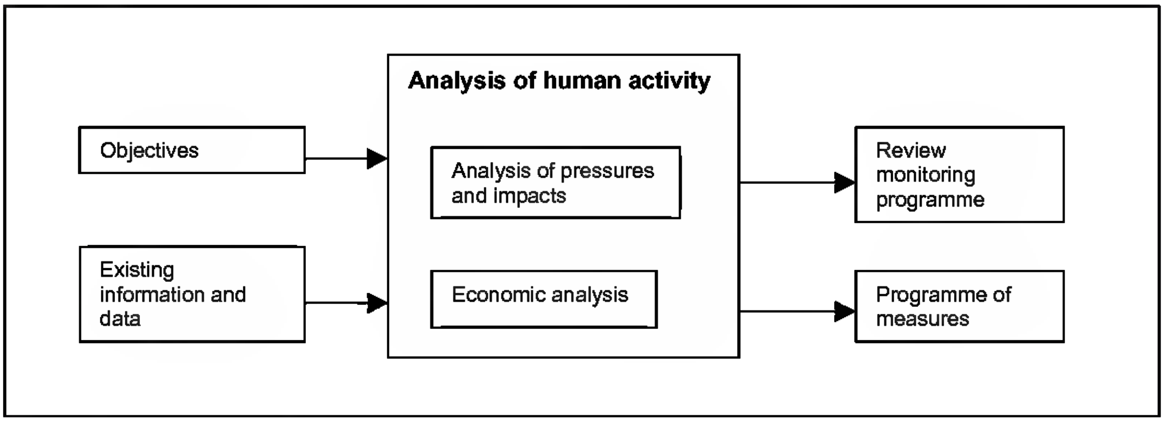


Figure 2.2 *Elements of the planning process.*

One of the most fundamental elements of this larger process is the setting of the environmental objectives (Article 4) since the review of pressures and impacts must identify water bodies that fail, or are at risk of failing, the specified objective. The objectives depend on both the overall objective to achieve good status by 2015, and possibly additional specific objectives that apply to *protected areas* as defined from other legislation. The objectives may also depend on the current status of the water body, since member states must, in general, prevent any deterioration in the status. The objectives are considered further in Section 2.3.

In the longer term, the achievement of the goals will be assessed through the monitoring of a water bodies' chemical and ecological state. The most important goal of the first review, required in 2004, is to understand the significant water management issues within each river basin and how they affect each individual water body. This may be considered a screening step prior to additional description and analysis at a later stage. This screening should identify issues to be addressed in the drawing up of the river basin management plan (RBMP), and it may also reveal a number of gaps in data or knowledge that should be filled during the process of drawing up the RBMP and the monitoring programme.

A factor that can affect the setting of objectives concerns the designation of a water body as artificial or heavily modified (Article 4). Guidance on such designation is available in WFD_CIS_Guidance_Document_No. 4. However, since designation of HMWBs will not be completed until 2009, the principles of the HMWB Guidance should be considered in undertaking the first pressures and impacts analysis. Indeed, the two processes should be seen as closely interacting parallel processes, and not independent activities.

The WFD establishes a number of objectives for surface waters and groundwater, and the pressures and impacts analyses must assess the risks of failing to achieve each of them. The objectives include new ecological objectives, the achievement of which may be compromised by a very wide range of pressures, including point source discharges, diffuse source discharges, water abstractions, water flow regulation, morphological alterations and artificial recharge of groundwater. These and any other pressures that could affect the status of aquatic ecosystems must be considered in the analyses.

The WFD requires the achievement of its principal objectives; good surface water status and good groundwater status, by the end of 2015 at the latest, unless Articles 4.3 – 4.7are applicable. Accordingly, the analyses of pressures and impacts must consider how pressures would be likely to develop prior to 2015 in ways that would place water bodies at risk of failing to achieve good status if appropriate programmes of measures were not designed and implemented. This will require consideration of the effects of existing legislation and forecasts of how the key economic factors that influence water uses will evolve over time, and how these changes may affect the pressures on the water environment (refer WFD CIS Guidance Document No. 3). Such forecasts should be provided by the economic analyses of water use required under Article 5. The pressures and impacts analyses will also need to identify which of the risks to the WFDs' objectives are expected to be addressed by the implementation of measures specified under other Community legislation. This information will enable the economic analyses to assess, and provide advice on, the most cost-effective combinations of measures that can be used to address the other risks to the achievement of the WFDs' objectives.

The WFDs' objective of preventing or limiting inputs of pollutants into groundwater [Article 4.1(b)(i)] does not specify which pollutants should be prevented from entry and to what extent others should be limited. It is therefore not clear how to assess the risks of failing to achieve this objective until clarification of its purposes is provided.

Such clarification may be provided in a daughter directive to be established under Article 17. This Daughter Directive is also expected to establish criteria for the identification of significant and sustained upward trends [Article 4.1(b)(iii)]. Until these criteria have been established, Member States will need to decide what constitutes a significant and sustained upward trend according to their own criteria.

The review of the pressures and impacts is required in the design of monitoring programmes which must be operational by 2006 (Article 8), and also to help develop programmes of measures which must be established by 2009, and made operational by 2012 (Article11). Article 14encourages the active involvement of all interested parties in the implementation of the WFD and requires Member States to *inform and consult the public*. Therefore, water agencies and authorities should make this review as transparent as possible. This Article specifically requires public consultation in the production of the RBMP, to which the pressures and impacts analysis makes a significant contribution.

Information sharing, consultation and public participation are requirements of the directive, and will also make implementation more effective. The Guidance Document on "Public Participation" provides further information about these forms of participation (WFD CIS Guidance Document No. 8).

Stakeholder participation is important as it can fulfil many functions, including:

- Developing a process agreed by all will increase the legitimacy of its outcome and thus facilitate an efficient and effective follow-up;
- Stakeholders can be a useful source of information and have expertise of direct use for the pressures and impact analysis (see Tables in Chapter 5);
- Survey of the public can be useful to understand how people value improvements in the environment and quality of our waters, and how far they are ready to pay for environmental improvements;
- Public involvement and the network of partners developed through participation can be useful to develop a sense of ownership over the River Basin Management Plans and may increase the effectiveness of measures taken to meet the Directive's objectives.

The Directive only specifies key dates for consultation, but rightly does not specify dates for the participation process, as this will depend on local institutions and socio-reference conditions set-up. However, it is recommended to start the participation process early (e.g. as part of the characterisation of the river basin before 2004) to improve its effectiveness.

See also Chapter 5 of this document showing who needs to get involved in carrying out and using the IMPRESS analysis.

Article 15 specifies the reporting requirements of the review undertaken under Article 5. Member states are required to provide summary reports of the reviews within three months of their completion (i.e. by March 2005 at the latest for the first review). Subsequently, reporting on these reviews will be contained in the RBMPs, which must be published first in 2009, and thereafter every six years (2015, 2021…). Therefore, from 2009 a schedule with a six-year cycle shall be established, with the review of pressures and impacts occurring two years prior to the publishing of the RBMP.

Article 6 requires that a register of *protected areas* is established by 2004, but this information is required at an earlier date to enable the review of pressures and impacts. The timescales and associated links are summarised in Table 2.1

Table 2.1 *Actions and dates by which they must be achieved (note that in practice many actions must be completed within a fixed period of the completion of a prerequisite task).*

Action	Date
Impact review completed by member states (Article 5, Article 15, Annex II)	2004
Register of protected areas established (Article 6)	2004
Summary reporting of impact review to Commission (Article 15)	2005
Monitoring programme operational (Article 8)	2006
First River Basin Management Plan completed (Article 15)	2009
Programme of measures established (Article 11)	2009
Programme of measures operational (Article 11)	2012

2.2 *Key terms*

While it is clear from the WFD that the impacts are the result of pressures, neither term is explicitly defined. For this reason a common understanding of the terms and the most effective approach has to be developed. In this Guidancethe widely-used Driver, Pressure, State, Impact, Response (DPSIR) analytical framework has been adopted with definitions as in Table 2.2, and illustrated using an example in Figure 2.3.

Table 2.2 *The DPSIR framework as used in the pressures and impacts analysis.*

Term	Definition
Driver	an anthropogenic activity that may have an environmental effect (e.g. agriculture, industry)
Pressure	the direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry)
State	the condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)
Impact	the environmental effect of the pressure (e.g. fish killed, ecosystem modified)
Response	the measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice Guidance for agriculture)

It is clear from these definitions that in the analysis of *pressures* and *impacts*, it is necessary to include information on *drivers*, and changes in the *state*, but that *responses* need not be considered. The distinction made here between state and impact separates effects that are sometimes combined, or confused. One reason for this is that because many of the impacts are not easily measurable, state is often used as an indicator of, or surrogate for, impact. This is seen in many existing methodologies (e.g. quality targets and classification systems) in which physico-chemical parameters are used to quantify ecological status. While such methods imply a well-understood relationship between state and impact, in practice this is not the case, and is the subject of on-going scientific research. In addition to this uncertainty, the parameters defining ecological status will not be finally established until after the first pressure and impact review has to be completed. The approach adopted in this guidance, therefore, provides a framework for analysis that reflects current understanding of how aquatic ecosystems function, and enables future integration of specific ecological criteria.

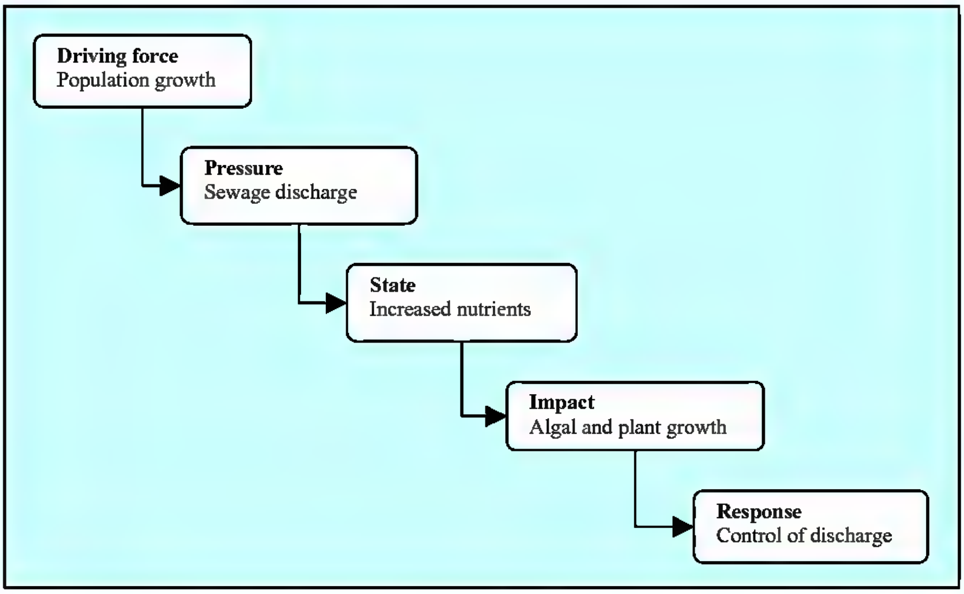


Figure 2.3 *An illustration of the DPSIR analytical framework (note that the response is not considered in the analysis of pressures and impacts described in this guidance).*

It is worth noting in the context of the DPSIR framework as described above, that objectives defined by the WFD relate to both the state and the impact, since, standards from other European water quality objective legislation relate to the concentration of pollutants in the water body (i.e. its state), while the biological elements of the WFD clearly indicate impacts.

Despite this problem of nomenclature, the meaning of the WFD is clear. If the water body fails to meet its objective, or is at risk of failing to meet its objective, then the cause of this failure (i.e. the pressure or combination of pressures) must be investigated. Thus *when the Directive states that significant pressures must be identified, this can be taken to mean any pressure that on its own, or in combination with other pressures, may lead to a failure to achieve the specified objective*. Such an interpretation introduces a scale dependence, which is considered in Section 2.3.2. It is also worth noting that the actual criterion used to assess significant pressures for both surface and groundwater is that they are *at risk of failing* to meet objectives. The process of analysing pressures and their impacts is a "risk assessment" process but in this Guidanceis always referred to as a pressures and impacts analysis.

Other terms are defined in the glossary in Annex II.

2.3 Relevant considerations

2.3.1 Water Body Definition

The requirements described above all relate to a *body of surface water*, or a *body of groundwater*. The WFD defines both of these terms, and as part of the definition notes that surface water bodies should be *discrete* but need not, for example, be a whole river, while groundwater bodies should be *distinct*. Draft Guidancehas been prepared within the CIS on the identification of discrete and distinct water bodies: *Horizontal Guidanceon the application of the term "water body" in the context of the Water Framework Directive* (WFD Guidance Document No. 2). This addresses scaling issues and the importance of defining water bodies with reference not only to water body type and morphological change, but also to pressures and impacts. In the absence of finalised definitions of water bodies, this Guidanceaddresses the *process* of pressure and impact analysis which should be independent of any outstanding issues relating to water body definition.

2.3.2 Scaling Issues

Different kinds of pressures do not impact the different water bodies at the same space and time scales. Hence the analysis of pressures must be carried out to ensure that a) the final reporting that is produced with the collected information is consistent with the WFD objectives and b) that data collection is feasible on the long term.

Most impacts cannot be monitored or even assessed directly. In many cases, their identification is derived from observation of changes in the state and the likelihood of these changes to be caused by known pressures. The correct time and space scales of data collection of both pressures and states are the most important points that make it possible to establish sound (therefore recognised as true) relationships, and consequently appropriate programmes of measures. The assessment of the relevant space and time scales is made easier when considering that a pressure results from a load exerted during a certain time over a certain target, that has a particular size. For example, the abstraction of a certain volume of water may have no impact if pumped throughout the year but be a significant pressure if taken out of a river only during the summer months.

The correct identification of pressures requires consistent identification of the relevant targets, their size and the susceptibility to being impacted. The spatial scale is derived from this identification. For practical purposes, compromises must be made to minimize the burden of data collection. Considering the many data sources that are likely to provide ad-hoc data for pressure assessment, that can be used either for surface or groundwater impact analysis, some common rules are suggested.

Regarding the temporal scale, it is important to adopt appropriate temporal scales in the pressures and impacts analysis since some pressures may result in impacts many years in the future, and some future impacts will relate to past pressures that no longer exist. However, most data sources provide yearly data. This scale may often be satisfactory to address long-term impacts. For example, large lakes or groundwater bodies are impacted by cumulative inputs lasting up to dozens of years. By contrast, river or sea-shore pollution, tourism or agricultural abstraction impacts result from peak demand on limited resources. In the latter case, the yearly data does not provide information on significant pressures over a shorter time scale.

Correctly addressing all impacts requires, with respect to time scale:

- Within-year data, indicating the annual pattern, to at least comprise the mean value, the peak value and its duration, the optimum being a monthly value,
- Long-term between-years data, if relevant, including diffuse sources to rivers (e.g., the release from sediments of toxic substances discharged through a former industrial activity).

Regarding spatial scales, the important features of data are the location, especially if the water body comprises very different components (e.g. main river channel and its tributaries, recharge area of a confined groundwater etc) that respond differently to the pressure. Pressure location can be analysed as precise information or as density information. In the first case, the relevant component of the water body is identified. In the latter, the area on which the pressure is exerted must be identified and small enough to make it possible to link the pressure to its target. For example, considering confined groundwater, the important data is the emissions on the recharge area only, not over the total extent of the water body.

These principles are further clarified in the following Chapters.

2.3.3 Different starting points

The timetable for completing the first pressures and impacts analyses and reporting their results is very short. The first analyses will therefore rely heavily on existing information on pressures and impacts and existing assessment methods. Because previous Community water legislation has been focused on pollution, the information and expertise on other pressures and their impacts is very variable between and even within Member States, depending on national legislation and policies.

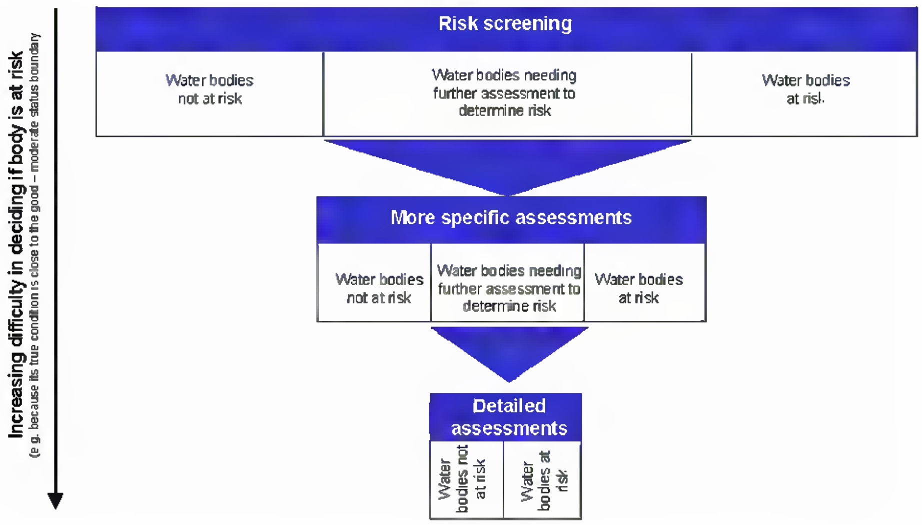


Figure 2.1 *The pressures and impacts analyses should be focused in such a way that the effort involved in assessing whether any body, or group of bodies, is at risk of failing to achieve its environmental objectives is proportionate to the difficulties involved in making that judgement.*

2.3.4 Grouping water bodies

Grouping water bodies, provided this is done on a sound scientific basis, will also be important in ensuring the most cost effective approach to the pressures and impacts analyses. The ability to group bodies will depend on the characteristics of the river basin district and the type and extent of pressures on it.

2.3.5 Taking account of uncertainty

The first pressures and impacts analyses must be complete by the end of 2004. However, the environmental conditions required to meet most of the Directive's objectives will not have been firmly defined by this date. For example, the values for the boundaries between the ecological status classes for surface waters are not expected to be finally determined until after the end of the intercalibration exercise (WFD Annex V 1.4) and the start of the monitoring programmes in 2006 (Article 8). The environmental quality standards for the priority substances, which form part of the definition of good surface water chemical status, will not be finalised until the agreement of Article 16 daughter directives. Elements of the groundwater objectives also await clarification in the Article 17 daughter directive. The confidence and precision in the estimated environmental effects of different pressure types will also be very variable, depending to a great extent on the quality of national and local information and assessment expertise. This is because consideration of many of the pressures and impacts relevant under the Water_Framework_Directive has not previously been required by other Community water legislation.

Member States will need to complete the first analyses using appropriate estimates for pressures and impacts but they should be aware, and take account of, the uncertainties in the environmental conditions required to meet the Directives' objectives and the uncertainties in the estimated impacts.

The consequence of these uncertainties is that Member States' judgements on which bodies are at risk, and which are not, are likely to contain more errors in the first pressures and impacts report (the 'IMPRESS' report) than will be the case in subsequent planning cycles. It will be important for Member States to be aware of the uncertainties so that their monitoring programmes can be designed and targeted to provide the information needed to improve the confidence in the assessments. Where the assessment contains significant uncertainty, those water bodies should be categorised as at risk of failing to meet their objectives. Obvious failing of pressures is not an uncertainty.

2.3.6 Understanding the objectives

So far it has been noted that pressures to be included in the analysis are those that, alone or in combination, cause impacts which prevent objectives being achieved. To do this clearly requires some understanding of the objectives, and this is addressed in this Section.

To summarise, the review of the impact of human activities has to include all environmental objectives of Article 4 WFD, which are:

- Achievement of good ecological status and good surface water chemical status;

- Achievement of good ecological potential and good surface water chemical status for artificial water bodies;
- Achievement of good groundwater status (i.e. good groundwater chemical status and good groundwater quantitative status);

and, if they lead to more stringent objectives:

- Prevention of deterioration in status of surface waters and groundwater;
- Achievement of objectives and standards for Protected Areas;
- Reversal of any significant and sustained upward trends in pollutant concentrations in groundwater; and
- Cessation of discharges of Priority Hazardous Substances into surface waters;

and, for the second review in 2013 and any following:

- Achievement of good ecological potential and good surface water chemical status for heavily modified (HMWBs).

The WFD defines four types of objective; ecological status, ecological potential, chemical status and quantitative status, but these are not all applicable to all water bodies (see Table 2.3). Groundwaters clearly have different objectives; there is no concept of ecological status, the definition of chemical status is quite different to the definition for surface waters, and uniquely for groundwaters, there is the separate assessment of quantitative status. However, as outlined below for surface waters, quantitative information is required as part of the hydromorphological assessment. Ecological potential is only applicable to surface water bodies designated as artificial or heavily modified. Prior to such designation, which need not be completed until 2009, analysis of pressures and impacts will most usually assume the criterion for a natural water body (i.e. ecological status).

The nature of the objectives are considered separately for surface and groundwaters in the following Sections. A number of general points can be made that apply to all water bodies:

I. For each of the applicable objectives the target is, generally, to achieve "good status" by 2015. Answering the question of whether a water body is at risk of failing to achieve this objective therefore involves two determinations; initially the current condition of the body needs to be evaluated, followed by an assessment of whether it is likely to achieve its objectives by 2015. For surface waters, the period until 2015 provides an opportunity to identify pressures, introduce measures to achieve the objective, and to carry out monitoring to demonstrate that it has been achieved. But, it also means that some account must be taken of changes to the pressures that occur during this period. While this is also true for groundwaters, the long residence times of water within many aquifers means that the analysis of pressures and impacts must take account of present day pressures causing problems at a future date. This issue is addressed specifically within the groundwater Section below.
II. Additional objectives may be applicable if other community legislation designates the water body as falling in a protected area; this too is discussed further below.
III. Numerical limits have not yet been set to define the boundaries in each of the different elements of status, although these will eventually be set based on the Guidance of the Reference Conditions working group and the Intercalibration study (WFD CIS Guidance Documents No.'s 10 and 6 respectively). In the meantime expert judgement within the competent authority must be used to set

interim values for use in the first round of assessments. It is recommended that where possible the interim values should be to reasonable estimates of the final values. Adopting values that are too strict could lead to unnecessary monitoring and measures, while adopting values that are too lax will delay necessary actions. Where expert judgement is used it should be open and transparent.

IV. While this Guidance describes the process of pressure and impacts analysis against these objectives, it should be noted that the WFD also provides for circumstances where there may be exemptions or relaxation of the provisions (Article 4, parts 6 and 7). In outline, these refer to temporary deterioration in the status, and deterioration caused by new sustainable development, respectively. However, such circumstances should be identified as part of the pressures and impacts analysis, and not taken as an *a priori* rationale for by-passing the analysis.

Table 2.3 Objectives applicable to different water body types.

	River	Lake	Transitional water	Coastal water	Heavily modified or artificial	Groundwater
Ecological status	✓	✓	✓	✓	×	×
Ecological potential	×	×	×	×	✓	×
Surface water chemical status	✓	✓	✓	✓	✓	✓
Ground water chemical status	×	×	×	×	×	✓
Groundwater quantitative status	×	×	×	×	×	✓

Objectives for surface waters

Ecological status and ecological potential both contain three elements; these are biological, chemical and physical (or physico-chemical), and hydromorphological. The overall ecological status is determined by the lower of the biological and chemical components. Note that the objective for surface waters is not just that good status is achieved, but also that no deterioration of quality occurs. Thus, if ecological status of a water body is currently assessed as "high", it must not deteriorate to "good" in the future.

Biological elements

This is again sub-divided into three components; flora, benthic invertebrates, and fish fauna (this component is excluded in coastal waters). Together these are used to place the water body in one of five classes; high, good, moderate, poor and bad. The process by which this classification is achieved is addressed by the REFCOND (refer to WFD CIS Guidance Document No. 10) and Intercalibration working groups (refer to WFD CIS Guidance Document No. 6) of the CIS. Generally high is "undisturbed" or "nearly undisturbed", good indicates "slight disturbance", moderate indicates "moderate disturbance", poor indicates "major alterations", and bad indicates "severe alterations".

Once the process is defined, the analysis of monitored data will allow the classification of the water body, and may trigger the requirement to investigate why the water body fails to meet its objective. While this is probably achievable, the reverse is far more problematic, i.e. it is likely to be much more difficult to say if a change in chemical or hydromorphological status will cause a downgrading in biological status (for example, the link between nutrient status and the abundance of fish is generally not well understood). One exception to this is for a massive exceedence (i.e. greatly beyond the built in safety factors) of a limit for a priority substance which has a direct toxic effect on an indicator species used in the biological assessment.

Chemical and physico-chemical elements
Two components, general and specific pollutants, are recognised (see Table 2.4). While for specific pollutants, environmental quality standards can be set (the WFD provides guidance), numerical limits do not exist for the general components. As noted for the biological elements, the relationship between these general aspects of water quality and biological status is poorly understood.

Table 2.4 Components of the chemical and physico-chemical element of the ecological assessment

Component	Sub-components	Class	Definition
General	Thermal conditions Oxygen conditions Salinity Acidification status Nutrients status Transparency (lakes only)	High Good Moderate	Totally or nearly totally undisturbed. With levels established to ensure functioning of ecosystems to achieve biological elements. Conditions consistent with the achievement specified for biological elements.
Specific pollutants (priority substances and other substances identified as being discharged in significant quantities)	Synthetic	High Good Moderate	Below detection limits. Within EQS limits. Conditions consistent with the achievement specified for biological elements.
	Non-synthetic	High Good Moderate	Below normal background level. Within EQS limits. Conditions consistent with the achievement specified for biological elements.

Hydromorphological elements
The components used in this assessment vary between water body type, but the classification is as for the general chemical elements (i.e. high, good and moderate) with similar definitions of the classes (Table 2.4). The hydromorphological elements are not used in the determination of ecological status, but could be the cause of the failure to achieve good or high ecological status.

Implications for the analysis of pressures and impacts for surface waters
While it necessary for the analysis to consider effects of pressures on the biological elements, there will be uncertainties in the links between biology, chemistry and hydromorphology. Member States should take account of these uncertainties in undertaking the assessments. Since the classification of the chemical and hydromorphological elements is linked to the biological condition (see Table 2.4), but without critical values being defined. What will be required, in the short term at least, is a set of numerical values for the general chemical components that are

deemed satisfactory by expert judgement, in a particular region or eco-region, to indicate risk of failing to achieve good ecological status. This Guidance will not propose such values, but by assuming they exist can describe methods of analysis, and draw attention to existing examples of such classifications.

Heavily modified water bodies and the timetable
For water bodies designated as artificial or heavily modified, the principal objective is to achieve good ecological potential rather than good ecological status. Water bodies intended to be designated as heavily modified must be subject to two risk assessments: (1) an assessment of the risk of failing good ecological status because of physical alterations, and (2) an assessment of the risk of failing good ecological potential. However, there are serious practical difficulties in completing both these assessments for all potential heavily modified water bodies before the end of 2004. Note that only water bodies failing good ecological status because of substantial physical alterations can be considered for designation as heavily modified water bodies under Article 4.3. The first pressures and impacts analyses will therefore identify potential heavily modified water bodies.

Objectives for groundwaters.

For groundwaters the objectives are essentially:

1. To implement measures to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of the groundwater body (groundwater status consists of two parts; quantitative status and chemical status and the overall status of groundwater is taken to be the poorer of the two);
2. To protect, enhance and restore all bodies of groundwater, and ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status by 2015 in accordance with the provisions laid down in Annex V;
3. To reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to progressively reduce pollution of groundwater.

If a groundwater body currently has good status but it is thought that pressures may cause its status to be rendered poor by 2015, then the body is "at risk" and will require further characterisation. It should be noted that a body currently determined to have poor status will automatically be "at risk".

Article 17 of the WFD requires the Commission to propose a daughter directive on groundwater, which is expected to establish criteria for defining significant trends in pollutant concentrations, and addition criteria for defining good groundwater chemical status. The daughter directive will also clarify the meaning of the requirement to "prevent or limit the input of pollutants into groundwater" (1 above).

Objectives for protected areas.

In addition to those objectives in Table 2.3, it is required that objectives for protected areas established under Community legislation should also be met. For example, if a water body falls within a Nitrate Vulnerable Zone then the objectives of the Nitrates Directive (1991/676/EEC) must be met. In this instance, for groundwaters the

Nitrates Directive gives the criterion as < 50 mg/l NO_3, and for surface waters, the criteria are derived from the Drinking Water Directive (75/440/EEC), which gives the same mandatory upper limit value of 50 mg/l NO_3. Thus while the WFD introduces the new concept of good ecological status, it also incorporates the numerical limits of earlier legislation (Table 2.5).

Article 7of WFD requires Member States to establish drinking water protected areas for bodies of groundwater and surface water providing more than 10m^3 a day as an average or serving more than 50 persons, or bodies that are intended for that use in the future. The objective for these areas is to avoid deterioration in quality in order to reduce the level of purification treatment required.

Table 2.5 Existing community legislation designating protected areas.

Directive	Reason for protection of waters
2000/60/EC (Water Framework Directive)	Drinking water protected areas.
76/160/EEC (Bathing water Directive)	Bathing waters
78/659/EEC (Freshwater fish Directive)	Fresh waters needing protection in order to support fish life.
79/923/EEC (Shellfish waters Directive)	Shellfish waters
79/409/EEC (Birds Directive)	To protect birdlife
92/43/EEC (Habitats Directive)	Natural habitats of wild fauna and flora
91/271/EEC (Urban Waste Water Treatment Directive)	Nutrient sensitive areas
91/676/EEC (Nitrates Directive)	Prevent nitrate pollution

The first stage in undertaking this element of the assessment required by the WFD is straightforward since the only information required is whether or not the water body is in a protected area. If so, the required analysis will have been carried out and reported. If not, no action is required. Existing legislation that can define protected areas is listed in Table 2.5. It has already been noted that compiling a register of such protected areas is required by the WFD.

However, for some protected areas, notably those designated as Natura 2000 sites under the Habitats Directive, the requirement is to meet the water-related biological criteria of a particular habitat. This is clearly a more complex undertaking than comparing with threshold values, as illustrated above for the Nitrates Directive, but again existing reports under the terms of the Directives should provide a basis for the analysis required.

Recap of the objectives

The environmental conditions required to meet the objectives applicable to a water body depend on the water body type, and are derived from a number of sources. The objectives can be existing fixed numerical limits, or derived from the concept of "good status" that requires more explicit definition. For each particular pressure and impact analysis it will be necessary to have such numerical limits for general chemical elements (e.g. dissolved oxygen) although none is contained in the WFD. Such values will need to be determined through expert judgement within the competent authority. It is recommended that such judgement tries to anticipate the values that are likely to be adopted in the longer term.

2.3.7 Wetlands

Wetland ecosystems are ecologically and functionally part of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in CIS horizontal Guidance Documents on water bodies (WFD Guidance Document No. 2) and further considered in Guidance on wetlands, currently under development.

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal Guidance on wetlands currently under development.

2.4 Summary of the process and actions required

Ideally, a pressures and impacts assessment will be a four-step process;

1. describing the "driving forces", especially land use, urban development, industry, agriculture and other activities which lead to pressures, without regard to their actual impacts;
2. identifying pressures with possible impacts on the water body and on water uses, by considering the magnitude of the pressures and the susceptibility of the water body;
3. assessing the impacts resulting from the pressure; and,
4. evaluating the likelihood of failing to meet the objective.

In the first instance (i.e. for 2004) the list of pressures and the assessment of impacts on a water body, and possibly on up- or downstream situated water bodies, shall ensure the identification of all of the potentially important problems. Assessing the likely impacts arising from each of the pressures will produce a list that can be used to identify points where monitoring is necessary to better understand if the water body is at risk of failing to achieve good status. This list then becomes a basis for developing a programme of measures which might be undertaken in order to achieve good status.

For the first stage, (i.e. for 2004) a screening approach is likely to simplify the tasks, as it means focusing on the search for pressures on those areas and pressure types that are likely to prevent meeting the objectives. However, this is a substantial task for the first review of the impact of human activities, and Member States should aim to achieve the best estimate of significant pressures in the time available. To improve confidence, the estimates of the type and magnitude of pressures should be crosschecked, where possible, with monitoring data and with information on the key drivers for the pressures. For example, estimates of point source inputs of organic matter from urban wastewater treatment systems made using information on discharges could be crosschecked with information on population sizes and average per capita inputs to assess whether the majority of relevant discharges have been identified.

The identification of significant pressures could involve a combined approach of assessing monitoring data, model usage and expert judgement. These pressures and furthermore those water bodies at risk of failing the environmental objectives shall be identified and reported. This reporting process must be practicable for Member States, but also demonstrate transparency of Member States' decision-making processes (e.g. in exercising its experts' judgement).

3. General approach for the analysis of pressures and impacts

3.1 Introduction

The preceding Chapters have described the scope and purpose of the WFD, and resolved issues relating to the general requirements to undertake a pressures and impacts analysis. The remainder of the Guidance provides advice on how this can be implemented. This Chapter explains the general approaches that can be taken according to water body type and data availability. In doing so it aims to show where the process and data requirements are common to the various water bodies within a river basin.

The key stages of the general approach as laid down in the WFD are:

- Identifying driving forces and pressures;
- Identifying the significant pressures;
- Assessing the impacts; and,
- Evaluating the likelihood of failing to meet the objectives.

These are addressed in the following Sections (3.2 to 3.6), and visualised in Figure 3.1. To undertake the four key stages, three supporting elements must be considered (shown on the left of Figure 3.1). The description of a water body and its catchment area will underpin the pressures and impacts analysis, and there are many types of information that may be useful, e.g. climate, geology, soil and land use. During the process, monitoring data relevant to the water body may also be introduced, and how this is used will be discussed in the Section on assessing the impacts (Section 3.4). A comparison of monitoring data with driving forces may also help to screen where pressures are likely to cause a failure in meeting objectives. It is also necessary to understand the objectives against which the actual state will be compared (see Section 2.3.6).

There will be many instances in which these key stages need not be undertaken as a linear sequence. An example of such a case would be where monitored data from the water body, which define an impact, can be used to refine the identification of significant pressures. While it may be appropriate to adopt a different sequence for the analysis, it is required that all key stages are addressed.

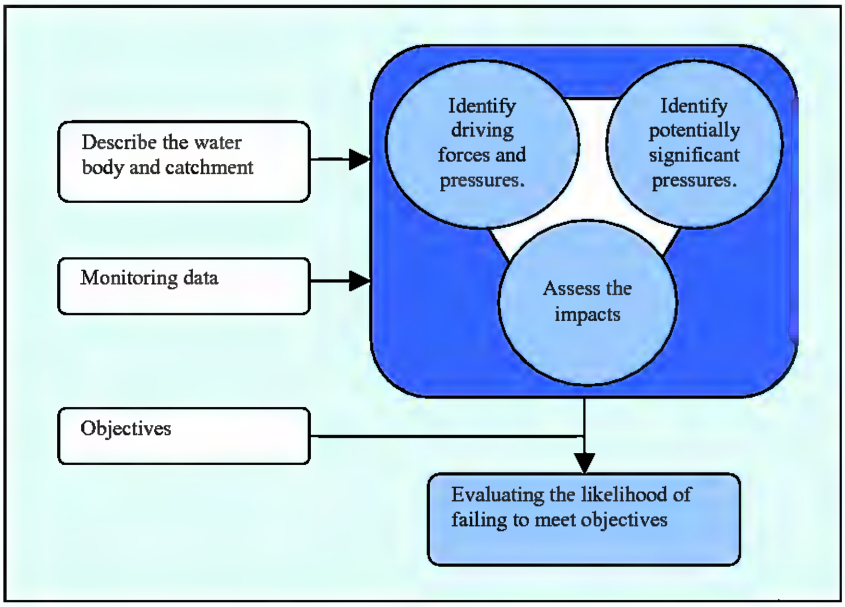


Figure 3.1 *Key components in the analysis of pressures and impacts. Those components on blue backgrounds on the right-hand side are the main components of the analysis, and are described in detail within this guidance, while those elements on white backgrounds on the left-hand side are supportive and are described only briefly within the guidance.*

In general this Guidance tries to apply similar considerations to surface and groundwaters. However, Section 3.9 considers issues that are particular to groundwaters, and Sections 3.11 and 3.12 provide reviews of the tasks required for the analysis for surface waters and groundwaters respectively. These may be regarded as checklists for the process with explanation, justification and rationale removed. Section 3.10 describes reporting requirements relating to the pressures and impacts analysis.

The subsequent Chapters provide more detailed information on tools (Chapter 4), data (Chapter 5), and illustrations based on case studies (Chapter 6).

3.1.1 Who needs to get involved in carrying out and using the pressures and impacts analysis

Assessing "who needs to get involved" requires addressing some of the following questions:

- Who can or will provide basic or additional input into the IMPRESS analysis?;
- Who will use the results of the pressures and inpacts analysis?; and,
- Who will be influenced by the follow-up of the results of the IMPRESS analysis?

Answers to these "Who" questions are likely to include a wide range of organisations, stakeholders, and individuals which will vary according to questions. For example, experts from Ministry of Environment or other ministries (land planning, nature protection units, GIS units, agriculture, etc.), experts from river basin agencies or regional authorities, managers in charge of developing river basin management plans, ministry heads of water departments, researchers and consultants, historians, the public and a wide range of stakeholders that have interest and/or developed expertise in specific fields (see Tables in Chapter 5) and are involved in water management and will, presumably, be involved in the creation of the RBMP.

Developing a stakeholder analysis with possible involvement of key stakeholders can be an appropriate step for finding answers to these questions (see "public participation" WFD CIS Guidance Document No. 8 Annex I). It also helps in identifying key steps in the analytical process when involvement or input from specific stakeholders is required (different "Who" for different steps).

Points 3.2 and 3.3 of this Guidance give a more detailed inventory of the relationships between certain driving forces and pressures allowing stakeholders of interest to be identified.

3.2 Identifying driving forces and pressures

In addition to a general description of the water body, it is essential to identify the driving forces that may be exerting pressures on the water body. A broad categorisation of driving forces is shown in Table 3.1. This is expanded into a more complete list of driving forces and pressures in Chapter 4, which can be used as a checklist to form an inventory of the relevant pressures. In using this checklist it may be helpful to note all pressures without concern for their significance.

Table 3.1 Broad categorisation by driving force of pressures to be considered (Note that this is expanded into a complete list of pressures in Table 4.1).

DIFFUSE SOURCE	urban drainage (including runoff) agriculture diffuse forestry other diffuse
POINT SOURCE	waste water industry mining contaminated land agriculture point waste management aquaculture
ACTIVITIES USING SPECIFIC SUBSTANCES	manufacture, use and emissions from all industrial/agricultural sectors
ABSTRACTION	reduction in flow
ARTIFICIAL RECHARGE	groundwater recharge
MORPHOLOGICAL (Refer also to WFD CIS Guidance Document No 4 on HMWB)	flow regulation river management transitional and coastal management other morphological
OTHER ANTHROPOGENIC	miscellaneous

Driving forces (DF) are sectors of activities that may produce a series of pressures, either as point and non-point sources. As screening data, DF are quantified by aggregated data, simple to obtain, for example: number of hectares of arable land, population density, etc., for a certain area. Comparing this DF data with appropriate aggregated monitoring information quickly allows assessment of the likelihood that the considered DF is related to environmental pressures. In that case, only the expected pressures should be investigated in greater details.

The screening procedure is not only a way to speed up data collection by focusing on those pressures that are reasonably expected. It provides an independent assessment of pressures and impact relationships, which is valuable especially if emission and abstraction registers are poorly populated.

Information describing driving forces and pressures will be required for both surface water and groundwater bodies, as, for example agricultural activity may exert a pressure on both surface water and groundwater bodies. Similarly, an activity may exert a pressure on a number of downstream water bodies. For these reasons it is sensible to collate the data on the basis of river basins, or river basin districts, and then to abstract from this the particular information relevant to any individual water body. Clearly the use of a GIS will facilitate this process. However, this Guidance does not address the management of this information since this is the remit of the Geographical Information Systems Working Group within the CIS (see WFD CIS Guidance Document No 9).

3.3 *Identifying significant pressures*

3.3.1 Introduction

The inventory of pressures is likely to contain many that have no, or little, impact on the water body. In the case of surface waters, the WFD recognises this by only requiring significant pressures to be identified, and within this Guidance significant is interpreted as meaning that the pressure contributes to an impact that may result in the failing of an objective. For groundwaters, the initial characterisation requires a general analysis of pressures, corresponding to that described in Section 3.2, but again set in the context of evaluating the risk of failing to meet objectives. Thus, although the processes are described separately and differently for surface and groundwaters, a similar general approach to the identification of pressures that require further investigation can be adopted.

This requires an understanding of the nature of the impact that may result from a pressure, and appropriate methods to monitor or assess the relationship between impact and pressure. Possible impacts are considered below using the major pressure headings from Table 3.1.

Pollution pressures from diffuse and point sources

A pollution pressure results from an activity that may directly cause deterioration in the status of a water body. In most cases, such a pressure relates to the addition, or release, of substances into the environment. This can be the discharge of a waste product, but may also be the side-effect or by-product of some other activity, such as the leaching of nutrients from agricultural land. A pollution pressure may also be caused by an action such as a change in land use, for example sediment fluxes are modified by urbanisation, forestry, and a change between winter and spring planting of crops. The most usual categorisation of pollution pressures is to distinguish between diffuse and point sources (see Tables 3.2 and 3.3). However, the distinction between point and diffuse sources is not always clear, and may again relate to spatial scale. For example, areas of contaminated land might be considered as either diffuse or point sources of pollution.

In case of diffuse pollution driving forces are usually not directly related to pressures, but pollution reaches water bodies on hydrologically driven pathways.

Table 3.2 Examples of diffuse source pressures and their impacts.

Activity or Driving force	Pathway causing Pressure	Possible change in state or impact
Agriculture	Nutrient loss from agriculture by • surface runoff • soil erosion • artificial drainage flow • leaching (*i.e.* interflow, spring water and groundwater) (includes excess fertilisers and manures and mineralization of residues)	Nutrients modify ecosystem
	Pesticide loss by pathways mentioned above	Toxicity, contamination of potable water supplies
	Sediment loss by soil, bank and riverbed erosion	Smothering of bed, alteration of invertebrate assemblage, loss of spawning grounds
Industry discharges to the atmosphere	Deposition of compounds of nitrogen and sulphur.	Acidification of surface and groundwater bodies. Eutrophication
Transportation	Pollutant spillages	Gross pollution of water bodies
	Use of salt as de-icer	Elevated chloride concentration
	Use of herbicides	
	Engine exhausts	Increase in acidifying chemicals in atmosphere and hence deposition

Table 3.3 Example point source pressures and their impacts.

Activity or Driving force	Pressure	Possible change in state or impact
Industrial (IPPC and non-IPPC)	Effluent disposal to surface and groundwaters	Toxic substances have direct effect, increased suspended solids, organic matter alters oxygen regime, nutrients modify ecosystem
Urban activity	Effluent disposal to surface and groundwaters	As above
Landfill	Chemical fluxes in leachate	As above
Animal burial pits (e.g. following epidemic)	Contaminated leachate	As above
Former land use	Contaminated land	Various
Thermal power generation	Return of cooling waters cause alteration to thermal regime	Elevated temperatures, reduced dissolved oxygen, changes in biogeochemical process rates
	Biocides in cooling water	Direct toxic effect on aquatic fauna.
Dredging	Sediment disposal	Smothering of bed, alteration of invertebrate assemblage
	Removal of substrate	Loss of habitat
Fish farming	Feeding, medication, escaping	Nutrients, diseases, veterinary products, artificial fish population, modified food web

Quantitative resource pressures

Quantitative status is only referred to specifically within the WFD for groundwater bodies, but quantitative pressures must be assessed for all water bodies. For surface waters these pressures are used to assess hydromorphological status. In all water bodies quantitative pressures are also important as they have an effect on dilution, residence time, and storage. Examples of quantitative pressures are contained in Table 3.4.

Table 3.4 Example quantitative pressures and their impacts.

Activity or Driving force	Pressure	Possible change in state or impact
Agriculture and land use change	Modified water use by vegetation. Land sealing	Altered recharge of groundwater body
Abstraction for irrigation, public & private supply	Reduction in flow or aquifer storage	Reduced dilution of chemical fluxes. Reduced storage. Modified flow and ecological regimes. Saline intrusion. Modified dependent terrestrial ecosystem.
Artificial recharge	Increased storage	Increased outflow. Contamination of groundwater.
Water transfer	Increased flow in receiving water	Modified thermal, flow and ecological regimes

Hydromorphological pressures

Hydromorphological pressures can have a direct impact on surface waters in addition to the impact on quantitative status. Examples are contained in Table 3.5.

Table 3.5 Example hydromorphological pressures and their impacts.

Activity or Driving force	Pressure	Possible change in state or impact
Dredging	Sediment disposal	Smothering of bed, alteration of invertebrate assemblage
	Removal of substrate	Loss of habitat
	Change in water level	Change in water table, loss of wetlands, loss of spawning areas.
Physical barriers (dams, weirs etc.)	Variation in flow characteristics (e.g. volume, velocity, depth) both up and downstream of barrier.	Altered flow regime and habitat.
Channel modification (e.g. straightening)	Variation in flow characteristics (e.g. volume, velocity, depth)	Altered flow regime and habitat.

Biological pressures

Biological pressures are those that can have a direct impact on living resources, either quantitatively or qualitatively.

Table 3.6 Example biological pressures and their impacts.

Activity or Driving force	Pressure	Possible change in state or impact
Fisheries	Fishing	Reduced fish fauna, especially on migratory and amphibiotic fish
	Fish stocking	Genetic contamination of wild populations
Introduction of alien species	Competition with indigenous species	Substitution of populations, destruction of habitats, food competition

3.3.2 Methods

The assessment of whether a pressure on a water body is significant must be based on a knowledge of the pressures within the catchment area, together with some form of conceptual understanding, of water flow, chemical transfers, and biological functioning of the water body within the catchment system. In other words there must be some knowledge that a pressure may cause an impact because of the way the catchment system functions. This understanding coupled to the list of all pressures and the particular characteristics of the catchment makes it possible to identify the significant pressures. However this approach often requires two stages. In the first one, correlation assessment can be carried out. It has the advantage of using monitored data and doesn't require complex hypotheses. When necessary and appropriate, strict causality assessment may then be required using, for instance, numerical modelling, that will simulate the impact of numerous pressures. However these tools are seldom reliable, since they are based on hypotheses on the functioning of the ecosystem. Some likelihood assessment and models are considered in the Section on assessing impacts.

An alternative is that the conceptual understanding is embodied in a set of simple rules that indicate directly if a pressure is significant. One approach of this type is to compare the magnitude of the pressure with a criterion, or threshold, relevant to the water body type. Such an approach cannot be valid using one set of thresholds across Europe since this fails to recognise the particular characteristics of the water body and its vulnerability to the pressure. This approach effectively combines the pressure identification with the impact analysis since, if any threshold is exceeded, the water body is assessed as likely to fail its objectives. While simple, these methods can be an effective method of encapsulating expert judgement, and be based on sound science. These methods are described in more detail and with examples in Section 4.3. It can be more effective if coupled to state monitoring, as suggested in the examples.

A successful pressures and impacts study will not be one that follows prescriptive guidance. It will be a study in which there is a proper understanding of the objectives, a good description of the water body and its catchment area (including monitoring data), and a knowledge of how the catchment-system functions (Figure 3.2). One should be aware of the relations between water bodies within a river basin district, e.g. relations concerning pollution of downstream lakes and coastal waters (eutrophication, sediment pollution, bioaccumulation) or upstream river continuity issues. In such cases pressures only causing impacts far outside the water body itself should be included in the analysis as well.

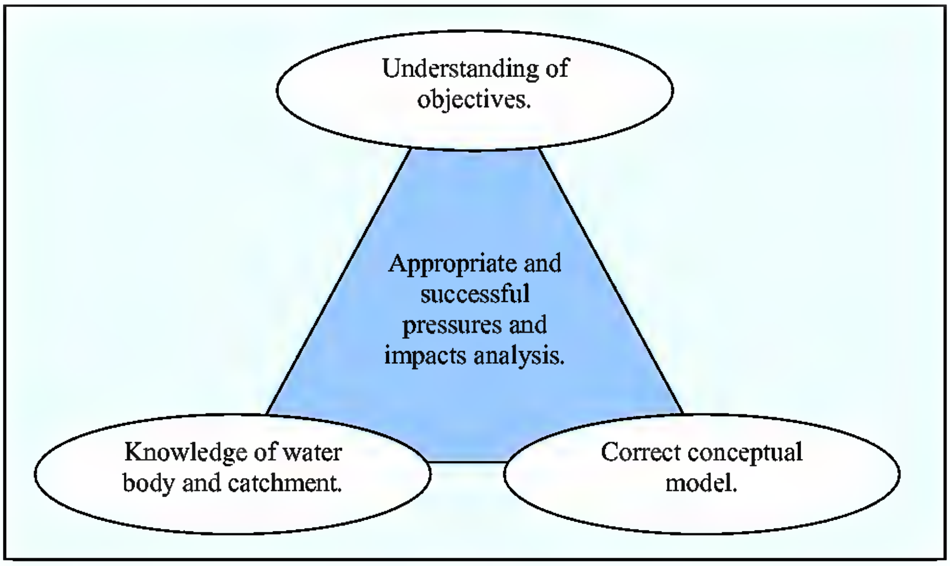


Figure 3.2 *The three prerequisites for an appropriate and successful pressures and impacts analysis.*

3.3.3 Variations in pressures and impacts

By definition the pressure of point sources cannot be spatially uniform, but it is probably also true that the pressures from diffuse sources, and quantitative pressures, are spatially variable within the catchment area of a water body.

As already mentioned, it is also the case that a specific pressure will not always cause a particular impact. Scale, both temporal and spatial, is one of the issues that that will determine the impact of a pressure. Other characteristics of the catchment area of the water body may also have an influence and of course the particular characteristic will relate to the nature of the pressure. For example, the impact of acid rain will be greater on the catchment located on granite geology with thin soils that have little acid neutralisation capacity, than on a catchment with calcareous (limestone or chalk) geology and soils with high acid neutralisation capacity. This effect is also recognised for other pressures, for example, the particular problems of nitrates within nitrate vulnerable zones, and the concept of groundwater vulnerability to pollution, which explores many characteristics associated with the groundwater body.

Recognising this variability leads to two conclusions. Firstly, it is easier to provide guidance on identifying all pressures (i.e. potential pressures) than on identifying significant pressures (i.e. those that may cause an impact likely to cause a failure of an objective). The latter will generally require a case-by-case assessment that considers the characteristics of the particular water body and its catchment area.

Secondly, in situations where the variability in the pressures and their impacts could result in different parts of a water body having different status, it may be appropriate to redefine the boundaries of the water bodies in order to develop a practical programme of measures for each one. Where this is done, redesignation must follow the 'rules' for water body delineation set out in Commission Guidance (d'Eugenio, 2002).

3.4 Assessing the impacts

Assessing the impacts on a water body requires some quantitative information to describe the state of the water body itself, and/or the pressures acting on it. The type of analysis will be dependent on what data are available. Regardless of the particular process to be adopted, and as with the identification of significant pressures described above, the assessment requires a conceptual understanding of what causes impacts. For example, at its simplest this can be, that if effluent is discharged to a river, lake, or coastal water, there is likely to be at least a local change in the water quality, which might be adequately estimated by a conservative mixing model. In many situations a simple approach of this type may be completely suitable for assessing the impact of a pressure. However, in real situations there will be a vast range of catchment types, water body types, interacting pressures, process conceptualisations, data requirements and possible impacts, and adopting such a simple model in all cases may be naïve.

It is also the case that what initially appears a simple assessment can have hidden complexities. For example, the impact on the quantitative status of a groundwater body from the pressure of an abstraction might be investigated by a simple water balance model in which the change in storage is the difference between the recharge rate and the sum of the outflow plus abstraction. One criterion for good quantitative status is that both the outflow and the abstraction can be sustained in the long term. The level at which the outflow must be maintained is such that good ecological status is achieved in any associated surface waters. Thus, what appears to be a simple water balance of a groundwater body actually requires knowledge and understanding of the ecological status and ecological flow requirements of an associated surface water body.

For the pressures and impacts analysis the conclusion cannot be that this analysis can only be achieved by constructing a detailed, process-based, numerical computer model of the entire linked surface and groundwater system. This type of approach may be possible, in some situations and examples are described in the Chapter on tools (Section 4). In practice, the information required to adopt the modelling approach will rarely be available at present, and probably not generally in the foreseeable future. By implication, the initial analysis will usually be based on less demanding methods for which the required data are available, e.g. pressure screening tools (see Section 4.2 and 4.3). Such analyses will be subject to refinement as further analysis is needed to determine risk, relevant data become available, and useable tools are developed.

Using observed data to assess impacts

In situations where data are available for the water body itself, it may be possible to make a direct assessment of the impact. The types of data that might be used are as diverse as the impacts themselves (see Table 3.7).

Data itself is not enough to assess a possible impact: a correct indicator of the expected impact must be constructed. Moreover, it must be kept in mind that most pressures do not create a clear-cut impact, but substantially change the probability of adverse conditions. This is, for example, the case of hydrological regime perturbations: the natural hydrological regime is not favourable to fish life 100% of the time. The impact assessment requires an estimate of which change in the probability of occurrence of favourable circumstances represents a threat to the ecosystem. Commonly available hydrologic indicators are not helpful. For example, a fish ladder is efficient if the discharge is between certain limits, during certain times and at a precise moment of the year, when migratory fish are present. This requires specific calculation, based on daily discharge statistics and expert opinion (i.e. which discharge values at what time).

Water quality statistics present specific difficulties as well. Comparison in state (i.e. is there an impact?) requires comparison between series of data. To carry out a meaningful comparison, the internal structure of the data must be considered in order to allow for normal variability. Removing the seasonal and the hydrologic component of annual data dramatically reduces the calculated variance and allows comparison to be made between data sets monitored at short time intervals. These sophisticated statistical techniques may not be familiar to European water experts.

Table 3.7 *Possible impacts or changes in state that can be identified from monitoring data.*

BIOLOGICAL QUALITY ELEMENTS	
macrophytes	composition abundance
phytoplankton	composition abundance biomass
planktonic blooms	frequency intensity
benthic invertebrates	composition abundance
fish	composition abundance age structure
eutrophication	chlorophyll concentration
HYDROMORPHOLOGICAL QUALITY ELEMENTS	
hydrological regime	quantity and dynamics of water flow connection to groundwater bodies residence time
tidal regime	freshwater flow direction of dominant currents wave exposure
river continuity	
morphology	depth and width variation quantity, structure and substrate of the bed structure of the riparian zone, lake shore or intertidal zone
CHEMICAL AND PHYSICO-CHEMICAL QUALITY ELEMENTS	
transparency	concentration of total suspended solids turbidity Secchi disc transparency (m)
thermal conditions	temperature (°C)
oxygenation conditions	concentration
conductivity	conductance converted to concentration of total dissolved solids
salinity	concentration
nutrient status	concentration of nitrogen and phosphorus, loads in view of sea protection

CHEMICAL AND PHYSICO-CHEMICAL QUALITY ELEMENTS cont'd	
acidification status	pH alkalinity acid neutralising capacity (ANC)
priority substances	concentration
other pollutants	concentration

Modelling approaches

Modelling approaches allow impacts to be estimated, and should therefore be considered subordinate, or complementary, to monitored data from the water body. For the river network itself numerous modelling techniques have been developed from the original work on dissolved oxygen and BOD published in 1925 by Streeter and Phelps. Simple models of this type are widely available but differ in the range of chemical determinands modelled, the processes represented, and their numerical frameworks. Such models, if applied appropriately, are generally good at representing the water quality along a river in which the inflows from tributaries and point sources are well known or can be estimated reliably. An example application is contained in the Chapter on tools.

A limitation of such river models is that they represent diffuse source inputs as discrete point sources, and to run the model these must be defined, either using data or a diffuse (catchment) model. The diffuse model itself can be simple, for example nutrient loss can be based on export coefficients that represent the activity within the catchment area. Such a model is in fact quantifying the pressures that arise from diffuse sources, rather than the impact on a water body, and is described in this sense in the Chapter on tools (Section 4). This Section also describes tools that can estimate the point source loads to receiving water bodies.

Simple and reliable modelling approaches are available for all of the water body types recognised by the WFD. These models can represent a single domain (i.e. river, lake, transitional water, coastal water, or groundwater), or encompass many, or all, domains within a single framework. These models can represent various aspects of the flow regime, hydromorphology, and hydrochemistry of the water body, either separately or within an integrated framework. Examples of water body models are contained in Section 4.4.

Of course the complexity of all of these different domain models can be increased greatly from the relatively simple implementations described above. However, it is certainly not the case that a simple model will always be less accurate than a complex model.

Models also exist to characterize stream habitat, and many of them can be used to predict habitat conditions at various flow conditions. The expected output of this type of model can vary from being purely descriptive of the stream physical template, to having some biological assessment applications. Physical descriptive models are developed to evaluate the degree of alteration of a given stream channel in relation to some reference conditions. Biologically-based models are developed to infer the standing stock of a given species from the physical characteristics of a given stream. Nevertheless, in between these two extremes there exists a range of habitat models addressed to obtain other outputs as habitat usage of species, habitat quality (e.g. ecological potential for key species) or duration period of habitat suitability.

Using observed data to refine the assessment of impacts and pressures

Monitoring data may indicate that there are no current impacts. This information itself reveals that none of the pressures identified in the initial screening process is significant, or that the time lag required for a pressure to give rise to an impact has not yet passed. The latter is likely to be of particular importance when assessing groundwater bodies in which pollutants travel very slowly. Such data could also be used within a model as a check that the inputs to, and processes within, the model correctly reproduce the observed data.

When the observed data for a water body does not indicate that a pressure is causing an impact, there may be a causal relationship with an impact on other water bodies within the same river basin district. For example, just meeting the environmental objectives in upstream areas will not leave sufficient room for compliance with the same objectives in downstream areas. This requires communication and co-operation between several parts of the river basin district.

In situations where observed data shows there is an impact, knowledge of the nature of the impact should be helpful in undertaking the pressures and impacts analysis. There are three cases to consider:

1. The traditional situation in which the impact is quantified in terms of a chemical, or physico-chemical, parameter exceeding a threshold. This should be relatively straightforward to address using a simple conceptual model of known activities, and associated pressures. The analysis is rather similar to the approaches described above except that the result is known and essentially serves to validate the various assumptions that have been made in the process;
2. The impact is quantified in terms of a biological effect, but the physico-chemical or hydromorphological pressure that is causing it is not understood. In this case the pressures and impacts analysis can be undertaken in the expectation that the cause will be identified, and can be addressed even though the link is not fully understood. This would probably be accompanied by further biological investigation into probable causes; and,
3. Between these two cases would be a biological effect where the probable physico-chemical or hydromorphological effect is at least partly understood. In this instance the analysis might proceed as in 1, but with less robust information to inform the validity of the process.

Understanding the last two of these situations depends greatly on the information to come from the REFCOND working group and the CIS Intercalibration Study (refer WFD CIS Guidance Document No.s 10 and 6, respectively).

In all three of these situations it is perhaps easier to understand how a pollution pressure causes a change in physico-chemical state which may cause an impact on biological status, and consider the links both forwards from pressure to impact, and backwards from impact to pressure. For hydromorphological pressures the links are less clear. The HMWB Guidance offers some assistance in relating biological indicators to different types of hydromorphological pressure (Table 3.8).

Table 3.8 Biological indicators of morphological pressures (adapted from WFD CIS Guidance Document No 4 on HMWB).

Indicator	Pressure
Benthic invertebrate fauna and fish	Hydropower generation impacts in freshwater systems
Long distance migrating fish species	Disruption in river continuity inducing lag in migratory process
Macrophytes	Flow from reservoirs Regulated lakes (change in flow regime)
Benthic invertebrates and macrophytes/phytobenthos	Linear physical alterations, such as flood works.

3.5 Selecting relevant pollutants on river basin level

3.5.1 Introduction

In Section 2.3.6 of this guidance, an introduction was given as regards the rather complex approach for dealing with chemical pollutants within the concept of the "good ecological status" and "good chemical status" of the WFD. Whereas the "priority substances" are clearly identified in Annex X, one key question in the context of the analysis of pressures and impacts is the selection of **specific pollutants** (other than priority substances) for which data on pressures must be collected in order to assess whether there are impacts for the different water bodies in a river basin (district).

The subsequent paragraphs provide a generic approach that may be used for the selection of a list of relevant specific pollutants for water bodies within a river basin (hereafter referred to as "relevant pollutants"). More specific examples are provided in Annex IV of this guidance. It is evident, that such an approach may need to be adapted and refined for the specific situation in each river basin.

At this point, it should be clarified that the requirements of the WFD are related to several objectives for individual pollutants in a water body. However, it will be necessary to follow a three (or more) stage approach in order take account of the different scales of pollution problems in the aquatic environment:

1. **European level**: the "priority substances" (Annex X) represent a list of European relevance. These substances must be considered in the pressure and impact analysis and the "risk of failing the objectives" must be investigated for all water bodies;
2. **River basin (district) level**: a list of those relevant pollutants may be established which are likely to have a "risk of failing the objectives" in a large number of water bodies within that basin and where downstream effects (including the marine environment) may need to be considered. Such substances may be called "relevant pollutants for a river basin";
3. **Sub-river basin and water body level**: pollutants which cause an impact through a significant regional and local pressure, i.e. in one or few water bodies, may need to be considered in addition to the above-mentioned levels.

Hence, the issue on how to select a list of relevant pollutants is related to significant pressures or impacts. In the ideal case, there may be a clear relationship between a pollutant released to the environment at a number of well-known sources and causing a visible or measurable effect on the biology of a water body. This supposes at least a good knowledge of the uses or the sources of the pollutant on the pressure side, the occurrence of the pollutant on the status side and/or the effects on the impact side. However, given the high number of pollutants, there is a considerable gap of information and data for many pollutants, in particular:

- In many cases and for a lot of pollutants, pressures cannot be related to status or impact due to lack of data;
- Only a limited number of pollutants are continuously or regularly monitored;
- The relation between pollutants and impact covers the whole field of ecotoxicology; for example should acute/chronic or combined effects be reported?

Nevertheless, the analysis of pressures and impacts is the first important step towards the identification of those pollutants which are being regulated further in the context of the WFD, i.e., *inter alia*, monitoring and programme of measures.

The starting point in the WFD is the list of 'main pollutants' mentioned in annex VIII. This list can be considered equivalent to the "universe of chemicals", hence no chemical substance or pollutant can be excluded from the beginning.

The challenge is to develop an iterative approach which narrows the endless list of substances down to a manageable number of pollutants in a pragmatic and targeted step-by-step way ("from coarse to fine"). The final aim is to target the measures and the monitoring to those substances first which most affect the aquatic environment on the different levels mentioned above. In that respect, the "environmental quality standard" (EQS) set in accordance to Annex V, 1.2.6 is the most important benchmark since it represents the boundary between "good" and "moderate" status. However, there are a number of other objectives which have to be assessed in the context of the pressure and impact analysis such as the "no deterioration", the reduction of pollution as regards the trend and the avoidance of failing good status downstream.

The list of relevant pollutants may change during the different steps in the implementation of the WFD mainly due to a refinement of the analysis and assessments.

First, a list of pollutants needs to be established for which the pressure and impact analysis is carried out (completed by 2004). Only if a defined "list of candidate substances" is established, it is possible to collect data on significant pressures and impacts. For this first analysis, it may not be possible to derive EQSs for all candidate substances. In this case, alternative screening benchmarks are acceptable.

Second, the selection of those pollutants is required for which additional information is gathered through "surveillance monitoring" (by 2006). These substances may be a sub-list of pollutants for which the level of certainty in the pressure and impact analysis may not be sufficient.

Finally, the list of relevant pollutants must be identified for which measures are prepared (by 2007/2008).

During this process, it is important that the evolution of the relevant pollutants remains transparent and clearly linked to the objectives and the requirements of the WFD.

As a final remark, it should be mentioned that the WFD Annex V states that priority and other substances should be identified which are "discharged" into the water body. Unfortunately, the term discharge is not defined in the WFD but only under the Dangerous Substances Directive (Council Directive 76/464/EEC) as, in general terms, the "introduction into waters". In contrast, the term "discharge" is often used for point sources from effluents. Given that Annex II clearly requires the identification of all (significant) pressures from point and diffuse sources and given that the WFD mostly talks about "discharges, emissions and losses", it is evident that a broad interpretation which covers all sources and pathways into the aquatic environment must be considered throughout the WFD.

3.5.2 Generic Approach

The generic approach is detailed in Table 3.9 and illustrated in Figure 3.3. Note that these steps are presented in a linear, way but in fact interact which each other in a more complex way (as implied by the arrows in Figure 3.3).

Table 3.9 The generic approach to the identification of specific pollutants.

1. Starting point
The indicative list of the main pollutants set out in Annex VIII of the Directive. Only those pollutants under points 1 to 9 need further consideration as potential specific pollutants. The pollutants under points 10, 11 and 12 of the Annex are the general physico-chemical quality elements and are considered separately.
2. Screening
A screening of all available information on pollution sources, impacts of pollutants and production and usage of pollutants in order to identify those pollutants that are being discharged into water bodies in the river basin district. In the screening step, two sub-steps can be distinguished: a) collation of information, and b) deriving a list of pollutants.
2a. Collation of information
Data: ➢ Source/sectoral analyses: production processes, usage, treatment, emissions,; ➢ Impacts: change of the occurrence of pollutants in the water body (water quality monitoring data, special surveys; ➢ Pollutants: intrinsic properties of the pollutants affecting their likely pathways into the water environment. Information from existing obligations and programmes: ➢ Priority substances; ➢ 76/464; ➢ UNEP POPs list; ➢ EPER; ➢ COMPPS; ➢ Results of 793/93, users lists, etc.
2b. Deriving a list of pollutants
Assessment of information collated under Step 2a will result in a working list of those pollutants identified as being discharged into water bodies. Most of these pollutants will be selected by the combination of a top-down and bottom-up approach (see further Chapter 6, WRc-example on 'Selection of relevant pollutants (river-basin substances) experiences from Council Directive 76/464). Pollutants for which there is adequate confidence that they are not being discharged into water bodies may be excluded from further consideration.
3. Test for relevance

Step 2 deals only with the identification of pollutants being discharged into water bodies. Step 3 selects from these those pollutants that are likely to cause, or to already be causing, harm to the environment. This will depend on the intrinsic properties of the pollutants, their fate and behaviour in the environment and the magnitude of their discharges. Selection should ideally be based on an assessment of the environmental significance of the concentrations (and trends in concentrations) estimated for the pollutants or their breakdown products in the water bodies. However, effects data or an assessment of the significance of predicted loads may also be relevant in the selection process.

Two sub-steps are envisaged in the test for relevance a) estimating concentrations in water bodies; and b) comparing the estimated concentrations with suitable 'benchmarks'.

3a. Obtaining data on concentrations in, and loads to surface water bodies

By monitoring: i.e. measured data;

By modelling: i.e. estimated data (obtained by models varying from simple calculations to complex models as mentioned in Chapter 4. Tools).

3h. Comparing concentrations with benchmarks

Pollutants identified under Step 2 may be excluded where their concentrations are estimated to be lower than the most relevant critical value such as estimated LC50, NOEC, PNEC, EQS or critical load.

EQSs: are supposed to reflect the good status condition of a water body. They must be derived from ecotoxicological data. Exceeding EQS-values would be considered harmful to the environment. Where possible, monitored or estimated concentrations should be compared with the appropriate EQS;
Critical loads: identified for some reduction programmes (e.g. North Sea Conference) require load reduction for some pollutants. Only critical (i.e. environmentally significant) loads need be considered in identifying the specific pollutants.
Remarks:

Existing FQSs do not always reflect the actual effects concentrations. In addition, EQSs have not been derived for all potential specific pollutants. The best estimate for the EQS should be used based on the most recent ecotoxicological data. Effects data from monitoring programmes should be taken into account where available.
Natural background concentrations may exceed EQSs for non-synthetic pollutants.
Potential accumulations in sediment or biota should be considered.
Detection limits must be disregarded, as they have no discriminating basis in the context of environmental significance.

4. Safety net

A safety net is needed to ensure that pollutants that may be environmentally significant are not incorrectly excluded from the list of specific pollutants during Step 3 above. For example, the safety net should consider:

- Whether a number of small (individually minor) pollution sources may be expected to have a significant combined effect;
- Trends that may indicate an increasing importance of a pollutant, even though the FQS is not currently exceeded;
- The presence of pollutants with similar modes of toxic action and hence potentially additive effects.

For some pollutants the assessments made in Steps 2 and 3 may not provide adequate confidence that a pollutant is either not being discharged or not presenting a significant environmental risk. For example, confidence may be low if the tests for environmental significance under Step 3 are based on EQSs that were derived using insufficient or inadequate ecotoxicological data. In such cases, the uncertainty should be taken into account in deciding whether to identify the pollutant as a specific pollutant, and appropriate further investigations should be made to improve confidence in the selection procedure.

5 Final outcome

The final outcome must be a list of specific pollutants relevant to a river basin district or to particular water bodies within a river basin district.

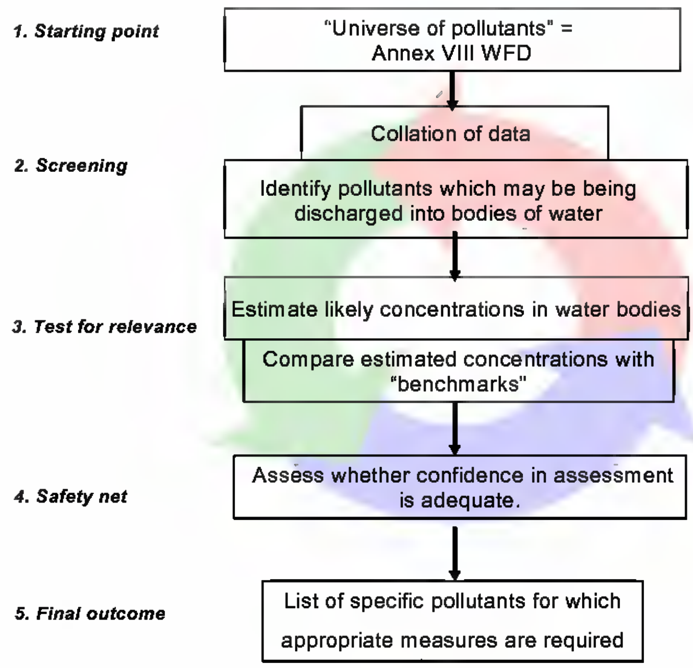


Figure 3.3 Steps needed to derive a selected list of pollutants

3.6 Evaluating the risk of failing the objectives

In theory, evaluating the risk of failing objectives should be a straightforward comparison of the state of the water body with threshold values that define the objective. This Guidance has proposed some general approaches to the estimation of the state of the water body, and most notably to elements relating to chemical and physical attributes. At present the threshold values are known for those elements of status that relate to protected areas and dangerous substances (Council Directive 76/464/EEC). For other aspects of status these values are not yet known e.g. the threshold values that define good chemical status.

In the period prior to the definition of these thresholds it will be necessary to use some interim thresholds defined by expert judgement, and applicable within eco-regions or smaller geographical units. For surface waters, and ground waters where the ecological status of an associated surface water body must be considered, a particular issue is to bridge the gap in understanding between biological status and physico-chemical conditions. This has been partially addressed by classification systems that exist within member states but at present they must be taken as indicative of conditions which could correspond to any particular biological status. While these classification systems differ in their detail, the classes are often labelled according to an overall assessment of status. For example, the best class may be *natural, background* or *excellent*. Below this there is usually a differentiation between a class that is slightly impacted, but has generally acceptable status (perhaps labelled *good*), and a class with greater impact that is seen as unacceptable (labelled *fair* or *moderate*). This distinction between good and moderate in the existing scheme could be used in the analysis prior to 2004 to separate bodies not at risk from those that are risk of failing WFD objectives.

It should be noted that such classification schemes generally only contain physico-chemical elements and therefore do not directly include morphological pressures. Thus while such a scheme might correctly reflect the state of the water body, it might hide the cause, e.g. a change in water chemistry could be caused by a change in flow regime.

To be usable these national schemes should meet one or more of the following requirements, which are related to the objectives of the WFD.

- The state data used for classification should
  for surface water (ecological status):
    - be closely related to the biological elements described in WFD Annex V;
    - be a relevant pollutant on river basin level;

  for surface water (chemical status):
    - be substances of WFD Annex X ;

  for groundwater:
    - describe the status (chemical and quantitative);
- The classification should have classes for
  - the background/natural state for surface waters;
  - a targeted state (e.g. "good status") below which the water body would be "at risk";
  - below classes which fail the target.
- The used quality objectives should be taken from EU-legislation and/or estimated Environmental Quality Standards in accordance with the procedure set out in WFD Annex V.

Examples of these schemes for impact assessment are presented in Annex IV, 4.

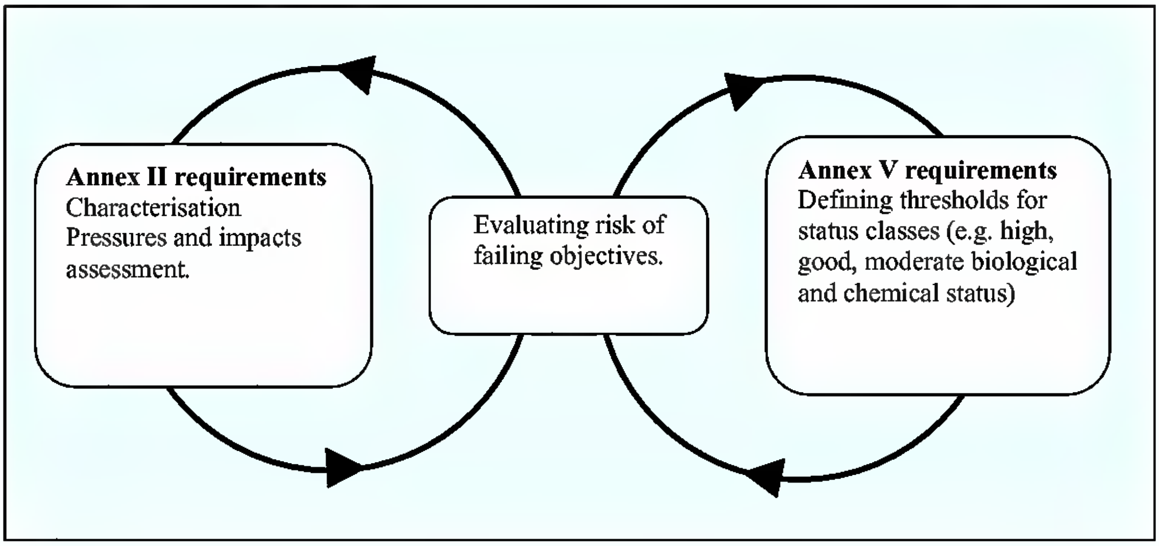


Figure 3.4 The iterative evaluation of the risk of failing objectives

For groundwater bodies, the use of monitoring data for evaluating the risk of failing to achieve good chemical status needs careful consideration, having regard to the specific environmental objective(s) that could lead to a failure to achieve good status.

It is clear that the process of evaluating the risk of failure is to some degree an iterative collaboration between those undertaking the pressures and impact analysis, and those defining thresholds for the as yet undefined elements of status (Figure 3.4).

3.7 Conceptual model approach

(Note: Model is used in this Chapter as a synonym for "understanding" and does not usually mean "numerical model"!).

A conceptual understanding of the flow system, chemical and, in the case of surface water, also the ecological variations within a water body and the interaction between groundwater and surface ecosystems is essential for characterisation.

A significant strength of the approach is that it allows a wide variety of data types (including, for example physical, biological and chemical data) to be integrated into a coherent understanding of the system. As new data are obtained they help to refine, or change, the model; conversely the model may indicate errors and inadequacies in the data.

A conceptual model is dynamic, evolving with time as new data are obtained and as the model is tested. Its development and refinement should adopt an iterative approach. The approach therefore fits in well with the various levels of knowledge required at different stages of the WFD. For example a basic model will be appropriate for initial characterisation; this (if appropriate) will be refined and improved during further characterisation, and again during the review cycle of the RBMP.

The construction of basic conceptual models of groundwater flow and chemical systems, and then of groundwater bodies must be undertaken early in the process of initial groundwater characterisation. This will include the delineation of the groundwater body boundaries and an initial understanding of the nature of the flow and geochemical system and interaction with surface water bodies and terrestrial ecosystems. It will also involve water quality information and an early assessment of pressures. In essence the model should describe the nature of the aquifer system, both in terms of quantity and quality, and the likely consequences of pressures. It is vital, even at the stage of groundwater body delineation that a coherent understanding of the body is reached. All data concerning the nature of the groundwater body collected during the characterisation process should be tested against the conceptual model, both to refine the model and to check for data errors.

3.8 Use of analogous water bodies

In situations with no observed data, one possible means to evaluate status is to use a similar *analogous* site for which data are available, and to assume that the assessment made from the observed data can be applied validly to both sites. To be most useful in the concept of the WFD pressures and impacts analysis the site for which data are available must have good status, since a failure may require more detailed study. The possibility of grouping water bodies for the purpose of pressure and impact analysis and monitoring is addressed in the *Horizontal Guidance on "Water Bodies"* (WFD Guidance Document No. 2), for example, bodies subject to similar pressures and with similar characteristics could be grouped.

A key concern in considering whether a site with data can be taken as analogous to the study site is the importance of proximity. Proximity in itself often indicates that many features of the two catchments will be similar (e.g. ecology, topography, geology, climate, channel characteristics and land use). However, since these characteristics can also change abruptly, proximity cannot be taken on its own as an indication of similarity. Indeed, it can be the case that a more distant catchment in fact provides a better analogy than a neighbouring catchment.

The assessment of similarity is probably best made on the basis of transparent and accountable expert judgement of the general characteristics. However, it is possible to formalise this process by having a numerical evaluation of each characteristic and combining these to give some form of objective measure of similarity. Such a scheme would require some local weighting of the characteristics included, and would therefore need to be developed regionally within Europe.

Major point source discharges, or other anthropogenic modifications that take effect at a particular location (e.g. abstraction, or impoundment) in either the study, or potential analogue catchment, will almost certainly mean that this approach cannot be used, since the particular characteristics of the point source impact will be highly dependent on the location within the catchment.

3.9 Specific considerations for the characterisation of groundwater bodies

The pressures on a groundwater body may have an impact, or measurable effect, upon it. The nature of the impact will depend on factors such as the type and severity of the pressure and the degree to which the groundwater body is susceptible to the pressure. Additionally, the geographical scale (e.g. distribution and density of pressures) and timescale effects (e.g. time lag for pollutants released at the land surface to reach the water table or migrate within an aquifer) are important considerations in assessing the risks to the groundwater body as a whole, and over time. The result of a pressure causing an impact may often be manifested in monitoring data after a considerable delay. For example, pesticide application to a wide area of land surface over a groundwater body may lead to increased concentrations of the pesticide in the groundwater many years after it was released. Monitoring information should be used, where available, to validate estimates of impacts obtained from pressure analyses.

Assessing impacts of pressures

Once the likely activities handling pollutants, abstracting from, or discharging to groundwater have been identified, the problem remains of translating this information into a measure of "pressure". There are two main issues to be addressed:

- For a given activity potentially producing a pollutant, how can the intensity and distribution of the activity be translated into a pressure?; and;
- How can the pressures assessed from different activities be combined to produce a measure of total pressure on the groundwater body?

Assessing the impact of pressures on groundwater bodies - initial characterisation

It is suggested that the concept of "potential impact" is introduced to describe the effects that a pressure is likely to have on a groundwater body, and that potential impact is used in the evaluation of whether the body is "at risk" of failing the Article 4 objectives. This concept recognises that, with the constraints on the characterisation process, it will not always be possible to accurately measure the impact by monitoring groundwater levels and quality. For pollution pressures the potential impact is judged by considering the pollution pressure (where this occurs at the ground surface) in combination with a measure of the vulnerability of the groundwater body to pollution (Figure 3.6). Thus, for example, a high pollution pressure caused by anthropogenic activities at the ground surface above an aquifer ***may*** have little impact on a groundwater body within the aquifer ***if*** that body is protected by a significant thickness of low permeability overburden. For quantitative pressures, such as abstraction, the potential impact of the pressure on the body is likely to involve reductions in water level and reduced outflows. These may be estimated using the conceptual model of the flow system, and undertaking a water balance for the groundwater body.

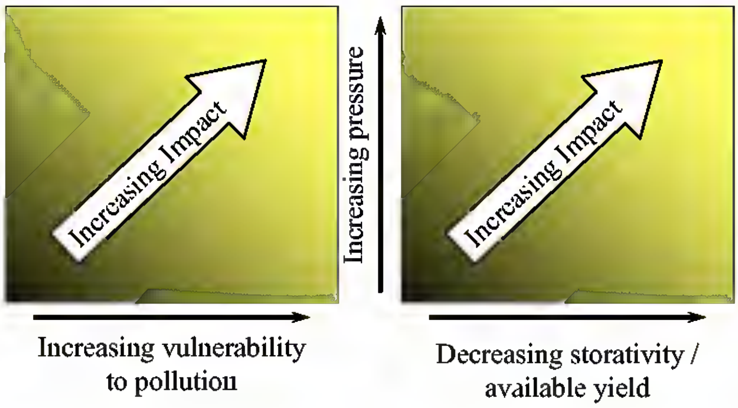


Figure 3.6 *Impact is a consequence of both the magnitude of the pollution or abstraction pressure and the susceptibility of the groundwater to that pressure.*

The assessment will typically be made following refinement of the conceptual model. Using that conceptual model, a decision must be made as to whether it is likely that the groundwater body is likely to fail to achieve good chemical status and, separately, good quantitative status. The overall assessment of whether the groundwater body is 'at risk' adopts the poorer predicted status, where they differ.

Assessments of the potential impacts resulting from pressures should be validated in areas where monitoring data are available. The data should also be used to ascertain any trends in water chemistry.

Assessing the impact of pressures on groundwater bodies - further characterisation

A "review of the impact of human activity" for 'at risk' groundwater bodies and those crossing Member State boundaries is explicitly required by WFD Annex II, Section 2.3.

The approach recommended follows that outlined for initial characterisation, but requires the collection of more detailed information and data, such as that detailed in Annex II, 2.3.

The wording of Annex II suggests that the information specified shall be included "where relevant". In this context "relevant" is taken to mean relevant to the assessment of risk of failure to meet Article 4 objectives. It does not give licence to avoid collecting information. The concept of "relevance" also involves questions of the level of detail that should be sought and, for human activities, the timescale over which the effects of the activity may be deemed relevant. In deciding these matters it is important to refer back to the purpose of further characterisation - to improve the assessment of risk and identify any measures to be required under Article 11. Thus, if the collection of more detailed information of a particular type is likely to improve the conceptual model sufficiently to enable the risk assessment to be enhanced, and if the extra detail can be obtained then the data should be collected.

3.10 Recommendations on reporting on the pressure and impact analysis

Article 15 (2) requires Member States to submit a summary report of the pressures and impact analyses to the Commission within three months of their completion (i.e. the first report must be submitted by March 2005).

This Section provides initial recommendations on the content and presentation of the summary report, in order to support consistency and comparability of results across the Community. All recommendations will be discussed within the EAF Reporting, which will provide the final Guidance on all reporting commitments.

The summary report has several aims:

- It fulfills Directive's reporting obligations with regard to the pressures and impacts analyses by Member States;
- If a common format is used this will provide a comparable basis for harmonization of water management on a river basin scale between countries within international RBDs;
- Provides a transparent overview of the analysis & results to communicate with government, stakeholders and the public.

The summary report sent to the Commission should be concise and give an overview of water bodies, their current state and the specific conditions of the RBD. The summary report will be complemented by reporting obligations within the respective RBDs. Suggested elements of the reporting required for 2005 are contained in Table 3.9.

Table 3.9 *Elements of reporting according to Article 15 "Review of the impact of human activity on the status of surface waters and on groundwater"*

- Short summary of relevant characteristics of the RBD (map of river basin district, protected areas, main water bodies, land use map);
- Summary of methods used (tools, thresholds, classifications) and assumptions made within the analyses;
- Cross reference to the other reporting obligations (article 5).

<u>Pressures and Impacts report:</u>
It is recommended that the following is produced as a report:

- Overall map of water bodies which are assessed to be at risk of failing their environmental objectives;
- Summary map for each general pressure type identified in Annex II identifying where (in which water bodies) that pressure type is identified as one of the main causes of the risk of failing to achieve the environmental objectives (i.e. for which the pressure is a significant pressure);
- The summary map should also include an indication of the variation in the level of uncertainty achieved in the pressure analysis;
- These maps may be presented in GIS format. This will be discussed with the GIS working group.

As an alternative the following could be produced:

- Overall map of water bodies which are assessed to be at risk of failing their environmental objectives;
- Supplementary table showing the main sources of pressures (e.g. substances);
- Summary table on number or area /percentage of water bodies which are at risk of failing their environmental objectives;
- Summary of major issues/pressures in the river basin district.

Regardless of the reporting format, the summary report should also include information on:

- applied methods, tools, thresholds, environmental quality objectives, classification schemes etc. used within the analyses;
- the amount of (un)certainty of analysis and results. The detailed RBD report may contain further information on the relative contribution of monitoring data, models and expert judgement within each analysis.

Further, more detailed information should be available on demand for public and stakeholder consultation. It is expected that this information may include:

- An overview of the available data on actual status of water bodies (chemical, ecological status) related to environmental objectives (a list of water bodies which are presently failing their environmental objectives);
- A list of the significant pressures in the district, subdivided according to Annex II, 1.4;
- A description of impacts and their connection to pressures;
- Delineation of the results of the pressure and impact analysis with maps:
    - overview map with river basin districts, locality and boundaries of water bodies;
    - maps of significant pressures in the river basin district;
    - maps of water bodies which are assessed to be at risk of failing the objectives in 2015.

The way this information is stored and made available will of course depend on nationally used data and reporting facilities.

Further reporting requirements may arise from the process of developing the RBMPs according to Article 13, WFD.

3.11 Review for surface water

For surface waters the WFD contains many specific requirements for the pressures and impacts analysis, while certain other aspects require interpretation and guidance. Thus while some particular substances and activities are identified, it is left open as to what constitutes a *significant* pressure. By taking this to mean any pressure that may contribute to the failure to achieve an objective, it is clear that understanding the objectives that are applicable to a water body is the foundation for the pressures and impacts analysis. Since at the outset of the analysis it is not known if an activity can contribute to such a failure, some knowledge is required of all activities within the catchment area. The analysis will then help to identify those that are significant, and must be based on some form of conceptual understanding, or model, of how the activity creates a pressure which causes an impact. The DPSIR framework provides a useful structure for this process.

The nature of the conceptual understanding coupled with knowledge of the water body's characteristics, will determine the type of pressures and impacts analysis that can be done. In practice a range of analyses will be used ranging from the simple to the complex. In some instances the simple methods may provide the only available option, but they may also be used as screening tools to decide whether more complex methods are necessary, or as the first stage in a recursive process.

These major elements can be broken down into list of key tasks and this is presented as a summary checklist as in the text box opposite.

Summary of key tasks for surface water

Data collation for river basin (prerequisite to the pressures and impacts analysis)::

- Access or establish database and data management systems on activities within the river basin district, and existing monitoring data.

Basic information specific to water body:

- Abstract information on driving forces in the catchment area of the water body;
- Identify pressures caused by the driving forces taking particular regard to those pressures listed under Annex II 1.4;
- Abstract data specific to the water body, including quantitative, hydromorphological, physical, chemical and biological data;
- Identify dependent water bodies and water bodies on which the water body under consideration is dependent as well as their basins;
- If relevant, ensure links with data managers of upstream and downstream water bodies, including foreign organisations.

Additional existing information and analyses:

- Review existing analyses of water monitoring, status, management plans etc.;
- Information collected under existing European Community legislation (use register of protected areas, Article 6) and national legislation;
- Review whether available methods are capable of producing the required assessments.

Objectives (Article 4)::

- Determine objectives pertinent to water body.
- Assess the existing monitoring data (biological, physico-chemical and hydromorphological), against the environmental objectives, or assumed equivalent objectives;
- Consider if analogous catchment approach helpful.

Pressures and impacts analysis, to be complete by 2004::

- Develop appropriate conceptual understanding considering characteristic of water body, catchment area, activities, driving forces, pressures, and objectives;
- Select appropriate tools based on conceptual understanding and data availability;
- Assess vulnerability of water body and dependent water bodies to impact from the identified pressures, to assess whether the water body is at risk of failing to achieve objectives;
- Explore the variability of pressures and impacts within the catchment of the water body – variability may indicate that it would be helpful to subdivide the water body for the purpose of developing a practical programme of measures;
- Ensure variability is not caused by uncertainty in source data or methods;
- Take forward the analysis by exploring changes and trends in activities and pressure anticipated in the period to 2015 and beyond;
- If failure is likely, review exemptions that may be applicable (provisional identification as heavily modified Article 4.3, temporary deterioration Article 4.6).;
- Review all steps above as (i) more, or better, data become available, (ii) new assessment tools become available, and (iii) as experience and expertise develop.

Outputs:

- Report on pressures and impacts analysis within 3 months of completion (Article 15, Chapter 3.10).;
- First list of water bodies "at risk";
- Use the results of the analysis to inform development of monitoring programme (Article 8) and programme of measures (Article 11).

3.12 Review for groundwater

A summary checklist of key tasks for the characterisation of groundwater bodies appears in the following text box.

Summary of key tasks for groundwater

Initial characterisation.

Using existing data:

- Collate data on pressures on the groundwater body, taking particular regard to those pressures listed under Annex II, 2, 2.1;
- Collate information on impacts on the groundwater, taking particular regard to those pressures listed under Annex II, 2, 2.1, and having special regard to the natural condition;
- Review existing groundwater monitoring data (chemical and water level), and data on dependent surface waters and ecosystems, having regard to the known pressures and impacts on the groundwater body, and the environmental objectives that are relevant to the body (Art. 4).;
- The development of a conceptual model of the groundwater flow, which also incorporates flow to/from associated surface waters, and a model for the chemical system are recommended as the basis for understanding and documenting the groundwater body, and to aid decision making;
- Assess vulnerability of groundwater to pollution from the recorded pollution pressures, to assess whether the groundwater body is likely to be at risk of failing to achieve good chemical status;
- Assess the water balance of the groundwater body, having regard to the recorded quantitative pressures, to assess whether the groundwater body is likely to be at risk of failing to achieve good quantitative status;
- Consider possible relationships between the groundwater body and connected wetlands;
- Consider both chemical and quantitative status to decide whether the groundwater body is likely to be at risk of failing to achieve good status, including an assessment of time-lag of pollutants in aquifers;
- A review of the delineation of the groundwater body may be undertaken if the data on pressures and impacts indicates that it may be helpful to subdivide bodies for the purpose of developing a practical programme of measures. However, any subdivision should conform to the 'rules' on groundwater body definition contained within Commission guidance.

Where there are no monitoring data for a groundwater body, the likely presence or absence of pressures and impacts should be considered when making a decision of the likely status of the groundwater body. Where it is clear from monitoring data that the groundwater body is 'at risk', or where there is inadequate data to make a decision with reasonable confidence that a groundwater body is 'at risk', the process should continue to Further Characterisation.

Further characterisation.

The key stages replicate Initial characterisation but relies on additional data and more sophisticated analysis techniques.

4. Tools to assist the analysis of pressures and impacts

4.1 Introduction and Overview

This Chapter focuses on the tools needed to carry out the General Approach as outlined in Chapter 3 and mentions some of those tools already available. At present there is no single tool capable of performing a complete pressure and impacts analysis for all types of water body, and it is very unlikely that such a tool will eventually exist. Therefore, this Guidance describes specific tools that consider one particular component of the process or environment (e.g. pressure assessment, surface water, groundwater, biology). The results from more than one tool may have to be integrated to undertake a complete pressure and impact analysis of a water body.

Before using any tool you must be sure that it is fit for the purpose for which you want to use it. You should have a clear objective defined, i.e. what questions you want to answer, and should select a tool that is capable of simulating the pressure and impact being considered and of providing the required results. You should be aware of the capabilities and limitations of each tool. The Guidance gives hints for those decisions.

In each Section and the Annex IV one or more example tool or model is described, but it is necessary to stress that they are just that – *examples not* IMPRESS *recommended or endorsed tools*. Most of the tools described are currently used within member states for functions similar, or possibly identical, to those required by the WFD, and in general such usage was mandatory for a tool to be included. Many more tools exist, and no doubt will become available in the future.

To be included in this Guidance the tool must to some degree be formalised into a set of rules or procedures. However, these will have been based on some form of expert judgement, perhaps in the form of, for example, a consensus widely held amongst practitioners, the current state of scientific knowledge, or an individual's experience and expertise. It would be wrong, therefore, to think that the tools described here are necessarily better than the expert judgement of the individual undertaking the pressure and impacts analysis. The value of local knowledge and experience should not be underestimated or dismissed in favour of a more formal process imported from elsewhere. Those undertaking the analyses should consider involving stakeholders since they are likely to introduce complementary knowledge and experience.

The toolbox considers a pressure checklist (Section 4.2) and screening approaches (Section 4.3). The pressure checklist contains an uncompleted list of pressures that should be considered as part of the pressures and impacts assessment. The use of screening techniques is understood to be most helpful in the short-term implementation of the Directive. The corresponding Section focuses on examples of how to use certain techniques with the aim to simplify the approach of the analysis.

The general approach is based on a logical succession of key stages, which realisation requires full availability of data and tools. In contrast, Section 4.4 also considers the current state, where a great deal of these required means is not available, or just not identified. Hence, it focuses on the identification of the tools that are required to respond to specific questions. This identification is carried out by analysing the relationships between pressures and impacts as well as those between state and impacts, as regards the objectives of the Directive.

In Section 4.4 the need for tools is compared with the existence. This is clustered into three categories:

1. The fully available tools, that have been to some degree formalised into a set of rules or procedures. These tools are, when possible, exemplified through their actual application that includes the conditions under which they can be applied. In this case, full description is presented in Annex IV;
2. Tools still being at a laboratory or pilot stage. This category includes defined methods which have not yet been implemented into an operational system. They require further development and engineering to be operational. However some tools can be replaced by some form of expert judgement;
3. The non existing tools. In this case, the need for development, possibly including research is indicated to pinpoint the possible gaps in application.

The Annex V contains four Sections that relate to types of tool identified within the General Approach. These types are:

- Pressure screening and assessment;
- Quantification of pollution pressures;
- Tools to combine pressures with impact assessment - Water body models; and
- Impact assessment.

4.2 Pressure Checklist

The pressure checklist contains an uncompleted list of pressures that should be considered as part of the WFD pressures and impacts assessment. The list can be considered as a reminder of the driving forces and the pressures that should be considered and therefore represents a precursor to the actual pressures and impacts analysis. The driving forces and pressures within this table are listed mixed and independent from whether paths, or sources of substance entries etc. are mentioned.

The pressure checklist is presented in two stages. First, in Table 4.1 the pressures have been grouped into four main classes of driving forces that may impact the different water body categories and prevent them from meeting the objectives. A tentative indication of these likely-to-be relationships is reported in the Table 4.1. This table is an entry to the following uncompleted list of pressures in Table 4.2, as the numbers in the first column of Table 4.1 refer to the corresponding lines in Table 4.2. Please note that Table 4.2 mirrors the structure of Table 3.1.

Table 4.1 Pressures to be considered. See Table 4.2 for more details.

		Water Body Category				**OBJECTIVES**				
n°	**DRIVING FORCES**	Rivers	Lakes	Coastal/Transitional	Groundwater	WFD (biota)	Tap water, NO3	Bathing, recreation	Habitats, Birds	Shell/fish farming
10	**Pollution**									
11	Household	x	x	x	x	x	x	x		
12	Industry (operating, historical)	x	x	x	x	x	x			
13	Agriculture	x	x	x	x	x	x	x	x	
14	Aquiculture /fish farming	x		x		x				
15	Forestry	x	x	x	x					
16	Impervious areas	x	x	x		x		x		
17	Mines, quarries	x			x	x				
18	Dump, storage sites	x		x	x	x			x	
19	Transports	x		x					x	
20	**Alteration of hydrologic regime**									
21	Abstraction (agri, industry, household)	x	x		x	x	x			x
22	Flow regulation works	x		x		x			x	
23	Hydropower works	x		x		x			x	
24	Fish farming	x				x				
25	Cooling	x								x
26	Flow enhancement (transfers)	x			x	x			x	
30	**Morphology (changes in)**									
31	Agricultural activities	x	x	x		x			x	x
32	Urban settlements	x	x	x		x	x		x	
33	Industrial areas	x	x	x		x			x	
34	Flood protection	x		x		x				
35	Operation, maintenance	x		x		x				
36	Navigation	x		x					x	
40	**Biology**									
41	Fishing/angling	x	x	x		x				
42	Fish/shellfish farming	x	x	x		x				x
43	Emptying ponds	x	x						x	x

Table 4.2 Uncompleted list of Pressures to be considered

n°	SOURCE	Source within the source type
10	DIFFUSE SOURCE	
12	urban drainage (including runoff)	industrial/commercial estates
11		urban areas (including sewer networks)
16		airports
19		trunk roads
19		railway tracks and facilities
19		harbours
13	agriculture diffuse	arable, improved grassland, mixed farming
13		crops with intensive nutrient or pesticide usage or long bare soil periods (e.g. corn, potato, sugar beets, vine, hops, fruits, vegetables)
13		over grazing – leading to erosion
13		horticulture, including greenhouses
13		application of agricultural waste to land
15	forestry	peat mining
15		planting/ground preparation
15		felling
15		pesticide applications
15		fertilizer applications

n°	SOURCE	Source within the source type
22		drainage
19		oil pollution
11	other diffuse	sewage sludge recycling to land
		atmospheric deposition
19		dredge spoil disposal into surface waters
19		shipping/navigation
	POINT SOURCE	
11	waste water	municipal waste water primarily domestic
11		municipal waste water with a major industrial component
11		storm water and emergency overflows
11		private waste water primarily domestic
11		private waste water with a major industrial component
19		harbours
12	industry	gas/petrol
12		chemicals (organic and inorganic)
12		pulp, paper & boards
12		woollens/textiles
12		iron and steel
12		food processing
12		brewing/distilling
12		electronics and other chlorinated solvent users
12		wood yards/timber treatment
12		construction
25		power generation
12		leather tanning
19		Shipyards
12		other manufacturing processes
17	mining	active deep mine
17		active open cast coal site/quarry
17		gas and oil exploration and production
15		peat extraction
17		abandoned coal (and other) mines
17		abandoned coal (and other) mine spoil heaps (bings)
17		tailings dams
18	contaminated land	old landfill sites
18		urban industrial site (organic and inorganic)
18		rural sites
18		military sites
13	agriculture point	slurry
13		silage and other feeds
13		sheep dip use and disposal
13		manure depots
12		farm chemicals
19		agricultural fuel oils
19		agricultural industries
18	waste management	operating landfill site
18		operating waste transfer stations, scrap yards etc.
18		application of non agricultural waste to land
14	aquaculture	land based fish farming / watercress / aquaculture
14		marine cage fish farming
12	manufacture, use and emissions from	priority substances
12	all industrial/agricultural sectors	priority hazardous substances
12		other relevant substances
	ABSTRACTION	
21	reduction in flow	abstractions for agriculture
21		abstractions for potable supply
21		abstractions by industry
24		abstractions by fish farms
23		abstractions by hydro-energy
21		abstractions by quarries/open cast coal sites
22		abstractions for navigation (e.g. supplying canals)
20	ARTIFICIAL RECHARGE	
26		groundwater recharge
30	MORPHOLOGICAL	
22	flow regulation	hydroelectric dams
21		water supply reservoirs
22		flood defence dams

n°	SOURCE	Source within the source type
22		diversions
22		weirs
36	river management	physical alteration of channel
35		engineering activities
31		agricultural enhancement
31		fisheries enhancement
32		land infrastructure (road/bridge construction)
36		dredging
36	transitional and coastal management	estuarine/coastal dredging
36		marine constructions, shipyards and harbours
31		land reclamation and polders
30		coastal sand suppletion (safety)
30	other morphological	barriers
	OTHER ANTHROPOGENIC	
12		litter/fly tipping
11		sludge disposal to sea (historic)
33		mine adits/tunnels affecting groundwater flows
40		exploitation/removal of other animals/plants
10		recreation
41		fishing/angling
40		introduced species
40		introduced diseases
10		climate change
31		land drainage

4.3 Screening approach within the general approach

The objective of the screening approach is to point out with simple assessments those water bodies that are clearly "at risk" or "not at risk" of failing to meet the objectives in 2015. This may happen either if the current state is good enough *or* too bad, *and* if there is no expected change in pressures. Compared to the general approach, the screening approach may be carried out in any order (assess state, assess lack or certainty of impact), using driving force assessment as substitute of pressures. Consequently, the screening approach preferably stands on existing data, not on modelling; otherwise the required transparency of the approach would not be met.

Three examples of screening techniques should be mentioned for the following cases:

1. If only pressure data are available, their screening can be used as hint of a risk of failing objective;
2. If driving forces are correctly assessed and computed on small areas, and can be used to stratify observation data;
3. If only observation data (state) is available. In this case, a pressure analysis supposed to be applied where unwanted state is observed

Examples for Case 1: In case state data are not sufficient enough to assess actual impact, techniques using only pressure data must be used. The LAWA pressure screening procedure was developed for the purpose of compiling the significant pressures, indicating which water bodies might be at risk and which elements of status (biological, substances) are to be considered in the monitoring programme. In some cases, data that have already been compiled on the basis of other directives (e.g. urban wastewater directive) can be used. This procedure is a useful check-list of what is likely to have an impact.

A second part of this LAWA screening procedure is mentioned in the Annex dealing with the assessment of impacts.

Table 4.3 Example criteria for significant pressures: German LAWA Pressure screening tool

Pressures: point sources	Criteria
Public sewage-treatment plants >2000 PE (derived from Urban Wastewater Treatment Directive)	- Annual volume of water discharge; - Population (P) and population equivalents (PE); - Substance loads according to Annex I of the German Wastewater Directive; - Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives.
Industrial direct discharge	- Statement of systems according to IPPC Directive = pollutants according to EPER; - Annual loads of plants with obligation to report according to IPPC Directive: consideration of the particular size threshold for the annual load of 26 substances (cf. Table 1: Size thresholds; EPER); - Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives; - Food industry facilities >4000 EP.
Storm water / combined wastewater discharges	- Discharge of wastewater from an urban area >10 km²; - Urban areas can be estimated e.g. basing on CORINE-landcover, multiplied with discharge coefficients.
Discharges with heat load	Discharges with heat load > 10 MW.
Salt discharges	Discharges > 1 kg/s chloride.
Pressures: diffuse sources	**Criteria**
Diffuse sources in general are surveyed while the inventory taking for groundwaters. Normally these data can be used also for the description of surface water bodies (this does not apply to erosion from surfaces with a gradient > 2%. If no results from description of groundwaters are available, the following values can be used for an estimation of diffuse pressures:	
	- Urban land > 15 % - Agriculture = 40 % - Sugar beets, potatoes and corn = 20%of agricultural land - Special crop land (vineyards, fruits, vegetables,..) = 5 % of agricultural land - Contaminated land = Individual case
Water abstraction	**Criteria**
	Abstraction without recirculation > 50 l/s
Water flow regulation	**Criteria**
Anthropogenic barriers	Parameter "anthropogenic barriers" (Stream habitat survey): ≥ 6
Backwater	Parameter "backwater" (Stream habitat survey): = 7
	Diversion stretches > x km
Morphological alterations	**Criteria**
Morphological alterations	Stream habitat survey and comparable data

The OECD-Vollenweider approach of lake classification was developed to assess the probability that a lake reaches a certain trophic state as a result of nutrient (principally Phosphorus) inputs. It can be used as screening tool, especially when the actual state can be compared with a possible natural one. The procedure is not longer described in this guideline, as it can be found in literature and national classification systems for lakes.

Example for Case 2: The EuroWaternet (EEA, see Chapter 6 and Annex V) uses the driving forces to stratify the pool of river monitoring stations. The representative observation data set obtained shows clear-cut differences in water quality according to the likelihood of pressures resulting from the presence of driving forces on catchments. Provided the basis for stratification is constructed with small elementary areas (e.g., in France, average size is 90 km^2), they constitute a proxy of the statistical population of water bodies catchments.

The representative observation data set can be used to assess time trends (for nitrate, ammonium, etc.). The use of simple filtering techniques allows to remove the interannual changes in river discharge, thus providing a statistical estimate of the trend under the "business as usual" scenario.

This approach uses only monitored data and simple driving force data, namely CORINE *land cover* and population census.

Example for Case 3: In case only monitoring data are available, the water quality classification results are usable as screening tools. Users will need to take account the limitations of these schemes in relation to the scope of the Directive's objectives. Requirements are listed in Chapter 3.5. Examples are included in the Annex to Chapter 4.

One Example – the German LAWA impact assessment tool - proposes to use thresholds for summaries of classification results for a water body as screening tools. Another example - the water quality accounts (WQA) technique (see Chapter 6) - may help to identify which kind of pressure is likely to be involved. The WQA processes quality indexes from the measured concentrations, thus making different water quality issues comparable, if the used classifications are comparable. The issues which determine the overall state of the water body can be pinpointed by comparing the water quality issues. Even though WQA and EuroWaternet start with the same data (from monitoring points), they yield complementary assessments of river quality issues that provide a powerful screening of water bodies causing problems.

The HMWB Guidance offers some tools to identify hydromorphological pressures and their impacts (see WFD CIS Guidance Document No. 4 on Heavily modified Water Bodies / HMWB). Chapter 3.4 and the Annex to Chapter 4 summarise the knowledge about main uses (driving forces), connected physical alterations and impacts.

4.4 Basic Considerations about Use of Numerical Models

Mathematical models of ecological, hydrogeological and geochemical systems may be used to simulate the movement of water, and the fate and transport of pollutants within water bodies. Models take a variety of forms and the question(s) that need to be answered (e.g. 'what is the likely chemical status of a groundwater body?'), the data availability and the time and funds available are all relevant considerations in deciding what complexity of model is used. In general the more complex the model, the greater the data requirements and the greater the time and costs needed to complete it. As a consequence, the accuracy of a robust numerical model may be greater than that which can be achieved using a simpler model. However, in the context of water body characterisation under the WFD there are many questions that may be answered adequately with a simple model.

An iterative approach is recommended, where assessors begin with simple conceptual understandings or analytical models and shift to mathematical models only where water bodies appear to be at risk, or where a detailed programme of measures is being developed. In many cases simple analytical models will be adequate to allow an assessment of contaminant behavior, however in certain situation more complex numerical models will be required.

Assessors may use numeric models to make predictions about combined point and diffuse source pollution effects on the wider groundwater body and on dependent surface waters and ecosystems, and to predict the effects of abstractions and artificial recharges on water resources. In addition, development of a numeric model helps assessors to:

- identify data and knowledge limitations;
- predict the impacts from a number of pollution pressures on remote receptors;
- predict the impacts from a number of abstraction or artificial recharge pressures on water resources, including any impacts on surface water bodies and dependent aquatic ecosystems;
- make predictions on the fate and transport of pollutants;
- include spatial and temporal variability in model predictions (which is often not possible with simpler analytical models).

4.5 Identification of tools: Comparison of need with existence and Examples

The IMPRESS guideline deals with impacts and pressures. Hence the tools are identified according to two leads: either they make it possible to quantify the pressure, supposedly leading to an impact or they enable to assess the state (the impact being assessed through change in state).

This identification is carried out for the main water body categories, i.e., rivers, lakes and ponds, groundwater and transitional waters. Some tools may obviously be common to several categories. To simplify the search, the pressures were grouped by identical function (e.g. nutrient discharges), notwithstanding the sources themselves.

The identification of tools is illustrated by constructing four matrixes, one per water body category. All tables have the same structure: the objectives are reported as column headers, and the pressures in lines. Each cell represents a "group of tools" that are understood to provide the expected information. The colour code of the cell qualifies the existence of at *least one tool* capable of quantifying the pressure and assessing the related impacts. Meaningless cells are indicated "NA for "not applicable". The state assessment is considered as a general tool related to category components, and is reported in a header line of each matrix.

4.5.1 Tools for rivers

Table 4.4 Assessment of the degree of availability of tools needed for riverine water bodies

RIVERS	WFD				Protected areas			
Tools categories : 1: Tools available and implemented 2: Tools available but not implemented 3: No available tool	Physico-chemistry	Flora	Invertebrates	Fish	Drinking water, nitrate	Bathing, recreation	Habitats, Birds	Remarks about methods and required data
Pressure quantification per pressure group								
POLLUTIONS								
Nutrients	1	2	2	2	1	1	NA	Moneris, Nopolu, Eurowaternet
General conditions	1	2		1	1	1	1	
Toxics	2	2	2	2	2	2	2	Only partial assessments
Pathogens	NA	NA	NA	NA	2	2	NA	
WATER REGIME								
Abstractions, derivation, storage		3	3	2	NA	NA	3	Tools do not encompass all uses
Change in flood regime	NA	2	2	2	NA	NA	2	Many indicators, no overall procedure nor local reference data
Change in low water regime	2	3	2	2	NA	NA	2	Only relationships with chemistry are documented, otherwise local expertise required
Hard change in discharge	2	3	2	2	3	3	2	Definitions to be formalised
MORPHOLOGY								
Break in longitudinal course	NA	NA	3	2	NA	NA	3	Indicators not available
Bed artificialisation	3	3	3	3	NA	NA	3	""
Maintenance, works in river bed	3	3	3	3	NA	3	3	""
Change in river course	NA	3	3	2	NA	NA	3	""
Change in facie*	3	3	3	2	NA	NA	2	""
Banks artificialisation	NA	2	3	2	NA	NA	3	""
Destruction /sealing of annexes	3	3	3	2	3	NA	3	""
BIOLOGY								
Direct capture	NA	NA	NA	2	NA	NA	3	Partial capture statistics
Fishing management	NA	NA	NA	2	NA	NA	NA	
Species introduction	NA	2	2	3	NA	NA	3	Links with nature conservation surveys to create
Introduction of diseases	NA	NA	NA	3	NA	NA	3	Poor documentation
State assessment	1	1	1	2	1	1	2	For instance LAWA, Finnish assessment tool, E&W grids, SEQ-eau. Water accounts and Eurowaternet to aggregate results.

Note, that existing classifications usually don't assess the difference of biological elements to the natural status as required by WFD, Annex V, 1.2. Therefore their results are of restricted value, but should be used in the first assessment in 2004 (further explanation in Chapter 3.6).

Pressure and impact quantification tools are available only for a *limited number of pressure types*, mostly dealing with organic and nutrient pollution loads. Considering the groups of tools, only 10% of these groups can be exemplified by implemented tools. On the contrary, a large number of groups (about 45% each) still require efforts either for implementation or scientific development, mainly in morphology linked assessments.

Quantifying the pressure would ideally be done using monitoring data. However such data do not exist in many circumstances, or are not monitored. Hence, the existing tools use alternative information to quantify the pressure. For agricultural pressure information on soil type, agricultural activity and management strategy are processed whereas for sewage effluents it might require the population equivalent of the inputs to the plant and the type of processing.

The output from the tool must be combined with another tool that combines the information on pressures, with a representation of the receiving water body. Thus, for example, the pressure resulting from an abstraction is first quantified, and then combined with information on a river system to determine the actual impact.

The currently implemented tools addressing **pollution pressures** (examples are taken from MONERIS, Nopolu, SENTWA, see Annex IV) are not fundamentally different. According to country requirements, and reporting needs, some processes are more or less detailed, as shown below, (more detailed presentation and references are provided in Annex IV):

- The German MONERIS (Modeling Nutrient Emissions in River Systems) estimates by various pathways the nutrient inputs into river basins of the German Baltic Sea catchment area. The model is based on a geographical information system (GIS), which includes digital maps as well as extensive statistical information and monitoring data in rivers, groundwater, drainage and point source effluents. The main pathways of water pollution are considered and, in the absence of ad hoc knowledge and data, they are processed thanks to lumped coefficients. One special feature of the model development is that the different sub-models were validated by using independent data sets, for example the groundwater model was developed with the observed nitrogen concentrations in the groundwater and not on the basis of the observed nutrient loads in the rivers;
- The Nopolu system encompasses a full description of the water-related characteristics of any territory, e.g. metropolitan France in which it is progressively implemented. Hydrologic and administrative apportionment relationships are managed by the system by the way of specific links (large cities discharging in a far away river) or by crossing information derived from GIS tables such as CORINE *land cover*. An important characteristic of the system is the possibility to aggregate and disaggregate results at any scale, thus responding to specific reporting requirement. The system is oriented towards assessment of state, pressure quantification and impact analysis, focusing on a thorough exploitation of observed data. The calculation of emissions aims at computing the real loads, taking stock of both monitoring data from large sources and statistical aggregates for area sources;
- The SENTWA model 'System for the evaluation of the nutrient transport to surface water' simulates the nutrient emissions from agriculture ("manuring") to surface water. It is a semi-empirical model that quantifies orders of magnitudes of nutrient emissions. It quantifies the load total N and total P (kg or ton N/P; kg or ton N/P per ha) on an annual or monthly basis and per river catchment in Belgian Flanders.

A current effort to compare models of pollution pressure by nutrients is carried out by the EUROHARP initiative (details are available on the http://www.euroharp.org site). Unfortunately, the work schedule does not match the 2004 reporting, but should help in later phases of the implementation of the directive.

A large number of tools for modelling impacts in rivers, of which SIMCAT (see annex) is an example, have been developed and calibrated. These models are however mostly developed to simulate physico-chemical mechanisms, and do not help assess the new issues introduced by the Directive.

No implemented tool capable of assessing the impact of changes in hydrological regime or morphology could be identified. However, the previous available discharge and elevation data could be used to design ad hoc indicators. For example, pike spawning conditions, fish ladder efficiency or dam filling impact, etc. can be assessed using statistics computed from daily discharge data and simple elevation – discharge relationships. The main gap is the current lack of reference data that apply to each considered water body: what is the water elevation over the meadow, what is the discharge on the equipped weir, how many "small" floods are there?

State assessment tools are often well documented and available. They use monitoring data which can be applied and the likely impacts derived from them.

Most countries have developed their own classification systems that show some differences in concept. The Finnish water quality classification system (see Annex IV) has been developed in order to give information on water usability for human purposes. It takes into account only ecological quality elements, which have a direct impact on water usability. It treats all water bodies similarly, not making any difference between different water categories or water body types. Classification is based mostly on chemical quality elements, but also on some biological elements such as hygienic indicators, chlorophyll and algal blooms. Criteria and threshold concentrations can be found in the Annex.

The England and Wales River Ecosystem Classification scheme, which thresholds are presented in the Annex, uses an 8 physico-chemical determinant grid that applies to monitoring points. The physico-chemical quantities used can be obtained from observed data or modeled output. Classes 1 and 2 are considered representing conditions suitable for salmonid and cyprinid fish populations.

The German assessment tool, set up by LAWA (State Working Group on Water) assesses the state of a water body from available environmental monitoring. Contrasting with other tools, it considers aggregated criteria, including the trophic state of the river network. An estimation of the probability that good ecological or chemical conditions will not be achieved within a period of observation is carried out according to the rule detailed in the Annex.

The French SEQ aims to consider all compartments of the water system (rivers, lakes, groundwater, transitional) and their components (water, biology, morphology). The state is assessed by comparing threshold values established for relevant groups of determinants considering the type of use. This approach takes stock of all available information and regulations, at the expense of a certain degree of complexity. More details are provided in Annex IV.

Summary related to tools suitable for rivers
Many tools are available, but unfortunately they focus on classical pollution that can be computed and modelled. Many developments are required for hydrological pressures. In this case, a common set of indicators could be defined, backed up by local identification of relevant threshold values. Morphology and biological pressures, that are not well understood, require developments to address ecological state assessment, including links with habitats and bird life in riparian areas.

4.5.2 Tools for lakes and ponds

Table 4.5 Assessment of the degree of availability of tools needed for lakes water bodies.

LAKES

Tools categories :
1: Tools available and implemented
2: Tools available but not implemented
3: No available tool

LAKES	WFD				Protected areas			
	Physico-chemistry	Flora	Invertebrates	Fish	Drinking water, nitrate	Bathing, recreation	Habitats, Birds	Remarks about methods and required data
Pressure quantification per pressure group								
POLLUTIONS								
Nutrient	1	1	NA	NA	1	NA	NA	OECD, Moneris, Nopolu
General conditions	2	2	3	2	1	2	3	
Toxics	2	3	3	2	2	3	3	
Germs	NA	NA	NA	NA	3	2	NA	
WATER REGIME								
Abstractions	2	2	3	3	NA	NA	NA	
Changes in high water period	2	3	NA	3	NA	NA	3	Some indicators
Change in low water period	2	3	3	3	NA	NA	3	
Withdrawal management	2	2	2	2	2	3	3	Local models
MORPHOLOGY								
Banks artificialization	NA	2	3	2	NA	NA	2	
Destruction of riparian areas	2	2	3	2	NA	NA	2	
BIOLOGY								
Direct captures	NA	NA	NA	2	NA	NA	3	
Management of fishing	NA	NA	NA	2	NA	NA	3	
Introduction of species	NA	3	3	2	NA	NA	2	
Diseases introduction	NA	NA	NA	2	NA	NA	3	
State assessment	2	1	3	2	1	1	2	Finnish assessment tool, SEQ-lacs.

Pressure and impact quantification tools quantifying pollution loads are no different from those applicable to rivers and they are not discussed again here. The most general tool providing impact assessment is the OECD model (known as "Vollenweider's model"), already mentioned in the "screening section". It can be used for more precise assessments than just screening, provided that more accurate input loads and renewal time are available.

Since many lakes result from dam construction, the impact of withdrawals on water quality has been investigated in many countries. Selective withdrawal models were used in the 1980's to implement dam management rules capable of changing the thermal stratification of stored waters and limit eutrophication.

In parallel, many studies were devoted to the understanding of the relationships between water level changes (due to water use) and the biological functioning of banks. The purpose was twofold: increase the amenity of the water body, especially during the tourist season, and lower the adverse impacts of reservoir construction.

Despite the fact that the results of these approaches cannot be considered as fully implemented tools, they can be used as basis for investigation, especially if the experts who worked on these water bodies are still in position to help implement the Directive.

State assessment tools are implemented on a routine basis in only a limited number of countries that monitor these waters. Most deal primarily with eutrophication issues, resulting in abundant literature. For assessment of the risk of failing objectives for waters used for drinking water and bathing, data on compliance with the EU-directives 75/440/EEC (surface water intended for abstraction of drinking water) and 76/160/EWG (bathing waters) could be used.

Summary related to tools suitable for lakes
Considering the groups of tools, virtually none can be exemplified by implemented tools. About half of them still require effort for implementation, the remaining requiring scientific development, mainly in hydrological regime linked assessments. Again there is a lack of tools describing impacts on the difference of species composition and abundance to the natural state of biological elements.

4.5.3 Tools for groundwater

Groundwater vulnerability maps or indices are useful tools for assessing the likely impact of pollution pressures during the characterisation process. By taking account of a range of factors, the susceptibility, or vulnerability, of groundwater to pollution from pollution pressure on the land surface can be ranked. Typically vulnerability-ranking methods take account of a range of parameters, including:

- Presence, nature and thickness of soils, including attenuating properties;
- Presence, nature and thickness of superficial (drift) deposits, including attenuating properties;
- Groundwater flow mechanism in the aquifer (e.g. matrix, fracture, dual porosity dominated);
- Depth to the water table.

Groundwater vulnerability maps, based on a regional assessment using an index-based system can be used as a screening tool to rapidly assess the relative scale of impacts arising from pressures. They may be useful for assessing whether groundwater bodies are 'at risk' from pollution sources at initial characterisation.

Groundwater vulnerability assessments may be combined with models of diffuse pollution source behaviour, such as those developed for nitrates in The Netherlands (**STONE;** details are available under the http://www.riza.nl/projecten_nl.html site) or for pesticides in the UK (**POPPIE;** details are available under the http://www.meds-sdmm.dfo-mpo.gc.ca/meds/Prog_Int/ICES/ICES_e.htm site), to consider the overall risks to water quality on a groundwater body scale.

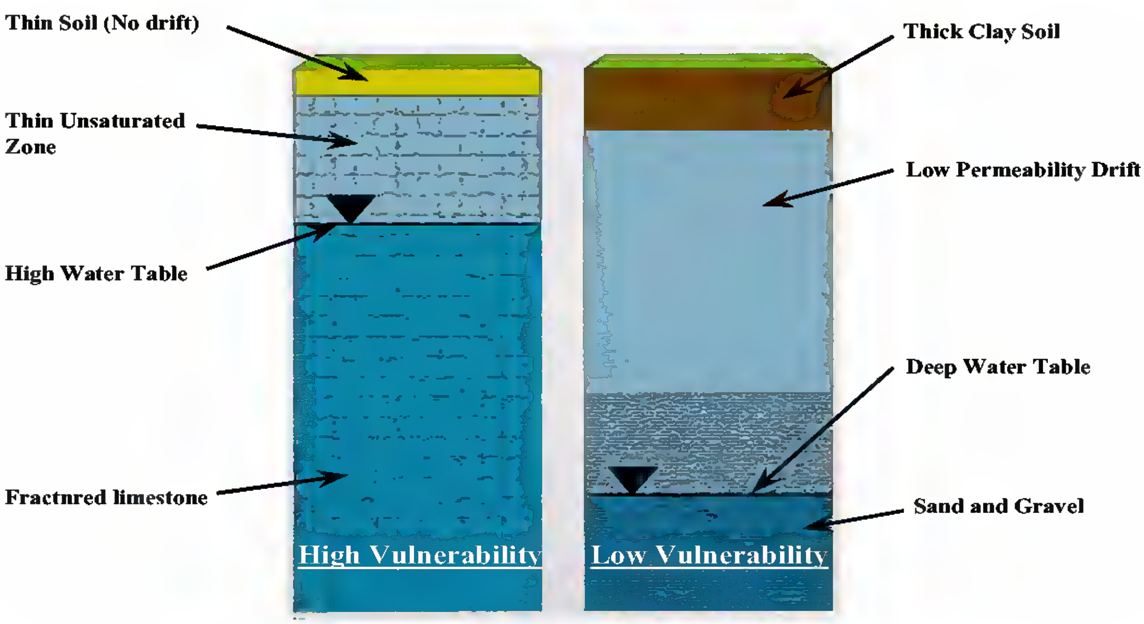


Figure 4.1 *High and low vulnerability groundwater bodies (Courtesy of UK Groundwater Forum).*

Groundwater models: Groundwater flow modelling is useful for three principal purposes. Firstly, it may be helpful for predicting the likely impacts of abstractions and artificial recharges on the groundwater body and associated water bodies, and subsequently assessing the whether the groundwater body is likely to achieve good quantitative status. Secondly, the development of a robust groundwater flow model is a necessary prerequisite to any contaminant transport modelling undertaken as part of the analysis of the pollution pressures on that body. Finally, the model is valuable later in the WFD process for developing an effective programme of measures and for management of the water body.

Groundwater flow models also, typically, simulate the interaction of groundwater with other parts of the hydrological cycle. Interactions between the groundwater and surface waters and wetlands may be simulated, which is vital for predicting the interactions between surface water bodies and their assigned groundwater bodies.
Groundwater resource models take many forms, from simple, normally analytical water balance models of the water inputs and outputs to a groundwater body, to complex numerical models of the groundwater flow system within a body.

Simple models include standard analytical solutions for the effects of abstractions of water table elevation. Commonly available tools such as **Aquifer Win**[32] (details are available on the http://www. aquiferanalysis.com/modelsum.thm site) and **P-Test** are already available that allow analysis of borehole pumping data to predict the impacts on water levels.

For regional studies or where more complex analysis is needed **MODFLOW** (details are available on the http://water.usgs.gov/software/modflow.html site) a numeric groundwater flow model produced by United States Geological Survey is widely used and is available as freeware. Alternative codes, such as **MIKE-SHE** (details are available on the http://www.dhisoftware.com/mikeshe/ site) are also used in a number of Member States to simulate groundwater flow on a catchment scale.

When the groundwater flow regime is understood it is possible to then consider the effects of pollution pressures. A range of tools already exist that may be helpful, including **ConSim** (details are available under the http://www.environment-agency.gov.uk/subjects/waters/groundwater site) an analytical model produced by the Environment Agency (England & Wales) that uses probabilistic techniques to predict the impact on groundwater quality from soil contamination and surface discharges. Where more complex codes are appropriate **MODFLOW** (details are available under the http://water.usgs.gov/software/modflow.html site) can be combined with freeware contaminant transport codes, **MT3D** or **MT3DMS** (details are available under the http://hydro.geo.ua.edu/mt3d/site) to predict the impacts from point source pollution. Proprietary pre-processors are also available for **MODFLOW.**

For diffuse pollution, existing numerical models are less helpful, however, groundwater vulnerability assessments are a valuable tool for assessing risks to groundwater quality in these circumstances. The Water Framework Directive does not differentiate between groundwater in different strata – all groundwater requires the same degree of protection from pollution. However, the impact that a pollution pressure is likely to have on groundwater varies from site to site, depending on the hydrogeological properties of the underlying soil, drift and solid geological strata. Consequently, for a given pollution pressure, the impact on the status of a groundwater body, and the potential programme of measures will vary in different aquifers.

4.5.4 Tools for transitional waters

State assessment tools are not yet fully developed, and maybe they are not completely defined since no full agreement exists across the scientific community. The best addressed issues are again those linked to causes of eutrophication and beneficial uses that are driven by obligations in relation with public health.

Pressure and impact quantification tools related to nutrient discharges were described in the river Section. The most prominent difference is the existence of the HARP/Nut and HARP/Haz guidelines agreed by the Ospar Convention, with the exception of Harp/Nut GL6, currently assessed within the Euroharp programme previously mentioned (see Annex).

The Harp/Nut guidelines are not a "tool", but they provide a coherent framework for quantifying the nutrient (and organic matter) loads discharged to sea and transitional waters, compared and calibrated with riverine fluxes where this comparison applies. This point is important to mention since the results are therefore very transparent, thus facilitating information of the public. The pollution assessment tools previously mentioned explicitly refer to these guidelines and compute outputs meeting the format requirements of the guidelines: by means (sewer, treatment plant, etc.) and by source (domestic, industrial, etc.) thus preparing the definition of measured programmes to combat pollution.

However, some adjustment should be made to allow reporting by water body, since Ospar asks for inputs to the sea only.

Table 4.6 *Assessment of the degree of availability of tools needed for coastal & transitional water bodies.*

COASTAL – TRANSITIONAL	WFD				Protected areas			
Tools categories : 1: Tools available and implemented; 2: Tools available but not implemented; 3: No available tool	Physico-chemistry	Flora	Invertebrates	Fish	Shellfish farming	Bathing / recreation	Habitats, Birds	Remarks about methods and required data
Pressure quantification per pressure group								
POLLUTIONS								
Nutrients	1	2	3	2	2	3	3	Moneris, Nopolu, Harp/Nut
General conditions	2	2	3	2	2	3	3	
Toxics	2	3	3	2	2	2	1	Harp/Haz
Germs	NA	NA	NA	NA	NA	2	NA	
WATER REGIME								
Change in tidal regime	2	2	3	2	2	NA	3	Navigation works, large estuaries modifications
Change in drift currents repartition	2	3	3	3	2	NA	2	
Hard change in flow	3	2	3	2	2	NA	2	Applies to estuary damming
MORPHOLOGY								
Break in longitudinal course	NA	NA	3	2	NA	NA	3	
Maintenance, bed modification	2	2	3	3	NA	NA	2	
Change in shoreline	NA	3	3	3	2	NA	3	
Shore and coast artificialization	NA	2	3	3	NA	NA	3	Eurosion, in dev.
Change in hydro/sediment facies	3	3	3	3	NA	NA	3	Eurosion, in dev.
Intertidal area sealing	NA	2	2	2	2	NA	2	
BIOLOGY								
Direct captures	NA	NA	3	2	NA	NA	3	CIEM/ICES
Introduction of species	NA	3	3	3	NA	3	3	
Disease introduction	NA	NA	3	3	NA	NA	3	
State assessment	1	2	3	2	1	1	3	For instance SEQ-ETM

Important impacts on transitional waters are related to changes in hydrological and tidal regime resulting from river and estuarine damming and from harbours and navigation works. One example using expert judgement for impact assessment is included in the Annex to Chapter 6.

Summary related to tools suitable for coastal and transitional waters
There is a lack of pressure and impact assessment tools in this water body type. More than on half of the tool groups fall into the third case, where research is needed, the other half requiring implementation.

4.5 Summary conclusion

Even though the identification of available tools could not be completed, it can be clearly seen that many requirements of the directive cannot be addressed simply by selecting and implementing a purchased computer programme.

A positive conclusion is that the screening tools cover a reasonable spectrum of water body category, pressures and objectives. Some of them are capable of providing trend analysis, under the baseline scenario. In can therefore be expected that the analysis demanded in 2004 could mostly be fulfilled on the basis of existing tools.

The negative conclusion is that the original points of the directive, assessing the pressures that cause impact on biology and ecological status, are not covered by available tools and that their development will require research in many cases, not only engineering.

The points discussed in this Chapter deserve further investigation. It is suggested that the working group should keep in touch in order to share the experience of implementation. This would enable continued identification of the needs, availability and practicability of tools required to implement the guidelines.

5. Information needs and data sources

The description of the general approach required for the analysis of impacts and pressures has noted the many types of information and data that will be required. These can be divided into those that are generally descriptive of the drainage basin and its water bodies (i.e. they are not specifically related to either pressures or impacts), data that describe pressures, and data that describe impacts. Thus far the data requirements have been specified generally for surface waters, with rather greater detail for groundwaters.

With all information and data it is likely that the best and most readily accessible sources are national or regional datasets within the member state. It is ***not*** the intention of this Guidance to list such sources. The Guidance does indicate ***what*** types of data may be useful in the analysis of impacts and pressures, ***why*** the data may be useful, and gives a ***European-scale source*** for the information, if one exists. Therefore the column "Source" in the following tables is not filled in completely. Competent authorities undertaking pressures and impacts analysis may need to be innovative in order to collect sufficient data, for example by asking stakeholders groups who may hold useful records (fishermen and angling groups will hold data about fish catches, for instance; local wildlife groups will hold useful ecological data).

It is recommended that, where possible, data is collected in digital form and used within a GIS.

ANNEX II, 1.1 "Characterisation of surface water body types" and 1.2, "Ecoregions and surface water body types" are assumed to have been completed before the pressures and impacts analysis begins. Therefore this Chapter focuses on sources of information relevant to 1.4, Identification of Pressures, and 1.5, Assessment of Impacts.

The type of data, which has to be collected, shall at first consist of data about the water body (type, morphology, geographical and meteorological terms, biological and physico-chemical conditions), because this is the starting point for an analysis of pressures and impacts. In addition data about the existing uses (data about pressures from urban, industrial and agricultural point and diffuse sources, about water abstractions, water flow regulation, morphology and land use) and about the state of a water body are necessary.

Because of the short timetable for completion of the first pressures and impacts analysis, this should mainly use existing data, collected on the basis of criteria which are suitable for execution, supplementing this with newly gathered information where necessary. The collected data can be used according to Chapter 4 (Tools) for the pressure and impact analysis. To assess the risk of failing the environmental objectives, the ecological status and therefore the biological and chemical status and the vulnerability of a water body must be evaluated. Data must be collected which provide a description of the water body and its catchment, an identification of the anthropogenic pressures and an estimation of the impacts on the basis of monitored biology and chemistry.

Each Member State will have differing types, sources and amounts of information. It is possible to identify a number of categories of data which will be common for all Member States. An important category are the other existing EC Directives, partly mentioned in the WFD, Annex II, 1.4. These directives provide information on a particular type of pressure (e.g. the Urban Waste Water Directive) or they contain environmental standards (e.g. the Nitrate Directive). Such directives provide information on different pressures. Other types of information can be existing National Requirements, such as National Classification Schemes, inventories required by National Legislation, etc.

In Table 5.2.1 "Information of pressures" and Table 5.2.2 "Information of impacts" the directives which are mentioned in the WFD Annex II, 1.4 and therefore must be considered, are listed first.

5.1 General Information

5.1.1 Descriptive information relevant to waterbodies

Data type	Use	SW	GW	Source
Water bodies				
Type of water body	Starting point for pressure and impact analysis.	✔	✔	
Spatial extent		✔	✔	
Meteorological				
Rainfall	Water balances.	✔	✔	National Meteorological Services, EEA, other European
Temperature		✔	×	
Geographical				
Topography	Identify drainage areas for water bodies.	✔	✔	Mapping services, EEA, other European
Solid geology	Aquifer characteristics. Water chemistry	✔	✔	National Geological Surveys and Institutes
Drift geology	Vulnerability of underlying aquifer. Run-off and drainage characteristics of catchment	✔	✔	National Geological Surveys and Institutes
Soils	Vulnerability of underlying aquifer. Run-off and drainage characteristics of catchment	✔	✔	National Soil Surveys and Institutes
Soil slope (%)	Run-off and drainage characteristics of catchment	✔	×	
Channel morphology, nature of seabed	Estimate the status and the susceptibility of a water body or to assess pressures	✔	×	
Land use				
Urban areas	Preliminary screening for point pollution sources.	✔	✔	National and regional statistical services, CORINE-Landcover (EEA)
Agriculture	Preliminary screening for point and diffuse pollution sources.	✔	✔	Agricultural administration, ,National and agricultural services, CORINE-Landcover, (EEA)
Industrial land	Preliminary screening for point pollution sources.	✔	✔	CORINE-Landcover, (EEA)
Mining/quarrying	Preliminary screening for point pollution sources	✔	✔	
Commercial forestry	Preliminary screening for point and diffuse pollution sources.	✔	✔	CORINE-Landcover, (EEA)

Data type	Use	SW	GW	Source
Fallow land	Preliminary screening for diffuse pollution sources.	✔	✔	CORINE-Landcover (EEA)
Recreation, e.g. golf courses	Preliminary screening for point and diffuse sources	✔	✔	
(Pattern of utilisation)	Preliminary screening for point and diffuse pollution sources.	✔	✔	

5.1.2 Key stakeholders that could be involved in the IMPRESS analysis

Key Stakeholders	Where they can help with information and expertise
Experts from Ministries (agriculture, transport, planning, economy,...	➢ Provide data for characterisation (for both groundwater and surface water):: - hydrological knowledge on behaviour of (ground) water bodies; - driving forces; - pressures; - changes in the state of the water body; - the impact of the pressures on the water status. ➢ Identification of key stakeholders; ➢ Assessing implementation and effect of existing community legislation, in general but also in relation to protected areas; ➢ Characterising water uses and their importance with regard to pressures; ➢ Defining coherent methodologies for assessing key variables at Member State level.
Water Service Suppliers , Water using sectors & stakeholders (farmers, industrialists, etc.)	➢ Provide data for characterisation (see above); ➢ Provide input for assessment of pressures.
Environmental NGOs	➢ Identifying key environmental issues; ➢ Assessing environmental impacts.
Stakeholders/civil society/public	➢ Providing specific input for the assessment of pressures.
Researchers/Experts (usually as consultants of the mentioned stakeholders)	➢ Assessing the impacts of pressures on water status (e.g. via modelling).

5.2 Information on pressures

5.2.1 Information on point sources of pollution

Data type	Use	Source
Urban Wastewater Directive (91/271/EEC) Data and Reports	Assessment of Urban Wastewater sites and their discharges. The monitored parameters are BOD5, COD, total suspended solids and for discharges to sensitive areas which are subject to eutrophication total phosphorus and total nitrogen.	National Data Storages and Reports
Integrated Pollution Prevention Directive (96/61/EC) Data and Reports	Collate sites authorised under the IPPC Directive and their discharges. At further characterisation consider detailed nature of activity.	National Data Storages and Reports, EPER

Data type	Use	Source
Activities authorised for purpose of Directive 76/464/EEC – Water pollution by discharges of certain dangerous substances	Collate locations of activities authorised under this Directive. At further characterisation consider detailed nature of activity	National Data Storages and Reports, EPER
Drinking Water Directive 75/440/EC	Information on quality of surface waters which are used as drinking water (physical, chemical and microbiological parameters are observed at regular intervals)	National Data Storages and Reports
Bathing Water Directive 76/160/EEC	Information on water quality of water bodies which serve as bathing waters (microbiological, physical, chemical parameters and other substances, which indicate pollution, are observed)	National Data Storages and Reports
Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life	Information on the quality of fresh waters (physical and chemical parameters are observed) regarding fish life	National Data Storages and Reports
Directive 79/923/EEC on the quality required of shellfish waters	The Directive set the minimum quality criteria which must be met by shellfish waters (coastal and brackish waters): the physico-chemical and microbiological parameters; the mandatory limit values and the guide values of these parameters; the minimum sampling frequency and the reference methods of analysis of these waters.	National Data Storages and Reports
Activities authorised for purpose of the Groundwater Directive (80/68/EEC)	Collate locations of activities authorised under the Groundwater Directive. At further characterisation consider detailed nature of disposal activity	National Data Storages and Reports, EPER
Agricultural fertiliser application / sales data. Use data where readily available.		Agricultural administration
Activities authorised for purpose of Directive 1999/31/EC	Directive on the landfilling of waste. The Directive provides information on the amount of waste ending up at landfill sites. Collate locations of activities regulated for the Directive on landfilling. At further characterisation consider detailed nature of activity.	National Data Storages and Reports, EPER
Sites regulated under Major Accidents Hazards (Seveso) Directive (96/82/EC)	The aim of the Directive is the prevention of major accidents. This involves dangerous substance limitation. Collate locations of activities regulated for the Major Accidents Hazards Directive. At further characterisation consider detailed nature of activity.	National Data Storages and Reports, EPER
Nitrate Directive (91/676/EEC) designated areas	Assessment of releases of agricultural nitrates	National Data Storages and Reports
OSPAR Guidelines for Harmonised Quantification and Reporting Procedures for Nutrients (HARP-NUT)	Assessment of nitrate discharges	National Data Storages and Reports
OSPAR Guidelines for Harmonised Quantification and Reporting Procedures for Hazardous Substances (HARP-HAZ)	Assessment of discharges of hazardous substances	National Data Storages and Reports
Animal disease epidemic burial pits	Identify locations of burial of significant numbers (>50) of animal carcasses for	Veterinary surveillance

Data type	Use	Source
	disease control purposes	
Known point sources from contaminated land, old landfills, mines etc.	Identify key sites that are likely point sources, but are not regulated under above directives	
Storm-water overflows from sewerage systems	Identify storm overflows that discharge to ground	Water management administrations
Sub-aerial deposition	Identify regions subject to atmospheric deposition (e.g. acid rain)	
Railway lines (herbicides) and road verges	Identify railway lines and herbicides applied	
Oil distribution pipelines	Identify location of sub-surface oil pipelines	
Soakaways from major roads	Identify where major highways (motorways etc.) drain to ground. At further characterisation identify pollution prevention measures.	
Potentially polluting activities (e.g. industry, opencast mining, petrol stations)	Identify areas where there are numerous potential point sources	
Rates of discharges to ground	Further detail on discharges identified above (further characterisation)	
Chemical composition of discharges	Effluent composition (further characterisation)	

5.2.2 Information on diffuse sources of pollution

Data type	Use	Source
Nitrate Directive (91/676/EEC) designated areas	Identify areas of aquifer with high, or rising, nitrate concentrations	National Data Storages and Reports
Pesticides Licensing Directive (91/414/EC)	Information on pesticide usage	Pesticide Licensing Administrations
Directive 98/8/EC on Biocidal Products	Information on usage of Biocidal Products.	National Data Storages and Reports
Drinking Water Directive 75/440/EC	see 5.2.1 "Point sources" (some of the mentioned data can give information on different pressures or impacts, so they possibly are listed multiple)	National Data Storages and Reports
Bathing Water Directive 76/160/EEC	see 5.2.1 "Point sources"	National Data Storages and Reports
Directive 76/464/EEC – Water pollution by discharges of certain dangerous substances	see 5.2.1 "Point sources"	National Data Storages and Reports
Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life	see 5.2.1 "Point sources"	National Data Storages and Reports
Directive 79/923/EEC on the quality required of shellfish waters	see 5.2.1 "Point sources"	National Data Storages and Reports
Agricultural fertiliser application / sales data. Use data where readily available		Agricultural administration
OSPAR Guidelines for Harmonised Quantification and Reporting Procedures for Nutrients (HARP-NUT)	Assessment of nitrate entries	National Data Storages and Reports
OSPAR Guidelines for Harmonised Quantification and Reporting Procedures for Hazardous Substances (HARP-HAZ)	Assessment of entries of hazardous substances	National Data Storages and Reports
Sub-aerial deposition (EMEP)	see 5.2.1 "Point sources"	

Data type	Use	Source
Railway lines and road verges (herbicides)	see 5.2.1 "Point sources"	
Oil filled pipelines	see 5.2.1 "Point sources"	
Chemical composition of discharges	see 5.2.1 "Point sources"	

5.2.3 Information on water abstraction

Data type	Use	Source
Water abstractions in the RBD: - amount of abstraction; - mean daily flow and low-flow river discharge; - lake level changes; - physico-chemical conditions; - sediment conditions; - existing or proposed schemes for artificial recharge of groundwater; It has to be considered that water abstractions possibly can be illegal.	Identify (or estimate in the case of illegal abstractions) abstractions with significant effect on the water body (water resources, chemical status, morphology)	Water management administrations, drinking water supply companies
Water abstraction in the RBD used for potable supply	Identify individual abstractions used for potable supply abstracting > XX m³/d or supplying > XX persons. Needed to identify drinking water protected areas	Water management administrations, drinking water supply companies
Drinking Water Directive 75/440/EC	Possible information on locations of abstracted water	National Data Storages and Reports
Activities authorised for purpose of Directive 80/68/EEC	Collate locations of activities authorised under the Groundwater Directive. At further characterisation consider detailed nature of activity	National Data Storages and Reports

5.2.4 Information on water flow regulation

Data type	Use	Source
Information on changes in the natural flow regime or of groundwater level	Identifying regulations with significant effect on natural flow regime or groundwater level	Water management administrations
Amount and succession of weirs in the RBD	Assessment of river continuity for water organism.	Water management administrations, navigation authorities
Number and capacity of reservoirs in the RBD	Assessment of river continuity and natural flow regime	Water management administrations
Not passable artificial barriers, e.g. dams	Assessment of river continuity for water organism.	Water management administrations
Range of backwaters	Assessment of river continuity for water organism.	Water management administrations
River profile, river bank structures / Stream habitat survey	Assessment of morphology and possible impact on biology	Water management administrations
Groundwater level		Water management administrations
Flow regulation with flow spills		Water management administrations
Flood-protection structures	Assessment of morphology and possible impact on biology	Water management administrations

5.2.5 Information on morphological pressures

Data type	Use	Source
River bank structures / Stream Habitat Survey	Assessment of morphology and possible impact on biology	Water management administrations
Amount and succession of weirs in the RBD	See 5.2.4."Water flow regulation"	Water management administrations, navigation authorities
Range of backwaters	See 5.2.4."Water flow regulation"	Water management administrations
Not passable artificial barriers	See 5.2.4."Water flow regulation"	
River profile	See 5.2.4."Water flow regulation"	
Flood-protection structures	See 5.2.4."Water flow regulation"	
Development on floodplains		

5.2.6 Information on pressures from land use patterns

Data type	Use	Source
Urban areas	Estimation of substance entries, modified flow regimes, soil erosion etc.	Agricultural administration, National data storages, National and regional statistical services, National and agricultural services, CORINE-Landcover
Agriculture (if possible subdivided in: • Cultivated land; • Sugar beets, potatoes & corn; • Special crop land; • Animal unit equivalents per hectare);		
Industrial land		
Mining, quarrying		
Recreation, e.g. golf course, aquatic theme parks		
Commercial forestries		
Fallow land (Pattern of utilisation)		

5.2.7 Information on other pressures

Data type	Use	Source
Other existing EC legislation		National Data Storages and Reports
Polders / reclaimed land		
Invasive species		Nature authorities and wildlife groups
Artificial recharges of groundwater in the RBD	Identify artificial recharge schemes to ascertain impact on groundwater levels; groundwater contamination	Water management administrations

5.3 *Information on impacts*

5.3.1 Information on susceptibility / vulnerability of water bodies

Data type	Use	Source
Statistical climate data	Information on susceptibility of water bodies, e.g. regarding substance- or heat-discharger	Climatic data
Stream Habitat Survey (rivers) including depth, amount of weirs etc.	Characterisation of rivers	Environmental data
Flow rates (rivers)	Characterisation of rivers	Measurement of discharge
Morphology (lakes): - mean water depth - mean water width - type of stratification (mixis)	Characterisation of lakes	Environmental data

Data type	Use	Source
- volume, residence-time (Vollenweider-model)		
Groundwater vulnerability data	Data on soil and drift presence and type. Depth to water table. Groundwater flow mechanism (e.g. fracture or matrix flow dominated system)	National Geological or Soil Survey / Institute)
Directives on Bathing Water (76/160/EEC) and Drinking Water (98/83/EC)	Susceptibility due to the existing uses.	National Data Storages and Reports
Birds directive (79/409/EEC)	Possible information on vulnerability of the area	National Data Storages and Reports
Natural habitats of wild fauna and flora Directive (92/43/EEC)		
Measurements of concentrations of possible pollutants in a water body	Information on susceptibility of the water body regarding pollutant discharges	Environmental data

5.3.2 Environmental data

Data type	Use	Source
Directives on Bathing Water (76/160/EEC) and Drinking Water (98/83/EC)	Assessment of status.	National Data Storages and Reports
Criteria according to the Fish-Life-Directive 78/659/EEC	Observation underneath relevant heat-discharger, regarding the temperature	National Data Storages and Reports
Physico-chemical substances Annex VIII of the WFD and criteria given by the 76/464/EEC-Directive	Assessment of chemical status	National Data Storages and Reports
Groundwater quality monitoring data - substances with article 17 standards; - conductivity; - substances relevant for article 4 objectives of dependent systems.	Review existing data from groundwater abstraction and monitoring boreholes for evidence of impacts	National water quality monitoring programmes; requisite surveillance of activities under Directive 80/86
Information on the chemical status of the water body from e.g. National Classification Schemes, "State of the environment" type reports, etc.	Assessment of chemical status	National Data Storages and Reports
Information on the biological status of the water body from e.g. National Classification Schemes, "State of the environment" type reports, etc.	Assessment of status	National Data Storages and Reports
Information on e.g. animal and plant species from International conventions such as the Ramsar Bureau, the Emerald network, information that has been gathered or other classifications such as UNESCO World Heritage Sites, Biosphere Reserves etc.	Assessment of status	
Phytoplankton (ANNEX V, WFD) - Trophic status	Assessment of eutrophication.	
Macrophytes and Phytobenthos (ANNEX V, WFD)	Assessment of morphology and organic pressures	Environmental surveillance, including that by wildlife groups

Data type	Use	Source
Benthic invertebrate Fauna (ANNEX V, WFD): - Saprobic status; - AQEM-Evaluation.	Assessment of organic pressures	Environmental surveillance, including that by wildlife groups
Fish fauna: Species composition and abundance	Assessment of the river-continuity and morphology	Environmental surveillance, including that by wildlife groups, fisherman, angling groups, etc.
Stream habitat survey	Assessment of the morphology of rivers	Water management administration

6. Examples of current practice relevant to the WFD pressures and impacts analysis

Annex V contains case studies presented by members of the IMPRESS working group as examples of current practice (summarised in Table 6.1 below). In providing the case studies the group members accept responsibility to provide further information, regarding what was actually undertaken with the study, how this has been taken forward since completion, and how similar methods can be used elsewhere.

It should be stressed that they are not presented as best practice examples in implementing the pressures and impacts analysis required by WFD. This is for two reasons. Firstly few, if any, pressures and impacts analysis have been undertaken in response to the WFD. The case studies are therefore based on previous analyses that conform, at least in part, to WFD requirements but without being driven by them. Secondly, the examples have not been assessed by IMPRESS as meeting the WFD criteria. They are intended to reflect what is done within the Member States, and to facilitate contact between users of the Guidance working in similar technical, operational or geographical areas.

It is hoped that the examples presented here are the seed for a living document that is supplemented by examples of the actual analyses required by the WFD. Thus with time, the content should move from reflecting current practice, to present case studies that truly represent best practice, and which can be considered exemplary in all aspects.

Table 6.1 *Summary of examples of current practice contained in Annex V.*

	Title	Link to guidance	Techniques used	Link to tools	Case study	Transfer -ability	Water body
1	Selection of **specific pollutants** by using ongoing implementation work of Council Directive 76/464/EEC[1] (Discharge of Dangerous Substances – DSD)	Relevant pollutions identification					
2 Belgium	Water Quality Plans in Flanders	Pollution Pressure quantification tool (4.3)	GIS Coefficient models	✓ SENTWA ✓ SIMCAT × Belgian Biotic Index/Prati Index	No	Yes	Surface
3 France	Water Integrated Emissions Inventory	Pressure quantification tool (4.3)	Coefficient models	No	Yes	Yes	Surface
4 Spain	Cartographic modelling	Water use pressure	GIS Water balance	No	Yes	Yes	
5 Portugal	Diffuse pollution case study River Guadiana	Quantification of pollution pressures	GIS Hydrological model		Yes	Yes	River
6 Denmark	Groundwater abstraction	Lowering groundwater table	2 & 3D models	No	No	Yes	Ground- water
7 Norway	Application of the River System Simulator for optimising environmental flow in the River Maana	Flow regulation, hydro-morphological pressures	Various models	× ENMAG HEC-RAS × QUAL2E × RICE × HABITAT	Yes	Yes	River
8 Spain	An approach for assessing alterations in the river water flows produced by reservoirs	Flow regulation	Modelling	No	Yes	Yes	
9 Netherlands	How to report on morphological alterations related to human pressures	Hydromorphology		No	Yes	Yes	Transitional & coastal
10 France	Screening and impact assessment using EuroWaternet methodology	Diffuse pressures	Statistical analysis	No	Yes	Yes	
11 France	Quantifying impact of pressures and likelihood of meeting objectives by means of the Water Accounts methodology.	Pressure screening	Thresholds	LAWA screening tool	No	No	River
12 Portugal	Water quality modelling in River Tejo	Impact modelling	Modelling	(QUAL2E model)	Yes	Yes	River
13 Germany	Criteria for the investigation of signification pressures and evaluation of their impacts for the purpose of reporting to the EU Commission.	Pressure screening tool and impact assessment tool	Thresholds	LAWA screening tool	No	Yes	Surface
14 Germany	Groβe Aue Development of a River Basin Management Plan	Pressure quantification, hydromorphological pressures	Statistical analysis	Models	Yes	Partly	Surface, Ground-water
15 Germany	Pilot project Middle Rhine: Development of a River Basin Management Plan	Pressure and impact assessment	Thresholds, Modelling	LAWA screening tool	Yes	Partly	Surface

[1] Council Directive 76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (OJ L 129, 18/05/1976, p. 23).

7. Concluding remarks

In its fourth official meeting (Lisbon 10/11 Sept 2002) the IMPRESS group discussed outstanding issues, issues not agreed and further work required. This Chapter summarises the results of this discussion.

Outstanding Issues: None

Further work required:

Short term actions (2002-3):
Threshold pressure screening criteria: Investigate whether threshold criteria should be developed by individual Member States to allow the pressures and impacts analysis to progress consistently across Europe.

Workshops on pressure and impacts analyses: Practitioners would benefit from opportunities to exchange expertise and experience gained as the first pressures and impacts analyses are undertaken. This should continue into the mid term with a second workshop once the initial assessments have been made and reported.

Template for reporting: Consistent reporting would be achieved by developing a template for reporting requirements.

Readability: It is appreciated by the IMPRESS group that the Guidance Document would benefit from an edit to improve readability. Such an edit should not change the content of the guidance.

Mid term actions (2004-5):
Maintenance of IMPRESS Case Studies Information System: The case studies included in the Guidance should be maintained as a reference source for practitioners. A particular benefit of this would be that new case studies could reflect *best practice* in implementing the directive, whereas those included at present reflect current practice that is in accordance with requirements of the directive.

Identification of other tools: There will be an on-going requirement to identify and co-ordimate tools for use within the pressures and impacts analysis.

Links to programme of measures, reference conditions and monitoring requirements: These are all important links that must function correctly for successful implementation of the Directive as a whole, but have been addressed within separate CIS working groups. These is also a need to identify measures that best address pressures and impacts to give cost effective mitigation of impacts to restore ecology.

8. References

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ANNEX I COMMON IMPLEMENTATION STRATEGY AND ITS WORKING GROUPS

CIS Working Group: Analysis of pressures and impacts; Lead: UK, Germany

CIS Working Group: Reference conditions inland surface waters; Lead: Sweden

CIS WORKING GROUP: TYPOLOGY, CLASSIFICATION OF TRANSITIONAL, COASTAL WATERS;
Lead: UK, Spain, EEA

CIS Working Group: Heavily Modified Water Bodies; Lead: Germany, UK

CIS Working Group: Geographical Information Systems; Lead: JRC Ispra

CIS Working Group: Intercalibration; Lead: JRC Ispra

CIS Working Group: Monitoring; Lead: Italy, EEA

CIS Working Group: Economic analysis; Lead: France, Commission

CIS Working Group: Tools on assessment, classification of Groundwater; Lead: Austria

CIS Working Group: Best practice in river basin planning; Lead: Spain;

ANNEX II GLOSSARY

Term	Definition
Abstraction	The deliberate removal of water from a water body, either surface or groundwater.
Artificial recharge	The deliberate introduction by man of water into the subsurface
Baseline scenario	Projection of the development of a chosen set of factors in the absence of policy interventions.
Diffuse Source Pollution[2]	Pollution which originates from various activities, and which cannot be traced to a single source and originates from a spatially extensive land use (e.g. agriculture, settlements, transport, industry). Examples for diffuse source pollution are atmospheric deposition, run-off from agriculture, erosion, drainage and groundwater flow.
DPSIR	The Driver, Pressure, State, Impact and Response framework for environmental analysis
Driver	An anthropogenic activity that may have an environmental effect (e.g. agriculture, industry), also driving force
flux	A transfer of a substances through a medium
Hydromorphology	The physical characteristics of the shape, the boundaries and the content of a water body. The hydromorphological quality elements for classification of ecological status are listed in Annex V.1.1 and are further defined in Annex V.1.2 of the Water Framework Directive.
Impact	The environmental effect of a pressure (e.g. fish killed, ecosystem modified).
load	The transfer of material, dissolved or particulate, associated with a flow of water
Point source pollution	Pollution arising from a discrete source , e.g. the discharge from a sewage treatment works
Pressure[3]	The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry of surface and groundwater bodies.
Response	The measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice Guidance for agriculture).
Significant pressure	In the context of the WFD, a pressure that, on its own, or in combination with other pressures, would be liable to cause a failure to achieve the environmental objectives set out under Article 4.
State	The condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)
Status	The physical, chemical, biological, or ecological behaviour of a water body

[2] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[3] Interim working definition. Discussions in the context of the WFD implementation are ongoing

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ANNEX IV PRESENTATION OF EXAMPLES FOR TOOLS (ANNEX TO CHAPTER 4)

0. Overview

The annex contains a list of tools mentioned in the main text, indicating their scope and some summaries of the tools themselves.

The tools may be presented in this annex, reported in Chapter 6 (Examples of current practice) or have been mentioned without summary. This is indicated in the table below. This table indicates the scope of the tool and which water body category it covers. The tools presented in this annex follow the order of the table.

Table Annex V.1: list, scope and location of summaries related to tools

Tool name	Location	Tool scope			Water body category			
		screening	Pressure & impact	State assessment	R	L	GW	C
1) Pressure Screening and Assessment Tools								
Pressure Checklist	Chapter 4	X			X	X	X	X
HMWB	This Annex	X	Morphology		x			
EuroWaternet	Best Practices Examples	X		X	x	(x)	(x)	
LAWA Pressure Screening Tool	Chapter 4	X			X			
Water Quality Accounts	Best Practices Examples	X		X	x			
OECD (lakes)	*Not Quoted*	X	Impact			X		
2) Tools for Quantification of Pollution Pressures								
OSPAR	This Annex		Pollution		x			x
MONERIS	This Annex		Pollution		x		x	x
SENTWA	This Annex		Pollution		x		x	
Nopolu	This Annex		Pollution	X	x	X	x	x
3) Tools to Combine Pressures with Impact Assessment - Water Body Models								
SIMCAT	This Annex		Impact		x			
Groundwater models	See Chapter 4		Pollution, Transport					
4) Impact Assessment Tools								
Finnish assessment tool	This Annex			X	x	x		
England & Wales	This Annex			X	x			
LAWA assessment tool	This Annex			X	x			
French SEQ-"water body category"	This Annex			X	x	x	x	x

Before using any tool you must be sure that it is fit for the purpose for which you want to use it. You should have a clear objective defined, i.e. what questions you want to answer, and should select a tool that is capable of simulating the pressure and impact being considered and of providing the required results. You should be aware of the capabilities and limitations of each tool.

In the next Sections example tools or models are described, but it is necessary to stress that most of the tools described are currently used within member states for functions similar, or possibly identical, to those required by the WFD, and in general such usage was mandatory for a tool to be included. Many more tools exist, and no doubt will become available in the future.

Pressure assessment tools are applicable for most elements of the environment and are used to perform two principal functions. The first is to enable a preliminary assessment of whether a potential impact is worth considering further within the pressure and impacts analysis. It is likely that any such an assessment will be reviewed later in the analysis, particularly if observed impacts cannot be attributed wholly to those pressures initially deemed worth considering.

The second function is only applicable in rare situations in which no other information exists. In such cases, pressure assessment may be the only means to assess the risk of failing objectives. Such an assessment would be subject to review in the light of the data monitoring programme required by the WFD. This is most likely to be the case for groundwater bodies because of the time lag before pressures are manifested as observable impacts in the environment.

Care must be taken in the use of such pressure screening tools, since they cannot properly account for the vulnerability of different water bodies that result both through issues related to scale and the characteristics of the water body's catchment area.

1. Pressure Screening and Assessment Tools

Note: Most of the pressure tools are already described in other Sections of this Guidance due to their importance for the general approach and the practicability needs of the first characterization.

- **<u>HMWB pressure identification tool</u>**

The HMWB Guidance offers some tools to identify hydromorphological pressures and impacts. In Table Annex IV.2 main uses and the connected physical alterations are given.

Table Annex IV.2: Overview of main specified uses, physical alterations and impacts on hydromorphology and biology

Specified Uses	**Navi-gation**	**Flood protection**	**Hydro-power generation**	**Agri-culture/ Forestry/ Fishfarms**	**Water-supply**	**Recreation**	**Urbani-sation**
Physical Alterations (pressures)							
Dams & weirs	X	X	X	X	X	X	
Channel maintenance/dredging/removing of material	X		X	X		X	
Shipping channels	X						
Channelisation/straightening	X	X	X	X	X		X
Bank reinforcement/fixation/ embankments	X	X	X		X		X
Land drainage				X			X
Land claim				X			X
Creation of back waters through embankments	X					X	X
Impacts on hydromorphology and biology							
Disruption in river continuum & sediment transport	X	X	X	X	X	X	
Change in river profile	X	X	X	X			X
Detachment of ox-bow lakes/wetlands	X	X	X	X	X		X
Restriction/Loss of flood plains		X	X				X
Low/reduced flows			X	X	X		
Direct mechanical damage to fauna/flora	X		X			X	
Artificial discharge regime		X	X	X	X		
Change in groundwater level			X	X			X
Soil erosion/silting	X		X	X			X

2. Tools for Quantification of Pollution Pressures

- OSPAR Harmonised Quantification and Reporting Procedures for Nutrients and Hazardous Substances (HARP-NUT and HARP-HAZ)

Methods of assessing, quantification and reporting sources of nitrogen, phosphorus and hazardous substances are agreed in OSPAR in the HARP-Process (Harmonised Quantification and Reporting Procedures).
For **Nutrients** the following guidelines are available:
1. HARP framework and approach;
2. Aquaculture;
3. Industry;
4. Sewage Treatment Works and Sewerage (including storm waters and their overflow);
5. Households Not Connected to Sewerage;
6. Diffuse Sources and Natural Background Losses;
7. Riverine Load;
8. Source Apportionment;
9. Retention in River Catchments.

Guideline 6: *Quantification and Reporting of Diffuse Anthropogenic Sources, and Background Losses* mentions the following diffuse nitrogen and phosphorus loss pathways to surface waters (see analogous Figure 4.1):
- Losses by surface runoff (transport of dissolved nitrogen and phosphorus);
- Losses by soil erosion (transport of particular, adsorbed nitrogen and phosphorus);
- Bank and riverbed erosion;
- Losses by artificial drainage flow (through drainage pipes/tile drainage);
- Losses by leaching (net mineralisation, percolating waters *i.e.* interflow, tile drain flow, spring water and groundwater); and
- Direct atmospheric deposition on inland surface waters.

This guideline describes principles behind the estimation of losses from both diffuse anthropogenic sources, and natural background losses. Appended to the Guideline are examples based on methods used in Switzerland and Germany, the UK, Denmark, the Netherlands and Ireland.

The **Hazardous Substances** Guidelines include:
1. Overall HARP-HAZ Guidance Document;
2. Brominated Flame Retardants;
3. Cadmium;
4. Dioxins;
5. Lead;
6. Lindane;
7. Mercury and Mercury Compounds;
8. Nonylphenols (NP) and Nonyphenolethoxylates (NPE) and Related Substances;
9. Polycyclic Aromatic Hydrocarbons (PAH);
10. Uncontrolled PCB-containing products.

These guidelines include information on the following groups of sources of the mentioned substances:
- Agriculture;
- Transport/Infrastructure;

- Building Materials;
- Households;
- Industry (IPPC);
- Industry (non-IPPC);
- Waste Disposal;
- Contaminated Land;
- Other direct diffuse sources.

It is worth noting that the HARP-NUT guideline 6 on diffuse sources of nutrients was the only one not fully agreed within the OSPAR framework. These, and other methods, are currently being assessed within the EUROHARP project (http://www.euroharp.org/index.htm). EUROHARP will compare nine different contemporary methodologies for quantifying diffuse losses of N and P, on a total of seventeen study catchments across gradients in European climate, soils, topography, hydrology and land use. The selected methodologies are applicable at catchment scale and are currently used by European research institutes to inform policy makers at national and international levels. A primary objective of EUROHARP is to provide end-users (national and international European environmental policy-makers) with a thorough scientific evaluation of the nine contemporary quantification tools and their ability to estimate diffuse nutrient (N, P) losses to surface freshwater systems and coastal waters; and thereby facilitate the implementation of the Water Framework Directive.

Prior to the completion of this review, users are advised to select the most appropriate methodology for their circumstances. This requires some assessment of the inputs of N and P to the soil, and understanding of the processes and pathways through which they are lost from the soil. Since N and P losses can vary substantially, land cover and land use data are essential for the analysis, possible sources of these are the European-wide co-ordinated data-sets CORINE Land cover (Co-ordination of Information on the Environment) and NUTS (Nomenclature for Statistical Territorial Units). Data on atmospheric deposition may be obtained from EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe).

The methods generally use export coefficients that are related to one or more of the following: crop type, stocking density, soil type, climate, eco-region and slope.

Reference

OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, *Harmonised Quantification and Reporting Guidelines*

For Nutrients: Norwegian Pollution Control Authority (sft) 1759/2000 (ISBN 82-7655-401-6) http://www.ospar.org/eng/html/welcome.html (Measures -> Agreements -> List of Agreements (2000);

For Hazardous Substances: sft 1789/2001 (ISBN 82-7655-416-4) http://www.sft.no/english/harphaz/

- MONERIS

Germany used the model MONERIS (Modelling Nutrient Emissions in River Systems) for the estimation of the nutrient inputs into river basins of the German Baltic Sea catchment area by various diffuse pathways. The model is based on a geographical information system (GIS), which includes digital maps as well as extensive statistical information and monitoring data in rivers, groundwater, drainage and point source effluents. A detailed description of the German Emission method including all of the pathways is contained in the report "Nutrient Emissions into River Basins of Germany", which was published in UBA Texte 23/00 in 2000.

Whereas waste water treatment plants and industrial sources are directly discharged into the rivers, diffuse emissions into surface waters are caused by the sum of different pathways, which are realised by separate flow components (see Figure Annex IV.1). This separation of the components of diffuse sources is necessary, because nutrient concentrations and relevant processes for the pathways are mostly very different. Consequently six diffuse pathways are considered in the model, for which the losses were determined separately:

- atmospheric deposition;
- erosion;
- surface runoff;
- groundwater;
- tile drainage;
- paved urban areas.

Along the pathway from the source of the emission into the river substances are governed by manifold processes of transformation, retention and loss. Knowledge of these processes of transformation and retention is necessary to quantify and to predict nutrient discharges/losses into the rivers in relation to their sources. Since current knowledge of the processes and the up to now limited database especially for river basins of medium and large size, the description of the processes can not be done by detailed dynamic models.

Therefore, MONERIS estimates the different pathways with already existing and new conceptual approaches, which are developed especially for the modelling in the medium and large spatial scale. Topics of the model development were:

- to develop a GIS-supported method for regional differentiated estimation of discharges/losses from point and diffuse sources for river basins of a size of more than 500 km²;
- to establish a sub-model for regionally differentiated estimation of nutrient discharges from waste water treatment plants and industries by a countrywide detailed inventory of these waste water treatment plants and industries;
- to establish a sub-model for inputs of nutrients and suspended solids caused by erosion, which can be applied to all investigated river basins. This model is based on the modified uniform soil loss equation but considers only those areas, which are relevant for input into the river system. The sub-model was validated with observed loads of suspended solids and particulate phosphorus for river basins;
- to develop a sub-model which allows the estimation of groundwater concentrations of nitrogen from the nitrogen surplus in agricultural areas by means of a retention function. This retention function is dependent on the hydrogeological conditions, the rate of groundwater recharge and the nitrogen surplus itself. The retention model includes first raw estimates of the residence time of water within the unsaturated zone and aquifer of the river basins;
- to develop a GIS-supported sub-model for regionally differentiated estimation of the agricultural areas modified by tile drainage. The sub-model is based on soil types and a classification of soil water conditions and is validated by overlaying digitised maps of tile drained areas with a soil map;
- to establish a sub-model for different pathways of nutrient discharges/losses within urban areas considering the regional differences in the sewer systems and the development of storage volume especially for combined sewer systems; and
- to establish a sub-model for nutrient retention and losses in surface waters, which can be applied for all river basins. This model is based on the dependency of the nutrient

retention on the hydraulic load or the specific runoff in the river system. The model allows the estimation of the nutrient loads from the nutrient inputs in a river basin. Therefore, a direct comparison of calculated and observed nutrient loads is possible for river basins upstream of a monitoring station.

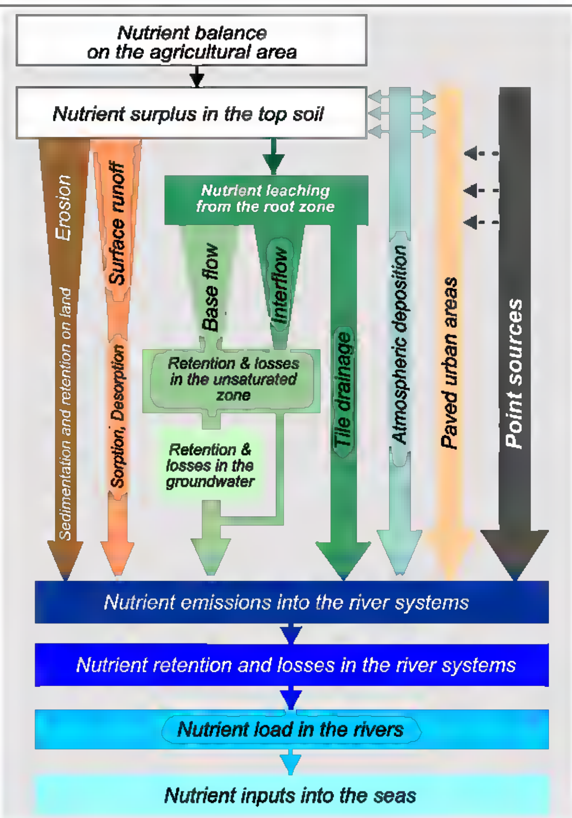

Figure Annex IV.1 Pathways and processes within MONERIS.

One special topic of the model development was that the different sub-models were be validated by using independent data sets, for example the groundwater model was developed with the observed nitrogen concentrations in the groundwater and not on the basis of the observed nutrient loads in the rivers.

The use of a GIS allows a regional differentiated quantification of nutrient discharges/losses into river systems. Therefore, estimates were not only carried out for large river basins. The MONERIS model was applied to 300 German river basins with a size between 100 and 5000 km² for the time period 1985, 1995 and 2000.

- SENTWA (System for the evaluation of the nutrient transport to surface water)

The SENTWA model 'System for the evaluation of the nutrient transport to surface water' is a model to simulate the nutrient emissions from agriculture (manuring) to the surface water. This model is formulated by the CODA (Centre for research in veterinary medicine and agrochemicals) from the Federal Ministry of Agriculture in 1993 on the basis of a German pilot study in the Elbe region. The CODA has adjusted the model for Belgium and has refined the model by validation and calibration of the model for the Regions 'Zwalm' (sandy loam) and 'Mark' (sandy) in Flanders (Belgium) (in 1997) by order of the Flemish Environment Agency (VMM).

It is a semi-empirical model that quantifies orders of magnitudes of the nutrient emissions from agriculture. It quantifies the load total N and total P (kg or ton N/P; kg or ton N/P per ha) on an annual or monthly basis and per river catchment. There are 11 river catchments in Flanders.

The model is designed as a tool for supporting and evaluation of the policy of agriculture/environment.

The model consists of 7 routes of emissions:

- Atmospheric losses;
- Direct losses :
    - direct losses by use of fertilizer (chemical manure);
    - direct losses by grazing of animals (organic manure);
    - direct losses by stabling animals (organic manure);
    - direct losses by saps of manure or silo's;
- Drainage losses (these are the losses at normal agricultural manuring);
- Ground water losses (these are the losses at normal agricultural manuring);
- Excess losses (these are the losses at excessive manuring);
- Erosion losses;
- Run off losses.

First, these losses are calculated on an annual basis (on the scale of the municipality) and then they are divided among the months taking into account different factors such as precipitation, use of fertilizer, agricultural practice, etc.

Which input is demanded?

Data of agricultural land use and of different kind of animals (cattle);
Data on excretion coefficients for the different kind of animals (cattle);
Data of use of fertiliser;
Data on transport of manure;
Data on precipitation;
Data on the yields of different crops;
Data on manuring standards;

These input factors are available on the scale of municipality, or provinces, or agricultural region developments:

- In 1999-2000 the model was rewritten in a more user-friendly way and in another programme language (DELPHI instead of DBASE) as instructed by VMM;
- In 2000-2001 ERM was commissioned by VMM to study the different parameters, factors, coefficients used in SENTWA in order to ameliorate the model if possible and useful;
- In the summer of 2002, the new calculations with the ameliorated model were carried out.;
- In the autumn of 2002, a refinement of the model for drainage losses, ground water losses and excess losses will be wound up. The calibration will be done for the agricultural region of the polder lands;
- <u>NOPOLU System (for example used to check in France EEA/ETC-W) emissions assessment methodology</u>.

Since 1993, Ifen (French national focal point of EEA) uses the NOPOLU system to handle data related to catchments and produce relevant data.

The system is based on full (although progressively implemented) description of the hydrologic and administrative features of metropolitan France. The catchments are analysed through 6210 polygons (aggregated up to 6 water agencies / 55 main catchments) and the administrative layers are analysed through more than 36,000 municipalities. The relationships between both definitions is managed by the system, by the way of specific links (big cities discharging in a far away river) or by crossing tables derived from CORINE *land cover*.

Data currently managed are river discharge, river monitoring data, rainfall (including efficient rainfall), water abstractions, industrial activities (including production, emission data, waste water treatment plants), urban activities (population, WWTP functioning, sewerage, including industries connected).

The main characteristic is that the system is highly integrated in order to facilitate cross comparison of results, with the objective to fulfil OSPAR guidelines as well as conforming with Directives. A second important feature is that:

- The system seeks individual data related to an item (e.g. WWTP running data), and if these are lacking it replaces them with standard values that can be highly regionalised. This is to prevent bias quantification, hence it is not totally "data provision dependent";
- Single system of GIS management is in use: the same data is used on the same areas to compute Water quality accounts, EuroWaternet representative networks as well as agricultural surplus, industrial emissions or riverine fluxes.

With regard to quantification of pressures, the main outputs are the quantification of pollution discharges (urban, industrial, agricultural), direct and diffuse that was set up and checked over by the Loire-Bretagne water agency in 1999.

The outputs can be provided at any scale and modality. For example, industrial emissions can be produced under the NACE (information is available under the http://nace.org/nace/content/AboutNace/aboutnaceindex.aspnomenclature site) by NUTS3, and disaggregated as direct discharge, through industrial treatment facility or via urban sewers. They can also be summed at any point of the catchments, to compare with the riverine fluxes, also calculated in NOPOLU, by processing river discharge and river chemical data.

The structure of the system is oriented to full transparency and disprovability, thanks to intermediate results. Hence, the agricultural pollution module firstly calculates the surplus that can be compared with independent data, and then the transfer, which is reconciled with urban and industrial discharges and riverine fluxes.

NOPOLU is constructed around Access 2000 (open to Oracle client/server) databases, most procedures are in Visual Basic, and it can process any external module (including APL). It is maintained by Beture-Cerec, subsidiary of JAAKKO PÖYRY.

3. Tools to Combine Pressures with Impact Assessment - Water Body Models

The tools described in the other Sections of this Annex enable some assessment of the likely significance of the pressure being considered, either by directly inferring that the water body is at risk of failing to meet its objectives, or by highlighting that the pressure requires further investigation.

Often the output from these tools must be combined with another tool that combines the information on pressures with a representation of the receiving water body. Thus, for example, the pressure resulting from an abstraction is first quantified, and then combined with information on a river system to determine the actual impact.

A great many models exist that may be useful in undertaking the pressures and impacts analysis required by the WFD. This Guidance cannot provide a comprehensive catalogue of these models, or recommend particular models. The following Sections are intended to inform the reader of the various types of model that exist, and that may be useful in a particular situation.

The models are often based on domains (i.e. characteristic areas), and most cases the domain relates to a water body type (e.g. river, lake, coastal water). These individual domain models can be linked together in various ways to represent a larger system, for example, a diffuse model (perhaps a pressure quantification tool described in Section 4.30) may be linked to river models and groundwater models to represent the whole hydrological system within a catchment area. Other models represent many domains within a single framework.

Many current projects at both national and European scale have the objective of providing detailed information on modelling techniques in support of the WFD. One prominent is BMW (Benchmarking Models for the WFD, http://www.vyh.fi/eng/research/euproj/bmw/homepage.htm). While, these project are unlikely to report until after the initial impact assessment should be completed, they may provide information on useful modelling techniques.

- **Hybrid Monte-Carlo deterministic model for rivers - SIMCAT**

This type of modeling tool places a deterministic description of transportation and in-stream processes within a Monte-Carlo framework. A large number of independent model runs are used to generate distributions of the water quality within the river network. To achieve this, the model requires all inputs (tributaries, discharges and abstractions) to be specified as either constant, normal, log-normal, 3-parameter shifted log-normal, or non-parametric distributions, on either an annual or monthly basis. Each model run samples of these distributions, either randomly, or using user-defined correlations between flow and quality, between discharge flow and flow in the receiving river, or between flow in tributaries and flow in the main river. From the derived distributions SIMCAT abstracts the mean and 95%ile or 90%ile for each determinand. Confidence limits are also provided.

SIMCAT does not solve the advection-dispersion equations, using instead a simple load addition formula at each reach to calculate concentration, and a flow-velocity relationship to calculate movement downstream. Pollutants are assumed to be instantly and uniformly mixed in the receiving water and to travel at the same velocity as the water in the receiving reach.

The model includes chloride, BOD, ammonia and DO as standard determinands. Chemical processes included are re-aeration, the decay of BOD, and nitrification of ammonia (based on a modified Streeter-Phelps equation) Processes are represented by first order decay with temperature sensitivity. All decay and re-aeration parameters, and velocity relationships can be specified separately for each reach.

Calibration can be either manual or using the model's internal calibration routine, which adjusts the fit of the model's output to measured data by adjusting parameters and diffuse flow. In auto-calibration mode, SIMCAT feeds in extra river flows so that the results match those at flow gauges, as a function of river length, and calculates a series of adjustments to quality parameters to match model quality distributions with those at monitoring stations.

The sequence of auto-calibration is that model results are first compared with data at a monitoring station. A set of adjustments to parameters and velocity which would allow exact agreement with measured data is calculated, and the model then goes back to the upstream monitoring station quality data and repeats its downstream calculations, using the new values for parameters, flow and velocity. The new model results are compared with the monitoring station data, and the process repeated, if necessary.

- ***Existing use***

SIMCAT is a model which has been developed in-house for the Environment Agency (England and Wales) and is widely used in water quality planning. Once a model is calibrated, it may be used by less experienced staff, as the model run method and output are simple and clear. A catchment model should, however, always be calibrated by competent technical staff, and carefully checked, as errors in the interpretation of input data, can, in this type of model where calibration is based solely on input data, lead to an erroneous calibration and thus misinterpretation of results.

- ***Relevance to pressures and impacts analysis***

This type of tool is primarily intended for investigation of impacts on general chemical quality of rivers from point sources of pollution. It enables the impact of the pressure from each source to be assessed individually and in combination. The diffuse loading can also be derived.

- ***Reference and Documentation***

The model manual provides a step by step guidance through the model set-up process. There is a Section on the model's statistical background which is comprehensive. The manual also gives the form of all the decay parameters used in the model, the time of travel equations and the methods of assessing confidence limits.

4. Impact Assessment Tools

- **<u>Finland national classification of water quality</u>**

The present Finnish water quality classification system has been developed in order to give information on water usability for human purposes, taking into account only those ecological quality elements, which have a direct impact on water usability. It treats all water bodies similarly, not making any difference between different water categories or water body types. Classification is mostly based on chemical quality elements, but also some biological elements (hygienic indicators, chlorophyll and algal blooms). Criteria and threshold concentrations can be found in Table Annex IVb.3.

Table Annex IV.3 : The Finnish national classification system.

Class	Class interpretation	Variables and their threshold values
I excellent	The watercourse is in natural condition, usually oligotrophic, clear or with some humus. Highiy suitable for all modes of uses.	colour < 50 mg Pt/l transparency > 2.5 m turbidity < 1.5 FTU faecal coliforms or faecal streptococci < 10 CFU/100 ml total phosphorus < 12 µg/l mean chlorophyll-α in the growing season < 3 µg/l
II good	The watercourse is in near-natural condition or slightly eutrophic. Water is still suitable for most modes of uses.	oxygen concentration in epilimnion 80-100%, no oxygen deficiency in hypolimnion colour 50-100 mg Pt/l (< 200 in natural humic waters) transparency 1-2.5 m faecal indicator bacteria < 50 CFU/100 ml total phosphorus < 30 µg/l mean chlorophyll-α in the growing season < 10 µg/l
III satisfactory	The watercourse is slightly affected by wastewaters, non-point loading or other changing activity, or is appreciably eutrophic due to natural causes. The watercourse is usually satisfactory for most modes of uses.	oxygen concentration in epilimnion 70-120%, some oxygen deficiency may occur in the hypolimnion colour < 150 mg Pt/l faecal indicator bacteria < 100 CFU/100 ml total phosphorus < 50 µg/l mean chlorophyll-α in the growing season < 20 µg/l
IV fair	The watercourse is strongly affected by wastewaters, non-point loading or some other changing activity. Water is suitable only for modes of use having few water quality requirements.	oxygen concentration in epilimnion 40-150%, oxygen deficiency in the hypolimnion faecal indicator bacteria < 1000 CFU/100 ml total phosphorus 50-100 µg/l mean chlorophyll-α in the growing season 20-50 µg/l algal blooms common concentrations of elements representing a health hazard: As < 50 µg/l, Hg < 2 µg/l, Cd < 5 µg/l, Cr < 50 µg/l, Pb < 50 µg/l total cyanide < 50 µg/l off-flavours often found in fish
V bad	The watercourse is extensively polluted by wastewaters, non-point loading or other changing activity Poorly suited to any form of watercourse use.	major problems of oxygen balance, oxygen saturation in the epilimnion during summer may exceed 150%; on the other hand total oxygen depletion at the surface may occur; at the end of the stratification season the whole hypolimnion may be anaerobic faecal indicator bacteria > 1000 CFU/100 ml total phosphorus > 100 µg/l mean chlorophyll-α in the growing season > 50 µg/l one or more of the following exceeds the threshold limit specific for class IV: As, Hg, Cd, Cr, Pb or total cyanide mercury concentration in predatory fish species >1 mg/kg oil film on the water surface often observed

- **Environment Agency (England and Wales) River Ecosystem Classification**

The England and Wales River Ecosystem Classification scheme is presented in Table Annex IV.4. The physico-chemical quantities used can be obtained from observed data or modelled output. Classes 1 and 2 are considered represent conditions suitable for salmonid and cyprinid fish populations.

Table Annex IV.4:The river ecosystem classification used by the Environment Agency of England and Wales

Class	Dissolved oxygen % saturation 10th %ile	BOD mg l^{-1} 90th %ile	Total ammonia mg N l^{-1} 90th %ile	Un-ionised ammonia mg N l^{-1} 95th %ile	pH lower limit 5th %ile to upper limit 95th %ile	Hardness mg l^{-1} $CaCO_3$	Dissolved copper µg l^{-1} 95th %ile	Total zinc µg l^{-1} 95th %ile
1	80	2.5	0.25	0.021	6.0-9.0	≤ 10 >10, ≤ 50 > 50, ≤ 100 > 100	5 22 40 112	30 200 300 500
2	70	4.0	0.6	0.021	6.0-9.0	≤ 10 >10, ≤ 50 >50, ≤ 100 > 100	5 22 40 112	30 200 300 500
3	60	6.0	1.3	0.021	6.0-9.0	≤ 10 >10, ≤ 50 >50, ≤ 100 > 100	5 22 40 112	30 200 300 500
4	50	8.0	2.5		6.0-9.0	≤ 10 >10, ≤ 50 >50, ≤ 100 > 100	5 22 40 112	30 200 300 500
5	20	15.0	9.0					

- **German impact assessment tool (LAWA)**

Data on the state of a water body available from environmental surveillance should be examined. Primarily data on the state of a water body will be considered to evaluate the impacts of the pressures and will be judged according to quality objectives and aggregation criteria. If these are insufficient, an assessment or consideration of a model based on established pressures is necessary. An estimation of probability that the good ecological or chemical conditions will not be achieved within a period of observation will be made on the basis of the criteria presented in Table Annex IV.5.

Table Annex IV.5: Information necessary for the assessment of impacts (LAWA)

Indicator	Threshold values
Saprobic status	> 30% of stream network > national biological quality level (here: biological quality level II)
Trophic status	> 30% of stream network > national quality level (here: trophic class > II, assessment basing on concentrations of Nitrate-N > 6 mg/l and Phosphate-P > 0,2 mg/l; 50-percentile
Physicochemical substances	Exceeding existing quality objectives or quality criteria of EU directive 76/464/EEC and knowledge about entries of priority substances
Warming	According to the EU Fish-Life Directive: - max. annual temperature: >21.5°C (salmonid water body) >28°C (cyprinid water body) - max. winter temperature: >10°C (salmonid water body) >10°C (cyprinid water body) - max. warming up: 1.5 K (salmonid water body) 3.0 K (cyprinid water body)
Salinisation	Median: Cl =400 mg/l

Indicator	Threshold values
Morphology	• River habitat survey -- overview method: More than 30% of the river distances within the management unit are surveyed with structural quality classes 6 or 7 for the compartment "river bed (consisting of the parameters: - curvature - bank fixation - anthropogenic barriers - water flow regulation - bank vegetation • Impairment of river continuity (anthropogenic barriers, backwater) >30% of stream network

- **French SEQ based quality assessment approach**

The French approach is based on three major concepts, all consistent with EEA and Eurostat recommendations. These concepts are:

- a water quality assessment scheme (SEQ system) encompassing water, biology and physical media. It applies to running, still, transitional and groundwater;
- a procedure to produce water quality statistics, implemented after the EEA EuroWaternet full recommendations and a procedure to produce water quality accounts, implemented after Eurostat/UNECE general methodology.

The SEQ system proper provides quality assessment for each monitoring point from observed data. It comprises three working tools:

1. System for evaluation of the quality of water (SEQ-Water) which assesses water physico-chemical quality and which has been used in France since 1999;
2. SEQ-Bio that assesses the biological quality of the stream;
3. SEQ-Physical that assesses the artificialization level of the stream.

The basic principle backing the SEQ approach is that the different uses or functions of any water body must be assessed through determinants of the same kind or through having the same effect. For example, to assess the stream water quality, SEQ-Water distinguishes 15 descriptors ("altérations"), each one of them grouping relevant determinants. The assessment is carried out using threshold tables (see Table Annex IV.6 for an example) that define class limits. The index is calculated through an algebraic function adjusted to the threshold values.

SEQ-system then calculates the indexes (scale 0-100) for the potential ability of water to biology, (which are closely connected to the physico-chemical component of the ecological status described by the directive), and the indexes of the potential ability of water for use (such as drinking water, leisure and aquatic leisure, and so on, according to the needs).

The index can be presented in a second step as 5 classes. These classes are represented with the classical description of five colours (blue, green, yellow, orange, red). The classes represent the same degree of water body impact. Therefore, classes can be compared between descriptors and functions, thus allowing complex aggregation methods to be applied in a second stage.

Table Annex IV.6: Example of the SEQ assessment grid, descriptor "salinisation", use: drinking water, medium: groundwater (source: http://www.eaufrance.tm.fr/francais/etudes/pdf/etude80.pdf).

Alteration Mineralisation et salinite

Parametres	Unites	bleu clair	bleu fonce	jaune	rouge
Conductivite (1)	µS/cm a 20°c	≥ 180 et ≤ 400	> 400 et ≤ 2500	< 180 ou > 2500 et ≤ 4000	> 4000
Durete	d°F	≥ 8 et ≤ 40		< 8 ou >40	
pH		≥ 6,5 et ≤ 8,5	> 8,5 et ≤ 9,0	< 6,5 et ≥ 5,5 ou > 9,0 et ≤ 9,5	< 5,5 ou > 9,5
Residu sec (1)	mg/l	≥ 140 et ≤ 300	> 300 et ≤ 2000	< 140 ou > 2000 et ≤ 3000	> 3000
Chlorures (2)	mg/l	25	250		> 250
Sulfates (2)	mg/l	25	250		> 250
Calcium	mg/l	≥ 32 et ≤ 160		< 32 ou >160	
Fluorures	mg/l	≥ 0,7 et ≤ 1,5	< 0,7	> 1,5 et ≤ 10	> 10
Magnesium	mg/l	30	50	400	
Potassium	mg/l	10	12	70	
Sodium	mg/l	20	200		
TAC	d°F	≥ 8 et ≤ 40		< 8 ou >40	

(1) au moins l'un des deux paramètres doit être pris en compte.
(2) au moins l'un des deux paramètres doit être pris en compte.

The SEQ version 2 will soon be released, with a new computerised tool. It will include all 33 priority substances defined in annex X of the directive.

Full details are available in the PDF document that can be downloaded from http://www.eaufrance.tm.fr/ (downloading from the pages is only possible in French).

ANNEX V CASE STUDIES

A summary of the following case studies is contained in Chapter 6 of the main Guidance Document.

Title: **No: 1**

Selection of **specific pollutants** by using ongoing implementation work of Council Directive 76/464/EEC[4] (Discharge of Dangerous Substances – DSD)

Type of impact:

Increasing loads of chemicals, toxicity, ecotoxicity, accumulation and secondary poisoning

Type of pressure:

Point and diffuse sources of chemicals

Type of analysis or tool:

The Water Framework Directive requires the establishment of measures for against pollution in order to reach the objectives. On one hand, the priority substances (Annex X) are regulated in accordance to Article 16. On the other hand, other specific pollutants need to be identified on a river basin (district) scale (cf. Section 3.5 of the guidance).

Council Directive 76/464/EEC already provides for such a mechanism under Article 7 where Member States shall establish pollution reduction programmes for relevant pollutants of list II of that Directive. These so-called "list II substances" must also be selected out of a number of pollutant groups which are similar to the one in Annex VIII WFD.

It is recommended (and to some extent mandatory) to make best use of the implementation of this requirement of 76/464/EEC for the first analysis of pressures and impacts under the Water Framework Directive because, in particular:

- ✓ the transitional provisions (cf. Art. 22 (2) to (6)) require the implementation of 76/464/EEC is required as a minimum requirement and smooth transition must be ensured since the directive requirement will only be repealed in 2013;
- ✓ the rulings of the European Court of Justice which need to be respected;
- ✓ the experience and knowledge available in the Member States and Candidate Countries (which are currently identifying pollution reduction programmes as part of their accession commitment).

Further information on the relation of 76/464/EEC and WFD is available (see references).

Information and data requirements

Depending on the approach used, the following information will be needed, in particular:

- ✓ intrinsic properties (e.g. physico-chemical properties, persistence, (eco-)toxicity, bioaccumulation);
- ✓ emission inventories (e.g. European Pollutants Emission Register (EPER)[5], Article 11 of Directive 76/464);
- ✓ marketing and use data;

[4] Council Directive 76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (OJ L 129, 18/05/1976, p. 23).
[5] Commission Decision 2000/479/EC of 17 July 2000 (OJ L 192, p. 36).

- ✓ existing monitoring data (until 2006);
- ✓ surveillance, operational and investigative monitoring data (beyond 2006);
- ✓ Potential sources and emission routes;
- ✓ Fate and behaviour models;

Brief description including figures

The generic group of pollutants listed in Annex VIII cover a large number of individual substances. It is up to the Member States to establish an appropriate list of "**specific pollutants**" to be assessed for their relevance. However, the methodology for identifying **specific pollutants** is not specified in the Directive.

It is therefore recommended that the identification of **specific pollutants** under the Water Framework Directive should be further developed from the approaches used under Directive 76/464/EEC and the priority setting procedures elaborated for the selection of the priority substances.

It is evident that the 33 (group of) priority substances[6] and the eight list I substances[7] of 76/464/EEC which are not included in the Annex X WFD in the pressure and impact analysis since they will form the "chemical status".

For other **specific pollutants**, the starting point should be the substances identified as list II substances under Article 7 of 76/464/EEC. In addition, a candidate list of pollutants may be established which should be the starting point of a screening and priority setting process involving several steps.

Finally, the prioritisation process developed on European level, the so-called COMMPS[8] process, could be of additional use for the final selection of **specific pollutants** on a river basin scale. Moreover, the output of the Expert Advisory Forum on Priority Substances may also be useful for the pressure and impact analysis for other **specific pollutants**.

Based on the experiences of the implementation of the Directive 76/464/EEC, Member States have applied a wide range of approaches to identify "relevant list II substances".

However, it abstract terms, there are two generic approaches, which could be adopted for identifying potentially relevant pollutants:

- **Top-down approach** – this approach starts with the "universe of chemicals" and relies on all the available knowledge of the substances in order to screen for those substances which are of relevance in a river basin (district);

- **Bottom-up approach** – this focuses on those areas where existing monitoring data (biological and chemical) clearly identifies that the objectives may not be achieved. In addition, a specific, targeted and time-limited screening monitoring may complement the available information.

In most cases, a combination of both approaches is used by Member States.

References

[6] Decision 2455/2001/EC establishing the list of priority substances (OJ L 331, 15 November 2001, p. 1)

[7] The eight remaining list I substances are: drins (aldrin, dieldrin, endrin and isodrin), tetrachloroethylene (PER), trichloroethylene (TRI), Carbon tetrachloride, DDT

[8] Combined Modelling-based and Monitoring-based Priority Setting

"Study on the prioritisation of substances dangerous to the aquatic environment" Office for Official Publications of the European Communities, 1999 (ISBN 92-828-7981-X) [9]

Study report commissioned by the European Commission: "Assessment of programmes under Article 7 of Council Directive 76/464/EEC" (November 2001) [10]

Summary of Workshop on the "Discharge of Dangerous Substances Directive (76/464/EEC) - Lessons Learnt and Transition to the Water Framework Directive' of 1-2 July 2002 in Brussels (available through contact).

Furthermore, an ongoing study project of the European Commission on "Transitional provisions for Council Directive 76/464/EEC and related Directives to the Water Framework Directive 2000/60/EC" will produce specific outputs in relation to the above-mentioned aspects. Moreover, the Expert Advisory Forum on Priority Substances will produce several results which might be useful for the selection of other specific pollutants. These reports and the above-mentioned information is or will become available on the water web site of DG Environment:

www.europa.eu.int/comm/environment/water.

Contact for further information

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[9] http://europa.eu.int/comm/environment/water/water-dangersub/pri_substances.htm
[10] http://europa.eu.int/comm/environment/water/water-dangersub/article7ofdirective77464eec.pdf

Title: **No: 2**

WATER QUALITY PLANS IN FLANDERS (Belgium)

Type of impact:

Status and change of water quality of surface waters.

Type of pressure:

Point and diffuse sources from households, industry and agriculture (and WWTP)

Type of analysis or tool:

Point source – households: number inhabitants x pollution factor (PE)
Point source – industry (only main companies): sampling results of discharges
Point source – agriculture:

- inhabitants is included in households;
- animals: inventories (number of animals x excretion factors).

Point source WWTP: sampling results of discharges
Diffuse source – households: number inhabitants x pollution factor x reduction factor
Diffuse source – agriculture: SENTWA-model (calculation of losses of nutrients)
Load reduction: GWQP-mass balance ; SIMCAT-model (WRc – water quality model)
Status of waterbodies: Biological (Belgian Biotic Index), Physical-chemical (Prati-index)

Information and data requirements

Basic information: map of catchment areas, PE-equivalents, EQS, list of industrial main polluters.

Variables: number of inhabitants, industrial and WWTP discharges, livestock inventories, manure transport, inventories of the actual and planned sanitation projects, water quality data, water flow, load and removal rates of WWTPs, production and removal of WWTP sludge, permitted industrial loads, costs of the sanitation projects.

Brief description including figures

With exception of the driving forces, the approach is an application for water quality of the DPSIR-framework. On catchment level, the pressures (discharges and inflows) and the effect of it on the quality of water bodies are assessed, considering point and diffuse source pollution from households, industry, agriculture and WWTP. The actual status and evolution for the last decade of the water quality of the water bodies is described.

At pressure (discharges and inflow) and status level a series of general physical and chemical pollutants (Q, BOD, COD, N, P, SM, O_2, etc.) (and in some cases also heavy metals) have been reported and loads have been calculated. For 3 parameters (COD, nitrogen, phosphorous) calculation of pollution loads result in 'load balances'. This makes it possible to calculate load reductions (at inflow and discharge level) in order to meet the environmental quality standards (EQS) (see Figure).

The policy instruments are described and result in a number of measures that can be used in a scenario or cost analysis (see Figure). A first attempt for scenario analyses has been made and a scenario has been defined for households, industry and agriculture. For that, measures have to be quantified. The result of this exercise reveals if the proposed measures are sufficient to reach the EQS in the future.

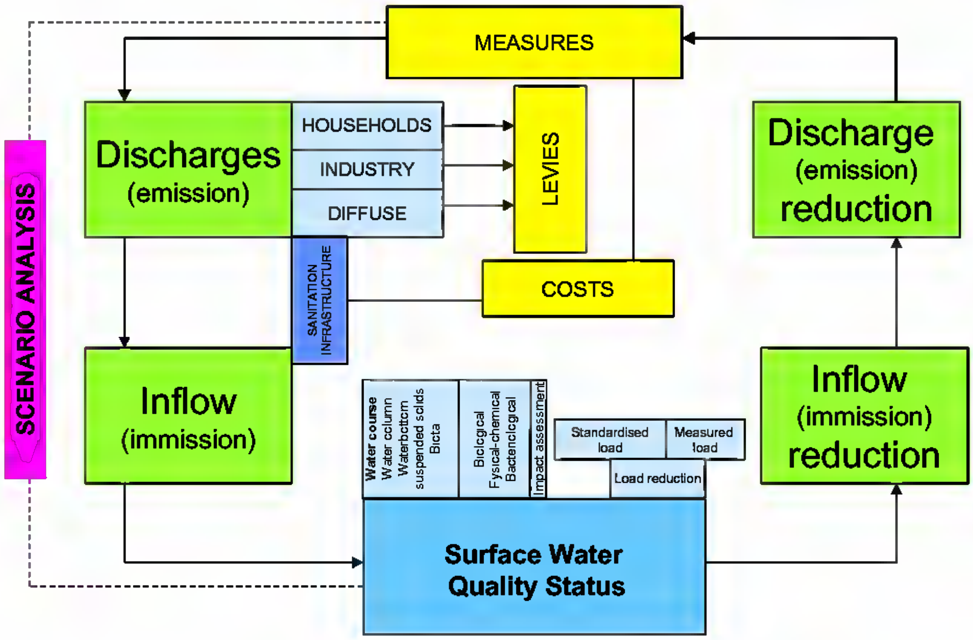
The outcome results in 2 types of reports. A summary report, in which the load balances (and in particular load reductions) are stressed, and an extended technical-scientific document, describing all aspects of water quality considered. This TS-document consists of a manual, describing the framework and all sources and tools used, and the report containing all basic information, results and conclusions. In annex a list of tables and figures is added.

This method is/will be applied to the approx. 260 stream catchments (hydrographical zones) within the 11 distinct river catchments of Flanders. The data collated in 34 tables provides information in a comprehensive way on sampling/monitoring of waste water and water quality, loads and load reductions, as well as a description of the catchments, the functioning of the WWTP-infrastructure, the water uses, etc. in relation to the target groups.

Important and useful are in particular:

- the framework, relating all aspects of water quality (see Figure as a flowchart). This framework is dynamic as it allows expansion with new topics e.g. analyses of cost-effectiveness;
- the use of pressure indicators (ratios) which enables results to be compared – on the one hand - from the pollution sources on the level of discharges, inflow and after sanitation measures have been completed, and – on the other hand – between the pollution sources (households, industry and agriculture), regardless the surface area covered;
- the availability of information on catchment level, to be summed on any other higher hydrographic level (e.g. river basin);
- the calculation of load reductions (see Figure: inflow reduction), tested against different EQS. Hydrographical zones may be ranked according to the reduction priorities tested against several legal or ecological EQS of COD, N and P. *Example: tested against an EQS of 0.3 mg/l P, load reduction within the river Nete basin must reach 85% or 1.924 kg/d; the contribution of the households to this is about 25% or 481 kg/d; the reduction is specifically high (> 75%) in 10 hydrographical zones.*

<u>Abbreviations:</u> COD: Chemical Oxygen Demand, EQS: Environment Quality Standard, GWQP: (General) Water Quality Plan, N: nitrogen, P: phosphorous, PE: population equivalent, WWTP: waste water treatment plant.



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Title: **No: 3**

WATER INTEGRATED EMISSIONS INVENTORY (ETC-WATER) (France)

Type of impact:

Increasing loads of pollutants, eutrophication

Type of pressure:

Point and diffuse sources of OM, P, and N from households, industry and agriculture.

Type of analysis or tool:

Use and organisation of the already existing national and international statistical sources for the purpose of emission calculations.

Information and data requirements

NB: all data can be considered at a regional and time level and adjusted from monitoring for any actual source or type of source (point/diffuse).

Point source – households: number inhabitants x pollution factor (PE)

Point source WWTP: sampling results of discharges

Point source – industry ((only companies >400 fiscal PE)): Loads by pollution factor and sampling results of discharges

Point source – agriculture: animals: inventories (number of animals x excretion factors), per species, region.

Diffuse source – households: number inhabitants x pollution factor x reduction factor, impervious urban areas

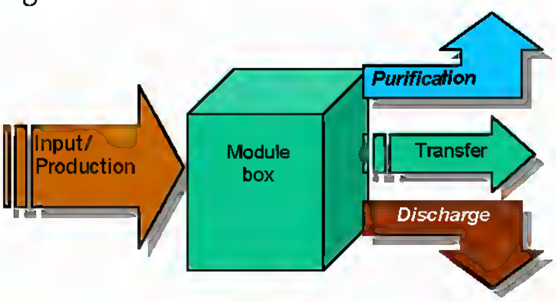
Diffuse source – industry : impervious industrial areas

Diffuse source – agriculture: - Use of fertilisers; model for calculation of losses of nutrients.

Brief description including figures

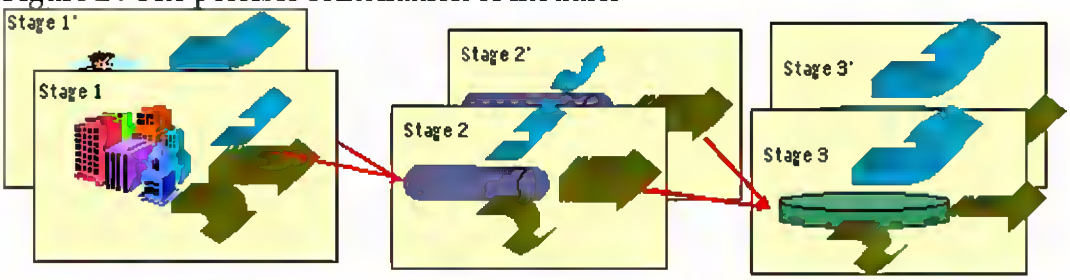
The methodology

Figure 1: The basic module



All emissions are computed as network of elementary modules, to systematise calculations (Fig. 1).
A module receives or produces a certain amount of pollution, purifies a part of it, discharges another part and transfers the remaining quantity to the module downstream (Fig. 2).
This schematisation allows any type of aggregation and presentation of final results (e.g., part of industrial effluents purified in domestic treatment plants.)

Figure 2 : One possible combination of modules



Depending on the organisation of the information system, each country has its own procedures and different data and information are available. This can also be the case at the national or regional level. To overcome these difficulties, the methodology developed in the Loire Bretagne Basin in France proposes to use the best possible data available at the most disaggregated level and coefficients when the data do not exist. The main advantage of this is to have a clear overview of the existing information system. The inventory can be completed and improved when data becomes available or the quality of this data improves and nonetheless to produce information, even if the raw data do not exist in a suitable form.

This of course needs some expert judgement and also a clear presentation of the calculation steps but allows the use of data and information coming from different organisations. This is also economically sound in using the best information and data already available.

Another main idea of the methodology is that the different types of emissions can be described with the same conceptual model. Any emission process is analysed as a combination of modules or steps, thus enabling simple data processing and multi-purpose reporting.

The application

Using this methodology, the project was applied on the so-called „Loire-Bretagne Water Agency" with the following geographical unit, temporal unit, sources and substances.

The area concerned by the Loire-Bretagne water agency extends over 156,217 km2. At the catchment level, the territory is broken down into 16 catchments, 12 for the Loire river and its tributaries, 3 for Brittany and 1 for Vendée.

At the administrative level, it extends over 10 Regions (NUTS2) and 31 "départements" (NUTS3), both being only partly included in the Water agency area. The 7281 municipalities (NUTS5) are totally included in the aforesaid area and the data were considered at this level.

Agriculture is one of the main activities: two-thirds of French livestock is grown on this area, as well as two-thirds of the slaughtering and meat processing activity. Half of the national milk production and derivatives also comes from this area.

Measurement habits concerning water in France are based on the mean value of the month of maximal activity and given in tons per day. However, many statistical data are available only yearly, based on the civil year and the data are considered at this level.

The methodology has the ambition to build a unique system and thus to cover all the sources. For the purpose of this exercise, Ifen decided to collect only the data on emissions liable to reach the inland waters quickly. The sources identified were agriculture, industries and domestic.

The three substances studied are organic matter, and the nutrients Phosphorus and Nitrogen.

The data used have many different sources, the main criteria is the potential availability for the whole country with the same organisation.

The main interest of the methodology is to consider all the main sources and all the data available concerning these. It integrates all the available data to provide trends and evaluations of the relative part of each source in the overall pollution.

It's easy to change one hypothesis or one set of data and recalculate the results. Another point to highlight is that all the hypothesis and calculations are transparent and can be adapted to one specific condition or the use of one specific calculation model.

Some results

Figures 3 and 4 show the results at an administrative level that is the „departements" (pink lines and one chart for each). For the administrators of those regions it is important to know the proportion of emissions or raw pollution between sources and the main source of each substance. In this example the main source of organic matter is domestic. Regarding the quantities assessed, there is a huge difference between the raw and the global pollution: many processes occur along the transfer of the pollutant from its production to its discharge into water. The flexibility of the approach allows the results to be utilised at different administrative levels like the region or the „departement". This is also possible at the hydrographic level: the 16 catchments of the Loire-Bretagne Water Agency.

Finally, it is also possible to aggregate different sources or to focus only on one source to allow the comparison between zones as regards the quantities discharged into waters.

In fact the only limit of these exercises is the original scale of the data: if the original data is available at the regional level, it is not possible to represent the results at a smaller geographical scale like the „commune" level. It is then very important to use the most disaggregated data to allow the maximum flexibility.

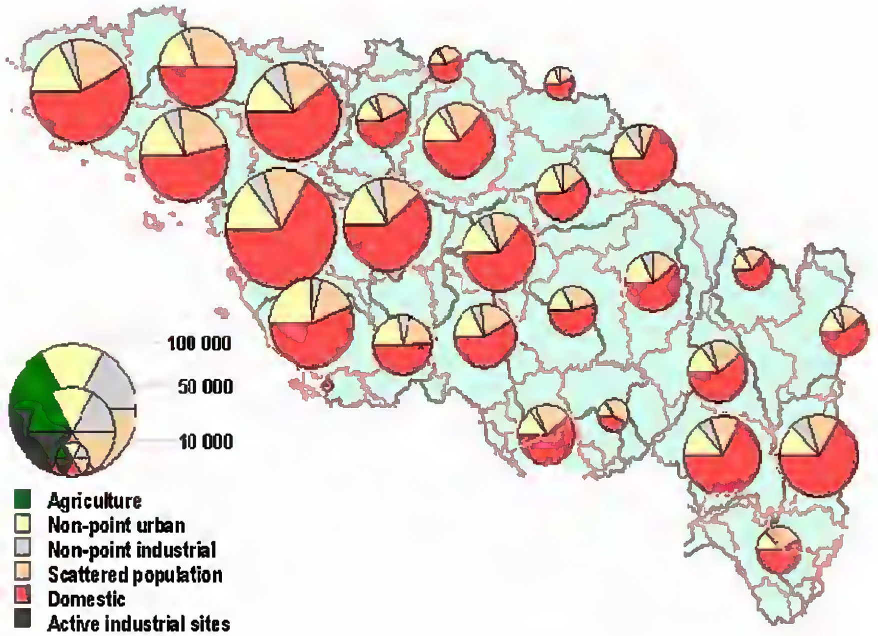


Figure 3: organic matter raw pollution apportionment between departements (BOD5 in kg/day)

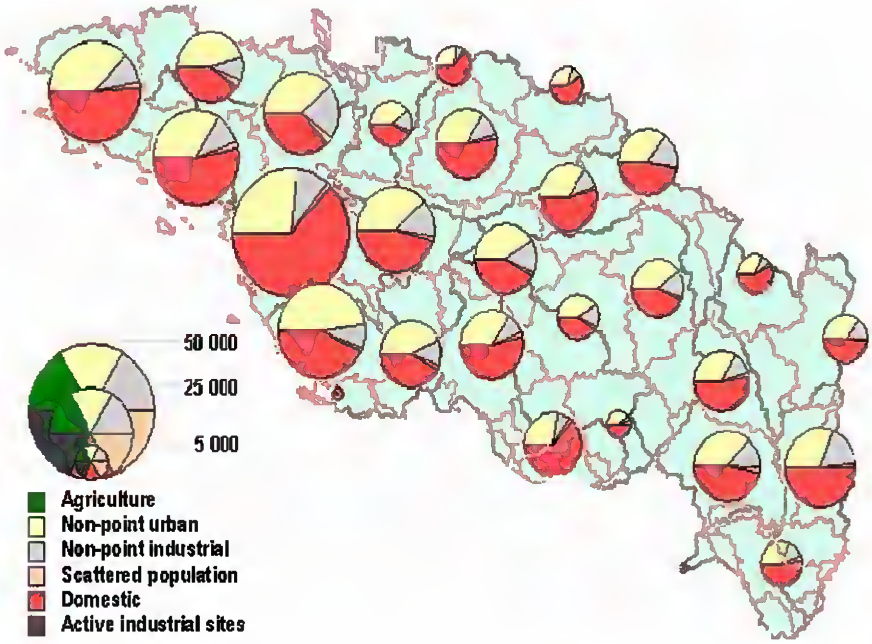


Figure 4: Organic matter global pollution apportionment between departements (BOD5 in kg/day)

References

Fribourg-Blanc, B. 2002. *EUROWATERNET-Emissions A European Inventory of Emissions to Water: Proposed Operational Methodology, draft 4*, provisional, Medmenham, European Topic Centre on Inland Waters, p.65, English

Detailed results available on CD-Rom (in French), apply to Philippe Crouzet

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Title: **No: 4**

CARTOGRAPHIC MODELLING OF WATER USE SYSTEM

Type of pressure:

Water abstraction

Type of analysis or tool:

Tools for Water Balance description ("Consumption and Water Management Indexes")

Information and data requirements

Maps of natural water resources, of water demands (urban, industrial, agricultural), of additional water from desalting processes and interbasin water transfers.

Brief description including figures

The objective of this practice is to have an evaluation of the pressure of spatial distribution of water demands on water resources.

A distributed model calculates the risk of water scarcity from the information of natural water resources and water demands. Figure 1 shows the procedure carried out by the model for each cell. The area selected for the cells of the grid used in the model is 1 km2, this gives a total for Spain of 500.000 cells.

The potential water resources available (surface and ground water) are determined from the natural resources (renewable resources generated in Spain), which are part of the natural water resources that represent the potential total water available.

The difference between total water resources and potential water resources represent the environmental requirements. These resources cannot be accounted to reach the productivity objectives of the system. Only the rest of the water resources (potential water resources) are the ones that can be used in the system and therefore are the only ones included in the water balance (between water resources and demands).

The additional water from desalination processes (Fig.2) should be added to the potential water resources.

Another factor that should be considered is whether any water transfers are presently in operation. These water transfers do not increase the potential water resources at national level but they modify their distribution (Fig.3).

The total demand (water abstraction) is the addition of urban, industrial and agricultural demands. However water returns should be taken into account, which come back to the natural water system and may be used downstream in the basin. This is the reason to separate the consumptive and non- consumptive fraction of each one of water uses. In this way the consumptive and non- consumptive water demand for each one of the water uses can be calculated. The addition of these two fractions gives the total demand (Fig.4).

For each one of the grid cells the water balance is calculated between the potential water resources and the total consumptive water demand. This balance allows maps to be obtained with the spatial distribution of water deficit and water surplus

(Fig.5 and Fig.6). These maps are only illustrative in character since they are the first approach to the problem. As it is known, water is not used in each cell in isolation.

Therefore a spatial aggregation is needed, which has been based on the water management units defined in the Basin Water Plans. This allows the water deficit and water surplus to be identified in the different management units included in each of the basins (Fig.7 and Fig.8). The aggregation of all grid cells of each basin shows the total balance of the basin (Fig.9 and Fig.10).

The processes explained above assumes that all the potential water resources generated in the system, plus the possible additional water from desalination processes and/or water transfers are fully used in the system.

The previous statement also assumes that the necessary infrastructure to use all the water resources are available and that the water is of the required quality for each use. Therefore the only water supply limits would come from limitations of the available water resources.

A system will be said to be in deficit when it cannot supply consumptive use demand, although it has the necessary infrastructure and the required water quality. On the other hand a system in surplus does not mean it has no water supply problems. This may occur if the necessary infrastructure required is not in place or if the required water quality has not been achieved.

To balance the water required with consumptive demands, it is assumed that water reuse in the system is the maximum possible.

This deficit and surplus are of different levels and will also depend on the size of the systems.

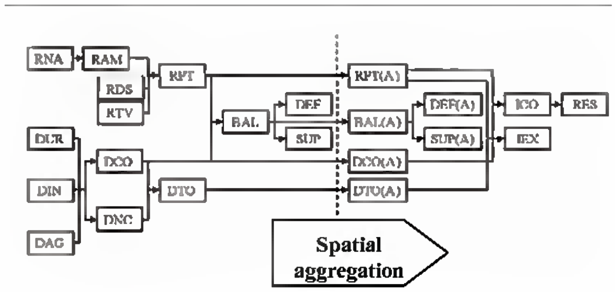
To try to clearly show the water management index and the water consumption index (Introduction à l´économie générale de léau Erhard-Cassegrain and Margat, 1983), they are used to show a map of water scarcity risk (Fig.11 and Fig.12).

The water management index is the result of dividing the total water demand and the potential water resources. It has to be pointed out that a water management index near or larger than "1" may not mean, in some cases, a water scarcity. This is because if the water abstractions are not concentrated in a specific area, part of the water returns might be used downstream.

The water consumption index is obtained by dividing the consumptive demand and the potential water resources. This ratio can also be used as an indicator of scarcity risk. A value greater than 0,5 could indicate "eventual" scarcity, in the other hand if the value is near 1 could mean that the scarcity is "structural". A low value of water consumption index indicates that water resources have a very low use.

It can be observed that the deficit system has a water scarcity of a structural type. In this system the potential water resource is systematically lower than the level of water consumption that is trying to reach.

But there are a number of systems that have water surplus but also have the risk of suffering an eventual water scarcity. The reason for this is that their levels of water consumption are relatively close to the potential water resources. In these systems a number of successive dry years might produce water supply problems because the lack of enough water resources in those years.



RNA	Natural Resources	RDS	Desalinated Water	DEF	Deficit
DUR	Urban Demand	RTV	Transferred Water	SUP	Surplus
DIN	Industrial Demand	DCO	Consumption Demand	ICO	Consumption Index
DAG	Agricultural Demand	DNC	Non-consumption Demand	IEX	Management Index
RAM	Environmental Requirements	DTO	Total Demand	RES	Risk of scarcity
RPT	Potential Resources	BAL	Balance	(A)	Added

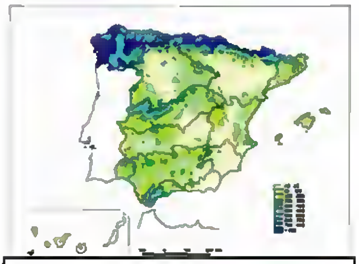


Figure 1. Natural water resources (mm/year)

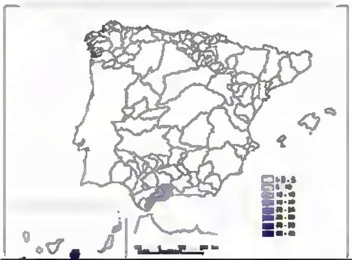


Figure 2. Desalinated water (Mm³/year)

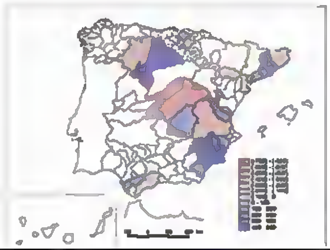


Figure 3. Transferred water (Mm³/year)

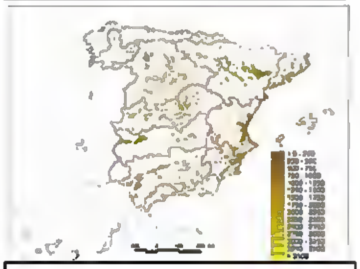


Figure 4. Total demand (mm/year)

Figure5. Deficit spatial distribution (mm/year)

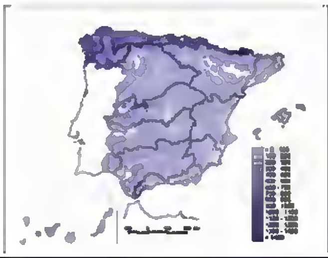


Figure 6. Surplus spatial distribution (mm/year)

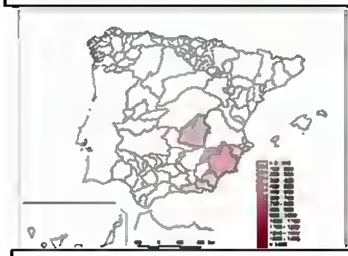


Figure 7. Deficit aggregation in water management units (Mm³/year)

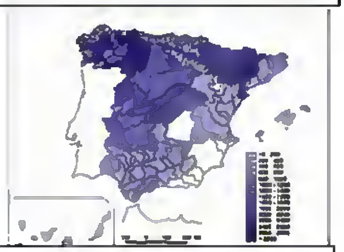


Figure 8. Surplus aggregation in water management units (Mm³/year)

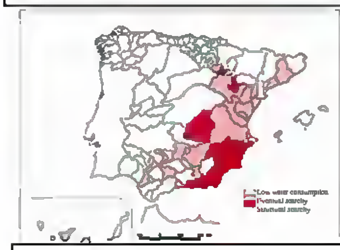


Figure 11. Water scarcity risk in water management units

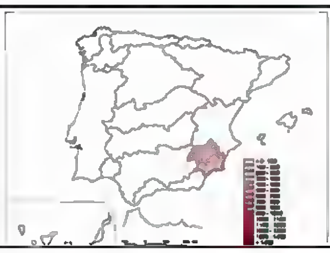


Figure 9. Deficit aggregation in basins (Mm³/year)

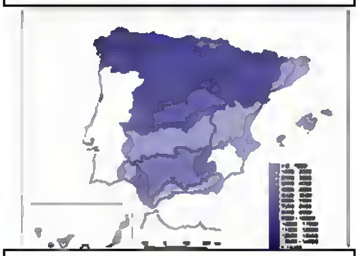


Figure 10. Surplus aggregation basins (Mm³/year)

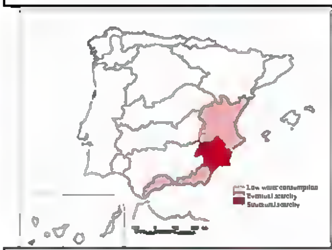


Figure 12. Water scarcity risk in basins

References

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Title: **No: 5**

DIFFUSE POLLUTION CASE STUDY: GUADIANA RIVER WATERSHED (Portugal)

Type of impact:

Increase of nutrients loads that can lead to eutrophication problems

Type of pressure:

Diffuse sources of P and N based on land use.

Type of analysis or tool:

A simple methodology was developed on a grid-based water quantity and quality model for mean annual values. Integration of Geographical Information Systems (GIS) it is an important tool that will allow characterising the spatial variability of the watershed by using spatial analysis tools.

Information and data requirements

Physical watershed characteristics, land use and topographic, and hydrological characteristics, precipitation/runoff, together with values of nutrients exportation.

Brief description including figures

Methodology

The first step is to create a mean annual runoff grid based on a distributed hydrological model. In this work, the methodology used is described in GOMES (1997), which is based on Temez aggregate model, implemented cell by cell in A.M.L. language in Arc/Info-Grid. The equations of this model, which rule evapotranspiration, water retainance in soil, infiltration and runoff process, are applied to each cell. This model uses precipitation (mm) and potential evapotranspiration (mm) as input variables and has 3 parameters, a flow parameter, a maximum retention of water in soil (mm) and a maximum infiltration rate (mm).

Runoff (mm/year) = f (precipitation, evapotranspiration, parameters)

Pollutant loads need to be assigned to each cell in order to calculate loading of pollutants in a river system. The combination between distributed maps of the watershed characteristics, namely land use and geology, with the exportation coefficients of phosphorus, and will allow estimating of the nutrient content that reaches to the streamlines (Table I).

Table I Export values of phosphorus E_P and nitrogen E_N (mg m^{-2} $year^{-1}$) (Jørgensen, 1980)

Landuse	Ep Geological classification		En Geological classification	
	Igneous	Sedimentary	Igneous	Sedimentary
Forest				
Range	0.7 - 9.0	7.0 - 18.0	130 - 300	150 - 500
Mean	4.7	11.7	200	340
Forest + pasture				
Range	6.0 - 16.0	11.0 - 37.0	200 - 600	300 - 800
Mean	10.2	23.3	400	600
Agricultural areas				
Citrus	18.0		2240	
Pasture	15.0 - 75.0		100 - 850	
Cropland	22.0 - 100.0		500 - 1200	

The linkage between the coefficients of nutrients to the polygon coverage of land use will be converted to a grid with the same cell size as the runoff map and this will be the load map. Using spatial tools of a GIS will allow integration of the distributed runoff map and the digital terrain model (DTM) of the watershed to obtain the accumulated flow in the streamlines. The same amendments are made to the phosphorus load map. This will result in the annual concentration of phosphorus in the streamlines.

Concentration (mg/l) = Load (mg/year) / Flow (dm³/year)

After the calculation of the concentration values it's possible to compare them with nutrients data measured in the water quality sampling stations to validate this methodology. Nevertheless the nutrients measured in each station reflects the total pollution that reach the streamline – point and non-point.

Application

This methodology was applied to the Guadiana river, and only for phosphorus because it is the limiting factor which determines the development of eutrophication. This river is an international basin, with a total area of 66 860 km^2 and has it's headwaters in Spain, and only 11 600 km^2 of the area is our national basin.

This river has an important role in the south of Portugal, a region with drought problems. The agricultural activities and animals in pasture have a great impact in this basin as non-point pollution sources, which causes a large amount of nutrient exportation to the water and soil.

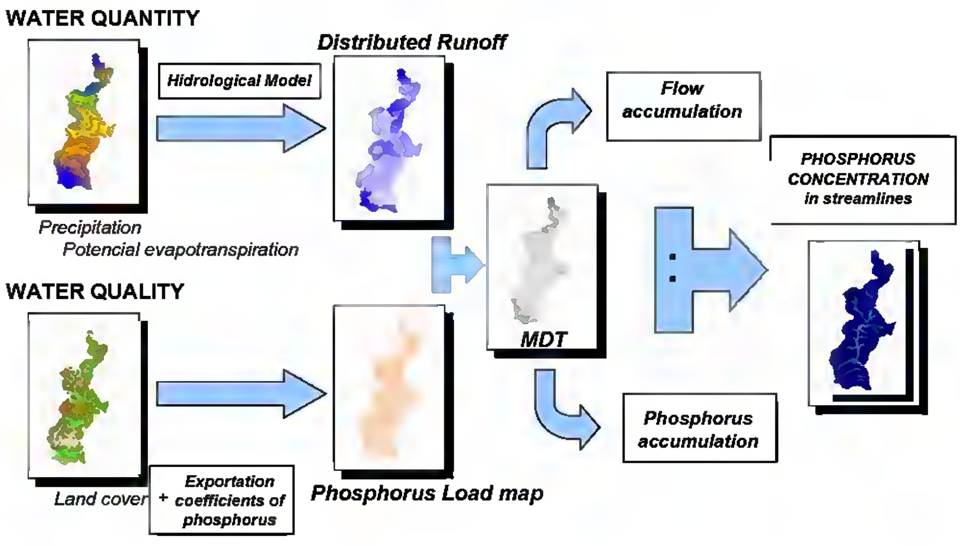

Figure 1 – Methodology application to Guadiana River (Portuguese basin).

Results

For modelling the runoff map it's necessary to have the distributed maps of precipitation and potential evapotranspiration. After calculating the distributed maps of runoff and phosphorus load (Figure 2) it's necessary to integrate these two variables in the streamlines. The accumulated flow and the accumulated phosphorus load in the streamlines is made by using a flow direction map originated from DTM, that shows the direction in each cell that the runoff takes to reach the streamlines. The concentration values are calculated in mg/l of P by dividing the load values with the flow values.

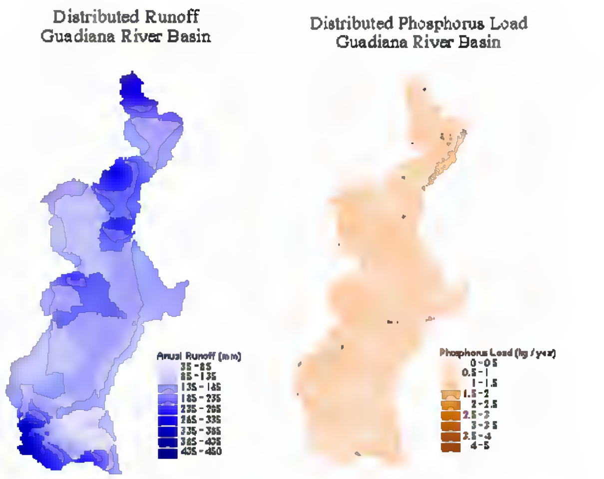

Figure 2 - The input distributed maps to calculation of phosphorus concentration.

A comparison between the estimated values of P and the observed values was made in the water quality sampling stations in the rivers (Figure 3). This Figure also shows the main point sources pollution, industrial and domestic. They are spread all over the basin but more concentrated in the North part.

By comparing these two values (observed versus estimated), we shouldn't forget that estimated value only takes in account the diffuse pollution provoked by land use. It's missing the correspondent impact of animals in pasture and point sources pollution to have the total phosphorus concentration in the rivers.

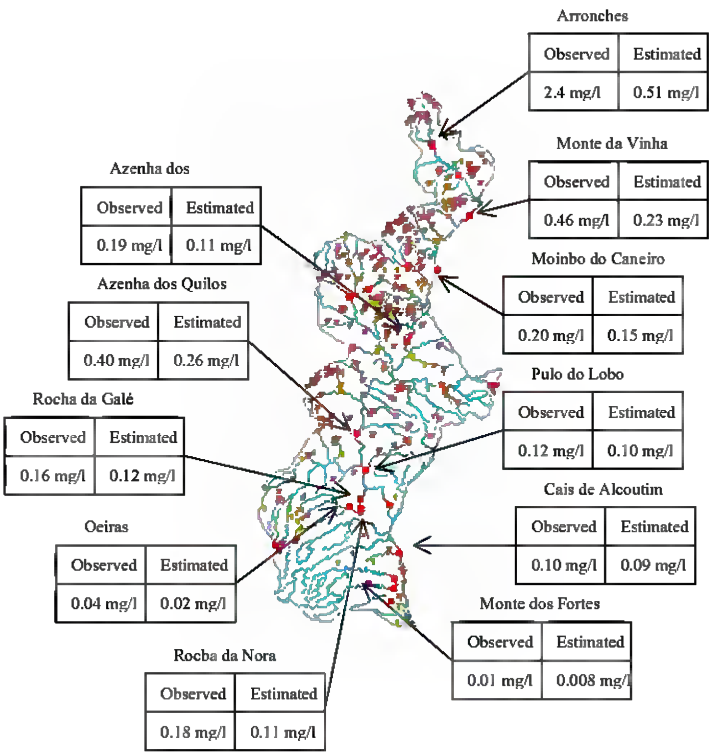

Figure 3 - Comparing the observed values with the estimated in the water quality stations.

In general it can be verified that the higher values of phosphorus concentration are in the North part of the basin and the estimated values are more approximated with the observed ones in the South. This can be explained because there are less point sources in this zone, which reflects the contribution of diffuse pollution.

Regarding sampling data, (Figure 4) it can be concluded that a dilution of the phosphorus concentration is observed as coming to the South part of the basin. Also, in terms of percentage, the estimated values related to the observed ones increase as they come towards the South part of the basin, which illustrates more contribution of the non-point pollution to the total amount of P.

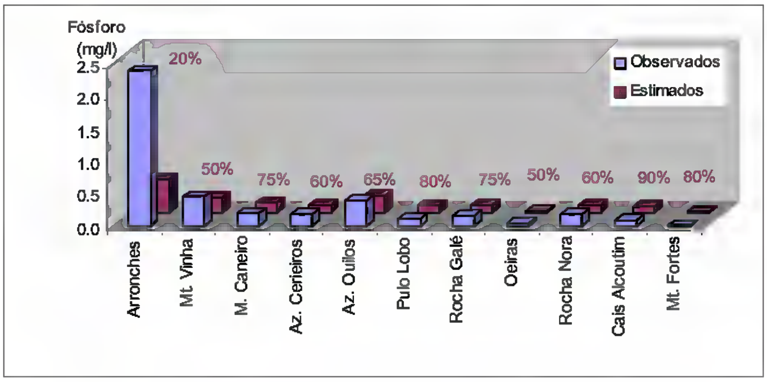

Figure 4 – Comparing phosphorus concentration (observed versus estimated) and their relation in terms of percent.

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Title: **No: 6**

GROUNDWATER ABSTRACTIONS (Denmark)

Type of pressure:

Lowering of groundwater table, reduction of streamflow

Type of impact:

On groundwater: Alterations in directions of groundwater flow, possibly leading to saline intrusion. Also deterioration of groundwater quality as a result of e.g. upwelling, oxidation in upper layers, increased infiltration.

On surface waters: Reduced dilution of chemical fluxes from e.g. wastewater, modified ecological regimes (resulting from change in a long range of parameters, such as changes in temperature of water in streams as a result of reduced influx of groundwater!).

Type of analysis or tool:

Monitoring: Measurements of changes in both groundwater levels (soundings), and changes in groundwater chemistry (e.g. chloride, sulphate, iron, nickel) to quantify effect of groundwater abstraction.

Model Approach: 2- or 3-dimensional hydrologic models (numeric computer models) used to assess changes in groundwater flow as result of abstraction, and also to calculate water balances. More refined 3-dimensional models can be used-to assess interactions with surface waters and calculate e.g. changes in streamflow.

Information and data requirements

For the application of models often-extensive requirements have to be met for input data. These data are often derived from existing monitoring data and pumping tests of groundwater wells.

For an adequate representation of the hydrological system you need distributed values for a long range of parameters (e.g. hydraulic conductivity and porosity), that are specific for the hydrologic system modelled and also for the geographical setting, to ensure valid results of the model. The more complex and accurate the model, the more comprehensive the data-requirements.

Furthermore, data for both calibration and validation of models must be available in order to test, if the model can precisely reproduce the responses of the hydrological system. These data can often be extracted from monitoring data, so that one part of the monitoring data are used when setting up and calibrating the model, and another part of the data are held back for later validation of the model.

Brief description including figures

Whereas monitoring directly can document failure to achieve good status for both surface and groundwater bodies, especially for groundwater bodies there is often a need to complement the assessment of impacts with models and calculations of the future impacts due to the inherent time delay of pressures on groundwater bodies.

Water balance models can be used on catchment scale. Both as "simple" conceptual models, but also as more elaborate numerical computer models. They can be used to calculate both amounts in cubic meters available for abstraction, and in this relation also be used in quantification of impact on e.g. surface waters, typically on streams.

This is widely recognised in Denmark, where hydrological models are used both in permitting water abstractions under consideration of the risks of saltwater intrusion or damage on associated surface waters/ecosystems. But also when calculating if remediation is necessary for example to ensure acceptable streamflow – and how it is most appropriately done (e.g. if this should be in the form of reduced abstraction or pumping of groundwater to the stream). In the example below, streamflow has been modelled in the County of Roskilde at different stations in order to calibrate the model and determine the hydraulic and other parameters of the system. The model will subsequently be used to assess the maximum groundwater abstraction permissible under consideration of the environmental objectives of the stream. Especially the low discharges are critical in this respect.

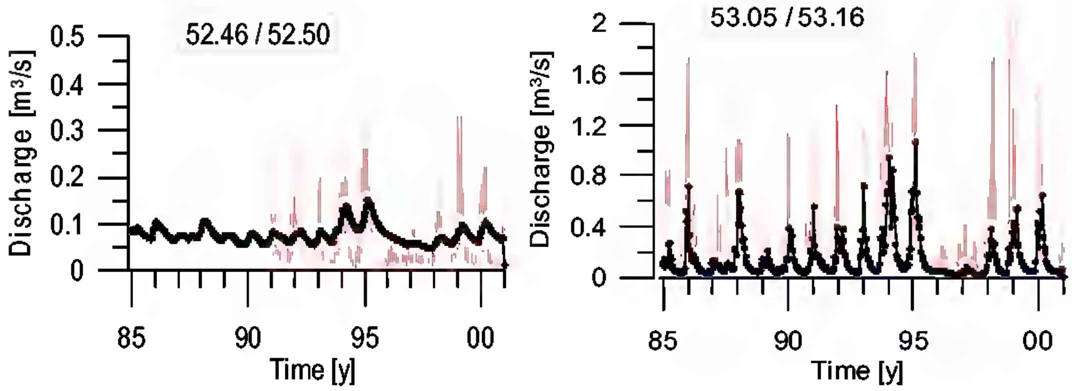

Figure 1: Calibration of hydraulic model on streamflow-data. Thick line: model results. Thin dashed line: recorded discharge. Left a poorly calibrated/determined, and therefore less precise, model. Right a well-calibrated/determined model.

(County of Roskilde (2002): Grundvandsmodel for Roskilde Amt by WaterTech a/s).

Also, the use of computer models makes it possible to make a qualified estimate of travel times for the impact of a given pressure in the form of pollution. This is relevant for assessing the impact on e.g. water supply wells, and also for other cases of groundwater pollution.

Lastly, computer models of hydrologic systems are in relation to groundwater used to delineate groundwater recharge areas. This is highly relevant in tracking the origin of a given impact and thereby the pressure/driving force, and, as a preventive measure, in spatial planning, so as to keep sensitive areas free from polluting activities.

References

County of Roskilde (2002): Grundvandsmodel for Roskilde Amt by WaterTech a/s.

Project report on the state of knowledge of relations and interactions between groundwater and surface waters (including the effects of abstractions). The text is in Danish, but with an abstract in English:

http://www.mst.dk/udgiv/Publikationer/2002/87-7972-157-5/html/default.htm

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Title: **No: 7**

APPLICATION OF THE RIVER SYSTEM SIMULATOR FOR OPTIMISING ENVIRONMENTAL FLOW IN THE RIVER MAANA (Norway)

Type of impact:

Altered flow regime

Type of pressure:

Water flow regulation

Type of analysis or tool:

The models ENMAG, HEC-RAS, QUAL2E, RICE and HABITAT in the River System Simulator (Alfredsen et al 1995) were used in this study.

The modelling approach was to set up and calibrate the model no flow release in the bypass Sections of the river, and simulate the impact of releasing 1 m3/s, 2.5 m3/s, 5.0 m3/s and 10 m3/s water as environmental flow.

How the decision was made based on the model

The scientists judged all model results manually, and a common integrated recommended flow was proposed.

In what ways did the application process represent state-of-the-art?

Three well-known and fully documented models (ENMAG, HEC-RAS and QUAL2E) and two newly developed models (RICE and HABITAT) were integrated with a common database and presentation tools in the River System Simulator. The integration represents the state-of-the-art.

Modeller-end-user communication

The end-user for the project, "The Eastern Telemark River Regulation Association", had established a reference group with participation of local and regional authorities, hydropower companies and local politicians. The project reported the progress to this reference group once a year. In the starting phase of the project, several meetings between two of the modellers and the end-users were arranged. The end-user had established a reference group. The final output of the project was seven scientific reports and one summary report.

Information and data requirements

The data collection strategy for hydraulic, habitat and fish data was to collect data intensively over shorter periods where water was released back into the river. Other data were collected on a continuous regular (monthly, daily and every 10 minutes) basis. Several of these models require the same input data. The following data were collected:

Technical and hydrological data for the power plants and the reservoirs in the system to run the ENMAG model.

Cross-section and water level data to run HEC-RAS, QUAL2E and RICE models.

River ice cover, water and air temperature data for the RICE model.

Data on the water quality parameters total P, total N, bacterial count, coliform and thermo tolerant coliform bacteria, pH, turbidity and water temperature were collected for the QUAL2E model at twelve sites along the river and at the outlet of several power plants. These data were collected once a month during a period of 14 months as well as during several periods of test water release to the river.

Water depth, current velocity and substrate size were collected for the HABITAT model along 5-12 transects at five fish habitat stations. Fish habitat use data was collected by snorkelling at the same stations during summer situations.

Brief description including figures

The River Maana in the central southern Norway about 150 west of Oslo is regulated with a large dam in the mountains and a total of 5 hydropower plants. The licence for the regulation was due for re-licensing, and this study was done to analyse environmental flow requirements with respect to water-covered area (aesthetics), trout rearing habitats, water quality, ice conditions and power production. The River System Simulator (Alfredsen 1995) was used to simulate and integrate the impacts of a range of 1-10 m3/s environmental flows to be released in the bypass sections of the two most downstream hydropower plants.

The affected bypass sections are of approximately 6 km and 8 km. Fish habitat simulations were done in detail at 5 selected representative reaches of 25, 48, 59, 60 and 286 m length. The other subjects were studied on the whole river part of 14 km.

References

The study is reported in several openly available Norwegian reports, also including one summary report:

Harby, A. (ed). (2000) Vassdragssimulatoren for Maana. Hovedrapport. SINTEF, Trondheim, Norway. (in Norwegian).

An article for international publication is submitted to Environmental Modelling and Software. Parts of the study is reported in:

Harby, A. and Alfredsen, K. (1999) Fish habitat simulation models and integrated assessment tools. International Workshop on Sustainable Riverine Fish Habitat, April 21-24, Victoria, B.C., Canada.

References to modelling tools:

Alfredsen K., Bakken T.H. and Killingtveit (eds) (1995) The River System Simulator. User's Manual. SINTEF NHL report 1995.

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Title: **No: 8**

AN APPROACH FOR ASSESSING ALTERATIONS IN THE RIVER WATER FLOWS PRODUCED BY RESERVOIRS

Type of pressure:

Water flow regulation

Type of analysis or tool:

Index for the maximum potential alteration of the natural water regime produced by water flow regulation.

Information and data requirements

- Map of water storage capacity upstream of any point of the hydrological network.
- Map of natural water yields.

Brief description including figures

The objective of this practice is have a straightforward index to evaluate the maximum potential alteration that could be produced by the water flow regulation.

The map of maximum potential alteration of the natural water regime produced by water flow regulation was made by calculating, using GIS techniques, the ratio between the map of annual water yields and the map of water storage capacity upstream of any point of the hydrological network.

Regulation dams can produce the greatest alteration on the temporal flow regime. Indeed regulation dams are constructed to modify the natural river discharge according to human requirements and such activity alters the natural water regime. The degree of degradation at any point of a river depends on three parameters: the volume regulated upstream of that point, the relative amount of water regulated related to the resources flowing through the river (in other words the storage-to-flow ratio), and the reservoir operational management.

The alterations produced by the management of the reservoir could be null if it reproduces the natural regime, or could make a total alteration of the regime if it stores all the resources and no water is released to the river. This latter case represents the worst effect that a dam can produce to the river flow, and it can be used to quantify the potential alteration of the natural water regime. First, a map of water storage capacity shows the volume of water that can be regulated upstream of each point. Then if the map of annual water yields is divided by the map of water storage capacity, the map of maximum potential alteration of the natural water regime produced by water flow regulation will be obtained.

Figure 1: map of water storage capacity shows the largest volumes exceeding 5.000 Mm^3, which are in the low courses of the large rivers (Guadalquivir, Ebro, Tajo, Duero and Guadiana), while there are some small basins which hardly reach 1.000 Mm^3 (Norte, Sur, C.I. de Cataluña, Galicia Costa and Segura).

Figure 2: shows the map of natural water yields

Figure 3: shows the map of maximum potential alterations by flow regulation. It presents a very different aspect compared to the water storage capacity map. Basins with very high absolute storage capacity, as the Ebro, show little altered regime due to its great natural contribution, while other rivers with also large contribution presents much greater possibilities of alteration (Tajo or Guadalquivir).

Furthermore, it must be recalled that we are referring to a maximum potential alterations, thus real alteration can be much lower than these. If one thinks, for example, in the frequent case of hydropower damming with high storage capacity and also high percentage of water returns, the potential alteration of natural waters regime downstream would be very high, but the real alteration produced would be very small.

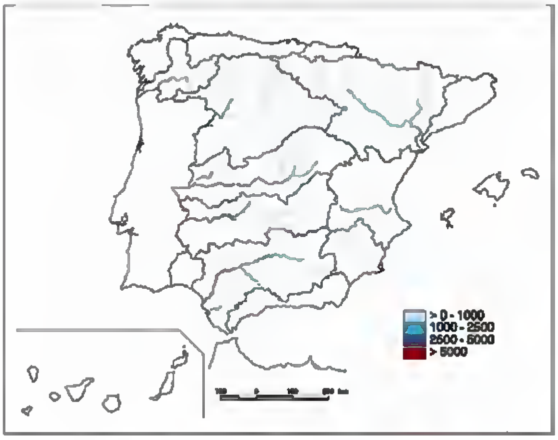

Figure 1: Map of water storage capacity upstream of any point of the hydrological network (Mm^3).

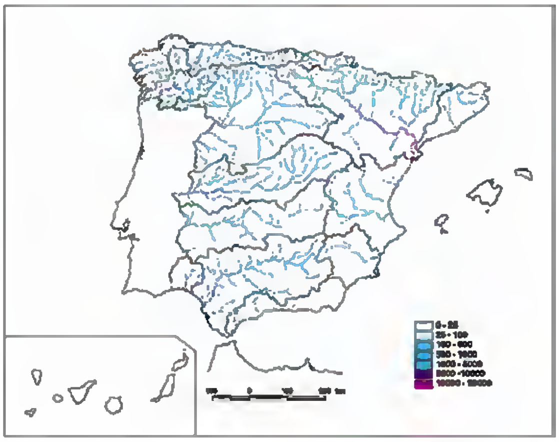

Figure 2: Map of natural water yields (Mm^3/year) Average (1940-1996)

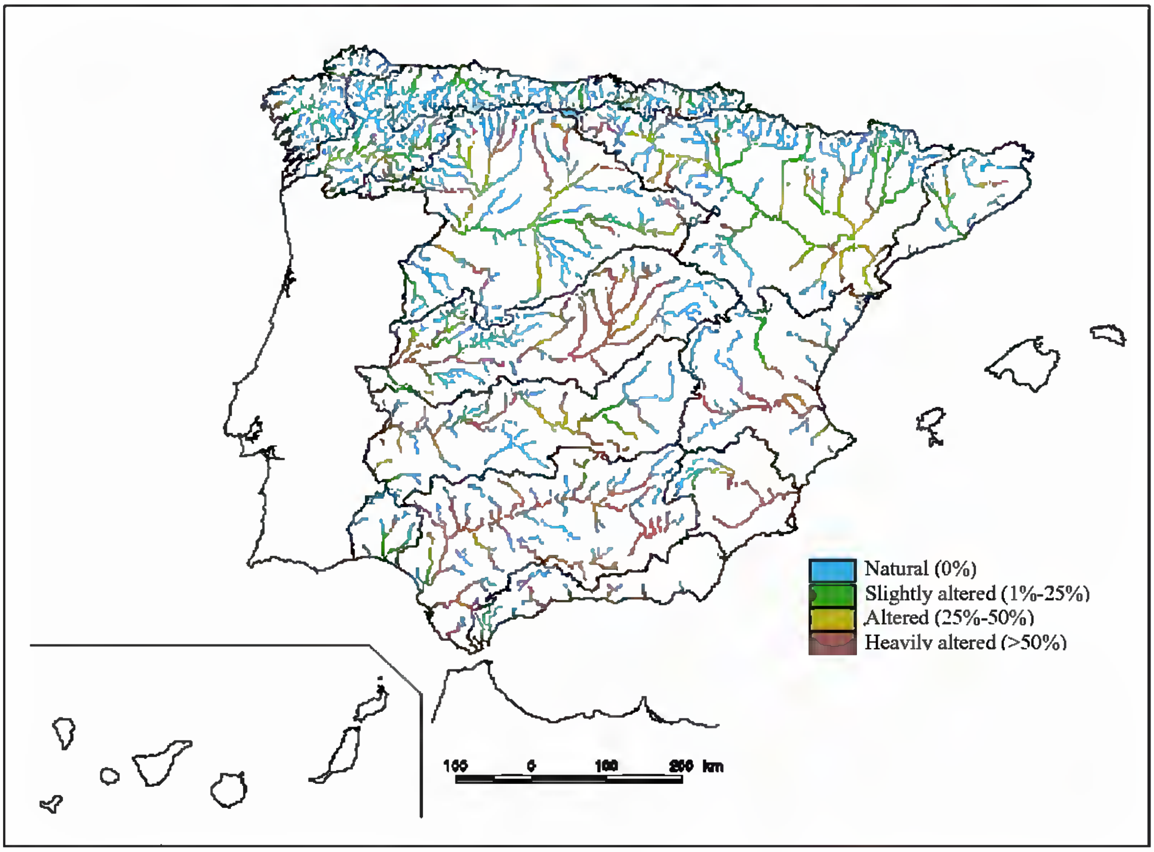

Figure 3: Map of maximum potential alterations by flow regulation.

References

MIMAM (2000), Libro Blanco del Agua en España. (Ministry of Environment(2000), White Paper on Water in Spain) (Language: Spanish)

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Title: **No: 9**

HOW TO REPORT ON MORPHOLOGICAL ALTERATIONS RELATED TO HUMAN PRESSURES? (Netherlands)

Type of impact:

Altered flow regime results in significant changes of natural dynamics and habitat conditions.

Type of pressure:

Substantial change of estuarian flow characteristics resulting in morphological changes in the estuary

(Driver: Current and future demand for shipping requires deepening and widening of navigation channel in Westerscheldt estuary.)

Type of analysis or tool:

During the analysis there were no uniform criteria or reference conditions available from the HMWB-group or REFCOND for transitional and coastal waters. Therefor a set of objectives and indicators from the Long Term Vision for the Scheldt (TWG Scheldt Commission) is used as a preliminary set of reference conditions.

Information and data requirements

Data on habitat area (GIS), water depth, flow regime, sediment composition and sand transport.

Brief description including figures

The Westerscheldt is the major shipping channel to the ports of Antwerp and Vlissingen. In order to support economical developments the navigation channel has been deepened to grant access to larger ships and reduce dependency of the tidal changes. In the Westerscheldt estuary the continuous dredging and dumping activities related to this deepening have a major effect on the quality status of the system. Important effects are subsequent changes in morphology and habitat composition within the estuary. The Westerscheldt can be characterised as a transitional water and presumably as 'heavily modified'. This means with respect to the morphological state of the estuary that certain man-made alterations of the system are accepted as irreversible. This certainly reflects the presence of dikes for safety reasons and also to the navigation channel because of the economical importance. This implicates that the quality objective for this water body is the Good ecological potential, meaning the best possible ecological conditions within the irreversible changes.

The WFD requires an identification and analysis of the significant human pressures, including man-derived changes on hydromorphology. In order to structure the analysis 5 steps have been taken:

Step 1: system characterisation

The parameters of the most important system characteristics (annex II (par.1.2.3., V (par. 1.1.3. and 1.2.3) of the WFD have been used as a starting point for this description.

Step 2: establishing reference conditions and morphological quality objectives

A reference condition of the morphological status that sufficiently meets the WFD quality objective given by GEP had to be described. Such a reference condition was not sufficiently specified and quantified in the available literature. Since a static (geographical of historical) reference condition is not practical to use in a dynamic estuarine system, the objectives of the 'Long-term vision of the Scheldt estuary (LTV)' are used to derive significant pressures and impacts and to identify criteria to monitor system changes. The LTV focuses on the preservation of essential natural dynamics in an estuary. Two major system objectives are used for this purpose: (1) the multichannel system should be kept intact (2) there should be sufficient space for dynamic sedimentation / erosion processes and changes in habitats.

Step 3: Identification of significant pressures

The assessment whether a pressure on a water body is significant must be based on a general conceptual understanding of the pressures (e.g. water flow) and their impacts on the system (e.g. the related changes in morphology and the ecological functioning and habitats of the system). In the case of the Westerscheldt expert knowledge was used to firstly list all potentially relevant pressures and then in a second step to identify the most significant pressures. Significance only becomes meaningful if determined towards an objective or reference condition. The criterion used for the prioritising was the relevance of the pressure for reaching the system objectives as described in the LTV.

Step 4: Assessment of impacts

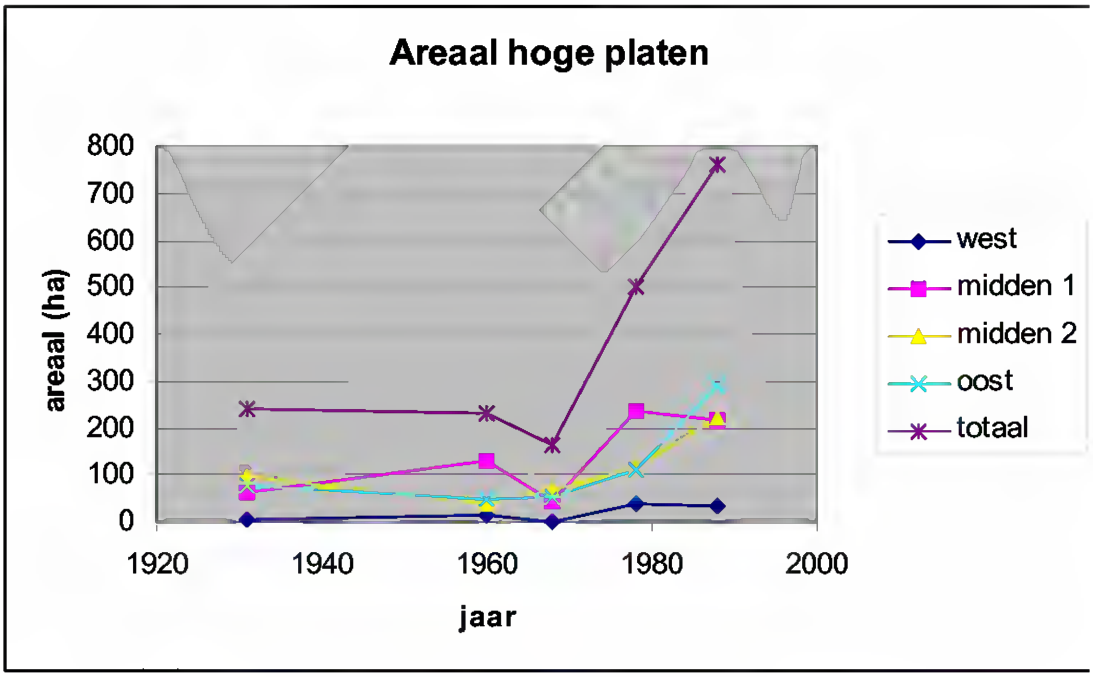
Important goal of the first review in 2004 is to identify the major pressures and their impacts. The pressure with the strongest impact is 'deepening and widening of the navigation channel'. Consequently this activity also has the largest potential to meet or fail the future objectives as formulated in the LTV.

Step 5: Identification of relevant indicators for monitoring impacts

The relationship between pressure and impact has been used to identify relevant indicators to monitor morphological changes. For the multi channel relevant indicators seem to be i.a. shore-length of tidal flats, intertidal area, ebb/flood domination, net sediment-transportation, relation primary channel transport versus secondary channel transport. For the objective of enough space for natural dynamics relevant indicators of the height of intertidal flats and lower salt marsh area have been suggested.

Unfortunately the relationship between pressure/ impacts and morphological criteria has not been established thoroughly enough to be able to derive an operational classification system yet, so much depends on expert knowledge. Nevertheless trends away from achieving good ecological status can already clearly be identified for this indicative parameters. (see the graph on increase of area of higher salt marshes which mean that the area of relevant lower salt marsh is strongly reducing). The first review in 2004 is a screening step. It designates the prime aspects that should be treated in the RBMP. For morphology it reveals a number of relevant gaps in knowledge that should be filled in the next steps towards the RBMPs.

Higher salt marsh area



References

- Pilot report on pressures and impacts for the WesternScheldt area – RIZA & Royal Haskoning, in Dutch (English summary included), currently in preparation (finalised in September 2002), report will be made available on : www.waterland.net/eu-water
- Long Term Vision Scheldt Estuary – Resource analysis (RA/00-445), Januari 2001

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Title: **No: 10**

SCREENING AND IMPACT ASSESSMENT USING EUROWATERNET METHODOLOGY FRENCH APPLICATION (France)

Type of impact:

Organic matter, nutrients, eutrophication, in rivers

Type of pressure:

Point and diffuse sources of OM, P, N, estimated trough their driving forces.

Type of analysis or tool:

Statistical technique to organise use of monitoring data and assess spatial and temporal relationships between pressures and impacts

Information and data requirements

Monitoring stations location and observation raw data,

Catchments structure,

CORINE *land cover*, administrative and catchment limit

Population per NUTS5

Other information can be entered in the stratification system

Brief description including figures

The methodology

Land cover types and population density define the main driving forces that impact river quality. The proportion and combination of land cover types and population density are used to define strata of potential pressures that make it possible to earmark each monitoring station. The stratification process takes into account the sub-catchment and the catchment size as well in order to select stations equally across the whole territory.

The stratification aims at clustering the monitoring stations by groups of identical input discharge. If the strata are well defined, then it is expected that the pollution density (as kg y^{-1} $(km^2)^{-1}$), on the one hand and standard discharge (in m^3 y^{-1} $(km^2)^{-1}$) on the other hand produce concentration data belonging to the same statistical population.

Under these hypotheses, the stratum means and stratum variance can be computed as combinations of point means and variances. Consequently, it becomes possible to compare strata, combinations of strata * catchment and time trends.

The application

Implementation of EuroWaternet in France is now fully operational. A detailed statistical study, using geostatistical processes (multidimensional kriging) demonstrated that 6 strata (dense urban, urban, mixed (urban + intense agricultural), intense agricultural, moderate agricultural, low impact) were sufficient to describe the drivers impacting rivers.

As response to EuroWaternet requirements, 512 sampling stations were selected. For domestic purposes, this selection was extended to ~1500 stations (number is slightly year dependent) which are used for representing the water quality issues, **when statistical indicators are involved.**

In a second stage, the methodology is used to define the optimum share of stations as function of pressures on catchments. An optimum network of 2500 stations was defined and is currently under closer examination. This result is not presented here, since it is not in line with pressures and impacts. However, it is emphasised that quality of monitoring greatly determines the accuracy of impact assessment.

Some results

The stratification can be reported as a map of stratum types per elementary catchment (currently 6210). The colour code in each catchment represents the cumulated expected impacts from the upstream part of the catchment.

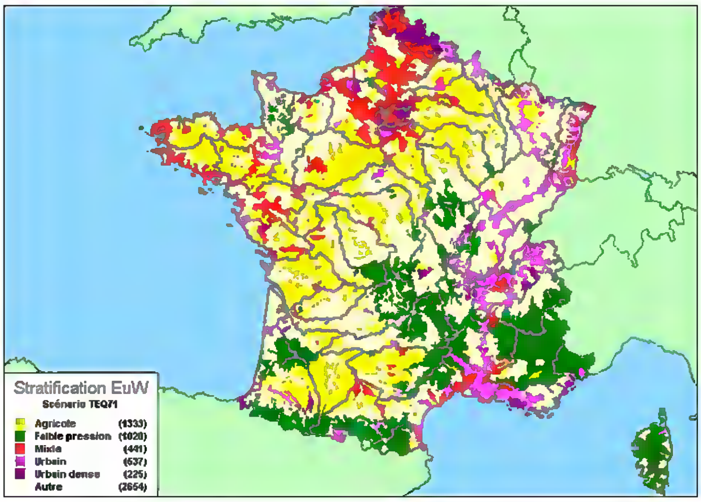
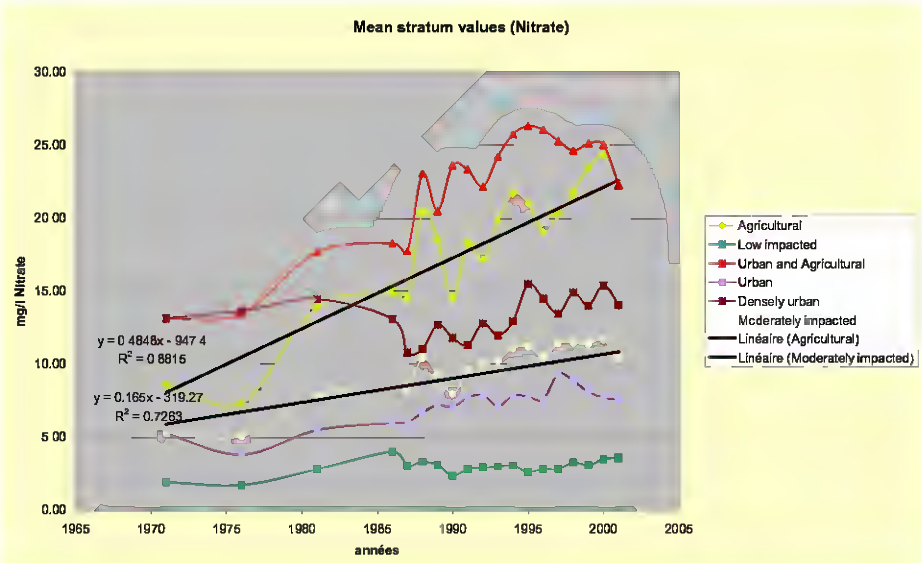


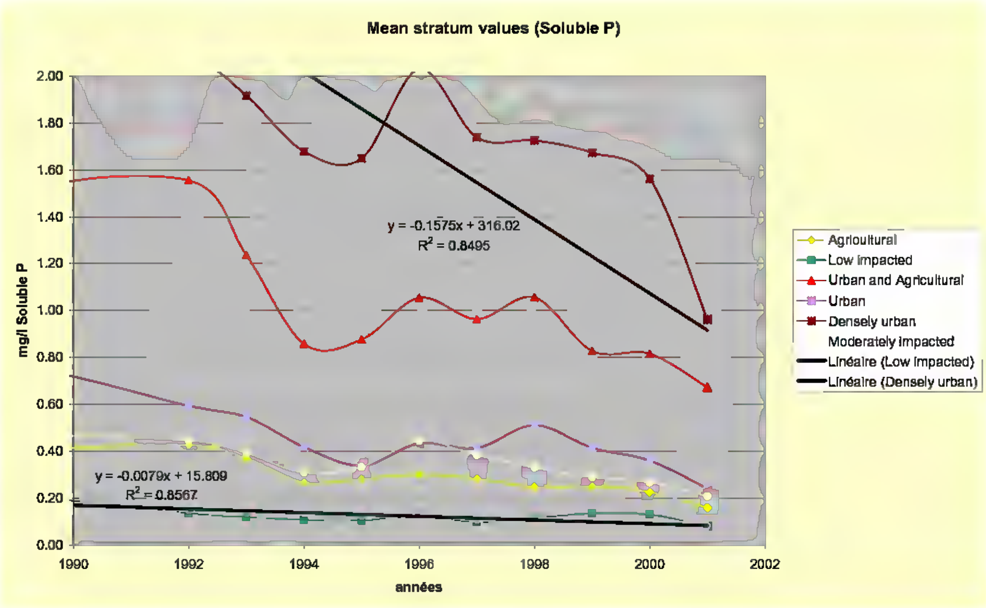
Fig. 1 Current EuroWaternet stratification types used in France.

The stratum type applies to any station situated on the main channel of the river draining any of the 6210 elementary catchments defined. The greyed lines indicate the 55 operational catchments used to force point selection even across metropolitan France.

The foreign part of catchments are considered in the calculations.



In the above example, nitrate per stratum (in this case all French EuroWaternet points are processed) shows clear upwards trends in intense agricultural, mixed and moderately impacted (agricultural) strata. Hydrology effect is not removed from averages, this procedure emphasises the time trend, supposedly in relation with activities.



In the above example, soluble Phosphorus per stratum (in this case all French EuroWaternet points are processed) shows clear downwards trends in all strata. The improvement is very effective in the most impacted strata, in relation to sewage purification and decrease in detergent P-borne. Hydrology effect is not removed from averages. In this case, the quality of relationship would have been improved, since P averages are very sensitive to dilution.

In both exemplified cases, trends, with baseline scenario, can easily be carried out and indicate which water bodies would be at risk or not of failing objectives.

References

Leonard J., Crouzet P., 1999. *Construction d'un réseau représentatif. Contribution au réseau "EUROWATERNET" / Qualité des cours d'eau de l'Agence Européenne de l'Environnement.* Orléans, Institut français de l'environnement, 70 p. (coll. *Notes de méthode, 13*).

Beture-Cerec, ARMINES, 2001. "Eurowaternet. Construction d'un réseau représentatif de qualité des cours d'eau. Phase II-Rapport final". (*type du rapport: Final, rédigé par Chantal de Fouquet, Guillaume Le Gall, pour le compte de* 'Ifen et Agences de l'eau') Orléans, 233 p., (6 annexe(s)), accès: total.

EEA, 2001. "Revisiting technical issues related to river quality reporting within the current Eurowaternet process. New insights to assessing sectoral policies efficiency". (*type du rapport: Draft, rédigé par Philippe Crouzet, pour le compte de* 'EEA/EIONET') Copenhagen, 38 p., accès: limit.

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Title: **No: 11**

QUANTIFYING IMPACT OF PRESSURES AND LIKELIHOOD OF MEETING OBJECTIVES BY MEANS OF THE WATER ACCOUNTS METHODOLOGY (EUROSTAT). FRENCH APPLICATION (France)

Type of impact:

Organic matter, nutrients, eutrophication, pesticides, biological status in rivers

Type of pressure:

Point and diffuse sources of OM, P, N, etc estimated either through their driving forces or actual pressures.

Type of analysis or tool:

The Water Accounts methodology apportions the water quality assessments (not raw concentrations) in proportion of the size of water bodies. This method yields a quantity of quality that can compare with pressures (as loads) or with costs (as amount of money).

Information and data requirements

Monitoring stations location and observation raw data,

Quality assessment method to calculate quality indexes or classes,

Catchments structure and river network structure,

Standard discharges values (average, low flow values) to calculate weighting data.

Brief description including figures

The methodology

Water accounts methodology was designed first to build observation systems representative of the river network structure (whereas EuroWaternet yields representative sample of the monitoring network and responds to different objectives).

Several countries, including France, adapted it on behalf of Eurostat. The aim is to allow comparisons of quality state between catchments or NUTS areas and to make it possible to assess the cost of quality improvement.

The heart of the method is very simple: each river segment has a weight, calculated as length times the standard discharge. This quantity, named SRU (Standard River Unit / UMEC Unité de Mesure des Eaux Courantes) homologous to local energy content can therefore be added, compared and has a finite value, independent of map accuracy.

In a second step, quality assessed (or extrapolated) for each segment is processed as quantities of quality. Since quality classification schemes refer to classes, it becomes possible to match quality related to nitrate with quality expressed as biological indicator, provided the classification scheme is internally consistent.

The most developed state of methodology is now available, after recent French and EEA developments providing a full chain of production from monitoring data to aggregated indexes (catchment and NUTS) and b) comprehensive set of indicators as well as a trial in four countries (Ireland, UK, Slovenia and France).

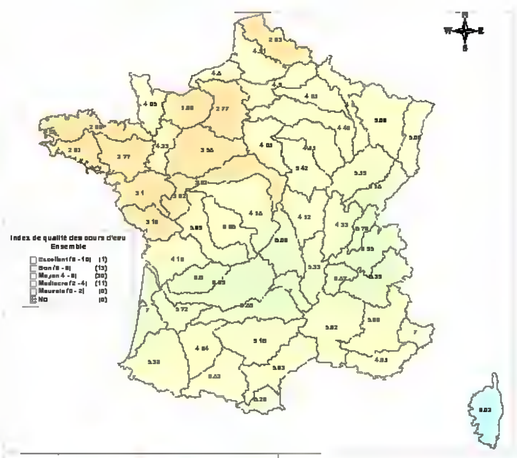
The application

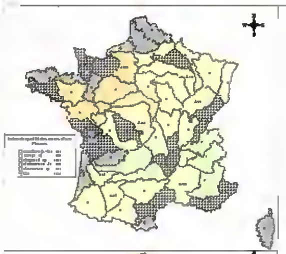
For the time being, the most comprehensive application was carried out in France. However, examples are given for other countries to demonstrate the flexibility of the method.

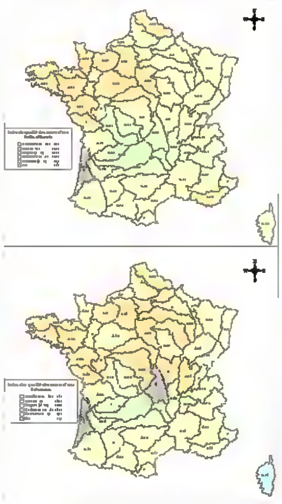
Thanks to the latest developments, the following information is provided by the application of the software available (in France NOPOLU).

- Quantity of SRU, per quality class, for the different assessment types, if relevant, per river rank, aggregated per catchment (any size type) or NUTS. These quantities directly compare with stock-like units: volume of discharge, amount of money;
- RQGI (River Quality Generalised Index), which is a generalised water quality class encompassing the distribution of quality classes over the aggregation domain (from all river types of a country to a river size class of a catchment);
- Pattern Index, indicating what is the profile of a quality problem of the considered domain of aggregation (mediocre everywhere, good with "black spots", etc.);
- Relative importance index, obtained by comparing the SRU resulting from different quality assessments. For example, comparing nitrate and eutrophication. Quantitative information, for all aggregation units becomes available. Of course, changes in time can be compared as well.

Some results

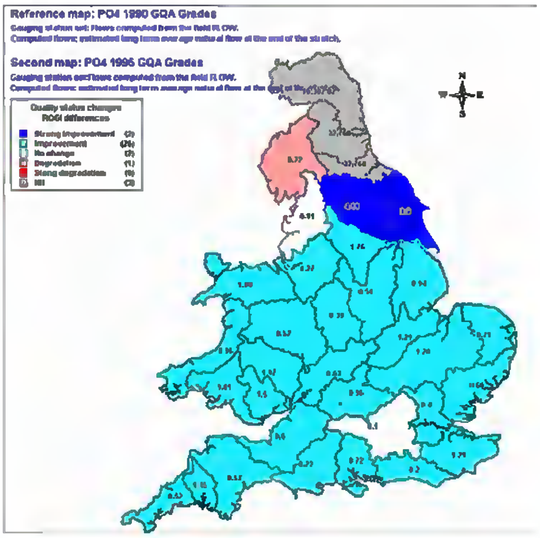


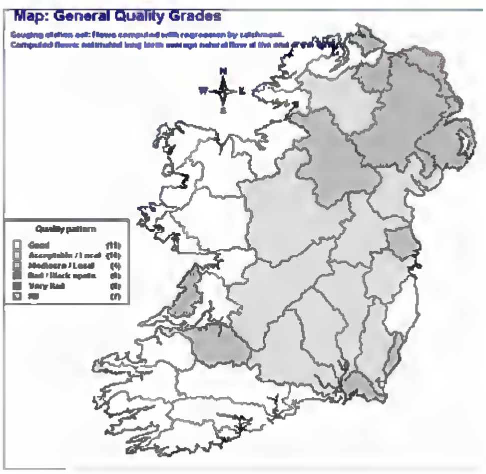




The five maps above (from the 2002 French State of the Environment report) show the aggregated **RQGI**, all rivers (left), for the 55 reporting catchments, and the RQGI broken down in four size classes (left, right, up, down; largest, large, medium and small rivers)

The right bottom map represents the changes in water index in England and Wales, per catchment, with respect to phosphorus contamination of waters. The range of colours indicate improvement (blue) or degradation (red).





The other figure, on the right, shows the pattern of river quality in the Republic of Ireland, considering biological quality. The patterns suggest that local pollutions are responsible for the observed mismatches with good quality objectives. This can facilitate orientation of assessments and further action plans.

References

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European Environment Agency, 2001. *Trial application of the Water Accounts methodology to calculate River Quality Global Index. (England and Wales, France, Republic of Ireland, Slovenia). Copenhagen*, EEA. in: *Trial application of the Water Accounts methodology to calculate River Quality Global Index.* CD-Rom par Beture-Cerec, 2001.

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Title: **No: 12**

WATER QUALITY MODELLING IN TEJO RIVER (Portugal)

Type of impact:

Analysis of water quality in the main river

Type of pressure:

Water quality in tributaries and loads from point sources

Type of analysis or tool:

The water quality model adopted for the simulation of the river was the Enhanced Stream Water Quality Model QUAL2E model (EPA, 1987).

Information and data requirements

Information and data on flows and on water quality were obtained on the Networks Monitoring. Loads from point sources (urban wastewater and main industries).

Brief description including figures

Methodology and Application

Tejo river basin is one of the largest in the Iberian Peninsula, with an area of about 80 629 km², being 55 769 km² (69%) in Spain, and 24 860 km² (31%) in Portugal. This river travels along 230 km in Portugal and discharges to Atlantic Ocean, after crossing Lisbon City.

In the last years the natural regime has changed and the flow from Spain has decreased significantly due to the construction of a large number of reservoirs and the increase of water demands. As a consequence, the water quality characteristics, within the basin, have also been significantly changed during the recent past due to anthropogenic actions.

Concerning the production of drinking water, the greater Lisbon area and several municipalities in the lower Tejo region, with a population of more than two million people, are supplied by several surface water abstractions. Due to great social, ecological and economic importance, the Tejo watershed has been studied with the purpose of identifying the relevant point and non-point pollution sources, to characterise water quality and adequacy to the observed and proposed uses. With all this information available it's possible to apply and calibrate models to simulate the evolution of water quality, for different scenarios of hydrologic conditions and pollutant loads.

Several water quality models were evaluated for suitability to the Tejo River. The water quality model adopted for the simulation of the river was QUAL2E model (EPA, 1987), which was considered to be more adequate to the program goal and the available data.

The river reach studied is between the boundary section, used as headwater, and the beginning of the estuary (last element in the system), with a length of 150 km. A computational element length of 2 km was chosen as sufficient to describe spatial detail along the river. In the river reach under study there are two dams, Fratel and Belver. Due to their hydraulic characteristics and operational conditions they were treated as a stream segment were the flow is unidimensional and is not affected by stratification. Phisiographic data was based on transversal profiles surveyed in the 1970's. Information and data on flows were obtained on the Freshwater Network Monitoring. Figure 1 shows the reaches and computational elements considered. Also illustrated are the 25 point loads considered and localisation of dams.

Figure 1 – Reaches, computational elements and 25 point loads considered, and localisation of the dams.

Currently, there are 50 water quality sampling stations in the Tejo watershed, where sampling is done monthly. The Tejo river model input used observations of water quality at stations located at the national border (headwater in the model) and at the last element in the system (beginning of the estuary). QUAL2E can incorporate fixed downstream constituent concentrations into the algorithm. When no direct observations were available, inflows and associated concentrations of water quality were estimated. Estimate values of these flows were made by hydrologic balances of river segments, based on the locations of sampling stations. Nutrient concentrations in flows entering the river were estimated with the available data.

The Tejo River model calibration utilised prototype observations of water quality for nine sampling stations. Annual means and summer means were selected to represent two hydrologic and climatologic regimes. Summertime characteristics with low flow conditions were simulated, permitting to analyse the behaviour of the river in the worst conditions of wastewater discharge with increase of pollutant loads to the system. Several calibration data sets corresponding to specific sampling data in summertime were selected to provide a variety of hydrologic conditions.

Results

A geometric representation of the hydraulic characteristics of the stream channel was used. Stream velocities and flows determined by the model were found to be suitable to represent the Tejo River. The two dams present in the first 50 km of the river are responsible for the low velocities observed.

Figures 2 and 3 illustrate the results of the application of QUAL2E to the Tejo River for summer conditions. The results are analysed taking in account the field observations, the major uses of the river and compared to water quality objectives set by national and international legislation. Calibration sequence for quality variables was temperature, dissolved oxygen, BOD, phosphates, nitrates and ammonia. Results of calibration were generally good, except for ammonia.

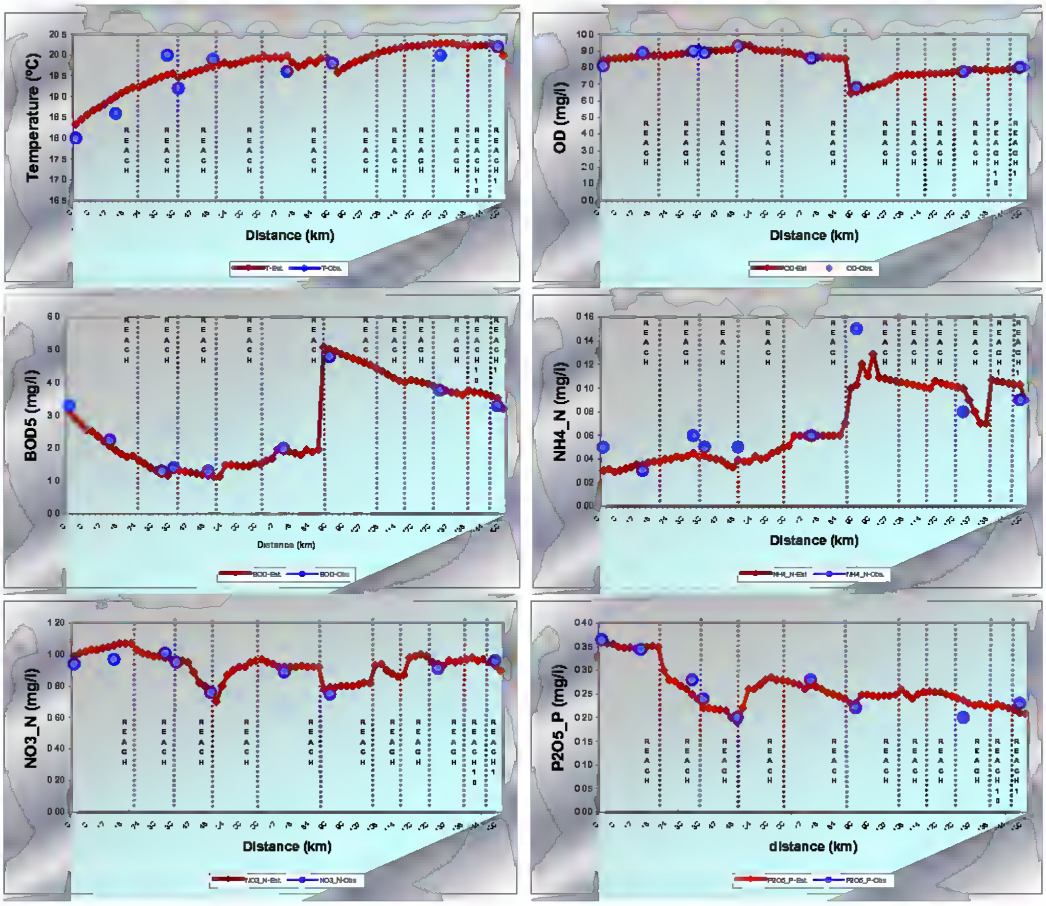

Figure 2 - Comparison between QUAL2E output and observed values in the sampling stations of Tejo.

The profiles obtained for the parameters (Figure 3) represent the actual impact on water quality from the different sources of pollution that affects the Tejo River. The big reservoirs in Spain have some effect by reducing BOD, but in terms of nutrients high amounts continue to reach to the border. This will affect the two reservoirs in the national part that have already problems of eutrophication. On other hand, in the national basin there are some problems, especially the impact of the paper industry and Zêzere plus Nabão Rivers, which have a representative flow. Also two important tributaries, Almonda and Alviela Rivers represent a significant contribution of pollution that affects the Tejo River more downstream.

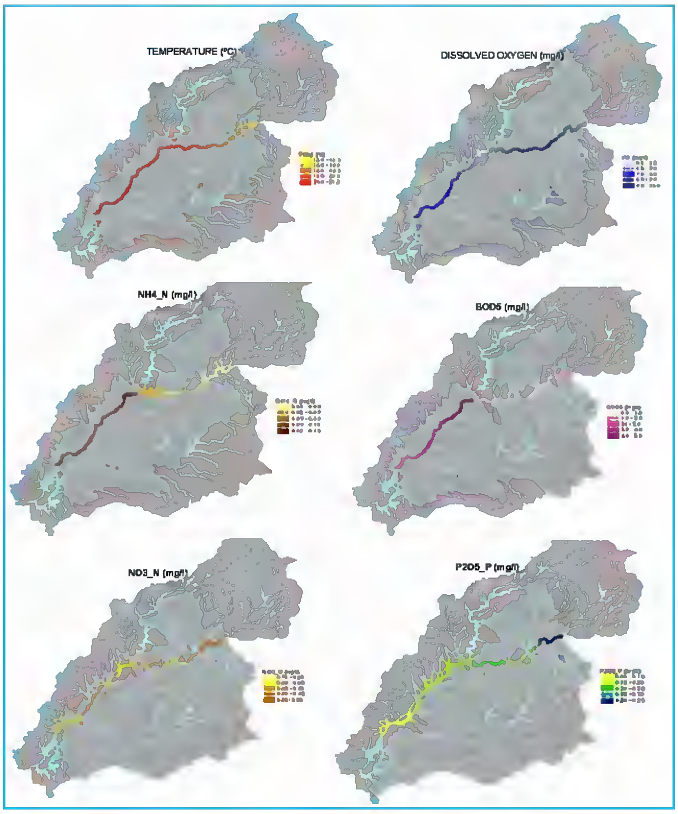

Figure 3 - Profiles of QUAL2E using GIS maps.

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Title: **No: 13**

CRITERIA FOR THE INVESTIGATION OF SIGNIFICANT PRESSURES AND EVALUATION OF THEIR IMPACTS FOR PURPOSE OF REPORTING TO THE EU COMMISSION; - STRATEGY PAPER OF THE WORKING GROUP OF THE GERMAN STATES ON WATER (LAWA) – (Germany)

Type of impact:

Status and change of water quality (eutrophic and saprobic status, toxicity, rewarming), changes of habitat, changes of the hydrological regime

Type of pressure:

Point sources, diffuse sources, water flow regulation, morphological alterations, heat input

Type of analysis or tool:

Analysis of existing data on emissions and on the state of a water body, threshold values or balance models for diffuse sources; analysis of impacts based on quality objectives and threshold values, knowledge of experts

Information and data requirements

Data on emissions (communal waste water discharges, industrial waste water discharges) data on land use, data of the state of water body (physicochemical measurements, data on quality of waters and structures of the water body), data about water abstraction

Brief description including figures

For the purpose of investigating significant pressures and evaluating their impacts, a strategy paper was compiled in Germany by the State Working Group on Water (LAWA). The objective is an efficient procedure, agreed on by all states, for compiling the inventory in accordance with Annex II of the Water Framework Directive (WFD) by the end of 2004. For the first description, the strategy paper is oriented on the availability of meaningful and stable data. Should a more extensive description be required, more detailed data will be compiled and, if necessary, collected locally.

Table 1: Data to be collected for different pressures

PRESSURES	**Criteria**
Point sources	
• Public sewage-treatment plants >2000 PE (derived from Urban Wastewater Treatment Directive)	Annual volume of water discharge Population (P) and population equivalents (PE) Substance loads according to Annex I of the German Wastewater Directive Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives
• Industrial direct discharge	Statement of systems according to IPPC Directive = pollutants according to EPER Annual loads of plants with obligation to report according to IPPC Directive: consideration of the particular size threshold for the annual load of 26 substances (cf. Table 1: Size thresholds; EPER) Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives Food industry facilities >4000 EP
• Storm water / combined wastewater discharges	Discharge of wastewater from an urban area >10 km^2
• Discharges with heat load	Discharges with heat load >10 MW
• Salt discharges	Discharges >1 kg/s chloride
Diffuse sources	Not yet finally defined, coordination with criteria for endangerment of groundwater bodies
Water abstraction	Abstraction without recirculation >50 l/s
Water flow regulation	Procedure for small/medium-sized water bodies: o Parameter "anthropogenic barriers" (Stream habitat survey): ≥6 o Parameter "backwater" = 7 or according to general procedure: o Impassable anthropogenic barriers and backwater
Hydromorphological alterations	Based on the results of river habitat survey or similar investigations: "Water-body bed dynamics" with structural classes 6 and 7

For the purpose of compiling the significant pressures, the WFD indicates which substances and groups of substances are to be considered. In some cases, data that have already been compiled on the basis of other directives (e.g. communal wastewater directives) can be used. Table 1 illustrates what information is to be gathered for the various pressures.

Supplementary to the emissions data, data on the state of a water body available from environmental surveillance should be examined. Primarily data on the state of a water body will be considered to evaluate the impacts of the pressures and will be judged according to quality objectives and aggregation criteria. As a rule in Germany these data are present in the spatial density adjusted for the quality aspects and the site of the impact. If these are insufficient, an assessment or consideration of a model based on established pressures is necessary. An estimation of probability that the good ecological or chemical conditions will not be achieved within a period of observation will be made on the basis of the criteria presented in Table 2.

Table 2: Information necessary for the assessment of impacts

Indicator	Threshold values
Saprobic status	30% of stream network > national biological quality level (here: biological quality level II; indicator macrozoobenthos)
Trophic status	➢ 30% of stream network > national quality level (here: trophic class > II, indicator: chlorophyll a, pH, O2) ➢ also in discussion, but not yet finally defined: assessment by nutrient content/load of the rivers
Physicochemical substances	Exceeding existing quality objectives or quality criteria of EU directive 76/464/EEC and knowledge about entries of priority substances
Warming	According to the EU Fish-Life Directive: - max. annual temperature: >21.5°C (salmonid water body) >28°C (cyprinid water body) - max. winter temperature: >10°C (salmonid water body) >10°C (cyprinid water body) - max. warming up: 1.5 K (salmonid water body) 3.0 K (cyprinid water body)
Salinisation	Median: CI > 400 mg/1
Morphology	- River habitat survey -- overview method: More than 30% of the river distances within the management unit are surveyed with structural quality classes 6 or 7 for the compartment "river bed". - Impairment of river continuity >30% of stream network

The utilisation of the strategy paper has already been tested in the pilot projects "Große Aue" and "Middle-Rhine". The strategy paper will be continued from case to case in consideration of new developments.

References

"Kriterien zur Erhebung von signifikanten Belastungen und Beurteilung ihrer Auswirkungen und zur termingerechten und aussagekräftigen Berichterstattung an die EU-Kommission", Strategy paper of the Working Group of the German States on Water (LAWA) , 2002; Language: German

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Title: **No: 14**

CASE STUDY "GROßE AUE" – DEVELOPMENT OF A RIVER BASIN MANAGEMENT PLAN FOR THE CATCHMENT „GROßE AUE" WITHIN THE RIVER BASIN DISTRICT WESER

Type of pressure:

Urban discharges, land use, water flow regulation

Type of impact:

Urban discharges, land use: Increasing loads, alteration in saprobic status

Water flow regulation: Morphological alterations, migration barriers

Type of or tool:

Urban discharges, land use: Monitoring of all sewage treatment plants and combined stormwater discharges, evaluation of data from CORINE landcover. Combined assessment of point sources and diffuse sources, for nitrogen and phosphor with a mass balanced model as statistic tool (MOBINEG).

Water flow regulation: Two ways of river habitat survey

Information and data requirements:

Urban discharges: Sources of Data: StUA (environmental authority) Minden (North Rhine-Westphalia); Bezirksregierung (regional gouvernment) Hannover (Lower Saxony):

- Self-control with data-sets depending on the size of sewage water treatment plants;
- Officially controlled 4 times a year.

Land use: Sources of Data: Federal Statistical Agency, basing on Dates of:

- Landwirtschaftskammer (agricultural administration) North Rhine-Westphalia;
- Landwirtschaftskammer (agricultural administration) Lower Saxony.

Water flow regulation: River habitat survey

- River habitat survey North Rhine-Westphalia: Operational detailed assessment; basing on „on-location" knowledge; Scale: 100 m
- River habitat survey Lower Saxony: Overview method; basing on maps, aerial view, collected data; Scale: 1000 m.

Brief description including figures

Aim of these pilot-project of the implementation of the Water Framework Directive was:

- to investigate the driving forces and pressures in the catchment area of the "Große Aue" (northern German low-lands) for surface and ground water bodies;
- to exemplify a programme of measures for achieving the good ecological status;
- to compile an orientation guide for provision, organisation and interpretation of data;

As main pressures, urban discharges (point sources), land use (diffuse sources) and water flow regulation were identified. To assess the influences of point- and diffuse sources on the input of the nutrients nitrogen and phosphor into surface waters a combined mass balanced model, MOBINEG, was used. With this tool effects of sources can be displayed clearly:

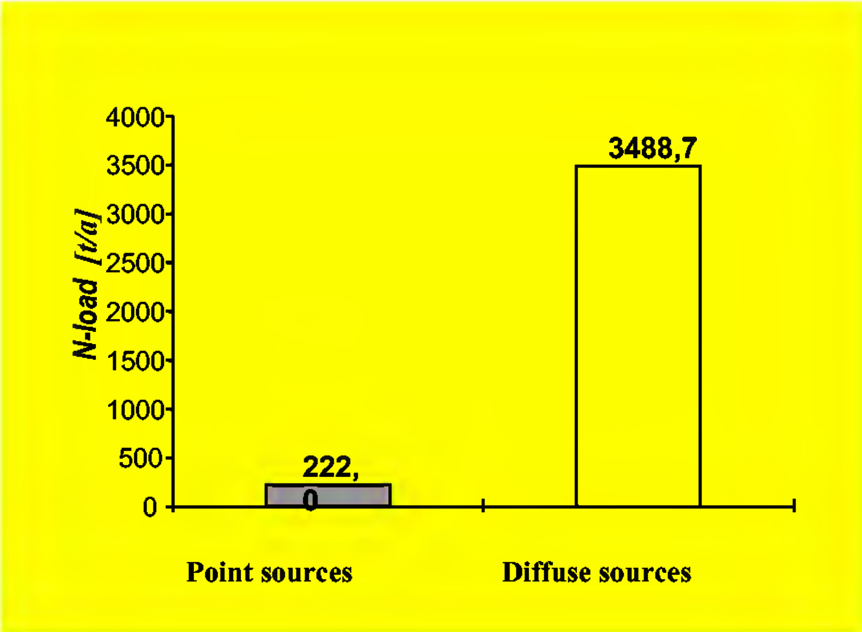


Fig. 1: N-loads from point- and diffuse sources in the catchment area of the river „Große Aue“

Referring to the diffuse discharges the cultivated areas are the main sources. Nearly 90 % of the diffuse nitrogen discharges to the surface water bodies come from cultivated areas.

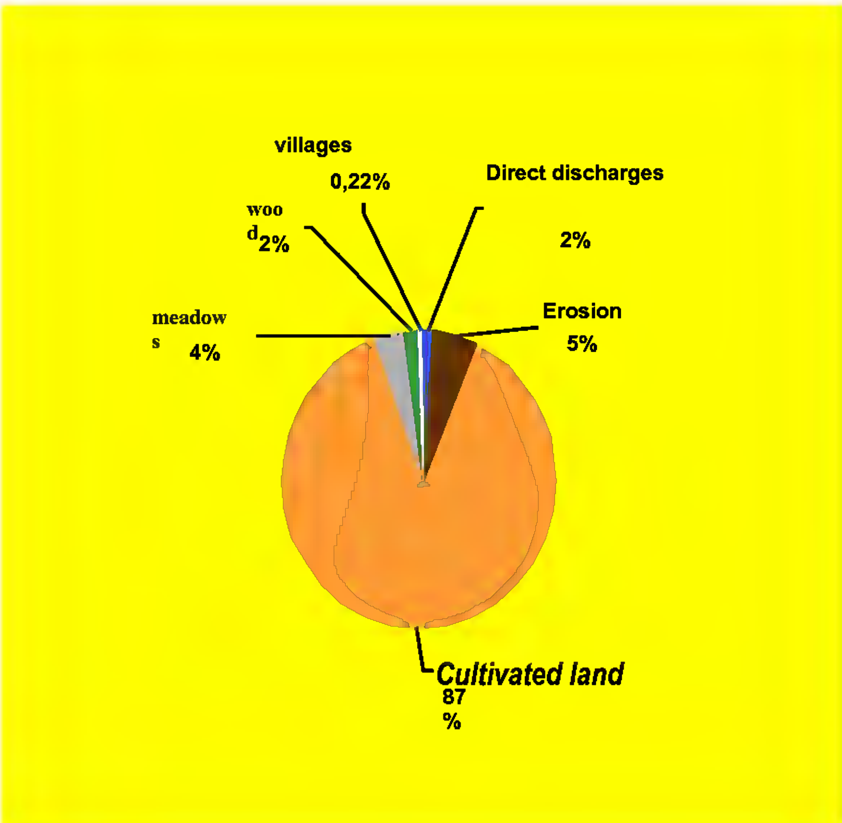
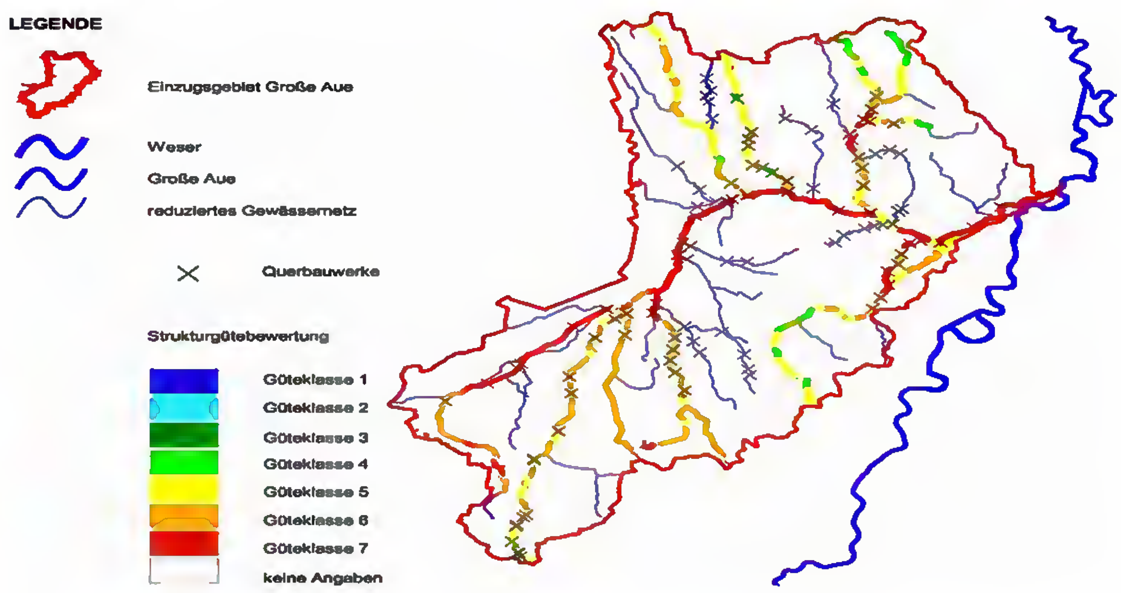


Fig. 2: Percentage of named diffuse sources concerning the N-loads in the catchment-area of the river „Große Aue“

Within the scope of the case study „Große Aue" investigations on the flora and fauna of the river „Große Aue" and several studies have been carried out. The present composition of species shows some lack in indigenous species and migratory fish, which result from impairment of river continuity as well as hydromorphological alterations (flow regulation, flood protection). The results of the river habitat survey are shown in the form of a map which also includes information about the migration barriers:

Fig. 3: Results of the river habitat survey



In Germany for the reason of investigating significant pressures and assessing their impacts the State Working Group on Water (LAWA) developed a viable strategy paper. The objective is an efficient procedure, agreed on by all states, for compiling the inventory in accordance with Annex II of the WFD by the end of 2004. For the first description, the strategy paper is oriented on the availability of meaningful and robust data. Primarily data of the state of a water body (saprobic status, trophic status, physico-chemical substances, structure of a waterbody) will be used to assess the impacts of the pressures and will be judged according to quality objectives and aggregation criteria. The utilisation of the strategy paper has already been tested in the pilot project "Große Aue".

References

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Title: **No: 15**

PILOT-PROJECT MIDDLE-RHINE: DEVELOPMENT OF RIVER BASIN MANAGEMENT PLAN

Type of impact:

Habitat alterations, modifications of the hydrological regime

Type of pressure:

Diffuse sources, water flow regulation, morphological alterations

Type of analysis or tool:

Analysis of available data of emission and of the state of a water body, balancing models, impact analysis basing on quality objectives and threshold values, expert knowledge

Information and data requirements:

Data of the state of a water body (physico-chemical measurements, water quality and structure of the water body), data about water abstraction, structural state of waters

Brief description including figures:

For purpose of surveying the significant pressures and assessing their impacts the LAWA-group in Germany developed a viable Strategy Paper (see previous example of current practice). With the "Middle-Rhine-Project" of the German federal states Hesse and Rhineland-Palatinate an example, following the LAWA-criteria, concerning the inventory taking according to ANNEX II of the WFD until the end of 2004, is given. Figure 1 shows the surveyed catchment area of the project:

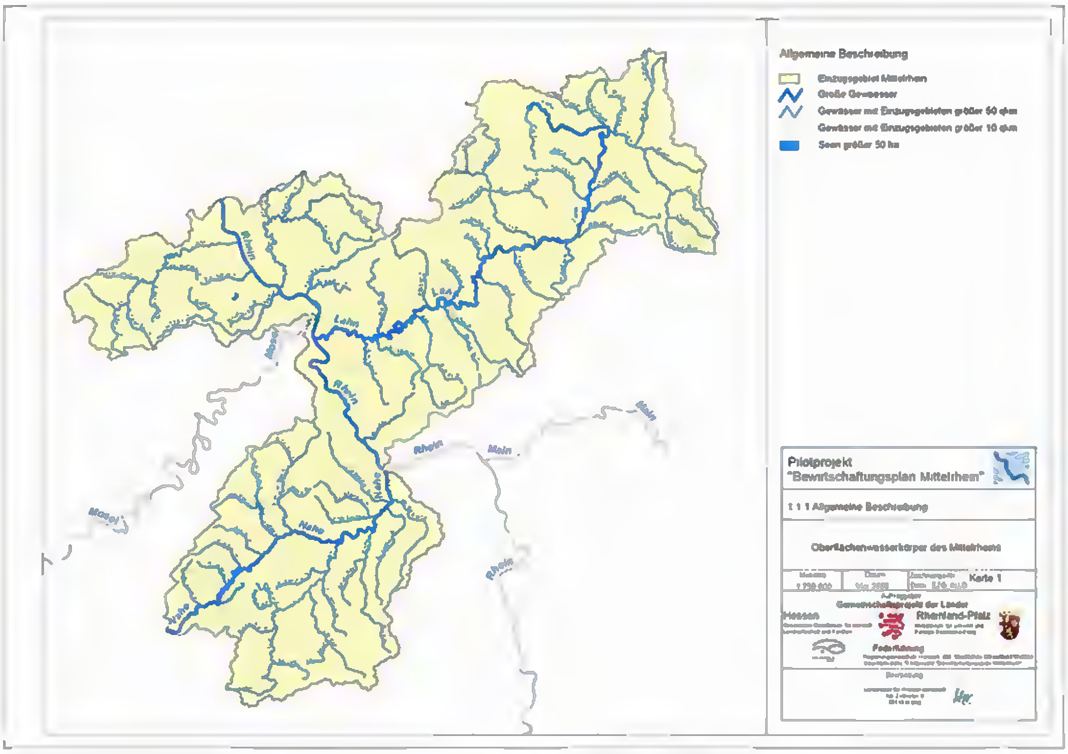

Figure 1: Catchment area of the "Middle-Rhine"

In the project some LAWA-criteria and their combinations concerning point and diffuse sources have been tested on the base of 10 km²-units. As an example the diffuse sources:

- Cultivated land > 50% (current value is still discussed);
- Urban land > 15%;
- Special crop land > 5%;
- Cultivated land > 50% and urban land > 15%;
- Cultivated land > 50% and special crop land > 5%;
- Special crop land > 5% and urban land > 15%;

have been tested. Figure 2 shows the significant areas:

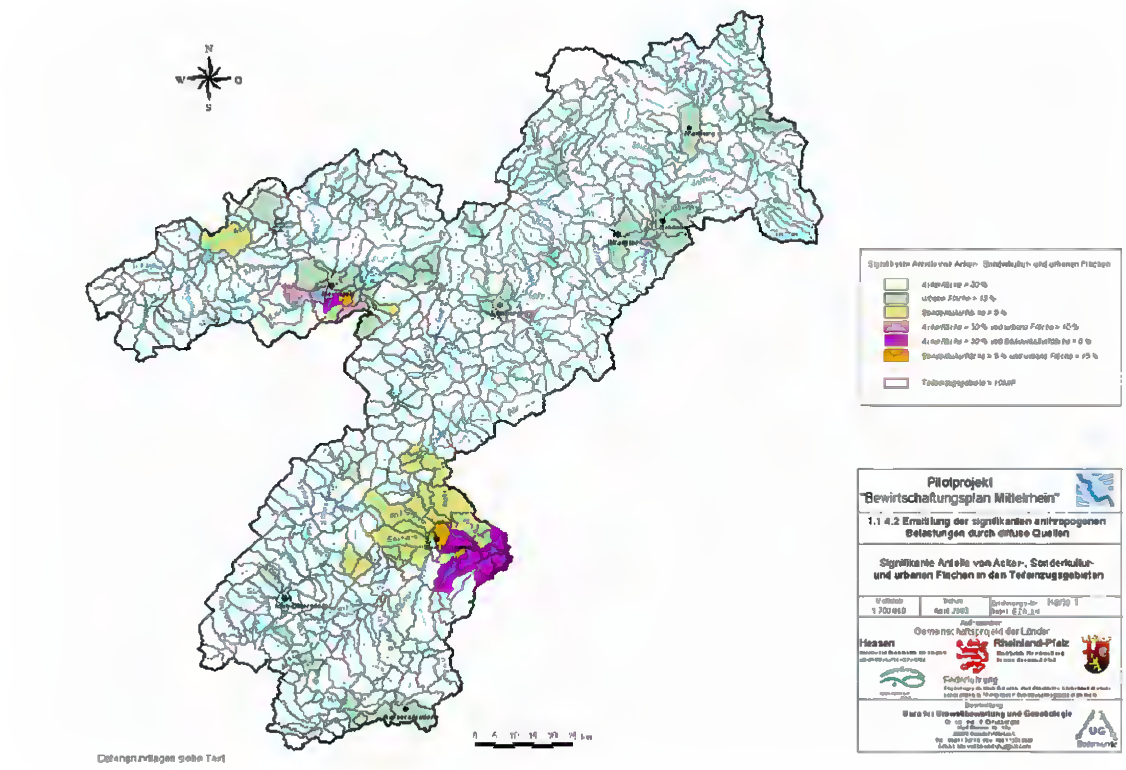

Figure 2: Significant areas concerning diffuse sources in the catchment area of the "Middle-Rhine"

In addition to the emission data, other available data on the state of a water body from environmental surveillance have been considered. For the assessment of the impacts, primary data on the state of a water body have been used. Concerning morphology the former LAWA-criteria regarding the of surveyed river distances (Stream habitat survey - method for little and medium size waters in Germany; LAWA (2000)) with:

- Structural quality class >4 in free landscape (has been adapted from 3 to 4)
- Structural quality class >5 in urban areas

have been tested.

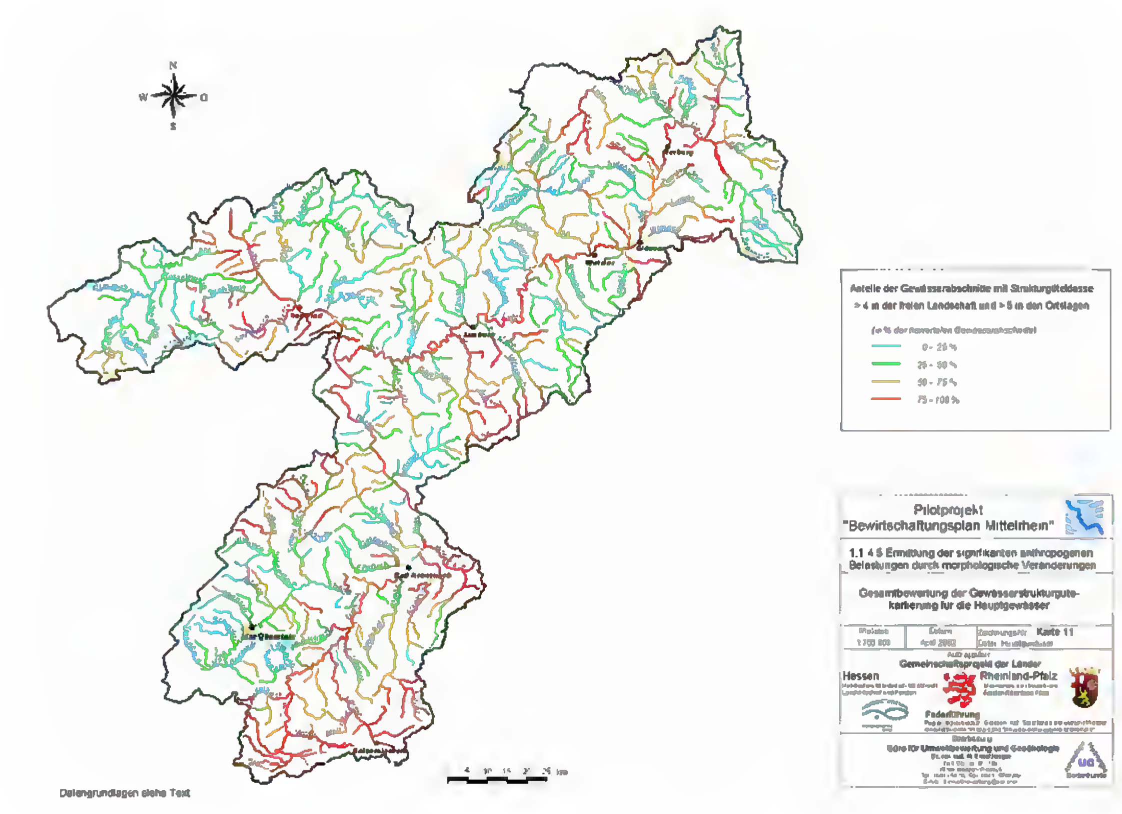

Figure 3: Amount of surveyed river distances with structural quality class >4 in free landscape or structural quality class >5 in urban areas in the catchment area of the "Middle-Rhine"

References

Pilot-Project „River Basin Management Middle-Rhine":Common Project of the german federal states Hesse and Rhineland-Palatinate, report (draft).

Pilotprojekt „Bewirtschaftungsplan Mittelrhein", 2. Statusbericht, Teile A und B, Entwurf vom 30.04.2002. Gemeinschaftsprojekt der Länder Hessen und Rheinland-Pfalz, Federführung: Regierungspräsidium Giessen , Geschäftsstelle Pilotprojekt „Bewirtschaftungsplan Mittelrhein"

Language: german

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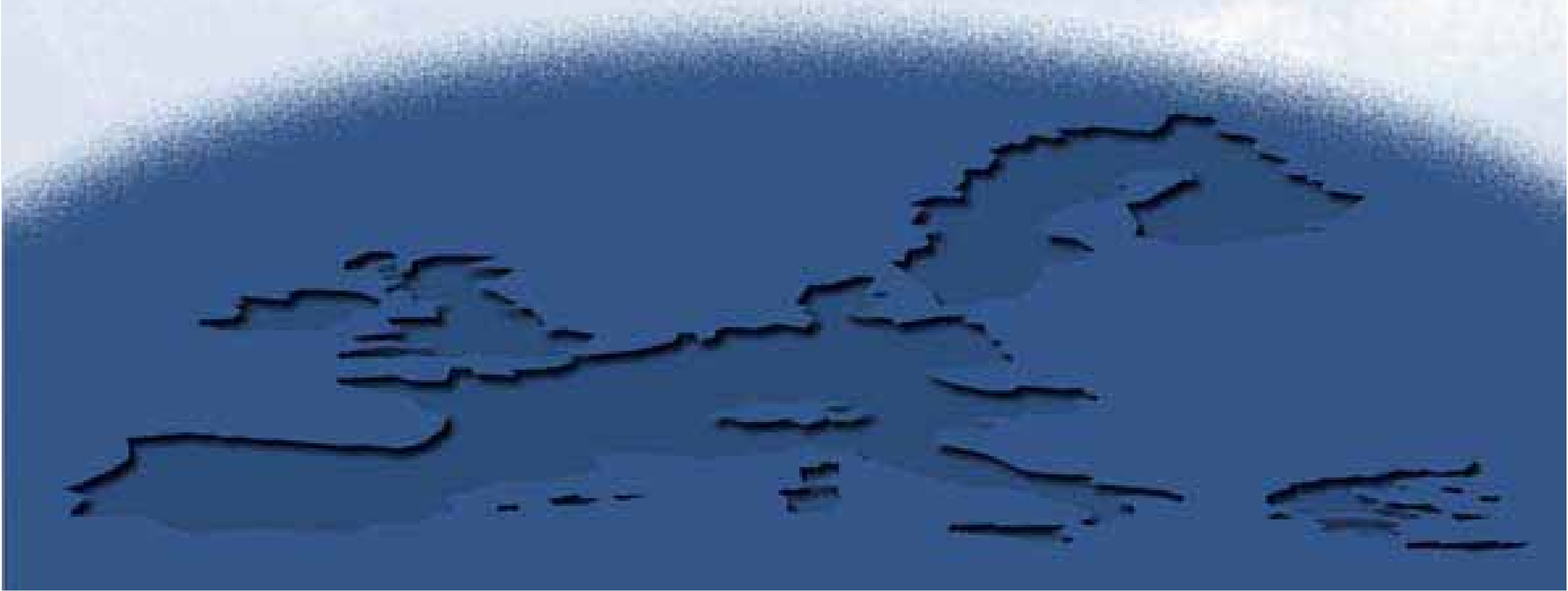
European Commission

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 4

Identification and Designation of Heavily Modified and Artificial Water Bodies



COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 4

Identification and Designation of Heavily Modified and Artificial Water Bodies

Produced by Working Group 2.2 - HMWB

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FOREWORD

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, an informal working group dedicated to the identification and designation of heavily modified and artificial water bodies within implementation of the Water Framework Directive was set up in April 2000 and named HMWB WG 2.2. The United Kingdom and Germany (Joint Chair) have the responsibility of the secretariat and co-ordination of the Working Group that is composed of representatives from 12 Member States and Norway as well as stakeholders and a limited number of Accession Country representatives.

The present Guidance Document is the outcome of this Working Group. It contains the main output of the HMWB Working Group activities and discussions that have taken place since April 2000. It builds on 34 case studies and on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the process of the Guidance development through meetings, workshops, conferences or electronic communication media, without binding them in any way to its content.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders, Martin Marsden (Scottish Environment Protection Agency, UK), Dr. David Forrow (Environment Agency of England & Wales, UK), Dr. Ulrich Irmer and Dr. Bettina Rechenberg (Umweltbundesamt, D), for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a *living document* that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

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ABBREVIATIONS

A	Austria
AWA	Artificial Water Body/Bodies
B	Belgium
COAST	WG 2.4 Typology and Classification of Transitional and Coastal Waters
CIS	Common Implementation Strategy
D	Germany
Designation test 4(3)(a) / (b)	Designation test according to Article 4(3)(a) / (b) of the Water Framework Directive
E	Spain
EC	European Commission
EEB	European Environmental Bureau
EQR	Ecological Quality Ratio
ES	Ecological Status
EU	European Union
EUREAU	European Union of National Associations of Water Suppliers and Waste Water Services
EURELECTRIC	Union of the Electricity Industry
E&W	England & Wales, UK
F	France
FFH	Fauna Flora Habitat Directive
GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	WG 3.0 on Geographical Information Systems
GR	Greece
HES	High Ecological Status
HMWB	Heavily Modified Water Body/Bodies
IMPRESS	WG 2.1 Analysis of Pressures and Impacts
km	Kilometre
km^2	Square-kilometres
MEP	Maximum Ecological Potential
MS	Member State
NGO	Non Governmental Organisation
NI	Northern Ireland, UK

NL	Netherlands
NO	Norway
PA	Physical Alteration
POM	Programme of Measures
RBD	River Basin District
RBMP	River Basin Management Plan
RHS	River Habitat Survey, UK
REFCOND	WG 2.3 on Reference Conditions for Surface and Inland Waters
S	Sweden
SCG	Strategic Co-ordination Group
Scot	Scotland, UK
SF	Finland
UK	United Kingdom
WATECO	WG 2.6 on Economic Analysis
WFD	Water Framework Directive
WG	Working Group
WWF	World Wildlife Fund for Nature

1 STRUCTURE OF THE DOCUMENT

- ***Section 1*** gives an introduction to the purpose and key objectives of the Water Framework Directive and describes what has been done to support the implementation of Directive. For this purpose, the Section illustrates the development of a Common Implementation Strategy and the establishment of CIS Working Group (WG) 2.2 on HMWB, the activities and outputs of the Working Group and the purpose of this Guidance Document.

- ***Section 2*** offers explanations of the importance and consequences of AWB and HMWB designation in the implementation of the WFD and gives insight into the links between the HMWB & AWB WG and other CIS working groups.

- ***Section 3*** describes the overall HMWB & AWB designation process, giving a short description of the individual steps leading to the identification of HMWB and AWB. The Section describes the function of provisional identification in the first cycle of the River Basin Management and presents some important issues of the designation process.

- ***Section 4*** gives details of the six steps leading to the provisional identification of HMWB, from water body identification (step 1) to the question as to whether the changes in the water body characteristics are substantial and result from physical alterations by human activity (step 6).

- ***Section 5*** describes the steps 7-9, leading to the designation of HMWB.

- ***Section 6*** describes the requirement to establish reference conditions and environmental objectives on which status classification is based, and presents the steps leading to the establishment of appropriate values for the quality elements of MEP and GEP. The Section also describes the appropriate timing for identification of MEP and GEP (steps 10-11).

- ***Section 7*** summarises some important issues regarding measures and related cost considerations throughout the process. It sets the HMWB and AWB process into a time and river basin planning context and gives an outlook to the HMWB process in future RBMP-cycles.

- ***Annexes*** contain a glossary of important terms used in this Guidance Document, a Section on information required for the river basin management plan, a list of WFD citations relevant to HMWB and AWB designation, a list of references used in the production of the Guidance, a list of contact details of the Working Group members and a list of case studies produced in the context of the HMWB Working Group.

2 IMPLEMENTING THE DIRECTIVE: SETTING THE SCENE

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

2.1 DECEMBER 2000: A MILESTONE FOR WATER POLICY

2.1.1 A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that today form the foundation of the Water Framework Directive.

2.2 THE WATER FRAMEWORK DIRECTIVE: NEW CHALLENGES IN EU WATER POLICY

2.2.1 What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

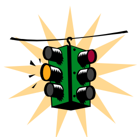
- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

2.2.2 …and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

2.2.3 What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory, assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 [Art. 3, Art. 24];
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 [Art. 5, Art. 6, Annex II, Annex III];
- To carry out, together with the European Commission, the intercalibration of the ecological status classification systems by 2006 [Art. 2(22), Annex V];
- To make operational the monitoring networks by 2006 [Art. 8];
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively [Art. 11, Annex III];
- To produce and publish River Basin Management Plans (RBMPs) for each RBD, including the designation of heavily modified water bodies, by 2009 [Art. 13, Art. 4(3)];
- To implement water pricing policies that enhance the sustainability of water resources by 2010 [Art. 9];
- To make the measures of the programme operational by 2012 [Art. 11];
- To implement the programmes of measures and achieve the environmental objectives by 2015 [Art. 4].



Look out!

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

2.2.4 Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular about:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

2.2.5 Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of *integration* that is seen as the key to the management of water protection within the river basin district:

Integration of environmental objectives, combining qualitative and quantitative ecological objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;

Integration of all water resources, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;

Integration of all water uses, functions and values into a common policy framework, i.e. considering water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, as well as water as a social good;

Integration of disciplines, analyses and expertise, combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;

Integration of water legislation into a common and coherent framework. The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to match modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;

Integration of all significant management and ecological aspects relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;

Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach for achieving the environmental objectives of the Directive. Programmes of measures are defined in River Basin Management Plans developed for each river basin district;

Integration of stakeholders and the civil society in decision making, by promoting transparency and information to the public, and by offering a unique opportunity for involving stakeholders in the development of river basin management plans;

Integration of different decision-making levels that influence water resources and water status, be they local, regional or national, for an effective management of all waters;

Integration of water management from different Member States, for river basins shared by several countries, existing and/or future Member States of the European Union.

2.3 WHAT HAS BEEN DONE TO SUPPORT IMPLEMENTATION?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

2.3.1 May 2001 – Sweden: Member States, Norway and the European Commission agreed on a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance. A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission who take on the role of overall decision body for the Common Implementation Strategy.

2.3.2 The HMWB Working Group

In accordance with Article 4(3), the Water Framework Directive (WFD) allows Member States to designate surface water bodies, which have been physically altered by human activity, as "heavily modified" under specific circumstances. If the specified uses of such water bodies (i.e. navigation, hydropower, water supply or flood defence) or the "wider environment" would be significantly affected by the restoration measures required to achieve good ecological status and if no other better, technically feasible and cost-effective, environmental options exist, then these water bodies may be designated as "heavily modified" and good ecological potential is the environmental objective.

As part of the EU WFD Common Implementation Strategy (CIS), a working group was established to develop Guidance on the process of HMWB and AWB designation. The CIS Working Group 2.2 on "Heavily Modified Water Bodies" (HMWB) is jointly managed by the United Kingdom and Germany and involves the participation of 12 Member States (MS),[1] Norway, some Accession Countries[2] as well as a number of Stakeholders.[3] A number of distinct "sub projects" were progressed by the Working Group:

- Production of 12 "Guidance papers" by the joint chair of the HMWB WG that were discussed at several Working Group meetings;
- thirty-four case study projects, carried out in the MS and Norway, that tested the "Guidance papers";
- a synthesis of the case study reports;
- production of this HMWB & AWB Guidance Document;
- production of a policy summary; and
- production of a toolbox supporting the Guidance Document.

Based on the main uses within the case studies, two "case study subgroups" were established, one concentrating mainly on "navigation", the other one on "hydropower" (see Annex V). The Working Group members and/or contractors responsible for these case studies exchanged their experiences during their work in extra subgroup meetings and in email discussions.

2.3.3 Production of 12 Guidance papers

The joint chair of the HMWB WG produced 12 Guidance papers covering the key aspects of the HMWB & AWB identification and designation process. Four meetings were organised involving the Working Group members and the European Commission to discuss and agree on these Guidance papers and to exchange experiences. The meetings were held on 12th April, 10th October 2000, 4th September 2001 and 18-19th June 2002 in Brussels. The Guidance papers were to help the production of the case studies which tested these papers. The Guidance papers served as the basis for this Guidance Document.

2.3.4 Case Study Project

In thirty-four case studies from different Member States and Norway a draft provisional identification and designation process for heavily modified water bodies was tested, supported by reference to the Guidance papers produced by the joint chair

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1 Austria, Belgium, Denmark, Spain, France, Germany, Greece, Netherlands, Portugal, Sweden, Finland and UK.

2 Hungary, Poland and Slovenia. The other seven Accession Countries are also members of the group but have so far not attended a working group meeting or the workshop.

3 EEB, EUREAU, Eurelectric and WWF.

of the HMWB WG. In these case studies, ecological reference conditions (maximum ecological potential) and objectives (good ecological potential) for HMWB were also defined, as far as possible. The case studies focused on the main specified uses (navigation, flood/coastal protection, hydropower generation, agriculture, forestry, urbanisation, recreation and water supply) that result in physical alterations across the MS. The case studies covered mainly rivers, only a few case studies were carried out on coastal waters (1), estuaries (2) and lakes (3). The case study projects started in October 2000 and were finalised in June 2002. For a list of case studies see Annex V.

2.3.5 European Synthesis Project

The synthesis project performed an analysis of the case studies and a synthesis of approaches taken in the individual case studies, identifying commonality and differences in approach. The analysis started in February 2002 and a first draft was distributed by the end of April 2002 (Hansen *et al.* 2002). A second draft will be produced as soon as possible and the final document will be published. The first draft of the synthesis project formed the basis for the production of this Guidance Document and the toolbox, providing examples of different designation approaches.

2.3.6 Production of the Guidance Document

Based on the draft synthesis report and on the twelve Working Group papers prepared by the Joint Chair (UK and D) and discussed during the first three meetings of this WG, a first draft Guidance on the designation of heavily modified and artificial water bodies was produced on 27th May 2002.[4] A workshop was held on the 30-31st May 2002 for Working Group members, case-study managers, and the other CIS WG members to discuss a number of outstanding issues of the draft Guidance Document. The discussions during the workshop served as a basis for the revision of the draft Guidance Document. A second draft[5] was then discussed at the last WG meeting in June 2002. A third draft[6] was produced and circulated to the WG for comments in August 2002. A final version of the Guidance[7] was produced and submitted to the Strategic Co-ordination Group meeting on 30th September 2002. It was then revised and presented to the Strategic Co-ordination Group meeting on 7-8th November 2002. This final version was agreed at the Water Directors meeting on 21st-22nd November 2002.

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[4] Guidance Document on identification and designation of Heavily Modified Water Bodies, First draft, CIS Working Group 2.2 on Heavily Modified Water Bodies, 27 May 2002.

[5] Guidance Document on identification and designation of [Artificial and] Heavily Modified Water Bodies, Second draft, CIS Working Group 2.2 on Heavily Modified Water Bodies, 15 June 2002. Directly after the WG meeting in June, a Second Draft dated 20 June was sent to the WG, including a different version of Section 6.

[6] Guidance Document on identification and designation of Artificial and Heavily Modified Water Bodies, Third draft, CIS Working Group 2.2 on Heavily Modified Water Bodies, 2 August 2002.

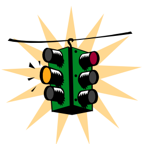
[7] Guidance Document on identification and designation of Artificial and Heavily Modified Water Bodies, Final draft, CIS Working Group 2.2 on Heavily Modified Water Bodies, 13 September 2002.

2.3.7 Production of the Policy Summary

The policy summary is an executive summary of the HMWB and AWB Guidance Document, addressed to the Water Directors. The document summarises the main issues of the HMWB and AWB designation process and is derived directly from the Guidance Document. It was presented and agreed at the Water Directors meeting together with the Guidance Document in November 2002.

2.3.8 Production of the Toolbox

To support the Guidance Document with practical examples illustrating the different steps of the HMWB and AWB designation process, a toolbox has been produced, extracting examples from the case studies. Working Group members have been asked to provide additional examples that help illustrate certain steps of the Guidance Document. A first draft was produced for the WG meeting in June 2002. A second draft was sent out for comments in October 2002 and a final toolbox has been issued in January 2003. The applicability of the toolbox will depend on the examples and will differ between the Member States. The toolbox does not constitute part of the Guidance Document and has hence not been subject to the agreement of the HMWB Working Group.



Look out! You can contact the experts involved in the HMWB activities.

The list of members of the Working Group with full contact details can be found in Annex 8.5. If you need more information on specific issues and input into your own activities, contact a member of the Working Group in your country. If you need more information on specific case studies, you can also directly contact the people in charge of carrying out these studies (contacts can be found in Table 5, Annex 8.6). You can find the case study reports on the following webpage:
http://www.sepa.org.uk/hmwbworkinggroup.

2.4 INTRODUCTION - A GUIDANCE DOCUMENT: WHAT FOR?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the identification and designation of artificial and heavily modified water bodies in the broader context of the development of integrated river basin management plans as required by the Directive.

The purpose of this Guidance is to introduce the requirements of the WFD with respect to HMWB and AWB identification and designation and to serve as a practical implementation guide for those who will be actively involved in the implementation of the WFD including the designation of HMWB and AWB. As the WFD does not always define or describe the terms and approaches to be used, and because some parts are ambiguous, this Guidance aims to develop a common understanding and interpretation of the WFD for the HMWB and AWB designation process and may, in part, describe pragmatic operational approaches to meet the WFD requirements.

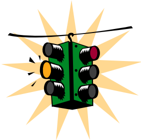
2.4.1 To whom is this Guidance Document addressed?

The Guidance Document is addressed to:

- administrative bodies responsible for implementing the WFD;
- administrative bodies influenced by the implementation of the WFD;
- planning engineers and other technical experts;
- interested public; and
- other stakeholders affected by the implementation of the WFD, especially with regards to the designation of HMWB (NGOs, water supply companies, hydropower, shipping, industry).

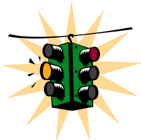
2.4.2 What can you find in this Guidance Document?

1. An introduction to the role of HMWB and AWB designation in the Water Framework Directive:
    - What are the key regulations of the Water Framework Directive concerning the identification and designation of HMWB and AWB? (see Annex III). What are the reference conditions and environmental objectives for these water bodies?
    - Links to other CIS working groups (see Section 3.2).
2. Practical Guidance on the stepwise approach of identifying and designating HMWB and AWB and setting reference conditions and environmental quality objectives:
    - Overall step-by-step approach of the HMWB and AWB identification and designation process (see Section 4).
    - Guidance on how to implement the different steps:
        - Provisional identification of HMWB (see Section 5);
        - Designation of HMWB and AWB (see Section 6);
        - Identification of reference conditions (MEP) and environmental quality objectives (GEP) for HMWB and AWB (see Section 7).
3. Cross-cutting issues and outlook (see Section 8).



Look out! The approaches and methodology in this Guidance Document must be adapted to regional and national circumstances.

The Guidance Document proposes an overall step-by-step approach. Because of the diversity of circumstances within the European Union, specific application may vary between the different water bodies across Europe. This proposed approach will therefore need to be tailored to specific circumstances.



Look out! What you will not find in this Guidance Document

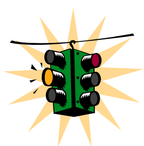
This Guidance Document is concerned with the designation of HMWB and AWB resulting from existing physical modifications. Implications from planned, new modifications [Art. 4(7)] are not considered in this document; the Guidance focuses on the first river basin management planning cycle (2008/9). The Guidance does not cover physically modified or artificial water bodies that Member States do not choose to designate. The Guidance is only concerned with water bodies where hydromorphological changes are a direct or indirect consequence of physical alterations which serve a specified use or the wider environmental interests.

3 HMWB AND AWB IN THE WATER FRAMEWORK DIRECTIVE

3.1 IMPORTANCE OF AWB AND HMWB IN THE IMPLEMENTATION OF THE WFD

For surface waters the overall goal of the Water Framework Directive (WFD) is for Member States to achieve "good ecological and chemical status" in all bodies of surface water by 2015. Some water bodies may not achieve this objective for different reasons. Under certain conditions the WFD permits Member States to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB) according to Article 4(3) WFD. The assignment of less stringent objectives to water bodies and an extension of the timing for achieving the objectives is possible under other particular circumstances. These derogations are laid out in Articles 4(4) and 4(5) of the WFD.

HMWB are bodies of water which, as a result of physical alterations by human activity, are substantially changed in character and cannot, therefore, meet "good ecological status" (GES). AWB are water bodies created by human activity. Instead of "good ecological status", the environmental objective for HMWB and for AWB is good ecological potential (GEP), which has to be achieved by 2015.



Look out! Purpose of Article 4(3) and its links to Article 4(4) and 4(5)

Article 4(3) is intended to be applied to major infrastructure projects associated with the listed specified uses. Such water bodies must be substantially changed in character because of hydromorphological alterations. Under these circumstances the tests specified in Article 4(3) may allow other objectives (GEP) for these waters because GES cannot be achieved

Article 4(5) deals with derogations for all waters including those concerned with hydromorphological alterations. Less stringent objectives can be set under specific circumstances. Article 4(4) allows for an extension of the deadline to achieve the environmental objective under certain conditions.

Where it is not possible to designate a water body subject to hydromorphological changes as HMWB then Article 4(4) or 4(5) derogations may apply. If a water body is designated as HMWB or AWB then Article 4(5) and/or 4(4) may be applied if GEP cannot be achieved.

The designation of HMWB and AWB is optional; Member States do not have to designate modified water bodies as HMWB or AWB.[8] The designation will not be an opportunity to avoid achieving ecological and chemical objectives, since GEP is an ecological objective which may often, in itself, be challenging to achieve.

The designation may, in some instances, help to protect wider environmental interests; e.g. when the removal of a modification would lead to the destruction of valuable environmental features. [9]

3.1.1 What is a Heavily Modified Water?

The concept of HMWB was introduced into the WFD in recognition that many water bodies in Europe have been subject to major physical alterations so as to allow for a range of water uses. Article 4(3)(a) lists the following types of activities which were considered likely to result in a water body being designated as a HMWB:

- navigation, including port facilities, or recreation;
- activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;
- water regulation, flood protection, land drainage;
- other equally important sustainable human development activities.

These specified uses tend to require considerable hydromorphological changes to water bodies of such a scale that restoration to "good ecological status" (GES) may not be achievable even in the long-term without preventing the continuation of the specified use. The concept of HMWB was created to allow for the continuation of these specified uses which provide valuable social and economic benefits but at the same time allow mitigation measures to improve water quality.

The designation tests can be applied when a:

- specified use results in a modification of a water body and restoration affects the specified use;
- non specified use results in the modification of a water body but restoration affects a specified use;
- non-specified or specified use results in the modification of a water body but restoration affects the wider environment.

8 Where modified or artificial waters are not designated the objective will be good ecological status.

9 The removal of a weir or dam may, for example, impact significant ecological (e.g. biodiversity) or historical (old mill) features. By designating the water body as heavily modified, the weir or dam probably will not have to be removed.

Article 2(9)

"Heavily modified water body means a body of surface water which as a result of physical alterations by human activity is substantially changed in character as designated by the Member State in accordance with the provisions of Annex II".

According to Article 2(9), there are three components to the definition of HMWB. To be a HMWB a water body must be:

- physically altered by human activity;
- substantially changed in character;
- designated under Annex II (Art. 4(3))[10].

The definition of HMWB provided in Article 2(9) emphasises that HMWB are considered to be water bodies that have been subject to physical alteration as a result of human activity. Article 4(3)(a) indicates that the relevant physical alterations result in hydromorphological changes that would have to be restored to achieve good ecological status. Consequently, this Guidance considers that hydromorphological changes result from physical alterations to the water body.

It is important to emphasise that changes in hydromorphology must be not only significant, but also result in a substantial change in the character of a water body, as typically found when a river is extensively modified for navigation, a lake modified for water storage or a transitional water when subject to major modifications for coastal defence. Such water bodies can be seen to be obviously modified and the modifications are neither temporary nor intermittent.

Considering the specified uses given under Article 4(3)(a) it is concluded that a "substantial" change in hydromorphology is one that is:

- extensive/widespread or profound; or
- very obvious in the sense of a major deviation from the hydromorphological characteristics that would have been there before the alterations.

It is clear that a water body could be described as substantially changed in character if <u>both</u> its morphology and hydrology were subject to substantial changes. It is less clear that a water body should be considered as substantially changed in character if only its morphology or its hydrology is substantially changed.

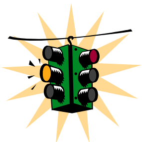
If the morphology of a water body is substantially changed in character, then the changes are likely to be long-term. Such changes in morphology are very likely to result in changes in hydrology, though these changes in hydrology may not necessarily

[10] The reference to Annex II is an error in the text. The early version of the WFD included the designation test in Annex II. The reference was not updated when the European Parliament Amendment moved the designation to Article 4(3).

be substantial. A common sense approach would suggest that such water bodies should be considered as substantially changed in character.

The situation is more difficult for water bodies subject to substantial changes in hydrology as such changes may only be temporary or short term. The water body may look substantially changed on one occasion but it may look like a normal water body on another occasion. In cases of temporary or intermittent substantial hydrological changes the water body is not to be considered substantially changed in character. Nevertheless, it may be that in some limited circumstances substantial hydrological alterations may result in long-term or permanent changes with additional substantial changes in morphology. In such specific cases, the application of the HMWB designation tests may be justified. Justification for the decision of a HMWB and AWB designation should always be provided.

Notwithstanding the agreed general approach described in the paragraph above, it was agreed that a slightly different approach could be taken for limited stretches of rivers, e.g. downstream of dams. Under these circumstances, substantial hydrological changes that are accompanied by subsequent non-substantial morphological changes would be sufficient to consider the water body for a provisional identification as HMWB.



Look out! A HMWB is substantially changed in character as a result of physical alterations

In the context of HMWB designation physical alterations mean any significant alterations that have resulted in substantial changes to the hydromorphology of a water body such that the water body is substantially changed in character. In general these hydromorphological characteristics are long-term and alter morphological <u>and</u> hydrological characteristics.

3.1.2 What is an artificial water body ?

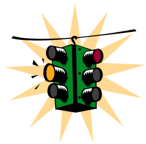
The WFD takes a very similar approach to AWB and HMWB. AWB must have been created by the same specified uses listed in Article 4(3)(a).

<u>Article 2(8)</u>

"Artificial water body means a body of surface water created by human activity".

A key question in order to differentiate between AWB and HMWB is the meaning of the word "created" as used in Article 2(8). More specifically, the question is whether "created" refers to creating a new water body from previously dry land (e.g. a canal), or whether it could also denote a water body that has changed in category (e.g. river into a lake as a consequence of damming, or coastal water into a freshwater lake due to reclaiming).

This Guidance interprets an AWB "as a surface water body which has been created in a location where no water body existed before and which has not been created by the direct physical alteration or movement or realignment of an existing water body". Note, this does not mean that there was only dry land present before. There may have been minor ponds, tributaries or ditches which were not regarded as discrete and significant elements of surface water. Where an existing water body is modified and moved to a new location (i.e. where previously there was dry land) it should still be regarded as a HMWB and not an AWB. The same applies to water bodies that have changed category as a result of physical modifications; such water bodies (e.g. a reservoir created by damming a river) are to be regarded as HMWB and not as AWB.



Look out! An AWB is created by human activity

An artificial water body is a surface water body which has been created in a location where no water body existed before and which has not been created by the direct physical alteration, movement or realignment of an existing water body.

3.1.3 Environmental objectives and designation of HMWB and AWB

Where a water body is substantially changed in character as a result of physical alterations by human activity, the WFD allows Member States to designate it as a HMWB. If a water body has been created by human activity then it may be designated as AWB. In order to designate a water body, it must undergo tests defined within Article 4(3). These tests require consideration of whether the restoration measures required to achieve "Good Ecological Status" (GES) have a significant adverse effect on the activity (use) and whether there are other means of undertaking the activity.

Once designated as HMWB or AWB, the environmental objectives are "good ecological potential" (GEP) and good chemical status, which also have to be achieved by 2015.

GEP is a less stringent objective than GES because it makes allowances for the ecological impacts resulting from those physical alterations that (i) are necessary to support a specified use or (ii) must be maintained to avoid adverse effects on the wider environment. This means that appropriate objectives can be set for the management of other pressures, including physical pressures, not associated with the specified use, while ensuring that the adverse ecological effects of the physical alteration can be appropriately mitigated without undermining the benefits they serve.

The objective setting process for HMWB and AWB should be in line with the same general principles as applied for natural water bodies.

The environmental objectives for natural, artificial and heavily modified water bodies are set in relation to reference conditions. For HMWB and AWB the reference condition is the maximum ecological potential (MEP).[11] The MEP is the state where the biological status reflects, as far as possible, that of the closest comparable surface water body taking into account the modified characteristics of the water body. With regards to its biological status the GEP accommodates "slight changes" from the MEP.

The designation of HMWB and AWB, the definition of the MEP, the identification of GEP as well as the programme of measures to achieve the relevant environmental objectives will be part of the River Basin Management Plans that are to be published by 2008 as first consultation drafts and 2009 as final plans. These have to be revised every six years.

3.2 LINKS TO OTHER WORKING GROUPS OF THE COMMON IMPLEMENTATION STRATEGY

It is important to read the HMWB & AWB Guidance in the context of the Guidance produced by the other CIS working groups. This Section describes the most important links between the HMWB and other working groups within the Common Implementation Strategy (CIS) and identifies those areas where a common understanding has been developed.

3.2.1 Pressures and Impacts Working Group 2.1 (IMPRESS)

The provisional identification of heavily modified water bodies is carried out in the characterisation process as specified in Article 5 and Annex II. The WG 2.1 IMPRESS provides the guidance on the description of pressures and impacts and the identification of water bodies which are at risk of failing their environmental objectives ("risk assessment") (WFD CIS Guidance Document No. 3).

It has been agreed that the HMWB Working Group would develop Guidance on that aspect of the characterisation process which is related to physical alterations of water bodies and their possible identification as HMWB. The HMWB & AWB Guidance together with the information provided by the HMWB case studies would then be used by IMPRESS to develop an integrated approach to the entire characterisation process. Within the overall risk assessment of IMPRESS, the HMWB WG will provide guidance on the identification and description of specified uses and related physical alterations (pressures) as well as their impacts on hydromorphology and biology.

Further integration of processes developed by the HMWB and IMPRESS working groups may be required. This should be done in co-operation with WG 2.9 on "best practice in river basin planning".

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11 For natural water bodies the reference condition is the "high ecological status" (HES).

3.2.2 Freshwater reference condition Working Group 2.3 (REFCOND) & Coastal waters typology, reference and classification Working Group 2.4 (COAST)

The "status" and "potential" WFD objectives and classifications are based on similar principles. Reference conditions are identified and then similar normative definitions (Annex V) are used to define the deviation from reference for each classification category. It is clearly important to ensure that this deviation is of a similar scale for HMWB and AWB as it is for "natural" waters (WFD CIS Guidance Document No. 10 – REFCOND and WFD CIS Guidance Document No. 5 – COAST).

3.2.3 Intercalibration Working Group 2.5

The Intercalibration Working Group will ensure that the interpretation of the WFD's normative definitions of high, good and moderate (Annex V) result in comparable deviation from reference conditions (WFD CIS Guidance Document No. 6). In particular, the WG 2.5 should ensure that the sensitivity boundaries between the high/good and good/moderate borders are comparable across Europe. The reference conditions for HMWB and AWB are determined by the nearest natural equivalent to the modified water body. This means that reference conditions for HMWB and AWB will be variable depending on the degree and type of modification. Discussions between the HMWB and Intercalibration working groups have led to an agreement that in most cases intercalibration of ecological potential boundaries is not required. Nevertheless an intercalibration exercise for HMWB and AWB could be useful, if those water bodies are the dominating water types.

3.2.4 Economic Analysis Working Group 2.6 (WATECO)

Another part of the Article 5 characterisation process is the economic analysis of water use. This forms the basis of the Article 9 on recovery of costs for water services and the consideration of the Article 4(3) tests for HMWB designation and Article 4(4), (5) and (7) derogations. The HMWB and WATECO working groups have worked together to ensure that the Guidance on the HMWB & AWB designation tests is based on a common understanding which ensures consistent applications of economic terms across the WFD requirements (WFD CIS Guidance Document No. 1).

3.2.5 Monitoring Working Group 2.7

The monitoring regime forms the basis for the definition of status according to the WFD. The Guidance produced by the Monitoring Working Group will therefore assist Member States in understanding the monitoring requirements for the identification of potential HMWB (WFD CIS Guidance Document No. 7). In the first planning cycle, WFD-compliant monitoring/classification tools will not be available, so Guidance on best practice is needed to ensure that existing data/methods are used to the best effect. The monitoring group could also help to identify the appropriate monitoring approach for heavily modified and artificial waters. The HMWB & AWB Guidance will provide recommendations for the use of the most sensitive biological elements concerning physical alterations.

3.2.6 River Basin Management Best Practice Working Group 2.9

The HMWB and AWB designation process is only one aspect of the RBMP and must be fully integrated with the key components of the Plan, for example: setting environmental objectives and identification of the most cost effective combination of measures. The HMWB & AWB Guidance provides a timetable based on the Directive's requirements. However, substantial changes to this timetable will be necessary in order to ensure that the sequence of tasks required by the RBMP can be delivered (WFD CIS Guidance Document No.s 8 and 11). This revised timetable is provided within the Best Practice Guidance.

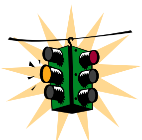
3.2.7 Geographical Information System Working Group 3.0 (GIS)

The links to the GIS Working Group are relatively straightforward and relate to the requirements to map the distribution of provisional identified HMWB and AWB (by 2004) and designated water bodies (in 2008/9) (WFD CIS Guidance Document No. 9). It may also be helpful to map the distribution of the relevant pressures which result in the designation of HMWB & AWB.

4 STEPWISE APPROACH FOR DESIGNATION OF HMWB AND AWB

A very large number of water bodies will have to be assessed for possible designation as AWB or HMWB between now and 2008/2009 (publication of the first draft/final RBMP) (for timing and RBMP see Sections 8.2, 8.3, and Annex II). It will be important therefore to ensure that the approaches and methods used for the designation process are practicable and comparable in all Member States. Moreover, it is important to develop appropriate options so that the complexity of the assessment methodology can be made proportionate to the circumstances. In the first planning cycle, there are serious practical difficulties in designating the HMWB, in defining MEP and GEP and in performing an assessment of the likelihood of not achieving the relevant environmental quality objectives in 2004 as required by Article 5 (and Annex II). The IMPRESS and HMWB working groups have therefore recommended, that for the provisional identification in 2004, the assessment for HMWB will be carried out against GES. This helps to overcome the practical difficulties of defining the MEP & GEP for HMWB at this early stage. For the assessments it might, under certain circumstances, be possible and advisable to group water bodies and assess them together.

Figure 1 illustrates the proposed overall stepwise approach to the identification and designation of HMWB and AWB as identified by HMWB-WG 2.2. In this Section, the steps of the general approach are summarised (steps 1 – 11), while the following Sections 5 - 7 describe the steps in more detail, including some proposed methods and explanations. It should be noted that step 1 and 3-5 are broader than the HMWB and AWB process. Step 1 is applicable to all water bodies and involves the application of the WFD CIS Guidance Document No. 2 on water body identification. Steps 3-5 are part of the broader Annex II (1.4 & 1.5) assessment of pressures and impacts, which is described in the IMPRESS Guidance (WFD CIS Guidance Document No. 3). **No additional work beyond that required under IMPRESS is required as part of these steps.**



Look out! Processes should be integrated to ensure consistency and avoid duplication in effort

The HMWB and AWB designation process described in this Guidance, when put into operational guidance by MS, should be integrated with other Guidance (e.g. CIS Guidance Document No. 3 - IMPRESS) to ensure consistency in approach and avoid duplication in effort.

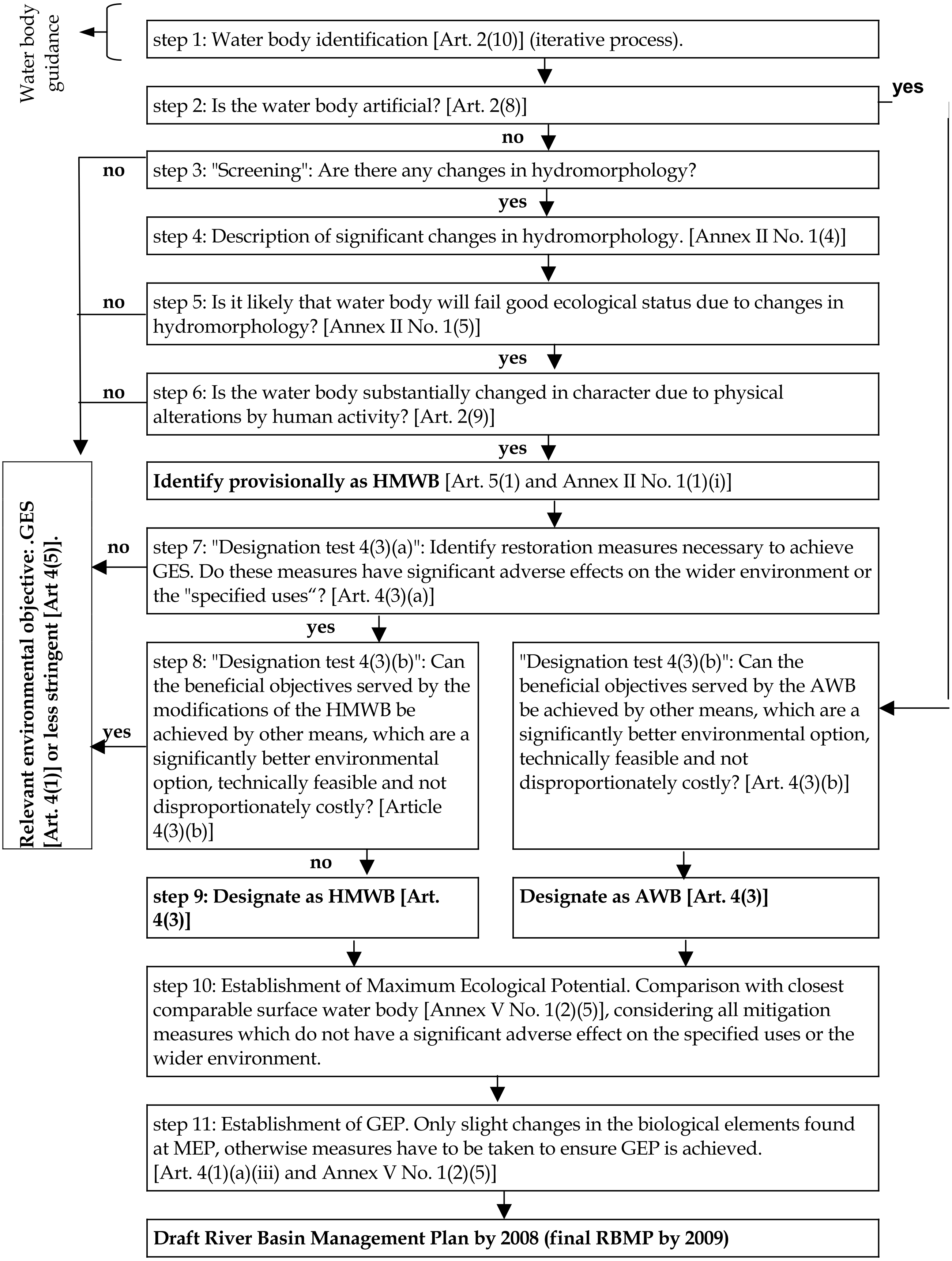


Figure 1: Steps of the HMWB & AWB identification and designation process

- **Step 1:** Distinct water bodies are to be identified and described according to the WFD CIS Guidance Document No. 2 on water body identification. Water body identification is an iterative procedure with possible adaptations in later stages of the designation process (mainly after step 6, the provisional identification of HMWB). The water body identification has to be done for all surface waters (natural, heavily modified and artificial waters), and is significant, because water bodies are the units for which status is being assessed, objectives established and achievement of objectives of the WFD checked.

- **Step 2:** The WFD gives distinct definitions for AWB and HMWB [Art. 2(8) and Art. 2(9) respectively]. In this second step it should be identified whether the water body concerned has been "created by human activity". If this is the case, Member States will have the option to identify it as AWB and consider it for designation or, in some circumstances, identify it as a natural water body. Where the intention is to designate as AWB, the first designation test (step 7) is not relevant and AWB should continue directly with the second designation test (step 8).

- **Step 3:** A screening process is proposed to reduce effort and time in identifying water bodies which should not be considered for the HMWB designation tests. This will include those water bodies that are likely to fail to achieve GES but which show no hydromorphological changes. This step is part of the Annex II (1.4) assessment of pressures.

- **Step 4:** For those water bodies which have not been "screened out" in step 3, significant changes in hydromorphology and resulting impacts should be further investigated and described. This includes the description of hydromorphological changes and the assessment of resulting impacts. This step is part of the Annex II (1.4 & 1.5) assessment of pressures and impacts.

- **Step 5:** Based on the information gathered in step 4 and an assessment of the ecological status of the water body, the likelihood of failing to achieve good ecological status (or an estimate of what GES may be, based on current knowledge) should be assessed. Within this step it has to be assessed whether the reasons for failing the GES are hydromorphological changes and not other pressures such as toxic substances or other quality problems. This step is part of the Annex II (1.5) assessment of impacts process to be completed by 22 December 2004.

The Guidance Document of IMPRESS[12] will give more explicit guidance for steps 3-5; in particular, guidance on the "risk assessment". The Monitoring Working Group will deal with the monitoring requirements for water bodies "at risk" as well as for all other water bodies.

- **Step 6:** The purpose of this step is to select those water bodies where the changes in hydromorphology result in the water body being substantially changed in character. Such water bodies can be provisionally identified as HMWB. The remaining water bodies likely to fail GES, which are not substantially changed in character, will be identified as natural water bodies. Environmental objectives for such water bodies will be GES or other less stringent environmental objectives.

12 WFD CIS Guidance Document No. 3 - IMPRESS.

It is only necessary to collect sufficient information during steps 1, 3, 4 & 5 to demonstrate that pressures and impacts result in a failure to achieve good status (as described by the WFD CIS Guidance Document No 3. - IMPRESS) and in step 6 (first step of the HMWB process) that the water body is substantially changed in character. These requirements can be satisfied in a simple descriptive manner in clear cut cases. For example, if a water body has irreversibly and definitely changed category, then it is easy to demonstrate that pressures and impacts prevent the achievement of GES (of the original water body category) and that it is substantially changed in character.

- **Steps 7-8-9**: Where Member States wish to designate a water body as heavily modified they must then consider them for the designation tests specified under Article 4(3)(a) & Article 4(3)(b). Artificial water bodies are only considered for the test under Article 4(3)(b). In the first "designation test" (**step 7**) necessary hydromorphological changes ("restoration measures") to achieve "good ecological status" should be identified. In the first test it has to be assessed whether these "measures" have significant adverse effects on either the "specified uses" or the "wider environment". If they do, then the second designation test (**step 8**) is to be carried out.

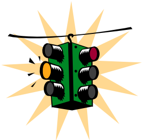
  The second designation test consists of several sub-tests. Firstly, "other means" to achieve the beneficial objective (e.g. replacement of surface water for drinking water supply with groundwater) are to be considered. Then, it has to be assessed whether the "other means" are a) technically feasible, b) a better environmental option and c) not disproportionately costly. If any of the sub-tests a), b) or c) are negative, the water bodies may be designated as heavily modified (**step 9**). If either the mitigation measures have no significant adverse effects (see step 7) or if "other means" can be found that fulfil the criteria a), b) or c) (see step 8), the water body must <u>not</u> be designated as heavily modified and the relevant environmental objective would be GES or a less stringent objective.

- **Steps 10-11:** These steps are not part of the designation process. However, they are relevant to AWB and HMWB only and are therefore covered in this Guidance Document. They concern the definition of reference conditions and the setting of the environmental quality objectives for heavily modified and artificial water bodies. In **step 10** the reference condition for HMWB and AWB, the Maximum Ecological Potential (MEP), is defined. Based on the MEP, the environmental quality objective, the Good Ecological Potential (GEP), is defined (**step 11**).

The information gathered in the different steps (1-11) summarised above will contribute to the RBMP. The RBMP will contain programmes of measures [Art. 11] that are required to ensure the achievement of the environmental objectives for natural, heavily modified and artificial water bodies.

In following the flow chart, it is clearly important to avoid unnecessary and superfluous administrative actions. For example, it will not always be necessary to undertake the assessment for each individual water body. Indeed in many situations it may be more effective to apply the tests to a group of water bodies where the environmental concerns and specified uses are similar. For example, for a river modified for navigation it may not be helpful to apply the process to individual water bodies. A larger scale assessment may produce a more effective and more complete assessment.

Similarly, for a major estuarine flood protection scheme, it may be more effectively assessed at the multi-water body level than by considering each individual water body.



Look out! Information on the measures and related costs and on timing and future RBMP cycles is given in Section 7!

Throughout the entire process different measures are considered in different steps. Related to these different measures there are differing cost considerations applicable; a summary is given in Section 8.1. Timing as well as changes in the future RBMP cycles are important when dealing with HMWB and AWB; these issues are covered in Sections 8.2 and 8.3.

5 STEPS LEADING TO THE PROVISIONAL IDENTIFICATION OF HMWB

5.1 INTRODUCTION

This Section considers steps 1 to 6 which lead to the provisional identification of HMWB in more detail.

These steps are part of the characterisation of River Basin District requirements as defined in Annex II of the WFD. Consequently the steps are closely linked to the work of the IMPRESS Working Group. A summary of the process is illustrated in Figure 2.

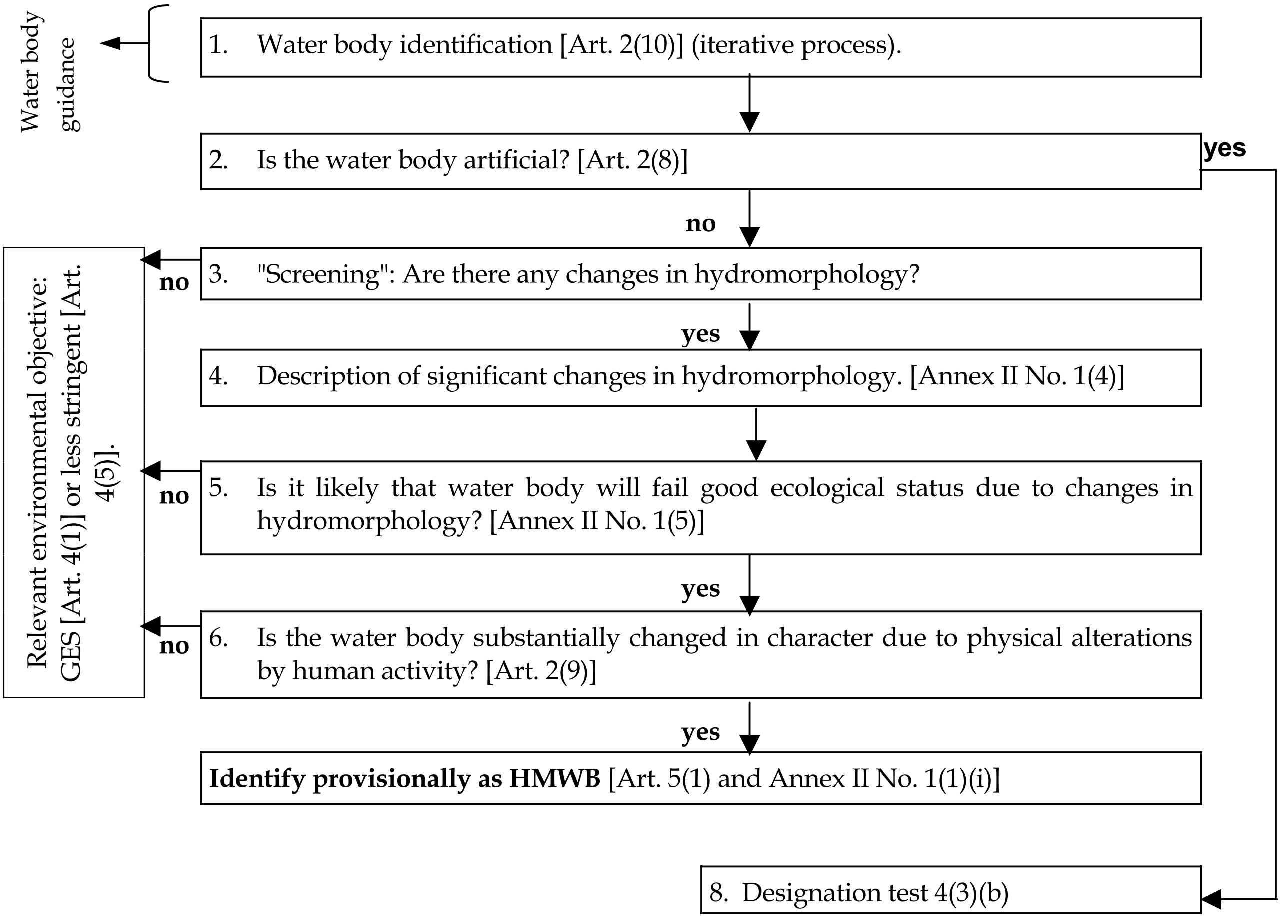
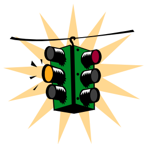


Figure 2: Steps leading to the provisional identification of HMWB

5.2 WATER BODY IDENTIFICATION (Step 1)

Water bodies have to be identified for all surface waters (natural, heavily modified and artificial waters). This step is of major importance for the implementation process, because water bodies represent the units that will be used for reporting and assessing compliance with the Directive's principal environmental objectives. Overall recommendations on how to identify distinct water bodies are given in the WFD CIS Guidance Document No. 2 on water body identification. This Guidance Document on HMWB and AWB discusses issues specifically relevant to water body identification for "physically altered" waters, as far as these are not included in the WFD CIS Guidance Document No. 2 (Examples in the toolbox).



Look out! Possibility to group water bodies for assessment

In some cases it will be possible to group water bodies for the identification and / or designation of HMWB and AWB. This could help to reduce the overall work load. The WFD CIS Guidance Document No. 2 on water bodies will indicate under which circumstances water bodies can be grouped for the assessments.

5.3 IS THE WATER BODY ARTIFICIAL (Step 2)?

The WFD gives distinct definitions for AWB and HMWB [Art. 2(8) and Art. 2(9) respectively] (see Section 3.1). In this second step it should be identified whether the water body concerned is an AWB, i.e. has been "created by human activity".

An artificial water body is defined, in this Guidance, as a surface water body which has been created in a location where no significant surface water existed before and which has not been created by the direct physical alteration of an existing water body or movement or realignment of an existing water body. Note, this does not mean that there was only dry land present before. There may have been minor ponds, tributaries or ditches, which were not regarded as a discrete and significant element of surface water and therefore not identified as a water body.

If the above characterisation of a water body is fulfilled, Member States will have the option to identify them as AWB and consider them for designation or, in some circumstances, identify them as natural water bodies. If a Member State considers that GES can be achieved in an AWB, then the Member State may wish to consider the AWB as a natural water body. This would allow GES to be defined for the water body rather than GEP (Examples in the toolbox).

5.3.1 Examples

AWB: Examples of AWB include canals constructed for navigation, drainage channels for irrigation, man-made ponds and dug ponds, harbours and docks, constructed dredging pools, gravel pits, surface mining lakes, storage reservoir for peak demand hydropower production or waters that are directed to the reservoir via diversions, and water bodies created by ancient human activities.

Not AWB: A water body that has changed category as a result of physical modifications is not an AWB, it is considered to be a HMWB (e.g. creation of a reservoir due to the damming of a river). AWB are not water bodies that have been moved or realigned, for example, a realigned river going through a newly developed channel on previously dry land. Such realignments involve the modification of an existing water body and consequently the new channels may be regarded as a HMWB.

Where the intention is to designate as AWB, the first designation test (step 7) is not relevant and the AWB should continue directly with the second designation test (step 8).

5.4 SCREENING (Step 3)

A screening process (step 3) is proposed to reduce effort and time in identifying water bodies which should not be considered for the HMWB designation tests. This will include those water bodies that are likely to fail to achieve GES but which show no hydromorphological changes (Examples in the toolbox).

5.5 SIGNIFICANT CHANGES IN HYDROMORPHOLOGY (Step 4)

For those water bodies which have not been "screened out" in step 3, significant anthropogenic pressures and the resulting impacts should be further investigated and described [Annex II No. 1.4]. This step 4 is part of the characterisation of surface waters as required in Art. 5(1) by December 2004.

5.5.1 This characterisation involves the identification and description of:

1. the main "specified uses" of the water body;
2. significant anthropogenic pressures [Annex II No. 1.4]; and
3. significant impacts of these pressures on hydromorphology [Annex II No. 1.5].

5.5.2 1. Identification and description of **the main "specified uses" of the water body:**

- navigation, including port facilities, or recreation;
- activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;
- water regulation, flood protection, land drainage; or
- other equally important sustainable development activities.

5.5.3 2. Identification and description of **significant anthropogenic pressures** [Annex II No. 1.4]:

Specified uses of water bodies generally result in pressures that might impact the status of the water body. In the context of HMWB and AWB identification and designation process, changes to hydromorphology resulting from "physical alterations" are relevant [Art. 2(9)].

Physical alterations include alterations in the morphology and hydrology of the water regime (compare glossary and step 6). For example, the most common physical alterations include dams and weirs, which disrupt the river continuum and cause alterations of the hydrologic and hydraulic regime. Physical alterations should usually serve a specified use, such as straightening for the purpose of navigation. However, physical alterations which do not serve a particular specified use any longer, should also be identified and described in the characterisation (e.g. weirs used to maintain water levels for mills which are no longer in use).

For the characterisation it is important to find out which pressures are of "significance", because only significant pressures (or physical alterations) are to be considered. Member States may use qualitative or quantitative approaches to describe the degree and level of significance of the physical alterations (Examples in the toolbox).

5.5.4 3. Identification and description of **significant impacts on hydromorphology** [Annex II No. 1.5]:

The significant impacts on hydromorphology should be further investigated. Both qualitative and quantitative appraisal techniques can be used for assessing impacts on hydromorphology resulting from physical alterations (Examples in the toolbox). The elements examined should include the elements required by the WFD [Annex V No. 1.1: river continuity, hydrological regime, morphological conditions, tidal regime], as far as data are available.

Special attention should be given to cumulative effects of hydromorphological changes. Small-scale hydromorphological changes may not cause extensive hydromorphological impacts on their own, but may have a significant impact when acting together. To assess the significant impacts on hydromorphology, an appropriate scale should be chosen (see also Guidance of the WG 2.1[13]). The following issues in scaling should be considered in assessing impacts and in the identification and designation of HMWB and AWB:

- Scaling due to impact assessment changes according to the pressure and impact characteristics, i.e. some pressures have lower thresholds for wide-scale impacts than others;
- Scaling may change according to the water body type and ecosystem susceptibility. Spatial and temporal scale (resolution of impact assessment) should be more precise in such water body types and specific ecosystems which are considered susceptible to the pressure.

[13] WFD CIS Guidance Document No, 3 "Analysis of Pressures and Impacts in the Water Framework Directive - Common Understanding", produced by the CIS WG 2.1.

5.6 LIKELIHOOD OF FAILING GOOD ECOLOGICAL STATUS (Step 5)

Based on the information gathered in step 4 and an assessment of the ecological status, the likelihood of failing to achieve good ecological status (or an estimate of what GES may be, based on current knowledge) should be assessed [Annex II No. 1.5]. This should consider whether the risk of failing GES is due to hydromorphological changes and not other pressures such as toxic substances or other quality problems. Step 5 is part of the "risk assessment"[14] process to be completed by 22 December 2004.

In order to assess the likelihood of failing to achieve GES, the ecological impacts of physical alterations on the water bodies in question should be estimated (Example in the toolbox). The effort expended in the assessments should be proportionate (i.e. a tiered assessment approach should be used). For water bodies which are likely not to achieve GES (e. g. water bodies which have changed category due to physical alterations), effort expended estimating GES should be limited and conclusions of non-achievement of GES should be rapidly reached. In these cases more effort can be expended in assessing GEP early and the risk of not achieving it could be investigated. Likewise, through risk screening, a conclusion on excluding those water bodies which are clearly going to reach GES from the HMWB or AWB identification and designation process should be reached early and with minimal effort.

5.6.1 Data requirements

For the implementation of the WFD a large amount of data is needed. The quality elements for water bodies are listed in Annex II No. 1 and include hydromorphological, chemical as well as biological data. The quality elements differ according to the water categories. For the HMWB identification and designation process data are not only necessary in step 5, but also in the different designation tests (steps 7 and 8), the establishment of MEP (step 10) and of GEP (step 11).

The assessment of the ecological status, necessary for the "risk assessment", can be based directly on biology. Alternatively indicative data (hydromorphological and physicochemical elements) can be used in situations where only these data are available (Example in Section 2.6 of the toolbox on provisional identification of regulated lakes in Finland is of relevance). According to the WFD, the biological status of a surface water is to be assessed using the appropriate elements in the different water categories [Annex V No. 1.1]. It is suggested that the preliminary assessment of the ecological status, to be completed by 2004, should be based on the most sensitive quality elements with respect to the existing physical alterations. It must be noted, however, that this procedure concentrates on the effects of physical alterations on some sensitive elements of the aquatic ecosystem.

To detect the reason for the possible failure of the environmental objective (i.e. the good status or potential) of a water body, indicative parameters differ according to the causes. The HMWB & AWB Guidance is particularly concerned with indicative data to

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14 The "risk assessment" is undertaken as part of the Article 5 characterisation process and identifies the likelihood of water bodies to fail the environmental quality objectives set under Article 4.

detect hydromorphological changes. Effects resulting from other impacts (e.g. toxic effects on macroinvertebrates, eutrophication concerning macrophytes) should be differentiated as far as possible. Some suggestions on the suitability of biological elements as indicators for physical alterations are made below:

- Benthic invertebrate fauna and fish are the most relevant groups for the assessment of hydropower generation impacts in freshwater systems;
- Long distance migrating fish species can serve as a criteria for the assessment of disruption in river continuity;
- Macrophytes are good indicators of changes in flow downstream of reservoirs as well as for the assessment of regulated lakes because they are sensitive to water level fluctuation;
- For linear physical alterations such as coastal defence work, benthic invertebrates and macroalgae might be the most appropriate indicators.

Defining the extent of ecological damage in the manner required by the WFD will not be possible until common ecological monitoring is in place by 2006. Since step 5 of the HMWB identification and designation process should be completed by 2004 (in time for the initial characterisation as in Art. 5), assessments may be estimates based on existing biological monitoring data and ecological classification systems.

Wetlands

Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in the WFD CIS Guidance Document No. 2 on water bodies and further considered in the Guidance on wetlands (currently under preparation).

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of the river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within the programmes of measures is examined further in a separate horizontal Guidance paper on wetlands (currently under preparation).

Look out! Links to other CIS working groups

Guidance on how to define reference conditions for assessing the ecological status of surface water bodies is being developed by the CIS WGs 2.3 (REFCOND) in WFD CIS Guidance Document No. 10 and WG 2.4 in WFD CIS Guidance Document No. 5 (COAST). The WFD CIS Guidance Document No. 3 of WG 2.1 IMPRESS will give more explicit Guidance for carrying out the "characterisation" and the "risk assessment". The Monitoring Working Group WG 2.7 (WFD CIS Guidance Document No. 7) will set the monitoring requirements for water bodies "at risk" as well as for all other water bodies.

5.7 IS THE WATER BODY SUBSTANTIALLY CHANGED IN CHARACTER DUE TO PHYSICAL ALTERATIONS BY HUMAN ACTIVITY (step 6)? PROVISIONAL IDENTIFICATION OF HMWB

If it is likely that the water body will fail to achieve good ecological status due to hydromorphological changes then a range of options exist for objective setting. In some cases, restoration measures can be taken before 2015, which will allow the water body to reach GES. In other circumstances, an extension of the deadline by the application of the Article 4(4) derogation will allow the water body to achieve GES later.[15] Clearly, less stringent environmental objectives can also be set if an Article 4(5) derogation is appropriate. These approaches will be required in those circumstances where a water body is subject to significant changes in hydromorphology but is not substantially changed in character.

If a water body is to be provisionally identified as heavily modified (Examples in the toolbox) the following criteria apply:

1. The failure to achieve good status results from **physical alterations** to the hydromorphological characteristics of a water body. It must not be due to other impacts, such as physico-chemical impacts (pollution);

2. The water body must be **substantially changed in character**. This is the case when there is a major change in the appearance of the water body. It is clearly a partly subjective decision as to whether a water body is (a) only significantly changed in character (e.g. water abstraction without morphological alterations) or (b) substantially changed in character when provisional identification as HMWB may be appropriate (e.g. long-term hydromorphological changes caused by a weir). Both may be likely not to achieve GES. However, the following considerations should be borne in mind:

    - When visiting a water body that is substantially changed in character, it should be very obvious that the water body is substantially changed from its natural condition;

15 According to Article 4(4) the maximum extension of the deadline is 2027.

- The change in character must be extensive/widespread or profound. Typically this should involve substantial change to both the hydrology and morphology of the water body;
- The change in character must be permanent and not temporary or intermittent;
- Many alterations to the hydrological characteristics of water bodies, such as abstractions and discharges, are not associated with morphological changes, and may therefore often be easily reversible, temporary or short-term. Consequently, such alterations would not constitute substantial changes in the character of water bodies and hence the application of HMWB designation would not be considered;
- The modification must be consistent with the scale of change that results from the activities listed in Article 4(3)(a): a canalised river, a harbour, a river constrained for flood protection or a dammed river or lake.

3. The substantial change in character must be the result of the **specified uses**. It must have been created by uses listed in Article 4(3) or uses which represent equally important sustainable human development activities (either singly or in combination).

In Table 1, an overview of the main specified uses and the connected physical alterations and impacts on hydromorphology as well as on biology is given. A more extensive list of physical alterations and impacts on hydromorphology and biology can be found in the HMWB synthesis report (Hansen *et al*., 2002).

Table 1: Overview of the main specified uses, physical alterations and impacts

Specified Uses	**Naviga-tion**	**Flood protection**	**Hydro-power generation**	**Agriculture/ Forestry/ Fish farms**	**Water supply**	**Recreation**	**Urbani-sation[16]**
Physical Alterations (pressures)							
Dams & weirs	X	X	X	X	X	X	
Channel maintenance/dredging/ removal of material	X	X	X	X		X	
Shipping channels	X						
Channelisation/straightening	X	X	X	X	X		X
Bank reinforcement/fixation/ embankments	X	X	X		X		X
Land drainage				X			X
Land claim				X			X

16 Urbanisation is not mentioned in Article 4(3)(a), but has been identified as an important use in the HMWB case studies. Therefore it presumes that it is an important sustainable human development activity.

Specified Uses	Naviga-tion	Flood protection	Hydro-power generation	Agriculture/ Forestry/ Fish farms	Water supply	Recreation	Urbani-sation[16]
Creation of back waters through embankments	X					X	X
Impacts on hydromorphology and biology							
Disruption in river continuum & sediment transport	X	X	X	X	X	X	
Change in river profile	X	X	X	X			X
Detachment of ox-bow lakes/wetlands	X	X	X	X	X		X
Restriction/Loss of flood plains		X	X				X
Low/reduced flows			X	X	X		
Direct mechanical damage to fauna/flora	X		X			X	
Artificial discharge regime		X	X	X	X		
Change in groundwater level			X	X			X
Soil erosion/silting	X		X	X			X

If a water body is not designated and it becomes apparent later on that it probably is heavily modified, provisional identification as HMWB and application of the designation tests is still possible after 2004. Similarly if a water body is provisionally identified as HMWB, Member States do not have to complete designation. They can at any time consider it as a non-heavily modified water body and set appropriate objectives under Article 4(1)(a)(ii), 4(4) or 4(5).

5.7.1 Scope, scale and extent of provisional identification

Within the provisional HMWB identification, the scale, scope and extent of water body identification should be considered. It may be necessary to adapt the boundaries of the initially identified water bodies (step 1) according to the substantial changes in hydromorphology. More specifically, where the hydromorphogical changes do not coincide with the boundaries of a surface water body, it may be appropriate to subdivide the water body in order to separate heavily modified stretches from the unaffected areas of the water body.

The following three examples may be helpful for the decision on whether to subdivide water bodies or not under different circumstances (Figure 3 - Figure 5):

- In Figure 3, two physically altered areas cover a major percentage of the absolute length/area of the original water body (8 km out of 10 km). The water body is, to a large extent, impacted by the same pressure and it would therefore be suggested **not to split** the original water body, but to apply provisional HMWB identification to the whole water body;
- In Figure 4, the original water body is modified by a physically altered area (6 km) covering a major percentage of the entire length/area of the original water body. In

this case it would be recommended **to split** the original water body into two distinct water bodies (1a & 1b). Water body 1b, impacted by the physical alteration, would be provisionally identified as heavily modified. The water body 1a would be regarded as a natural water body;

- In Figure 5, a series of small physically altered areas each covering < 1 km are present at a small stretch of the entire water body length. Here the question occurs, whether those < 1 km stretches should be identified as distinct water bodies and be provisionally identified as HMWB, or whether the overall impact is low and therefore the whole water body should be regarded as a natural water body. It is suggested **not to split** the water body and regard the entire water body as natural.

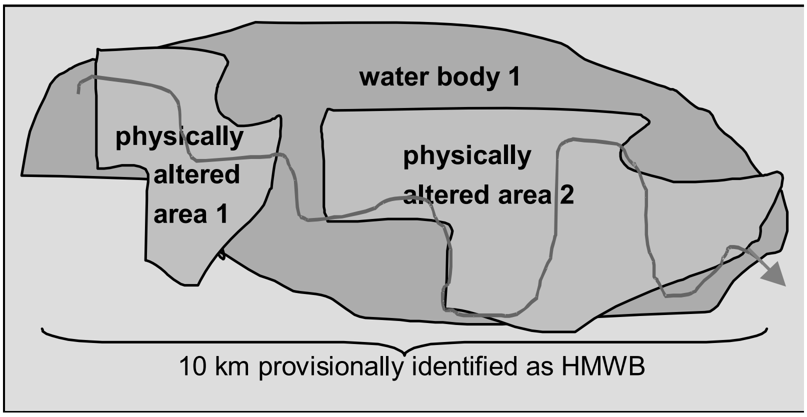

Figure 3: Example 1, no subdivision of the water body

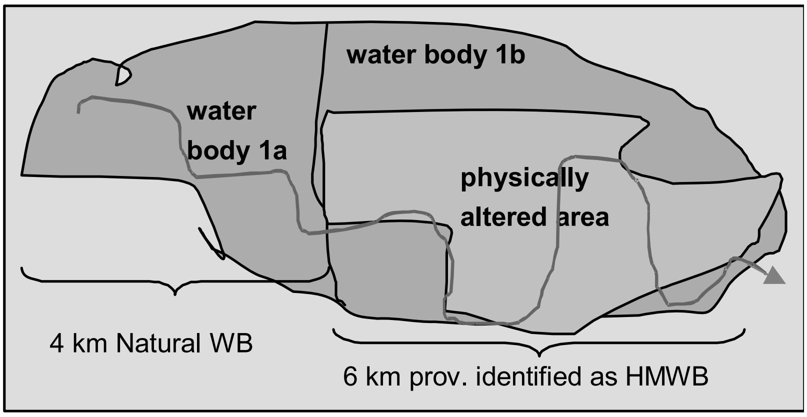

Figure 4: Example 2, subdivision of the water body

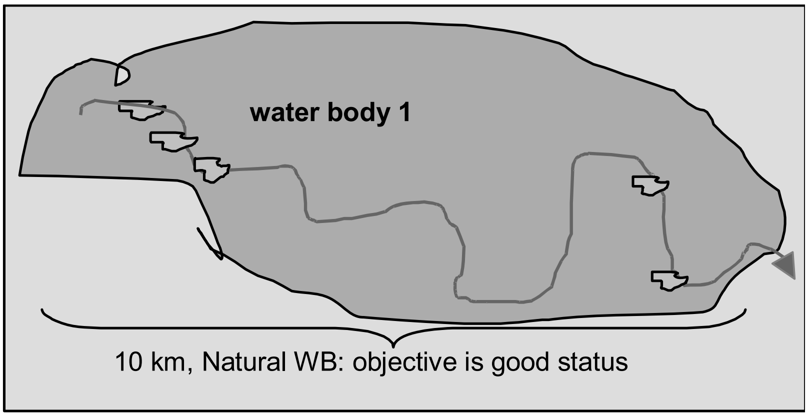

Figure 5: Example 3, no division of water body

Note: The provisional identification of HMWB refers to river stretches and not to the catchments or sub-catchments. In the three figures above the catchments are marked because it is difficult to only mark river stretches; the latter would be more appropriate.

Another important issue is that only water bodies which are substantially changed in character (due to physical alterations) themselves, may be provisionally identified as HMWB. If a physical alteration (e.g. dam) impacts the biological quality elements in the upstream part of a river system (for example fish migration is hindered), this upstream part may not be considered for provisional HMWB identification. If the GES cannot be achieved in this water body upstream of a physical alteration, the environmental objective may be less stringent.

6 TESTS LEADING TO THE DESIGNATION OF HMWB (Steps 7 - 9)

6.1 TIMING FOR DESIGNATION TESTS

Water bodies that have been provisionally identified as heavily modified (cf. Section 5) may be considered for designation.[17] The designation process must be completed in time for the consultation of the draft RBMP in 2008 and final publication of the RBMP in 2009. The designation process should be undertaken as soon as possible after the provisional identification. In addition it will be important to co-ordinate the designation process with the other requirements of the RBM planning process. In particular, the links to the following requirements should be considered:

- The designation process helps to identify which "restoration measures" or "other means" may be required to meet the environmental quality objective. Additionally, "mitigation measures" will be identified in the reference condition and objective setting process (cf. Section 7). These "mitigation measures" must be identified in time to allow for the assessment of the most cost effective programmes of measures for the draft RBMP in 2008 and for ensuring that the programmes of measures are operational by 2012 [Art. 11(7)];

- It may be efficient to undertake the designation process at the same time as the setting of less-stringent environmental objectives [Art. 4(5)] for both natural and HMWB which include similar tests (e.g. consideration of disproportionate costs).

6.2 DESIGNATION IS OPTIONAL AND ITERATIVE

It is stressed that Member States **may** designate a water body as artificial or heavily modified.

Provisionally identified HMWB do not, therefore, necessarily have to be considered for the designation tests, in this Section 6. Member States may decide not to proceed with the designation process at any stage, and may decide to consider the water body as natural, having to achieve GES. This decision may be influenced by additional information that may have become available since the identification process was performed.

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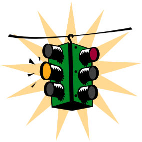
[17] Also other water bodies that have not been provisionally identified as HMWB may additionally be considered if evidence shows that they are at risk to fail the GES due to physical alterations (see Section 6.2).



Look out! Designation is optional!

The designation of HMWB and AWB is optional. Member States can choose not to designate a water body as a AWB or HMWB. The designation tests can be stopped at any point in the process. In this case the water body would be treated as a natural water body and the environmental quality objective would be GES.

For several reasons, water bodies designated as heavily modified in the first cycle may be regarded as natural water bodies in future cycles and vice-versa (Section 8). Designation is hence an iterative process. It should also be pointed out that new data or information may reveal water bodies, which have not been provisionally identified (in steps 1-6), as heavily modified, that should be considered for the designation tests. In future RBMP cycles, the designation of HMWB must be reviewed (cf. Section 8).

6.3 THE DESIGNATION TESTS

A water body may be designated as heavily modified if it has passed through the designation procedure involving both designation tests as specified under Article 4(3)(a) & (b) (steps 7 and 8). In some cases both tests do not have to be carried out entirely, see Figure 6.

For AWB only the designation test 4(3)(b) applies (see Section 6.8).

The designation tests are designed to ensure that HMWB are only designated where there are no reasonable opportunities for achieving good status within a water body. They are therefore water body specific. However, where the designation tests are applied at a regional or national scale it may be appropriate to apply the test to groups of water bodies, to reduce the overall work load involved in the designation tests. For example, if the main stem of a river was being considered for designation as a series of HMWB because it is used for navigation, it should be possible to consider the tests for groups of water bodies within the affected stretch. If water bodies are grouped, there must be no differences in the characteristics of the water bodies or the specified uses which could affect the outcome of the designation tests. Justification for grouping water bodies should be provided.

A step-wise approach for the identification and designation of HMWB and AWB which includes the designation tests is presented in Section 4. Figure 6 is based on Figure 1 but identifies more detail on the "Designation test 4(3)(a)" (step 7) and "Designation test 4(3)(b)" (step 8), which consist of several sub-steps.

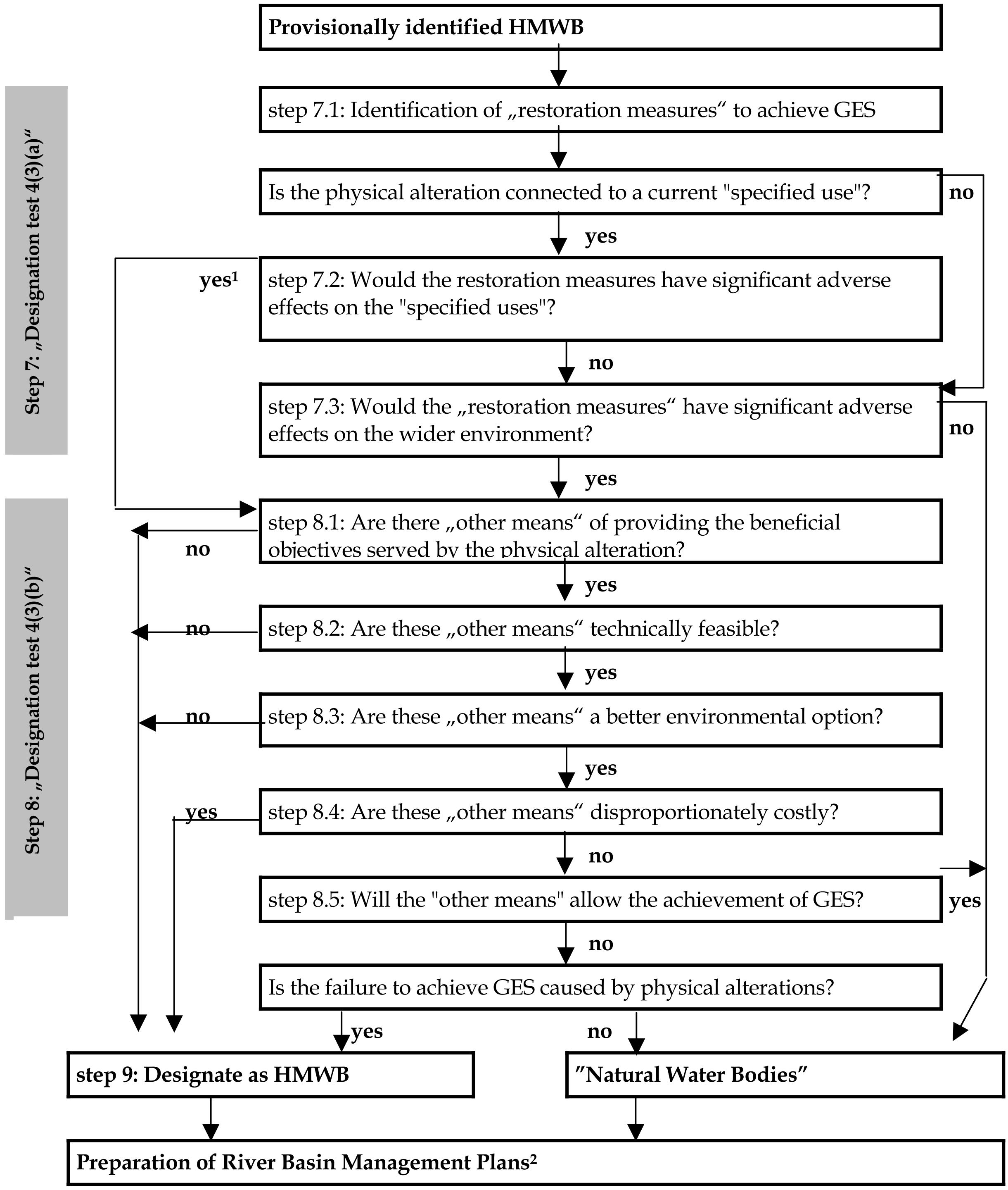


Figure 6: Steps leading to the designation of HMWB (steps 7-9)

Note 1: Step 7.2: If the restoration measures would have significant adverse effects on the "specified uses" you could directly proceed to the "Designation test 4(3)(b)", step 8.1. But for a better justification for designation you may also want to apply step 7.3.

Note 2: Preparation of River Basin Management Plans including: identifying objectives, identifying programmes of measures (POM), cost effectiveness analysis, derogation for an extended timetable and less stringent objective, consideration of Article 4(8), to ensure no deterioration of other water bodies.

6.4 DESIGNATION TEST 4(3)(a) (Step 7)

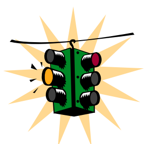
The designation test 4(3)(a) has three components, and is divided into sub-steps 7.1-7.3, accordingly (see Figure 6):

- First, the "restoration measures" for achieving GES are to be identified (step 7.1, see Section 6.4.1);
- Then, the adverse effects of these restoration measures on the specified uses have to be assessed (step 7.2, see Section 6.4.2); if the adverse effects on the specified uses **are significant**, you may go directly to step 8 (see Section 6.5), but you could also proceed to step 7.3 (see Note 1 to Figure 6). If they are **not significant** you proceed with:
- step 7.3 and assess whether the application of restoration measures would have significant adverse effects on the wider environment (see Section 5.4.3).

6.4.1 Identification of "restoration measures" to achieve GES (Step 7.1)

The first sub-step 7.1 of the designation test 4(3)(a) is to identify the hydromorphological changes which could lead to the achievement of GES. This process is complicated by the fact that water bodies will frequently be impacted by different pressures. Consequently, it will be necessary (but not always possible) to separate:

- measures to change hydromorphology;
- measures to improve the physico-chemical status; and
- direct measures to improve the biological status (such as manipulation of fish population or planting macrophytes).[18]



Look out! Hydromorphological conditions!

The Guidance Document for HMWB and AWB is dealing with hydromorphological conditions that result from physical alterations and with "restoration measures" which improve these hydromorphological conditions. The non-hydromorphological measures will <u>not</u> be considered in this Guidance Document but will be part of the programmes of measures (POM) to be set up for the RBMP.

The hydromorphological changes for achieving GES (hereafter called restoration measures) may range from measures aimed at reducing the environmental impact of

[18] All measures (including hydromorphological and physico-chemical improvements) ultimately aim to improve the biological status.

the physical alteration (e.g. increased compensation flows or fish passages) to measures resulting in the complete removal of the physical alteration. Measures can be directly related to the physical alteration (e.g. changing the physical alteration) or enhance the general ecological conditions (e.g. creation of habitats). In this sub-step the contribution that an individual measure could make towards achieving GES needs to be predicted. It should also be assessed whether an overall package of proposed restoration measures could lead to GES (Examples in the toolbox).

The measures should be well-defined (e.g. exact percentage of compensation flow) and should include an assessment of whether GES status will be delivered (full or partial delivery) (Example in the toolbox). Combinations of "partial" measures may allow GES to be achieved. The identification of suitable measures can be difficult, because information on the cause-effect relationship of measures is often not sufficient.

The costs of restoration measures are not considered here (see substep 7.2 and Section 8.1).

A list of examples for restoration measures for different specified uses ("navigation" and "hydropower") is given in the toolbox. This list can be used as an initial check list.

6.4.2 Significant adverse effects on specified uses (Step 7.2)

The second sub-step 7.2 of the designation test 4(3)(a) requires an assessment of whether the necessary "restoration measures" to achieve GES will have significant adverse effects on the specified uses (e.g. on navigation, on hydropower, on recreation, or on other specified uses).

It should be emphasised that the application of the test should consider the full range of possible restoration measures. For example, in a river, which has been modified for navigation that has artificial vertical embankments, it may be possible to create more natural banks which may allow GES to be achieved without causing significant adverse effects upon the use.

This sub-step 7.2 can only be applied to water bodies that have a current specified use-related physical alteration. If the physical alteration to the water body is due to a historic specified use which no longer exists, then you may directly proceed to step 7.3 (see Figure 6 and Section 6.4.7). Clearly, the specified uses of a water body may also change over time. For example, an abandoned drinking water supply reservoir may develop an important new specified use as a recreational resource (e.g. sailing). Then, the possible adverse effects on this changed specified use should be assessed in this sub-step 7.2.

6.4.3 What effects are to be considered?

Adverse effects on the specified uses are losses of/in important services (e.g. flood protection, recreation or navigation) or production losses (e.g. hydropower or agricultural goods) (Examples in the toolbox). In assessing "significant adverse effects" on the specified uses, economic effects will play an important role, but also social aspects may need to be considered (e.g. removal of flood defences may lead to displacement of population).

6.4.4 What aspects are not relevant in this sub-step?

In assessing whether the restoration measures have "significant adverse effects" on the specified use not all aspects are relevant. For example, when considering an estuary used for navigation, the focus of the test should be on the effect of restoration measures upon the movement of ships. The ability of the user to pay is not relevant at this stage as this would potentially discriminate against efficient and profitable enterprises. Similarly, at this stage disproportionate costs cannot be used as an additional consideration beyond the assessment of significant adverse effects on the specified use (see Section 8.1).

6.4.5 What is significant?

It is not considered possible to derive a standard definition for "significant" adverse effect. "Significance" will vary between sectors and will be influenced by the socio-economic priorities of Member States.

It is possible to give an indication of the difference between "significant adverse effect" and "adverse effect". A significant adverse effect on the specified use should not be small or unnoticeable but should make a notable difference to the use. For example, an effect should not normally be considered significant, where the effect on the specified use is smaller than the normal short-term variability in performance (e.g. output per kilowatt hour, level of flood protection, quantity of drinking water provided). However, the effect would clearly be significant if it compromised the long-term viability of the specified use by significantly reducing its performance. It is important to undertake this assessment at the appropriate scale. Effects can be determined at the level of a water body, a group of water bodies, a region, a RBD or at national scale. The appropriate scale will vary according to the situation and the type of specified use or sector. It will depend on the key spatial characteristics of the adverse effects. In some cases it may be appropriate to consider effects at more than one scale in order to ensure the most appropriate assessment. The starting point will usually be the assessment of local effects (Examples in the toolbox).

If the adverse effects are considered to be significant, the water body should be considered for the designation test 4(3)(b) (cf. Section 6.5). If there was no significant adverse effect on specified uses, the measures have to be checked as to whether they would have significant adverse effects on the wider environment (see Section 6.4.7, step 7.3).

6.4.6 If there is no specified use

Although the use for which the physical alteration was intended might not be there any more, in almost all cases the modified characteristics of the water body serve a specified use of some form (e.g. a dam originally built for water supply might alternatively be used for recreation).

In the rare cases where no uses whatsoever are served by the modified characteristics of the water body any more, step 7.2 of the designation test 4(3)(a) does not apply, since no specified uses exist upon which a restoration measure could have a significant adverse effect.

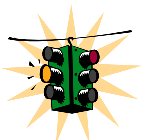
Proceeding to step 7.3, the possibility of the significant adverse effects of restoration measures on the wider environment needs to be assessed. If the restoration measures have a significant adverse effect on the environment, then the water body normally should be considered for the "designation test 4(3)(b)". However, without a specified use, “other means” for delivering the beneficial objectives of the specified use cannot be defined. Consequently, under these circumstances, if the wider environment is significantly affected by the restoration measures, the steps 8.2-8.5 are of no relevance and the water body can directly be designated as a HMWB.

6.4.7 Significant adverse effect on the wider environment (step 7.3)

The intent of this sub-step 7.3 of the designation test 4(3)(a) is to ensure that restoration measures required to achieve GES do not deliver environmental improvements for the water body whilst creating environmental problems elsewhere (Example in the toolbox).

6.4.8 What is the wider environment?

Article 4(3)(a) refers to the <u>wider</u> environment. Consequently a restricted definition of environment would not be appropriate and the environment is considered to include the natural environment and the human environment including archaeology, heritage, landscape and geomorphology.



Look out!

In general, a significant adverse effect on the wider environment would exist, if the damage to the wider environment caused by restoration measures exceeds the benefits for the improved water status itself (such as significantly increased $C0_2$ emissions or the generation and disposal of large quantities of demolition waste).

6.4.9 Examples of "restoration measures" that have an adverse effect on the wider environment

- Normally the restoration of flood plains increases the biodiversity of the environment. However, there may be some limited circumstances where the restoration of flood plains threatens a specific landscape and biodiversity that has developed over the years as a result of the elimination of the floods in riparian zones and former floodplains;
- The removal of a dam may lead to the elimination of wetlands that have developed in connection to the water storage;
- Building a channel around a physical obstacle to improve ecological continuum (see Section 7.2 MEP) to allow fish migration, may use considerable energy, damage an archaeological site and produce waste materials. It may therefore, in some circumstances, not be appropriate in relation to the benefit;
- A historical modification, such as a mill or a weir which no longer has a current specified use, may now have aesthetic or historical value. This feature should not necessarily be removed and some may wish to designate the affected water body as HMWB.

In general it has to be prevented that such adverse effects on the wider environment are significant.

This test also has links to Article 4(8) and 4(9) that require measures under the WFD to be consistent with the requirements of existing Community Environmental legislation. For example, where the modified water body or its floodplain is (or is to be) designated under another directive such as the Fauna Flora Habitat or the Birds Directive, the requirements for these directives must be taken into account. "Restoration measures" that would result in conflicts with these directives should be considered as having a "significant effect on the environment".

The importance of the improvement which would be delivered by the restoration measures relative to the impact on the wider environment has to be considered here. It would, for example, not be appropriate if a large environmental improvement programme was prevented because of a significant adverse effect on a small component of the wider environment (e.g. a reservoir that serves no current purpose which results in a valuable (local) wetland; removing the dam would result in losing the wetland, but it would allow fish migration for a large river length (region). In this example, the fish migration would probably represent a larger improvement to the environment than the loss of wetland, but it strongly depends on the circumstances).

If there are no significant adverse effects upon the specified use or the wider environment, the provisional HMWB should be regarded as a natural water body and restoration measures should be undertaken to ensure that the GES can be reached. In some circumstances, Article 4(4) or 4(5) derogations will be appropriate and less stringent environmental objectives may be set.

If there are significant adverse effects on either the specified use or on the wider environment then the water body should proceed to designation test 4(3)(b).

6.4.10 Significant adverse effect and timing

The WFD requires Member States to achieve good status by 2015. Timing is therefore a relevant consideration in the Art.4(3)(a) test. The selection of measures should allow for the achievement of GES by 2015, or if derogations under Art. 4(4) apply, by 2021 or 2027. The assessment should therefore first consider whether there is a significant adverse effect on the specified use or environment up to 2015. If there is a significant adverse effect then the time period up to 2021 and then 2027 should be considered.

6.5 DESIGNATION TEST ACCORDING TO ARTICLE 4(3)(b) (Step 8)

The designation test 4(3)(b) considers whether the beneficial objectives served by the modified characteristics of the water body can reasonably be achieved by "other means" (step 8.1), which are:

- technically feasible (cf. Section 6.5.2, step 8.2);
- significantly better environmental options (cf. Section 6.5.3, step 8.3); and
- not disproportionately costly (cf. Section 6.5.4, step 8.4).

Water bodies for which "other means" can be found that fulfil these three criteria and can achieve the beneficial objectives of the modified characteristics of the water body may not be designated as HMWB. The existing specified use may, in some cases, be abandoned and the physical alterations removed so that good status can be achieved.

6.5.1 Identification of "other means" for achieving the beneficial objectives (Step 8.1)

In considering the Article 4(3)(b) test it is important to distinguish between:

- "restoration measures", which are covered under the "designation test 4(3)(a)" (step 7), and involve changes to the existing specified use in order to achieve GES; and
- "other means" which will deliver the beneficial objectives of the modified characteristics of the water body and involve the replacement or displacement of the existing specified use.

The Article 4(3)(b) test should only consider the potential for "other means" of delivering the beneficial objectives of the modified characteristics of the water body, including the benefits of specified uses and the wider environment. Other means may include the following options:

- Displacement of the specified use to another water body. For example, the replacement of a hydropower station with a new one (in another water body) where it causes less environmental damage. Another example would be stopping navigation in one river because a canal connection would provide alternative transport links (Example in the toolbox);

- Replacement of the existing specified use with an alternative option to deliver the beneficial objectives. For example, replacing hydropower with other energy sources, or replacing navigation with rail and road transport at lower environmental costs, alternative flood defence strategies such as restoration of upstream flood-plains to remove flood defence hard engineering downstream, i.e. soft-engineering as opposed to hard-engineering solutions (Example in the toolbox).

The partial replacement or displacement of the beneficial objectives of the specified use should also be considered, while not necessarily allowing the achievement of GES.

6.5.2 Assessment of "technical feasibility" of "other means" (Step 8.2)

It then has to be assessed whether these "other means" are technically feasible. Technical feasibility is put here as the first check as it represents a relatively simple test and there is clearly no value in assessing the environmental impact of options that are not technically feasible.

"Technical feasibility" considerations include the practical, technical and engineering aspects of implementing the "other means". It addresses the question of whether “other means” of delivering the beneficial objectives of an existing specified use exist. It should not include consideration of disproportionate costs; these will be assessed as part of the later component of the test (step 8.4) (Example in the toolbox).

There may be some circumstances where it is appropriate to consider social issues which constrain the development of “other means”. The use of such social constraints should be fully explained within the RBMP.

6.5.3 Assessment of whether “other means” are better environmental options (Step 8.3)

The purpose of this sub-section 8.3 of the Article 4(3)(b) test is to ensure that proposed “other means” do represent a better environmental option and that one environmental problem is not replaced with another. The test is, therefore, similar in concept to the earlier Article 4(3)(a) test, which assessed whether possible measures have a “significant adverse effect on the wider environment” (step 7.3).

When assessing other means as better environmental options, the following issues should be considered:

- <u>Scope of "environment" in better environmental option:</u> It is suggested that in order to ensure a consistent approach with the Article 4(3)(a) test, the assessment should include - where appropriate - consideration of the “wider environment” such as archaeology and urban and other landscapes;
- <u>Issue of scale:</u> There is a range of scales at which the question of “better environmental options” can be assessed: local, regional, RBD, national or

international level. Clearly it may be appropriate to consider the impacts and benefits just on the water environment or on the wider environment (water, land, air). In the first instance it is suggested that the assessment should focus on local options. Further considerations should then be considered where appropriate.

An example for this is the possible replacement of navigation on a large river system. In this instance it may be appropriate to include an assessment at a regional, national or international level taking into account increased road or rail traffic and the potential impact on $C0_2$ emissions.

It is clear that the most appropriate scale used to assess "better environmental option" will depend on the kind of "other means" under consideration. Where there is uncertainty about the appropriate scale an assessment should be carried out at different scales (Examples in the toolbox).

6.5.4 Assessment of disproportionate costs of "other means" (Step 8.4)

Those "other means" which are considered to be "technically feasible" and which represent a "significantly better environmental option" should be subject to an assessment of whether they are "disproportionately costly".

This assessment is likely to focus on financial/economic costs. However, there may be some circumstances where it may be appropriate to consider social issues as part of the assessment of disproportionality of costs.

In undertaking this assessment it is important to take account of likely or planned capital expenditures associated with the existing specified use; this should include planned expenditures up to 2027, where appropriate. This is particularly appropriate (and important) in cases where the existing specified use is associated with large scale engineering works which are subject to regular maintenance, replacement or upgrading.

This represents a key baseline, against which the incremental costs and benefits of the alternative 'other means' are to be analysed and presented.

The following two options are recommended for assessing disproportionate cost :

6.5.5 a) Comparison of cost alternatives

Disproportionate costs can be determined by assessing the incremental costs and environmental impacts of the "other means". The benefits of the existing specified use and the alternative are assumed to be the same. The main cost elements to be considered are:

- For the existing situation: operational and maintenance costs, and capital costs for necessary replacements (including investment and interest costs);
- For each option/alternative ("other means"): capital costs (including investment and interest costs), operational and maintenance costs, and possible foregone benefits from changes in economic activities (e.g. reduction in agricultural

production resulting from the development of a retention area as an alternative to dikes for preventing floods).

6.5.6 b) Comparison of overall costs and benefits

Disproportionate costs can be determined by comparing the overall costs and benefits of the existing modification and the alternative ("other means"). In this assessment the overall net benefit to society of the modification and of the alternative are compared. The main elements that are to be considered include:

- Costs as listed in a);
- benefits of the existing specified use; and
- benefits of the alternative, especially benefits gained from the higher ecological status (e.g. angling, recreation).

In order to ensure that the environmental impacts of the existing specified use are properly compared with the "other means", it is recommended to consider the:

- existing specified use; and
- "other means", subject to typical sector-specific best environmental practice.

It will be important to ensure that the economic and environmental appraisal of the "other means" are in line with the best practice techniques customarily used for each type of modification (e.g. flood defence, navigation etc.) to ensure that the "other means" thereby identified can actually be financed and implemented.

After having assessed the costs (and in case b) also the benefits) of the existing specified use and the "other means" it has to be decided whether the costs are disproportionate. To pass this test it is not sufficient to demonstrate that the costs exceed the benefits. The costs must be disproportionately greater than the benefits. Clearly it is not possible to define by how much the costs must exceed the benefits before they become disproportionate (Example in the toolbox).

In the context of economic assessments, the WFD CIS Guidance Document No. 1 produced by the CIS-WG 2.6 on WATECO should be considered.

Examples on the assessment of disproportionate costs are provided within the toolbox.

6.5.7 Will the "other means" allow the achievement of GES? (Step 8.5)

Under some circumstances the "other means" may represent only a **partial** replacement/displacement of the use. In these cases "other means" would fulfil all relevant criteria (steps 8.2 - 8.4) but GES still cannot be achieved due to physical alterations. This will result in those circumstances where a "better environmental option" should be realised, but GES still cannot be achieved. In the following, some examples are given:

- Example (a) If a water body is modified by two uses and it is possible to find "other means" of delivering the beneficial objective of one of the uses. The second use may still require physical alterations that prevent the water body from achieving GES;
- Example (b) If a water body is modified by a single use and it is possible to find "other means" of delivering a proportion of the beneficial objective of the use. For example, if "other means" are available that would supply 50% of the drinking water (for example from groundwater) then the variation in water levels will be reduced. This may still not allow the water body to achieve GES but it may represent a "significantly better environmental option". The result may be an improvement in the environmental quality of the reservoir and the river downstream and it may allow new additional uses of the reservoir for example recreation. Such "other means" which offer "better environmental options" but do not achieve GES should be undertaken as part of the programme of measures.

If GES is not achieved by the other means, and this is caused by the physical alterations, the water body may be designated as HMWB.

If GES can be achieved by the other means, the water body must be regarded as natural.

6.5.8 "Other means" and timing

The WFD requires Member States to achieve good status by 2015. Timing is also a relevant consideration in step 8 [the Article 4(3)(b) test]. The selection of "other means" (i.e. alternative options in the sense of displacement or replacement) should allow for the restoration of the site by 2015, or, if derogations under Article 4(4) apply, by 2021 or 2027. In particular, the time constraint may influence the decision as to whether the "other means" are technically feasible or disproportionately expensive as part of this step 8 [Article 4(3)(b) test].

The assessment should therefore firstly consider, whether the "other means" are technically feasible and not disproportionately expensive during the period up to 2015. If this is not the case, then it should be considered until 2021 or 2027.

6.6 DESIGNATION OF HMWB IN 2008 (Step 9)

A water body may be designated as HMWB if it has passed through the designation procedure involving, if applicable, both designation tests (steps 7 & 8).

After applying the designation tests, Member States may still decide that they do not wish to designate the water body as a HMWB.

If there are no significant adverse effects neither on the specified uses nor on the wider environment, or there are "other means" of delivering the beneficial objectives then the water body should be regarded as natural.

6.7 GUIDANCE ON METHODS FOR APPLYING THE DESIGNATION TESTS 4(3)(a) & (b) (for Steps 7 and 8)

A very large number of water bodies will have to be assessed for possible designation as HMWB until 2008/9. Consequently, the methods used to comply with the requirements of the designation tests must be proportionate and pragmatic. The purpose of this Section is to identify appropriate methodological options so that the complexity of the assessment methodology can be made proportionate to the circumstances.

In order to reduce the workload for the designation tests, the possibility exists to group the water bodies for the assessment (see Section 6.3). It should be stressed that water bodies should only be grouped if they require similar levels of assessment, for example, if purely descriptive methods are to be used because the water body is obviously substantially changed in character. However, it would be entirely inappropriate to group water bodies which are obviously substantially changed in character with others where a more detailed assessment would be necessary to decide whether they are HMWB.

The designation of HMWB will be undertaken as part of the RBM planning process and is therefore subject to the requirements for the provision of public information and consultation as defined by Article 14. Information provided by the assessment methods must be sufficient to ensure that the process of decision-making associated with the Article 4(3) designation tests is transparent allowing for the active participation of the public in the planning process based on the provision of necessary appropriate information. In addition it is clearly important that the information is sufficient to demonstrate compliance.

Four potentially complementary types of appraisal methods are suggested.

1. **Descriptive (qualitative) methods** - can be applied where the position is clear-cut and detailed analysis is unnecessary. Descriptive methods may also be necessary where environmental or social impacts cannot be quantified;

2. **Simple quantitative measures for assessing the impact or benefit** – involves the description of relative change. For example, the percentage reduction in the beneficial output of a specified use. This can be expressed as a function of the output (for example kilowatt/hours for hydropower or tonnes transported p.a. for navigation). However, the preferred output is percentage change expressed in terms of EUROs as this allows a comparison between different sectors as well as temporal comparison within sectors. Ideally the absolute value of the output should also be included so that the scale of the change can be put into context;

3. **Benchmarking information** – where standard costs and/or benefits can be derived for individual sectors or types of measures. In some cases the benchmark will most

appropriately be considered in terms of the measure[19], in other cases it can be expressed in terms of cost-effectiveness (i.e. as a cost per unit of benefit achieved)[20];

4. **More in-depth economic assessment methods** – includes a range of tools of varying complexity. These may be used for marginal cases and for situations requiring high levels of investment.

The extent to which it will be necessary to move down this list of methods will depend on the costs and contentiousness of the options in question. It is considered that the first two types of methods will be most frequently used.

6.7.1 Methods for determining significant adverse effects (for Step 7)

Table 2 provides guidance on the type of analyses that may be considered. Simple qualitative descriptive methods are appropriate where the following situations apply:

- The adverse effects on specified uses are relatively small in relation to the specified use (clearly not significant); or
- The adverse effects on specified uses are very large and prejudice their viability (clearly significant). This is particularly relevant when the necessary "measures" imply the cessation of specified uses, functions and related human activities. For example, where the removal of flood defences would lead to widespread flooding of an urban area.

Where the situation is not clear-cut, a simple quantitative assessment should be carried out using relative assessment of impact.

Table 2: Preliminary guidance on the selection of methods for Article 4(3)(a) test.

INCREASING COMPLEXITY (move in this direction only when necessary, i.e. when a decision cannot easily be made with methods on the left of the table).

Test	Descriptive (qualitative) methods	Simple quantification	Benchmarking information	Economic assessment
Significant adverse effect on specified use (step 7.2)	If abandonment of, or very major change in, specified use/function/activity If very limited change in specified use /function/activity	When partial change in specified use/ function		Where significance of change in specified use/function is uncertain
Significant adverse effect on environment (step 7.3)	Description of scale of impacts relative to benefits provided by restoration measures		National / local scale benchmarking may be of assistance	

[19] e.g. annualised costs of a fish ladder in X Euros pa.

[20] Y Euros per fish passing etc.

It may be appropriate to consider the adverse effects at a local level, or at a local level in relation to regional or national significance. A locally significant adverse effect may become insignificant when considered in a regional or national context.[21] But it could also be vice versa. [22]

It is difficult to assess the "significance" of adverse effects on the environment, because there is a lack of methods to quantify or cost such effects. It may be appropriate to list the environmental impacts/benefits of the restoration measures together with a subjective estimate of the scale (e.g. large, moderate, small) (Example in Section 3.1.3 of the toolbox is of relevance).

To assist the assessment of the "significance" of adverse effects, a standard format is provided in the toolbox. This table lists the range of issues and information that may be considered.

6.7.2 Methods for evaluating "other means" (Step 8)

Table 3 indicates that technical feasibility and better environmental option would normally be dealt with the use of descriptive methods. In the case of "better environmental options" a simple table may be prepared comparing the existing specified use and the proposed alternatives with regards to their environmental impacts. In some cases, the quantification of the physical impacts of the existing specified use and alternatives may be possible.

Table 3: Preliminary guidance on the selection of methods for Article 4(3)(b) test.

INCREASING COMPLEXITY (move in this direction only when necessary, i.e. when a decision cannot easily be made with methods on the left of the table).

Test	Descriptive (qualitative) methods	Simple quantification	Benchmarking information	Economic assessment
Technically feasible (step 8.2)	Description of practical difficulties			
Better environ-mental options (step 8.3)	Qualitative assessment for impact on different media if conclusion is clear	If uncertain about which option is best	National / local scale benchmarking may be of assistance	
Dispropor-tionate costs (step 8.4)	Description of scale of costs and also benefits if conclusion is clear	N.A.	National / local scale benchmarking may provide sufficient clarity for good judgement	Where local situation significantly different from benchmark case or where other reasons for uncertainty exist

21 The reduction of power production within one particular hydropower station might be regarded as significant but on a regional scale it might be negligible.

22 If the power production of a hydropower plant is reduced by a small percentage, it might be regarded as not significant locally; but if the energy supply of a region depends mainly on hydropower and the production is reduced in each hydropower plant, it might be regarded as significant.

In many cases, the assessment of disproportionate costs may be quite straightforward and the qualitative description of the specified use and the consequences of its removal are sufficient to decide on whether the "other means" are disproportionately costly or not.

Where this is not the case, an economic assessment of the costs and benefits (listed in Section 6.5.4) should be undertaken.

To ensure that data on costs can be compared between existing modifications and "other means", and because of likely different life-times and temporal distribution of costs, all costs have to be annualised using standard discounted cash flow analysis and appropriate discount rates (Example in the toolbox).

6.7.3 Consultative mechanisms

Many of the designation tests may involve a subjective process involving a descriptive approach to the tests. In order to ensure a transparent approach and improve decision making it may be appropriate to use formal consultative mechanisms for decision making.

- Consultative for a - involving a participatory approach to identify whether the foreseen impacts on uses are considered as significant. This approach should take social issues and cultural/local perceptions into account[23] These fora would operate within the wider RBM stakeholder engagement and public participation process;
- Representative committees – involving the authorities responsible for water management;
- Expert group panels - technical assessment of the options by a multi-disciplinary team of experts. The selection of this "expert group" is subjective but should be well-justified and transparent. The group should include stakeholder experts.

6.8 DESIGNATION OF ARTIFICIAL WATER BODIES (Step 9)

The designation process, in relation to artificial water bodies, is difficult to understand. Therefore this Section has been introduced to consider how to operate the designation process for AWB. The suggested approach should be applied to AWB (see Figure 1). It aims to:

- minimise the amount of work involved in the designation of AWB; and
- ensure that the purpose of the WFD in protecting and enhancing the water environment is delivered.

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23 It is clearly in line with the requirements of Article 14 of the WFD to involve all interested parties.

6.8.1 Do all artificial water bodies have to be designated?

Article 4(3) states that Member States may designate a water body as artificial. This suggests that it may not always be necessary to consider designating waters which have been created by man as artificial. There may be some circumstances where long established water bodies, which are subject to little or no pressures, are indistinguishable from natural waters. Under such circumstances it may be appropriate to consider their current biological condition as HES or GES.

6.8.2 Application of "Designation test 4(3)(a)"

It is clear from the text of the Directive that the designation tests of Article 4(3) apply to AWB as well as to HMWB. However, the interpretation of Article 4(3)(a) in relation to AWB is problematic.

Article 4(3)(a)

the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on:….

In order to undertake the Article 4(3)(a) designation test, the restoration measures necessary to deliver GES must be identified. This is not possible for AWB because they were created in a location where no significant water existed before and therefore the HES natural condition would be "dry land" and a sensible GES could not be derived. Consequently, it should be assumed that test 4.3(a) does not apply to AWB. However, it is considered that the intent of Article 4.3(a) should apply to the process of AWB designation. This requires that restoration measures which result from the application of the designation process should not have a significant adverse effect on the specified use or on the wider environment.

6.8.3 Application of Article 4.3(b) test

The second "designation test 4(3)(b)" does not impose interpretation difficulties when applied to most AWB and should be used as a designation test. Consequently, when designating AWB, it should be considered whether there are “other means” which can deliver the beneficial objectives of the AWB.

It should be noted that the application of the "designation test 4(3)(b)" for AWB does not aim at considering whether water bodies are artificial or natural (or HMWB). The designation test is applied in order to see whether there are "other means" to achieve a significantly better environmental option for example resulting in an improvement of the condition of the water body.

7 REFERENCE CONDITIONS AND ENVIRONMENTAL OBJECTIVES FOR HMWB & AWB (Steps 10 & 11)

7.1 INTRODUCTION

In the HMWB and AWB identification and designation process it is necessary to identify the appropriate reference conditions and environmental objectives for AWB and HMWB (see steps 10 and 11 in Figure 1).

For HMWB and AWB the reference conditions on which status classification is based are called "Maximum Ecological Potential (MEP)". The MEP represents the maximum ecological quality that could be achieved for a HMWB or AWB once all mitigation measures, that do not have significant adverse effects on its specified use or on the wider environment, have been applied. HMWB and AWB are required to achieve "good ecological potential" (GEP) and good surface water chemical status. GEP accommodates "slight" changes in the values of the relevant biological quality elements at MEP. Member States must prevent deterioration from one status class to another, and aim to achieve GEP by 22nd December 2015 unless grounds for derogation to a less stringent objective under Article 4(5) or to an extended timescale under Article 4(4) are demonstrated. For the timing of establishing MEP and GEP see Sections 8.2 and 8.3.

7.2 ESTABLISHING THE MAXIMUM ECOLOGICAL POTENTIAL - MEP (Step 10)

A series of sub-steps are required to establish appropriate values for the quality elements at MEP (see Figure 7). In this process it is important to differentiate between "closest comparable surface water category" and "closest comparable surface water body type". The appropriate quality elements are chosen from the closest comparable categories, whereas closest comparable water body types are used to help determine the value of these elements for HMWB and AWB.

Step 10 - substep 1 (s 10.1): Choose the appropriate **quality elements** for MEP. Identify the closest comparable natural surface water category. This will either be a "river", "lake", "transitional water" or "coastal water". The appropriate quality elements are those of the closest comparable natural surface water category and are identified in Annex V No. 1.1.1- 1.1.4.

Step 10 - substep 2 (s 10.2): Establish the **hydromorphological conditions** required for MEP. The values for the biological and general physico-chemical quality elements at MEP depend on the MEP hydromorphological conditions. Establishing the MEP hydromorphological conditions is one of the first steps in defining MEP since it is these conditions which are impacted by the physical alterations and which will, primarily, dictate the ecological potential of a HMWB or AWB.

Step 10 - substep 3 (s 10.3): Establish the MEP **physico-chemical conditions**. Identify the closest comparable surface water body type. Physico-chemical conditions at MEP should be based on the conditions of this comparable type taking account of the MEP hydromorphological conditions. The physico-chemical conditions will be an important influence on the values for the biological quality elements at MEP.

Step 10 - substep 4 (s 10.4): Establish the MEP **biological conditions** that shall reflect, as far as possible, those associated with the closest comparable water body type (cf. S 10.3 above). The biological conditions at MEP will be influenced by the MEP hydromorphological and physico-chemical conditions.

step 10.1:

Choose quality elements for MEP (and GEP) based on comparable water category.

↓

step 10.2:

Establish MEP hydromorphological conditions, applying all hydromorphological mitigation measures which do not have significant adverse effects on the specified use or the wider environment.

↓

step 10.3:

Establish MEP physico-chemical conditions based on comparable water type and results of step 10.2.

↓

step 10.4:

Establish MEP biological conditions based on comparable water type and results of steps 10.2. and 10.3.

Figure 7: **Process for defining MEP (Steps 10.1 – 10.4)**

The following example shows how the establishment of MEP can be achieved according to Figure 7.

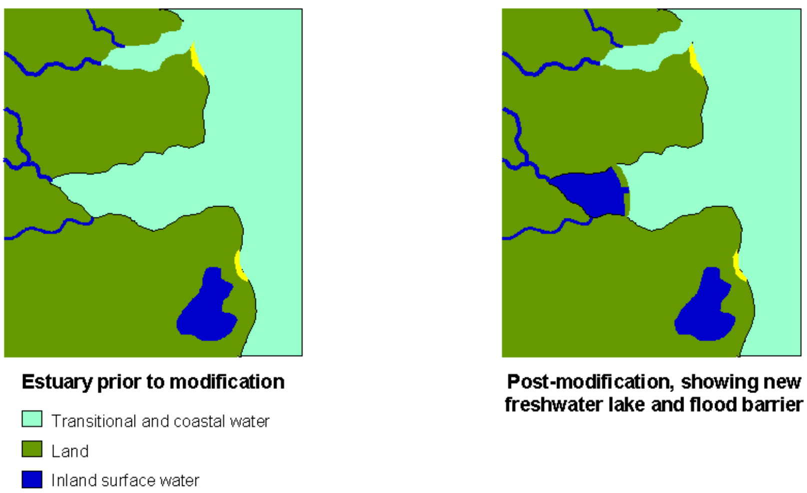

Figure 8: **Example showing an estuary turned into a freshwater lake**

The estuary was altered for flood protection (see Figure 8). It is clearly a substantial change in the character of the water body due to physical alterations. It is also an Article 4(3) specified use (flood defence).

Substep 10.1: The closest comparable natural water category in the present situation is a lake. The relevant biological, hydromorphological and physico-chemical elements of the lake category should be used to establish MEP (see Section 7.2.1

Substep 10.2: It is clear that the hydromorphological elements required for MEP **do <u>not</u> reflect the historical situation (estuary)** but should reflect the theoretical improvements which could be undertaken by hydromorphological mitigation measures (which have no significant adverse effect upon the use (flood protection)). The closest comparable lake type should be used to choose the values for those elements as far as possible (see Section 7.2.2).

Substep 10.3: The MEP physico-chemical conditions are those values found under the given circumstances of step 10.2 but reflect in general the condition at high ecological status for the most comparable lake water bodies (see Section 7.2.3).

Substep 10.4: The MEP biological conditions are those values found under the given circumstances of step 10.2 and 10.3 (see Section 7.2.4).

7.2.1 Choosing the appropriate quality elements for MEP (Step 10.1)

<u>Annex V No. 1.1.5</u>

"The quality elements applicable to artificial and heavily modified surface water bodies shall be those applicable to whichever of the four natural surface water categories above most closely resembles the heavily modified or artificial water body concerned".

The relevant hydromorphological, biological and physico-chemical quality elements are those for the most closely comparable water <u>category</u> (River, Lake, Transitional Water or Coastal Water) [cf. Annex V No. 1.1.1-1.1.4]. For example, if a river has been modified (e.g. impounded) to closely resemble a lake, the relevant quality elements will be those specified in the Directive for lakes [Annex V No. 1.1.2], rather than those for rivers [Annex V No. 1.1.1] (see Figure 9).

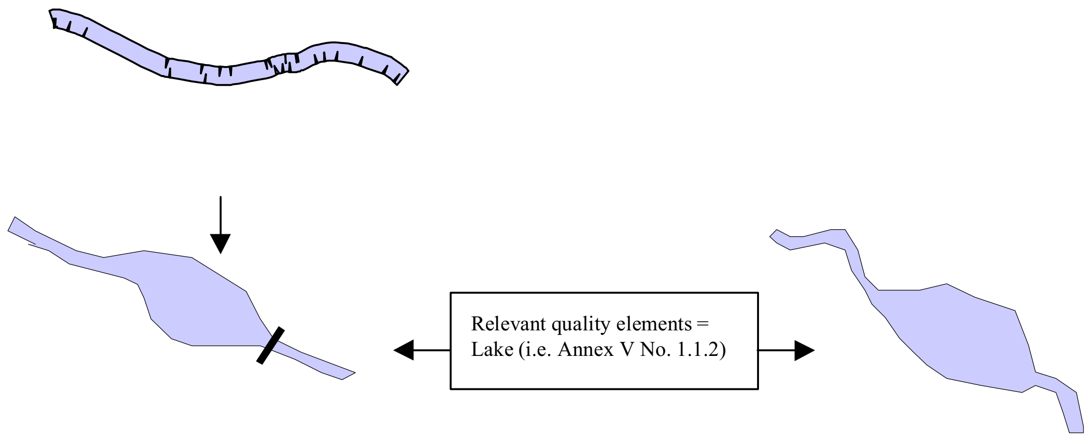

Figure 9: Example for choosing quality elements for MEP (s 10.1)

7.2.2 Establishing MEP hydromorphological conditions (Step 10.2)

Annex V No. 1.2.5

"The hydromorphological conditions [of a HMWB or AWB at MEP] are consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds."

The hydromorphological conditions at MEP are the conditions that would exist if all hydromorphological mitigation measures were taken to ensure the best approximation to the ecological continuum. The mitigation measures for defining MEP should:

(a) not have a significant adverse effect on the specified use (including maintenance and operation of the specified use; see Section 6.4.2). This consideration includes an assessment of possible economic effects incurred by mitigation measures but not an assessment of disproportionate cost of the measures themselves or on the wider environment (see Section 6.4.7); and

(b) ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds (Examples in the toolbox).

For the purpose of this guidance 'best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds' is interpreted as having the following requirements:

(a) An adequate quantity and quality of usable habitat to ensure that the structure and function of the ecosystem is maintained over space and time;

(b) Longitudinal and lateral continuity/connectivity of water bodies (e.g. river continuity, aquatic – semi-aquatic - terrestrial habitat connectivity) to enable biota access to the habitats on which they depend.

The best approximation to ecological continuum therefore requires consideration of all hydromorphological mitigation measures that could reduce any obstacles to migration and improve the quality, quantity and range of habitats affected by the physical alterations. This could include connectivity to groundwater and to riparian, shore and intertidal zones. However, the WFD emphasises migration in particular. Priority should therefore be given to reducing any obstacles that significantly inhibit longitudinal and lateral migration of biota.

The technical feasibility and the financial costs (i.e. capital costs) that would be incurred if the mitigation measures were implemented is not a consideration in setting the standards for the hydromorphological quality elements at MEP. Such cost considerations are relevant when deciding whether the achievement of GEP or a less stringent objective under Article 4(5) is appropriate for the HMWB or AWB. However, the mitigation measures should not have a significant adverse effect on the specified use (including economic effects), or the wider environment according to the designation test 4(3)(a). This can include an assessment of the economic effects on the specified use or the wider environment. Although all mitigation measures should be identified, it would not be useful to further consider measures that were impractical. Such impractical measures should be excluded from any detailed assessment.

The combination of considering only measures which do not have a significant adverse effect upon the use/environment and of excluding clearly impractical measures will result in the definition of reasonable values for MEP.

In designating and setting objectives for HMWB and AWB, Member States must ensure consistency with the implementation of other Community legislation [cf. Art. 4(8)], such as the Fauna Flora Habitat Directive (FFH) Directive (92/43/EEC) and the Birds Directive (79/409/EEC). At the same time, the requirements of the WFD need to be respected in the implementation of these directives. The definition of MEP must ensure that the achievement of GEP is compatible with the achievement of the objectives established under such legislation. In the case of the FFH and Birds Directives, the mitigation measures used to define MEP hydromorphological conditions must consider the needs of those flora, fauna and habitats for which the Directives have set objectives.

7.2.3 Establishing MEP physico-chemical conditions (Step 10.3)

Annex V No. 1.2.5

"The [general] physico-chemical quality elements correspond totally or nearly totally to the undisturbed conditions associated with the surface water body type most closely comparable to the artificial or heavily modified water body concerned.

Concentrations [of specific non-synthetic pollutants] remain within the range normally associated with undisturbed conditions found in the surface water body type most closely comparable to the artificial or heavily modified body concerned. (background levels = bgl)".

The general physico-chemical conditions and the values for specific non-synthetic pollutants should correspond to those of the most closely comparable water body type, given the MEP hydromorphological conditions (see above) (Example in the toolbox).

For some AWB and HMWB, the values for some of the physico-chemical quality elements in the closest comparable water body type may be significantly different from the values that could be achieved in the HMWB or AWB, given the MEP hydromorphogical characteristics (see above). The following examples illustrate how HMWB may have different physico-chemical conditions than the nearest equivalent natural water body:

- The hydromorphological characteristics of impoundment created for hydropower and water supply can dictate the oxygen and temperature conditions in the impounded water and in the downstream river. These may be different from those in a natural water body;
- The hydromorphological characteristics of a freshwater impoundment created from a dammed estuary may result in different levels of turbidity. These may be different from those in a natural water body.

These differences can be taken into account when defining MEP.

Since the values for these physico-chemical quality elements would not correspond "totally or even nearly totally to those for the closest comparable water body type" at high ecological status (HES), such AWB and HMWB would never achieve MEP. In some cases they would also be unable to achieve GEP and therefore would require derogation to a less stringent objective under Article 4(5). Where these physico-chemical conditions are directly connected to physical alterations necessary to sustain the specified use, it is suggested that these differences be taken into account when setting MEP. These considerations are only applicable to certain physico-chemical elements such as oxygenation, temperature and turbidity, and should not be applied to general pollutants which are not connected to the hydromophological alterations.

The requirements for specific synthetic pollutants at MEP are the same as those for unmodified, non-artificial water bodies with "concentrations close to zero and at least below the limits of detection of the advanced analytical techniques in general use" [cf. Annex V No. 1.2.5]. CIS WG 2.3 REFCOND and CIS WG 2.4 COAST will provide further guidance.

7.2.4 Establishing MEP biological requirements (Step 10.4)

Annex V No. 1.2.5

[Maximum Ecological Potential (MEP) is defined as the state where] "the values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body."

MEP is intended to describe the best approximation to a natural aquatic ecosystem that could be achieved given the hydromorphological characteristics that cannot be changed without significant adverse effects on the specified use or the wider environment. Accordingly, MEP biological conditions should reflect, as far as possible, those associated with the closest comparable water body type given the hydromorphological and resulting physico-chemical conditions at high ecological status to those established for MEP (see steps 10.2 and 10.3).

The Directive allows a number of methods to be used in establishing MEP values for the biological quality elements. The range of methods should also be used in establishing MEP values for the general physico-chemical quality elements and specific non-synthetic pollutants (see above). The methods are the same as those permitted in establishing the values for quality elements at HES.

They consist of:

(i) Spatial networks of sites meeting MEP criteria (Example in the toolbox);

(ii) Modelling approaches (Example in the toolbox);

(iii) A combination of (i) and (ii); or

(iv) Where it is not possible to use the above methods, expert judgement (Example in the toolbox).

7.2.5 Most comparable water body

A "comparable water body" can be one or more similar water body(s) that is/are, amongst other things, most similar in terms of category, type and other characteristics to the modified water body and from which spatial or temporal (i.e. hindcasting) data can be derived to support the establishment of MEP. The "comparable water body" helps to:

- choose quality elements to be regarded (derived from most comparable water body category); and

- set values for physico-chemical and biological quality elements regarded (derived from most comparable water body type).

The first priority is to look for a comparable natural water body (or a modelled or historical situation) (Example in the toolbox).

In many cases, the HES hydromorphological and sometimes also the physico-chemical conditions in the closest comparable water body type will be significantly different from the MEP hydromorphological and physico-chemical conditions. In establishing the MEP biological values, it will therefore be necessary to adjust the HES biological values of the closest comparable water body type to take account of the heavily modified or artificial characteristics.

In special cases, comparable natural water bodies will not be available. In these cases, which have to be justified, information from closely comparable HMWB and AWB at MEP (i.e. best possible rather than best available) should be used where it is available (Example in the toolbox). Information from best available sites could be used as long as best possible conditions can be extrapolated through modelling or expert judgement.

The following example shows how MEP can be established by reference to another HMWB.

If a series of large reservoirs were created in a mountainous region where large natural lakes did not exist, it may not be possible to identify a comparable natural water body within the ecoregion. Under these circumstances, it may be possible to identify a reservoir which is already close to MEP. A reservoir would be close to MEP if "all mitigation measures" to improve the hydromorphological characteristics of the reservoir had been undertaken. If "all mitigation measures" had not been undertaken, then the effect of undertaking "all mitigation measures" could be modelled and then used as the definition of MEP.

7.3 ESTABLISHING THE GOOD ECOLOGICAL POTENTIAL – GEP (Step 11)

Annex V No. 1.2.5

[The good ecological potential (GEP) is defined as the state where] "There are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential".

The good ecological potential (GEP) is the environmental quality objective for HMWB and AWB. Risk of failure of the ecological objective for AWB and HMWB is assessed against GEP (see Annex II No. 1.4).

The hydromorphological conditions at GEP must be such as to support the achievement of the GEP biological values. The values for the general physico-chemical quality elements at GEP also need to support the achievement of the GEP biological values. However, it is also required that the values for the general physico-chemical quality elements at GEP are such as to ensure the functioning of the ecosystem. The role of physico-chemical elements in the classification of water bodies is defined within the WFD CIS Guidance Documents No.'s 10, provided by the WG 2.3 (REFCOND) and No. 5, WG 2.4 (COAST). GEP also requires compliance with environmental quality standards established for the specific synthetic and non-synthetic pollutant quality elements in accordance with the procedure set out in Annex V No. 1.2.6 of the Directive.

The following substeps (s 11.1 – s 11.4) are necessary to establish GEP:

Step 11 - substep 1 (s 11.1): The establishment of the good ecological potential for HMWB and AWB is principally based on the **biological quality** elements (derived from MEP). GEP accommodates "slight changes" in the values of the biological elements from the MEP (Examples in the toolbox). The meaning and interpretation of the term "slight changes" is dealt with in the WFD CIS Guidance Document No. 10 - REFCOND and WFD CIS Guidance Document No. 6 - Intercalibration.

Step 11 - substep 2 (s 11.2): The **hydromorphological conditions** at GEP must be such as to support the achievement of the GEP biological values (Example in the toolbox).This will require the identification of the hydromorphological conditions necessary to support the achievement of the GEP values for the biological quality elements, and in particular the achievement of the values for those biological quality elements that are sensitive to hydromorphological alterations.

Step 11 - substep 3 (s 11.3): The values for the **general physico-chemical** quality elements at GEP are such as to support the achievement of the GEP biological values (Example in the toolbox). It is also required that the values for the general physico-chemical quality elements at GEP are such as to ensure the functioning of the ecosystem [Annex V No. 1.2.5]. The role of physico-chemical elements in the classification of water bodies is defined within the WFD CIS Guidance Document No.'s 10 and 5 provided by the WG 2.3 (REFCOND) and WG 2.4 (COAST).

Step 11 - substep 4 (s 11.4): GEP also requires compliance with environmental quality standards established for the **specific synthetic and non-synthetic pollutant** quality elements in accordance with the procedure set out in Annex V No. 1.2.6 (Example in the toolbox).

7.4 REPORTING AND MAPPING FOR HMWB AND AWB

The classification of HMWB and AWB requires the development of monitoring systems capable of estimating the values of the biological quality elements in AWB and HMWB and comparing those estimates with the values established for those elements at MEP. The ratio of the measured values of the biological parameters and the values for these parameters at MEP [the "ecological quality ratio"; cf. Annex V No. 1.4] will be used in classifying the status. Member States must establish values of the environmental quality ratio that correspond to the boundaries between the status classes. Some of the work of the EU Common Implementation Strategy working groups 2.3 (REFCOND) and 2.4 (COAST) may possibly help in establishing boundaries between ecological potential classes.

The classification of the ecological potential of HMWB and AWB is principally based on the degree of anthropogenic alteration away from the MEP values for the biological quality elements (see Section 7.2.4). For reporting purposes and mapping, MEP and GEP are combined in a single class [Annex V No. 1.4.2 (ii)], see following Figure 10.

Good and above Ecological Potential

1. Slight changes to the MEP values for the biological elements.

2. General physico-chemical quality elements within ranges established to ensure the functioning of the ecosystem.

3. Specific synthetic and non-synthetic pollutants do not exceed environmental quality standards set in accordance with the Annex V 1.2.6 procedure.

Moderate Ecological Potential

Moderate changes to MEP values for the biological quality elements.

Poor Ecological Potential

Major changes to the MEP values for the biological quality elements.

Bad Ecological Potential

Severe changes to the MEP values for the biological quality elements (i.e. large portions of the MEP biological community are absent).

Figure 10: **Reporting System**

7.4.1 Programme of measures

HMWB and AWB are required to achieve "good ecological potential" (GEP) and good surface water chemical status. Member States must prevent deterioration from one status class to another, and aim to achieve GEP by 22nd December 2015 unless grounds for derogation are demonstrated.

Where the results of the monitoring programmes achieved on the Annex II risk assessments indicate that a HMWB or AWB is likely to fail to achieve GEP, Member States must establish an appropriate set of measures to improve the ecological potential of a water body with the aim of achieving GEP by 2015 (Examples in the toolbox).

This requires a good understanding of how measures will improve the ecological potential of the water body. For example, the identification of the relevant GEP hydromorphological conditions will require an understanding of the relationships between hydromorphological and biological elements; this knowledge is still relatively limited. It would also be advantageous to understand biological response lag times within any particular water body.

For the design of effective and efficient programmes of measures (POMs), better information is likely to be collected over time. In the meantime, Member States will have to base the design of POMs on the best available knowledge and judgements.

If it is technically infeasible or disproportionately expensive to achieve GEP by 2015, Member States may extend the deadline for achieving GEP in accordance with Article 4(4) or establish a less stringent objective for the water body under Article 4(5). In this context the WFD CIS Guidance Document No. 10 produced by the CIS-Working Group WATECO for the assessment of disproportionate costs should be considered.

8 CROSS-CUTTING ISSUES AND OUTLOOK

8.1 OVERVIEW OF MEASURES AND THEIR COSTS IN THE HMWB AND AWB PROCESS

There are some issues within the designation process that are not particularly unique to one single step of the identification and designation process. These are summarised below.

Different kinds of **measures** are to be considered at different stages (steps) of the process. These include restoration measures in the designation test 4(3)(a) and mitigation measures for establishing MEP and GEP. For reaching the environmental quality objectives, a programme of measures needs to be set up for each RBD. This includes not only (mitigation) measures for AWB or HMWB, but also measures for natural water bodies.

When (restoration or mitigation) measures are being identified and their impacts assessed, the scale becomes important. It has to be taken into account that measures upstream might influence the conditions downstream and vice-versa. The identification of suitable measures can be difficult, because information on the cause-effect relationship of measures is often insufficient. Related to the identification (and at some points realisation) of different measures, considerations of **costs** and benefits as well as technical feasibility are relevant at several stages of the process to different extents, as shown in Table 4.

The following Table 4 gives an overview of the types of measures (second column) that are to be considered in the different steps (first column) of the designation and objective setting processes for HMWB and AWB. In the third column the related cost (and benefit) considerations are listed, and it is indicated where the consideration of technical feasibility is relevant.

Table 4: Overview of measures and cost considerations in the overall HMWB and AWB identification and designation process

Step	Measures to be considered	Costs (and benefits) related to measures /other means
1-6: Up to provisional identification	None.	Not considered.
7: Designation test 4(3)(a)	**Restoration measures** necessary to achieve GES.	• When assessing the adverse effects on the specified uses and on the wider environment, **costs** need to be considered. • The **benefits** of achieving GES must be considered, other benefits may be considered. • Costs of restoration measures (including disproportionality of costs) are **NOT** considered.
8: Designation test 4(3)(b)	Not "measures" but "**other means**" are considered.	• Comparison of current benefits with benefits of **other means**. • Disproportionality of costs of other means should be considered. • Technical feasibility of other means should be considered.
9: Designation	None.	Not considered.
10: Establishing MEP	All **mitigation measures**[24] that: • do not significantly adversely affect the specified uses or the wider environment; and • ensure the best approximation to ecological continuum.	• When assessing the adverse effects on the specified uses and on the wider environment, **costs** need to be considered. • The benefits to the water body of applying the mitigation measures should be considered. • Costs of mitigation measures (including disproportionality of costs) are **NOT** considered. • Technical feasibility of mitigation measures **NOT** to be considered.
11: Establishing GEP	**Mitigation measures** that: • do not significantly adversely affect the specified uses or the wider environment; and • improve water body to slight deviation of MEP.	• When assessing the adverse effects on the specified uses and on the wider environment, **costs** need to be considered. • The benefits to the water body of applying the mitigation measures should be considered. • Costs of mitigation measures (including disproportionality of costs) are **NOT** considered. • Technical feasibility of mitigation measures **NOT** to be considered.
For all water bodies (natural, artificial and heavily modified):		
POM for reaching the environmental quality objectives (EQO)	All **measures** according to Article 11 WFD (including other means and mitigation measures considered in the designation process)..	• Costs of measures (including disproportionality of costs) should be considered. • Select the most cost-effective combination of measures to achieve the EQO. • Technical feasibility of the measures should be considered.

24 According to Annex V 1.2.5 WFD, all hydromorphological mitigation measures should be theoretically considered in order to define the MEP. However, it would not be useful to consider impractical measures. For further explanation please see Section 7.2.2.

Within the first steps up to provisional HMWB identification (steps 1-6), no measures or cost and feasibility estimations are considered.

In the first designation test (step 7) all "restoration measures" necessary to achieve the GES are to be considered, regardless of their costs or technical feasibility. In this test it has to be assessed whether these restoration measures have a significant adverse effect on the specified uses or the wider environment. In assessing this, cost considerations are relevant (e.g. loss of revenue). In the second designation test (step 8), no measures are considered but "other means" (including displacement or replacement of current specified use),[25] that serve the same beneficial objective, are considered. These other means have to be assessed with regard to their technical feasibility and their disproportionality of costs.

In defining MEP (step 10) and GEP (step 11) conditions, all mitigation measures that do not have significant adverse effects neither on the specified uses nor on the wider environment are to be considered. The capital costs that would be incurred if the mitigation measures were implemented and disproportionality of costs are not relevant considerations in this context. The mitigation measures only define the reference conditions for the classification of HMWB and AWB. Setting this standard does not require the measures to be implemented. Again only cost in the context of impact on specified uses is relevant. When setting up the RBMP, the feasibility and costs play a major role and might lead to derogations.

8.2 TIMING IN THE FIRST RIVER BASIN PLANNING CYCLE

The first draft RBMP should be available for public consultation by December 2008 [Article14(1)(c)], while the final version is due one year later, in December 2009 [Article13(6)]. The RBMP shall be reviewed and updated at the latest in December 2015 and every 6 years thereafter [Article13(7)].

This Guidance Document provides advice on how the HMWB and AWB identification and designation process should be undertaken during the first RBMP cycle. An overview of the step-wise identification and designation process for the first planning cycle is given in Section 4. In this Section we describe the timetable for when particular process activities have to be completed within this first cycle. It will be important that the timing of these activities is considered within other relevant WFD Common Implementation Strategy working group Guidance Documents. Figure 11 identifies the major deadlines in the timetable of the HMWB and AWB identification and designation process in the first planning cycle.

As identified in Section 5.7 the provisional identification of HMWB and AWB will be complete by Dec 2004. For physically modified water bodies an assessment of the likelihood of failing to meet the "GES" objective (step 5) must be complete by Dec 2004 to determine whether a water body is to be provisionally identified as HMWB (step 6).

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25 For example: replacing a particular hydropower station with a new hydropower station in a different water body, or replacing hydropower with wind power.

For AWB an assessment of the likelihood of failing to meet a "GEP" objective must be complete by Dec 2004. Determination of "GES" and "GEP" prior to the Dec 2004 deadline will only be first estimations of these objectives based on available knowledge, data and tools. It is expected that further refinement of these objectives will be made later in the planning process as new tools and data become available, particularly as a result of further monitoring.

For provisionally identified HMWB, designation (or not; step 7-9), determination of GEP (step 10-11) and an assessment of the risk of failing to meet the "GEP" objective must be complete by Dec 2008. For identified AWB it is expected that between 2004-8 the water body will be designated as AWB, the estimate of GEP will be refined and the risk of failing to meet the refined GEP will be reassessed. If a designated HMWB or AWB does not meet the GEP objective, then a programme of measures or a case for derogation has to be developed by Dec 2008. This allows one year for consultation of the draft RBMP before publication of the final RBMP in 2009.

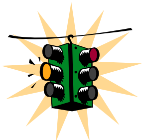
For some provisionally identified HMWB, Member States may wish to move the designation steps (steps 7-9), the first estimation of GEP and the assessment of the likelihood of failing the GEP objective forward. This may be particularly appropriate for modified water bodies that have changed category (e.g. river to reservoir). Here the assessment of the likelihood of failing the GES objective will be straightforward (comparing a reservoir with a river) as there will be little uncertainty over the identification of the water body as a provisional HMWB. Consequently, steps 5 & 6 should not involve complex assessments and steps 7-11 can start sooner.

As a general rule steps 7-11 and the assessment of the risk of failing the GEP objective should occur as soon as possible before Dec 2008.

By when?	What major task?	What needs to be done for HMWB and AWB?
2004	Characterisation of river basin district [Art. 5]	steps 1-6: Including: identification of water bodies (step 1); identification of AWB (step 2); description of hydromorphological changes (step 3); description of significant changes in hydromorphology (step 4); estimation of GES (non-AWB); likelihood of failing GES objective (Step 5; non-AWB); estimation of GEP (AWB); likelihood of failing GEP (AWB); and provisional HMWB identification (step 6).
2008/9	River basin management plan & public consultation [Art. 13 & 14]	steps 7-11: Including designation tests (steps 7 and 8), designation (step 9), identification of reference conditions (step 10) and environmental quality objective (step 11) for HMWB and AWB.

Figure 11: Major deadlines in the timetable for the identification and designation of HMWB and AWB in the first planning cycle

8.3 HMWB & AWB IN FUTURE RBMP CYCLES



Look out! The view of future RBMP cycles has some implications for the first process of designation

It is important to appreciate that the identification and designation of HMWB and AWB is not a "one off" process and the Directive provides for the flexibility to modify designations to take account of changes over time in environmental, social and economic circumstances.

The designation process in the second RBMP cycle will be different in several important aspects. Clearly it is not appropriate to give a detailed assessment of the designation process for future cycles here as it is likely to change as a result of experiences during the first planning cycle. We can, however, give an indication of the key differences that will be encountered.

8.3.1 Characterisation in the second cycle

The second characterisation of River Basin District (RBD) in the second RBMP cycle (first review) has to be finished by 2013 [Article5(2)]. The main difference with the first characterisation will be that water bodies (natural, HMWB & AWB) will already have been identified and a fully compliant monitoring programme should be in place.

Characterisation is likely to start with a review of monitoring data which will define the current (ca 2013) status of waters. On the basis of this information, water body definitions could be at least partly changed. This will ensure that water bodies can be used to correctly describe the status of surface waters. For example, if monitoring has demonstrated that the status of half a water body has changed, then the water body could be split in two, whereas if the status of two adjacent water bodies were now the same then they could be combined into a single water body.

The risk assessment process in the second RBMP cycle will be based on a better understanding of GES and GEP. Consequently, the risk assessment process will identify the risks of failure of good status for natural water bodies and GEP for HMWB and AWB.

8.3.2 Designation tests in the second cycle

In the second RBMP cycle the Article 4(3) designation tests will be applied in three circumstances: (i) (ii) and (iii) below:

(i) Suspected HMWB and AWB which were, possibly, mistakenly not designated in the first RBMP. For instance water bodies which were historically modified but which were mistakenly not identified and designated during the previous planning cycle (they have not deteriorated);

(ii) Newly modified water bodies. For instance water bodies that have become substantially changed in character as a result of the application of the Article 4(7) derogation.

Water bodies from situations (i) and (ii) will in general proceed in the same manner as in the first RBMP cycle, but without provisional identification of HMWB.

(iii) As part of the review of existing HMWB and AWB. The designations of HMWB and AWB must be reviewed every six years. It is assumed that these reviews will be undertaken as part of the production of the RBMP which will be complete in 2015. It is assumed that a review of HMWB and AWB will involve a reconsideration of the designation tests. This is likely to include a screening process which will assess whether the situation has changed since the original designation [Annex VII (B)]. Only where changes have occurred will the water body be considered for the designation tests in the second cycle. A review may be necessary if there has been a change in the:

- technical circumstances of the use (including operation and maintenance) or the disappearance of the use;
- use itself;
- available restoration measures, so that they may no longer have a significant adverse effect on the use or the environment;
- "other means" available to deliver the same beneficial objective of the use, so that they may no longer be disproportionately expensive or technically infeasible.

In future planning cycles existing HMWB and AWB may be "de-designated" and new HMWB and AWB being designated.

8.3.3 Review of MEP (and GEP) values in the second cycle

The values established for MEP in step 10, sub-steps 10.1-10.4, must be reviewed every six years (Annex II No. 1.3(ii)). This will mean that GEP also has to be revised every six years, as GEP is a "slight deviation" from MEP. This would involve a similar screening process as for the review of the designation tests.

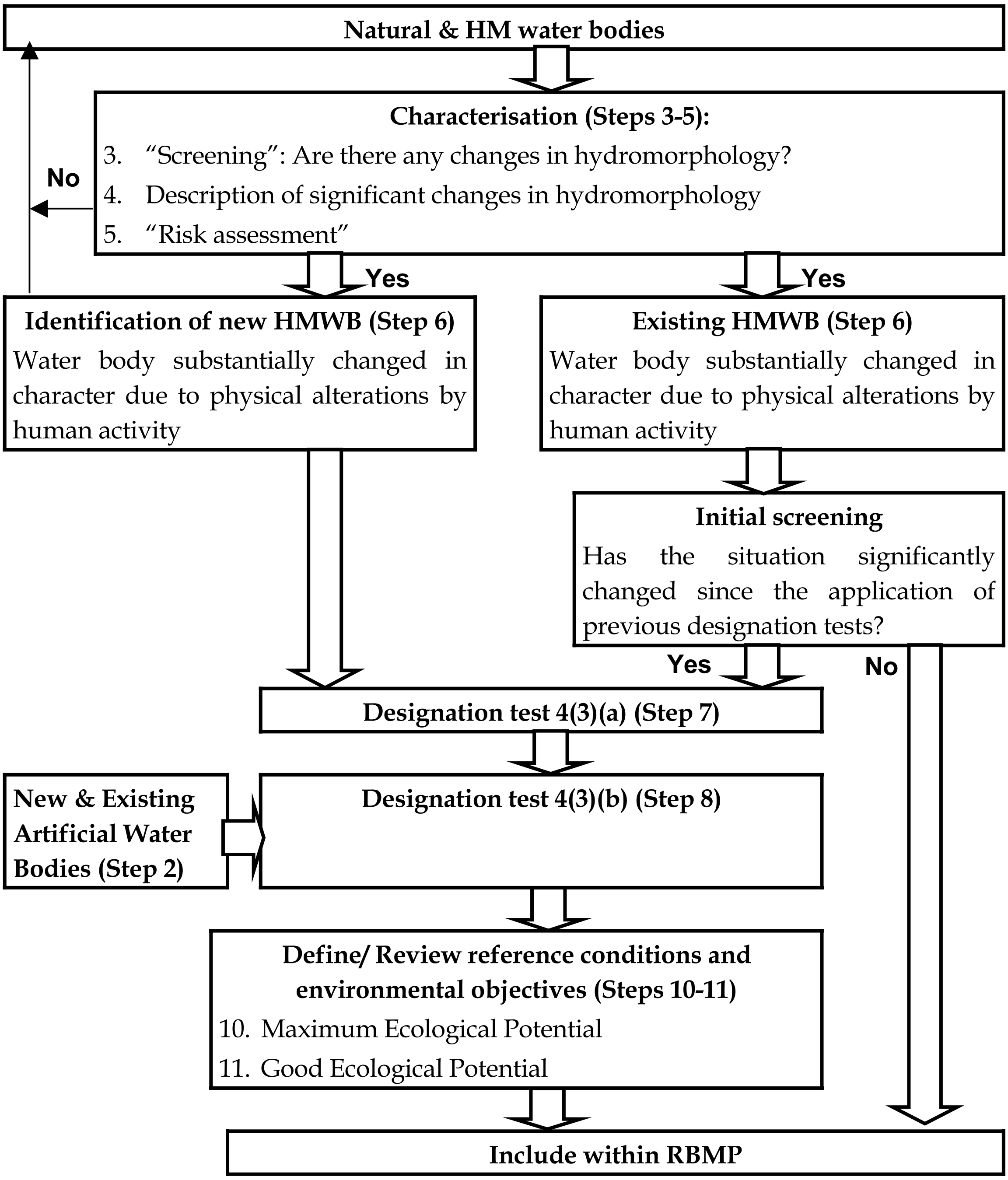


Figure 12: Consideration of HMWB during the second River Basin Management Plan

8.4 CONCLUSION AND OUTLOOK

This Guidance Document provides advice on how the HMWB and AWB identification and designation process should be undertaken during the first RBMP cycle (2008/2009). The designation process in the second and in subsequent RBMP cycles will be different in several aspects. It is important to appreciate that the identification and designation of HMWB and AWB is not a "one off" process and that the WFD provides for the flexibility to modify designations to take account of changes over time in environmental, social and economic circumstances.

This Guidance Document is based on the experiences of thirty-four case studies. It should, therefore, be applicable to most circumstances. However, further experiences in implementing the provisions relevant to HMWB and AWB in Member States will shed new light on the interpretation of the HMWB and AWB requirements of the Directive and the approach suggested in the Guidance and the accompanying toolbox. In the pilot river basins as well as in other river basins across Europe the Guidance will be applied in the coming months and years. This HMWB and AWB Guidance Document will require adaptations as a result of these new experiences and, as all other CIS Guidance Documents, the HMWB and AWB Guidance will remain a "living document".

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ANNEX I - GLOSSARY

Terms used within the Guidance (excluding terms already defined in Article 2 of the Directive).

Term	Definition
Beneficial objectives	The benefits that result from the artificial or heavily modified characteristics of a water body. These can include "specified use"-related or environmental benefits.
Common Implementation Strategy	The Common Implementation Strategy for the Water Framework Directive (known as the CIS) was agreed by the European Commission, Member States and Norway in May 2001. The main aim of the CIS is to provide support in the implementation of the WFD, by developing a common understanding and guidance on key elements of this Directive. Experts from the above countries and candidate countries as well as stakeholders from the water community are all involved in the CIS to: • Raise awareness an exchange information; • Develop Guidance Documents on various technical issues; and, • Carry out integrated testing in pilot river basins. A series of working groups and joint activities has been developed to help carry out the activities listed above. A Strategic Co-ordination Group (or SCG) oversees these working groups and reports directly to the Water Directors of the European Union, Norway, Switzerland, the Candidate Countries and Commission, the engine of the CIS. For more information refer to the following website: http://europa.eu.int/comm/environment/water/water-framework/index_en.html.
Impact	The environmental effect of a pressure (e.g. fish killed, ecosystem modified).
Modification	Change (or changes) made to the surface water body by human activity (which may result in failing to meet good ecological status). Each modification will have a current or historical "specified use" (such as straightening for navigation, or construction of flood banks for flood defence).

Term	Definition
Physical alterations	Modifications of the hydromorphology of a water body by human activity.
Pressure[26]	The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry of surface and groundwater bodies.
Restoration measures	Necessary hydromorphological changes to achieve GES (e.g. re-meandering of a straightened channel and introduction of "natural" pool-riffle sequences using references to historical channel form). Associated with "Designation test 4(3)(a)".
Specified use	Water uses as described in Article 4(3)(a)(ii)-(v).
WFD, The Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy.
Wider environment	The natural environment and the human environment including archaeology, heritage, landscape and geomorphology.

[26] Interim working definition. Discussions in the context of the WFD implementation are ongoing

ANNEX II - HMWB AND RIVER BASIN MANAGEMENT PLANS (FIRST CYCLE)

The RBMP must be produced for each river basin district [Article 13(1)], covering the information detailed in Annex VII [Article 13(4)]. The information detailed in Annex VII relevant for HMWB and AWB in the first cycle concern at least the following points A1, A2, A4 and A7 of Annex VII:

A1 requires a general description of the characteristics of the river basin district [Article 5 and Annex II No. 1.1/2/3], i.e. the identification of boundaries of water bodies, a mapping of types and an identification of reference conditions. Guidance on the identification of HMWB and AWB as well as the identification of the maximum ecological potential (MEP) have to be given by this HMWB and AWB Guidance Document. The process should be in line with the general identification of water bodies and the identification of reference conditions (REFCOND and COAST Guidance Documents).

A2 requires a summary of significant pressures and impacts of human activity [Article 5 and Annex II No. 1.4/5], i.e. an overall description of significant pressures such as important hydromorphological changes and an assessment of those surface waters being at risk of failing the environmental objectives. Guidance on the overall description of significant pressures and the assessment of impacts will be provided by the IMPRESS Guidance, the identification of significant physical pressures and their impact on hydromorphology and biology as well as the designated HMWB and AWB being at risk of failing the environmental quality objective (GEP) should be covered by the HMWB & AWB Guidance. The process of HMWB and AWB identification and designation should be in line with the general approach of IMPRESS.

A4 requires a map of the monitoring networks and a presentation, in a mapped format, of the results of the monitoring programmes [Article 8 and Annex V]. It is assumed that the Guidance on the monitoring requirements for HMWB and AWB will be provided by the Monitoring Working Group. Some advice for the selection of the most sensitive indicators for the operational monitoring of HMWB and AWB identified as being at risk will be provided by this HMWB Guidance Document.

A7 requires a summary of the programmes of measures [Article 11], including information on how the established environmental quality objectives [Article 4] are to be achieved. The HMWB & AWB Guidance and toolbox should assist in identifying those measures which could improve the status of HMWB and AWB resulting from physical impacts. Not only measures for the designation tests [Article 4(3)] will be provided, i.e. examples for restoration measures to achieve GES, but also mitigation measures - which have no adverse effects on "specified uses" or the wider environment - to identify MEP and to achieve GEP. The measures will consider all important specified uses and focus on the improvement of the hydromorphological circumstances.

ANNEX III - ELEMENTS OF HMWB IN THE WFD (ORIGINAL TEXT)

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

Title	Specification	Provision
Article 2	**Definitions**	
	4.	'River' means a body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course.
	8.	'Artificial water body' means a body of surface water created by human activity.
	9.	'Heavily modified water body' means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II.
	10.	'Body of surface water' means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.
	23.	'Good ecological potential' is the status of a heavily modified or an artificial body of water, so classified in accordance with the relevant provisions of Annex V.
Article 4	**Environmental objectives**	
	1.	In making operational the programmes of measures specified in the river basin management plans: (a) for surface waters (i) Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8;

Article 4 Environmental objectives

(ii) Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive, in accordance with the provisions laid down in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;

(iii) Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years from the date of entry into force of this Directive, in accordance with the provisions laid down in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;

(iv) Member States shall implement the necessary measures in accordance with Article 16(1) and (8), with the aim of progressively reducing pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous substances;

without prejudice to the relevant international agreements referred to in Article 1 for the parties concerned.

3. Member States may designate a body of surface water as artificial or heavily modified, when:

(a) the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on:

(i) the wider environment;

(ii) navigation, including port facilities, or recreation;

(iii) activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;

(iv) water regulation, flood protection, land drainage; or

(v) other equally important sustainable human development activities.

(b) the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.

Article 4 Environmental objectives

Such designation and the reasons for it shall be specifically mentioned in the river basin management plans required under Article 13 and reviewed every six years.

4. The deadlines established under paragraph 1 may be extended for the purposes of phased achievement of the objectives for bodies of water, provided that no further deterioration occurs in the status of the affected body of water when all of the following conditions are met:

(a) Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales set out in that paragraph for at least one of the following reasons:

(i) the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;

(ii) completing the improvements within the timescale would be disproportionately expensive;

(iii) natural conditions do not allow timely improvement in the status of the body of water.

(b) Extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan required under Article 13.

(c) Extensions shall be limited to a maximum of two further updates of the river basin management plan except in cases where the natural conditions are such that the objectives cannot be achieved within this period.

(d) A summary of the measures required under Article 11 which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, the reasons for any significant delay in making these measures operational, and the expected timetable for their implementation are set out in the river basin management plan. A review of the implementation of these measures and a summary of any additional measures shall be included in updates of the river basin management plan.

5. Member States may aim to achieve less stringent environmental objectives than those required under paragraph 1 for specific bodies of water when they are so affected by human activity, as determined in accordance with Article 5(1), or their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive, and all the following conditions are met:

(a) the environmental and socioeconomic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs;

Article 4 Environmental objectives

(b) Member States ensure:

- for surface water, the highest ecological and chemical status possible is achieved, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution.

8. When applying paragraphs 3, 4, 5, 6 and 7, a Member State shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation.

Article 5 Characteristics of the river basin district, review of the environmental impact of human activity and economic analysis of water use

1. Each Member State shall ensure that for each river basin district or for the portion of an international river basin district falling within its territory:

- an analysis of its characteristics;
- a review of the impact of human activity on the status of surface waters and on groundwater; and
- an economic analysis of water use.

is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.

2. The analyses and reviews mentioned under paragraph 1 shall be reviewed, and if necessary updated at the latest 13 years after the date of entry into force of this Directive and every six years thereafter.

Article 8 Monitoring of surface water status, groundwater status and protected areas

1. Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district:

- for surface waters such programmes shall cover:

(i) the volume and level or rate of flow to the extent relevant for ecological and chemical status and ecological potential, and

(ii) the ecological and chemical status and ecological potential.

2. These programmes shall be operational at the latest six years after the date of entry into force of this Directive unless otherwise specified in the legislation concerned. Such monitoring shall be in accordance with the requirements of Annex V.

Article 11 Programme of measures

3. 'Basic measures' are the minimum requirements to be complied with and shall consist of:

(i) for any other significant adverse impacts on the status of water identified under Article 5 and Annex II, in particular measures to ensure that the hydromorphological conditions of the bodies of water are consistent with the achievement of the required ecological status or good ecological potential for bodies of water designated as artificial or heavily modified. Controls for this purpose may take the form of a requirement for prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community legislation. Such controls shall be periodically reviewed and, where necessary, updated.

7. The programmes of measures shall be established at the latest nine years after the date of entry into force of this Directive and all the measures shall be made operational at the latest 12 years after that date.

Article 13 River basin management plans

4. The river basin management plan shall include the information detailed in Annex VII.

6. River basin management plans shall be published at the latest nine years after the date of entry into force of this Directive.

7. River basin management plans shall be reviewed and updated at the latest 15 years after the date of entry into force of this Directive and every six years thereafter.

Article 14 Public information and consultation

1. Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users:

   (c) draft copies of the river basin management plan, at least one year before the beginning of the period to which the plan refers.

Annex II

1. Surface Waters

1.1. Characterisation of surface water body types

Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies in accordance with the following methodology. Member States may group surface water bodies together for the purposes of this initial characterisation.

(i) The surface water bodies within the river basin district shall be identified as falling within either one of the following surface water categories - rivers, lakes, transitional waters or coastal waters - or as artificial surface water bodies or heavily modified surface water bodies.

(v) For artificial and heavily modified surface water bodies the differentiation shall be undertaken in accordance with the descriptors for whichever of the surface water categories most closely resembles the heavily modified or artificial water body concerned.

1.3. Establishment of type-specific reference conditions for surface water body types

(ii) In applying the procedures set out in this Section to heavily modified or artificial surface water bodies references to high ecological status shall be construed as references to maximum ecological potential as defined in table 1.2.5 of Annex V. The values for maximum ecological potential for a water body shall be reviewed every six years.

1.4. Identification of Pressures

Member States shall collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water bodies in each river basin district are liable to be subject, in particular the following.

Estimation and identification of significant point source pollution, in particular by substances listed in Annex VIII, from urban, industrial, agricultural and other installations and activities, based, *inter alia*, on information gathered under:

(i) Articles 15 and 17 of Directive 91/271/EEC;

(ii) Articles 9 and 15 of Directive 96/61/EC;

and for the purposes of the initial river basin management plan:

(iii) Article 11 of Directive 76/464/EEC; and

(iv) Directives 75/440/EC, 76/160/EEC, 78/659/EEC and 79/923/EEC.

Estimation and identification of significant diffuse source pollution, in particular by substances listed in Annex VIII, from urban, industrial, agricultural and other installations and activities; based, inter alia, on information gathered under:

(i) Articles 3, 5 and 6 of Directive 91/676/EEC;

(ii) Articles 7 and 17 of Directive 91/414/EEC;

(iii) Directive 98/8/EC;

and for the purposes of the first river basin management plan:

(iv) Directives 75/440/EEC, 76/160/EEC, 76/464/EEC, 78/659/EEC and 79/923/EEC.

Estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses, including seasonal variations and total annual demand, and of loss of water in distribution systems.

Estimation and identification of the impact of significant water flow regulation, including water transfer and diversion, on overall flow characteristics and water balances.

Identification of significant morphological alterations to water bodies.

Estimation and identification of other significant anthropogenic impacts on the status of surface waters.

Estimation of land use patterns, including identification of the main urban, industrial and agricultural areas and, where relevant, fisheries and forests.

1.5. Assessment of Impact

Member States shall carry out an assessment of the susceptibility of the surface water status of bodies to the pressures identified above.

Member States shall use the information collected above, and any other relevant information including existing environmental monitoring data, to carry out an assessment of the likelihood that surface waters bodies within the river basin district will fail to meet the environmental quality objectives set for the bodies under Article 4. Member States may utilise modelling techniques to assist in such an assessment.

For those bodies identified as being at risk of failing the environmental quality objectives, further characterisation shall, where relevant, be carried out to optimise the design of both the monitoring programmes required under Article 8, and the programmes of measures required under Article 11.

Annex V

1.1. Quality elements for the classification of ecological status

1.1.5. The quality elements applicable to artificial and heavily modified surface water bodies shall be those applicable to whichever of the four natural surface water categories above most closely resembles the heavily modified or artificial water body concerned.

1.2. Normative definitions of ecological status classifications

1.2.5. Definitions for maximum, good and moderate ecological potential for heavily modified or artificial water bodies

Element	Maximum ecological potential	Good ecological potential	Moderate ecological potential
Biological quality elements	The values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body.	There are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.	There are moderate changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential. These values are significantly more distorted than those found under good quality.

Element	**Maximum ecological potential**	**Good ecological potential**	**Moderate ecological potential**
Hydromorpho-logical elements	The hydromorphological conditions are consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Physico-chemical elements			
General conditions	Physico-chemical elements correspond totally or nearly totally to the undisturbed conditions associated with the surface water body type most closely comparable to the artificial or heavily modified body concerned. Nutrient concentrations remain within the range normally associated with such undisturbed conditions. The levels of temperature, oxygen balance and pH are consistent with those found in the most closely comparable surface water body types under undisturbed conditions.	The values for physico-chemical elements are within the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Temperature and pH do not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Element	Maximum ecological potential	Good ecological potential	Moderate ecological potential
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (< EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with the undisturbed conditions found in the surface water body type most closely comparable to the artificial or heavily modified body concerned (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 (1) without prejudice to Directive 91/414/EC and Directive 98/8/EC. (< EQS)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

1.4. Classification and presentation of ecological status

1.4.1. Comparability of biological monitoring results

(i) Member States shall establish monitoring systems for the purpose of estimating the values of the biological quality elements specified for each surface water category or for heavily modified and artificial bodies of surface water. In applying the procedure set out below to heavily modified or artificial water bodies, references to ecological status should be construed as references to ecological potential. Such systems may utilise particular species or groups of species which are representative of the quality element as a whole.

1.4.2. Presentation of monitoring results and classification of ecological status and ecological potential

(i) For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below. Member States shall provide a map for each river basin district illustrating the classification of the ecological status for each body of water, colour-coded in accordance with the second column of the table set out below to reflect the ecological status classification of the body of water:

Ecological status classification	Colour Code
High	Blue
Good	Green
Moderate	Yellow
Poor	Orange
Bad	Red

(ii) For heavily modified and artificial water bodies, the ecological potential classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below. Member States shall provide a map for each river basin district illustrating the classification of the ecological potential for each body of water, colour-coded, in respect of artificial water bodies in accordance with the second column of the table set out below, and in respect of heavily modified water bodies in accordance with the third column of that table:

Ecological potential classification	Colour code	
	Artificial Water Bodies	Heavily Modified
Good and above	Equal green and light grey stripes	Equal green and dark grey stripes
Moderate	Equal yellow and light grey stripes	Equal yellow and dark grey stripes
Poor	Equal orange and light grey stripes	Equal orange and dark grey stripes
Bad	Equal red and light grey stripes	Equal red and dark grey stripes

(iii) Member States shall also indicate, by a black dot on the map, those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants (in accordance with the compliance regime established by the Member State).

Annex VII River basin management plans

A. River basin management plans shall cover the following elements:

1. a general description of the characteristics of the river basin district required under Article 5 and Annex II. This shall include:

1.1. for surface waters:

- mapping of the location and boundaries of water bodies;
- mapping of the ecoregions and surface water body types within the river basin;
- identification of reference conditions for the surface water body types.

2. a summary of significant pressures and impact of human activity on the status of surface water and groundwater, including:

- estimation of point source pollution;
- estimation of diffuse source pollution, including a summary of land use;
- estimation of pressures on the quantitative status of water including abstractions;
- analysis of other impacts of human activity on the status of water.

4. a map of the monitoring networks established for the purposes of Article 8 and Annex V, and a presentation in map form of the results of the monitoring programmes carried out under those provisions for the status of:

4.1 surface water (ecological and chemical);

4.2 groundwater (chemical and quantitative);

4.3 protected areas;

7. a summary of the programme or programmes of measures adopted under Article 11, including the ways in which the objectives established under Article 4 are thereby to be achieved.

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ANNEX V – LIST OF CASE STUDIES AND CONTACTS

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NO	Suldalslagen R.	Pedersen, Tor Simon	Norwegian Water Researches and Energy Dir/Hydrology Dept	tsp@nve.no	[47] 22-959 205
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S	Eman R.	Weichelt, Ann-Karin	County Administrative Board Jönköping	Lansstyrelsen@f.lst.se	[46] 36-395000
	Daläven R.	Beier, Ulrike	National Board of Fisheries, Institute of Freshwater Research	Ulrika.Beier@fiskriverket.se	[46] 8- 7590338
	Ume R.	Jansson, Roland	Swedish Environmental Protection Agency/Department of Environmental Assessment	Roland@eg.umu.se	[46] 90-7869573
	Archipelago, Baltic Sea	Tullback, Klara	County Administrative Board	Klara.tullback@ab.lst.se	[46] 8-7854103
UK (E&W)	Kennet R. (Thames)	Dunbar, Michael	Centre for Ecology and Hydrology	Mdu@ceh.ac.uk	[44] 1491-838800
	Tame R.	Dunbar, Michael	Centre for Ecology and Hydrology	Mdu@ceh.ac.uk	[44] 1491-838800
	Sankey Brook	Dunbar, Michael	Centre for Ecology and Hydrology	Mdu@ceh.ac.uk	[44] 1491-838800
	Great Ouse R.	Dunbar, Michael	Centre for Ecology and Hydrology	Mdu@ceh.ac.uk	[44] 1491-838800
UK (Scot)	Forth Estuary	Black, A. R.	Geography Department, University of Dundee	a.z.black@dundee.ac.uk	[44] 1382-344434
	Tummel R.	Black, A. R.	Geography Department, University of Dundee	a.z.black@dundee.ac.uk	[44] 1382-344434
	Dee R.	Black, A. R.	Geography Department, University of Dundee	a.z.black@dundee.ac.uk	[44] 1382-344434
UK (NI)	Lagan R.	Corbelli, David	SEPA	David.corbelli@sepa.org.uk	[44] 17-86457700

The sub-groups and water body categories of the HMWB case studies

Country	Name of Case Study	Navigation subgroup (lead: D)	Hydropower subgroup (lead: A)	River	Lake	Transitional waters	Coastal waters
A	Bregenzerach R.		+	+			
	Danube R.	+	+	+			
	Wienfluss			+			
B	Dender R.	+		+			
D	Elbe R.	+		+			
	Seefelder Aach R.		+	+			
	Lahn R.	+	+	+			
	Ruhr R.		+	+			
	Mulde R.			+			
	Dhünn R.			+			
E	Lozoya R.		+	+			
SF	Kemijärvi L.		+		+		
F	Authie R.			+			
	Sarre R.			+			
	Rhone R.			+			
GR	Nestos R.		+	+			
NL	Haringvliet Est.	+				+	
	Hagmolenbeek-Hegebeek R.			+			
	Loosdrecht L.				+		
	Veluwerandmeren				+		
NO	Suldalslagen R.		+	+			
	Beiarn R.		+	+			
S	Eman R.		+	+			
	Daläven R.		+	+			
	Ume R.		+	+			
	Archipelago, Baltic Sea						+
UK (E&W)	Kennet R. (Thames)	+		+			
	Tame R.			+			
	Sankey Brook	+		+			
	Great Ouse R.	+		+			
UK (Scot)	Forth Est.					+	
	Tummel R.		+	+			
	Dee R.		+	+			
UK (NI)	Lagan R.	+		+			

Case studies and the specified uses

Country	Name of Case Study	Navigation	Flood/coastal protection	Hydro-power	Water supply	Agriculture / forestry	Urbanisation	Industry	Recreation	Other specified uses
	Notes: (*** : Specified use of high intensity, ** : Specified use of intermediate intensity, * : Specified use of lower intensity)									
A	Bregenzerach R.			***						
	Danube R.	**	***	***				**		
	Wienfluss		***				**			
B	Dender R.	***	*			*	*	**		
D	Elbe R.	***	***			**	*		*	Fishing
	Seefelder Aach R.		**	***		***		*	*	
	Lahn R.	**	**	***		*	*	*		
	Ruhr R.	*	**	**	***	*	***	**	***	
	Mulde R.		**	***	**	**	**	**		
	Dhünn R.		**	**	***	*	***		**	
E	Lozoya R.			**	***	*	*		*	
SF	Kemijärvi L.		**	***		*	*	*	*	Fish farms
F	Authie R.		**	**		***	**	*	*	Fish farms
	Rhone R.	***	***	***		*	**			
	Sarre R.	*	**			**	*			
GR	Nestos R.		**	***		**				
NL	Haringvliet Est.	***	***		**	*				
	Hagmolenbeek-Hegebeek R.	**	**			***				
	Loosdrecht L.	**	**		*	**	*		**	Fisheries
	Veluwerandmeren	*	**		*	**	*	*	*	Fisheries
NO	Suldalslagen R.			***		*	*	*	*	
	Beiarn R.		*	***		*			*	
S	Eman R.			***		*	*			Fishing

Country	Name of Case Study	Navigation	Flood/coastal protection	Hydro-power	Water supply	Agriculture / forestry	Urbanisation	Industry	Recreation	Other specified uses
	Notes: (*** : Specified use of high intensity, ** : Specified use of intermediate intensity, * : Specified use of lower intensity)									
	Dalalven R.			***		**				
	Ume R.		*	***		**	*	*	*	Fishing
	Archipelago,Baltic coastal	***	***			**	***	*	***	Fish farms
UK (E&W)	Kennet R. (Thames)	***	**		*	**	**	**		
	Tame R.	**	***			*	***	**		
	Sankey Brook	*	**		**	**	***	**		
	Great Ouse R.	**	***		*	***	**	**		
UK (Scot)	Forth Est.	**	***			**	***	***	*	Agricultural land take, industrial land take
	Tummel R.			***					*	
	Dee R.			***	*	*			*	Fish farms
UK (NI)	Lagan R.		**			***	***	*	*	

ANNEX VI - CASE STUDY REPORTS

Austria

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Netherlands

Backx, J.J.G.M., G. v.d. Berg, N. Geilen, A. de Hoog, EJ. Houwing, M. Ohm, M. van Oirschot and M. van Wijngaarden (2002), Heavily Modified Waters in Europe - Case Study on the Haringvliet Estuary, RIZA, Dordrecht.

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Spain

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Sweden

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UK, Scotland

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Black, A. R., O.M. Bragg, C.M. Caudwell, R.W. Duck, A.M. Findlay, N.D. Hanley, S.M. Morrocco, A.D. Reeves and J.S. Rowan (2002a), Heavily Modified Waters in Europe - Case Study on the Forth Estuary, Geography Department and Biological Sciences Institute, University of Dundee, and Department of Economics, University of Glasgow, Dundee, Glasgow.

Black, A. R., O.M. Bragg, R.W. Duck, A.M. Findlay, N.D. Hanley, S.M. Morrocco, A.D. Reeves and J.S. Rowan (2002b), Heavily Modified Waters in Europe - Case Study on the River Dee (Galloway, Scotland), Geography Department and Biological Sciences Institute, University of Dundee, and Department of Economics, University of Glasgow, Dundee, Glasgow.

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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 5

Transitional and Coastal Waters

Typology, Reference Conditions and Classification Systems

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 5

Transitional and Coastal Waters – Typology, Reference Conditions and Classification Systems

Produced by Working Group 2.4 - COAST

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Executive Summary

In May 2001 the Common Implementation Strategy was established. The objective of the Strategy has been to provide support to the implementation of the Water Framework Directive by developing coherent common understanding and guidance on key elements of the Directive.

The COAST working group was one of the working groups established within the Strategy. The remit of the group has been to develop a non-legally binding document providing Guidance on the implementation of Annexes II and V in relation to transitional and coastal waters.

This Guidance Document has been written over a relatively short period of time. A series of working group meetings were held and attended by technical experts and regulators from European Union Member States, Norway and some Accession States as well as experts representing Non-Governmental Organisations and Stakeholder organisations associated with water and environmental policy.

The Guidance is not prescriptive and will need to be adapted to fit local circumstances. It is also recognised that further work is required on the development of classification schemes as classification tools are tested and class boundaries are set.

The importance of continued communication between experts from different Member States is emphasised throughout the Guidance especially with respect to typology, reference conditions and classification.

Acknowledgements

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- Scotland and Northern Ireland Forum for Environmental Research (SNIFFER);
- Environment and Heritage Service (EHS), Northern Ireland;
- Scottish Environment Protection Agency (SEPA);
- Environment Agency of England and Wales;
- Bundesamt fuer Seeschifffahrt und Hydrographie (BSH), Germany;
- Umweltbundesamt (UBA), Germany;
- European Environment Agency;
- Ministry of Ecology and Sustainable Development, France;
- Seine-Normandie Water Agency, France;
- Swedish Environment Protection Agency;
- National Environmental Protection Agency (ANPA);

Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

A working group referred to as COAST was established to produce a practical Guidance Document for the implementation of the Directive for transitional and coastal waters. The working group was established in summer 2001 and was led by the UK with France, Germany, Sweden and the EEA forming the steering group. The working group included representatives from each Member State as well as some candidate countries and non-governmental organisations (NGOs) and stakeholder organisations.

This Guidance is the outcome of COAST. It synthesises COAST activities and discussions since summer 2001. It builds on the input and feedback from a wide range of experts and stakeholders in EU Member States and candidate countries who were involved in the development of the Guidance through meetings, workshops, conferences and electronic communication, without binding them in any way to its content.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders, Claire Vincent and the steering group, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a *living document* that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

Table of Contents

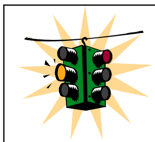
Introduction - A Guidance Document: What For?

This document aims to guide experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the key requirements for implementation of the Directive in relation to coastal and transitional waters.

TO WHOM IS THIS GUIDANCE DOCUMENT ADDRESSED?

If this is your task, we believe the Guidance will help you in *doing the job,* if you or your team are:

- **Developing typology, producing descriptions of reference conditions or developing classification schemes for coastal and transitional waters;**
- **Reporting the status of coastal and transitional waters to the European Union as required by the Directive;**
- **Using the results of the classification of coastal and transitional waters to develop policy**;
- **Implementing related parts of the Directive such as the Intercalibration or Pilot River Basin Studies exercises.**



Look out! The methodology from this Guidance Document can be adapted to regional and national circumstances.

The Guidance Document proposes a European approach. Because of the diversity of coastal and transitional waters across Europe the document has been kept as general as possible whilst still trying to provide a practical level of guidance.

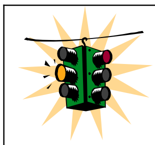
WHAT CAN YOU FIND IN THIS GUIDANCE DOCUMENT?

The Common Understanding of Terms

Typology

Reference Conditions

Classification



Look out! What you will <u>not</u> find in this Guidance Document:

- Guidance for coastal and transitional waters that are designated as Heavily Modified water bodies;
- A definitive typology for coastal and transitional waters;
- A set of reference conditions;
- A definitive classification tool or scheme;
- Guidance relating to lakes, rivers (WG 2.3) groundwaters and heavily modified water bodies (WG 2.2).

Historically there has been only limited classification in the transitional and coastal waters of Europe. Existing classification tools have relied heavily on expert judgement. Therefore this Guidance Document makes suggestions of schemes, tools and best practice which will have to be tested and developed over the next few years.

Section 1 – Introduction – Implementing the Directive.

This Section introduces you to the overall context for the implementation of the Water Framework Directive (WFD) and informs you of the initiatives that led to the production of this Guidance Document.

1.1. DECEMBER 2000: A MILESTONE FOR WATER POLICY

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the WFD (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the WFD.

1.2. THE WATER FRAMEWORK DIRECTIVE: NEW CHALLENGES IN EU WATER POLICY

What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancement, protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution;
- Contributes to mitigating the effects of floods and droughts.

…and what is the key objective?

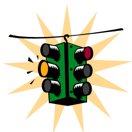
Overall, the Directive aims at achieving *good water status* for all waters by 2015.

1.3. WHAT ARE THE KEY ACTIONS THAT MEMBER STATES NEED TO TAKE?

- To identify the individual river basins lying within their national territory and assign them to River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (*Article 2 (22), Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving cost-effectively the environmental objectives of the WFD (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).

Table 1.1. Timetable of Implementation of the Water Framework Directive.

Year	Requirements
2000	Directive Adopted
2003	Transpose into National law Identify River Basin Districts and Competent Authorities Identify draft register of intercalibration sites
2004	Characterisation of water bodies, including Heavily Modified water bodies Review pressures and impacts and identify sites at risk of not meeting the environmental objective of 'good status' Establish register of Protected Areas Undertake economic analysis of water use Final register of intercalibration sites
2006	Comprehensive monitoring programmes operational
2007	Repeal some Directives
2008	Publish Draft River Basin Management Plans which will include a first draft of the classification of water bodies
2009	River Basin Management Plans produced to include final classification of the ecological status of water bodies Programme of measures for each RBD
2010	Water pricing policies contribute to environmental objectives
2013	Repeal some Directives
2015	"Good" Status to be achieved



Look Out!

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such circumstances that will be specifically explained in the RBMPs, the WFD offers the opportunity to Member States to engage in two further six- year cycles of planning and implementation of measures.

1.4. CHANGING THE MANAGEMENT PROCESS – INFORMATION, CONSULTATION AND PARTICIPATION

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

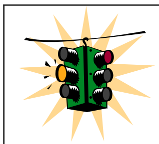
- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

1.5. INTEGRATION: A KEY CONCEPT UNDERLYING THE WATER FRAMEWORK DIRECTIVE

The concept central to the WFD is *integration* which is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Freshwater Fish Directive) have been reformulated in the WFD to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;

- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** whether local, regional or national, for effective management of all waters;
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.



Look out! A number of international marine conventions deal with the protection of large maritime areas such as the North East Atlantic (OSPAR), the Baltic (HELCOM) and the Mediterranean (BARCOM). These Conventions deal with many marine environmental protection issues including the issue of transboundary pollution. Throughout the drafting of this Guidance the COAST working group has tried to ensure good linkages with these Conventions and to build on the sound science that has already been developed. It is the intention to continue to improve the linkages between the Marine Conventions and the EU under the imminent EU Marine Strategy.

1.6. WHAT IS BEING DONE TO SUPPORT IMPLEMENTATION?

Activities to support the implementation of the WFD are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilots for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the WFD.

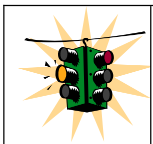
May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the WFD by developing a coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities has been launched to develop and test non-legally binding Guidance (see *Annex A of this Guidance Document*). A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision body for the Common Implementation Strategy.

1.7. THE COAST WORKING GROUP (CIS WG 2.4)

The COAST working group was created specifically to deal with the issues relating to transitional and coastal waters and to produce a non-legally binding document of practical advice for implementing the WFD, specifically Annexes II and V, in relation to these waters. The members of the working group included technical experts and regulators from European Union Member States, Norway and some Accession States as well as experts representing NGOs and Stakeholders organisations associated with water and environmental policy.



Look out! You can contact the experts involved in the COAST activities

A complete list of COAST members with full contact details is in *Annex B* of this Guidance Document. If you need input into your own activities, please contact a member from COAST in your country. If you want more information on specific pilot studies (Annex C), or classification tools and schemes and tools presented in the toolbox (Section 6) you may directly contact those people from the relevant Member State.

To ensure adequate input and feedback from a wide audience during the drafting of this document, the COAST group organised a series of working group meetings and workshops as well as widely circulating draft documents for comments.

Development of this Guidance Document was an interactive process. Between September 2001 and September 2002 a large number of experts and stakeholders have been involved in the development of this Guidance. The process has included the following activities:

- **Regular meetings** of the 40 or more experts and stakeholder members of COAST;
- A series of **meetings of the Steering Group** (representatives from UK (lead), France, Germany, Sweden and EEA). These meetings guided the project and agreed on the final structure and format;
- Organisation of **three eco-region workshops** (Baltic, Mediterranean and North-East Atlantic) on typology;
- The **collation of draft coastal and transitional types** from Member States. The purpose of this exercise was four-fold:
    - to determine the approximate number of coastal and transitional types;
    - to prevent Member States assigning different names to the same types and *vice versa*;

    - to identify where Member States have the same type and may therefore be able to share reference conditions;
    - to assist in the identification of suitable types for intercalibration.
- A series of **reference condition pilot studies** were carried out by several Member States and the lessons learnt from these have contributed to the Guidance Document;
- Invitation of **experts from other working groups to attend *COAST* meetings**;
- **Experts from COAST attending the meetings of other working groups**;
- Regular **interactions with experts from other working groups of the Common Implementation Strategy**:
    - WG 2.1 (Assessment of pressures and impacts);
    - WG 2.2 (Designation of heavily modified water bodies);
    - WG 2.3 (Reference conditions and classification for freshwater);
    - WG 2.5 (Intercalibration);
    - WG 2.7 (Monitoring).

  The links established with these working groups have resolved some of the issues encountered by COAST and also highlighted areas that needed consideration and discussion (Figure 1);
- The **working group leader, Claire Vincent, attended regular meetings of the Strategic Co-ordination Group and Working Group Leaders** in Brussels throughout the development of the Guidance.

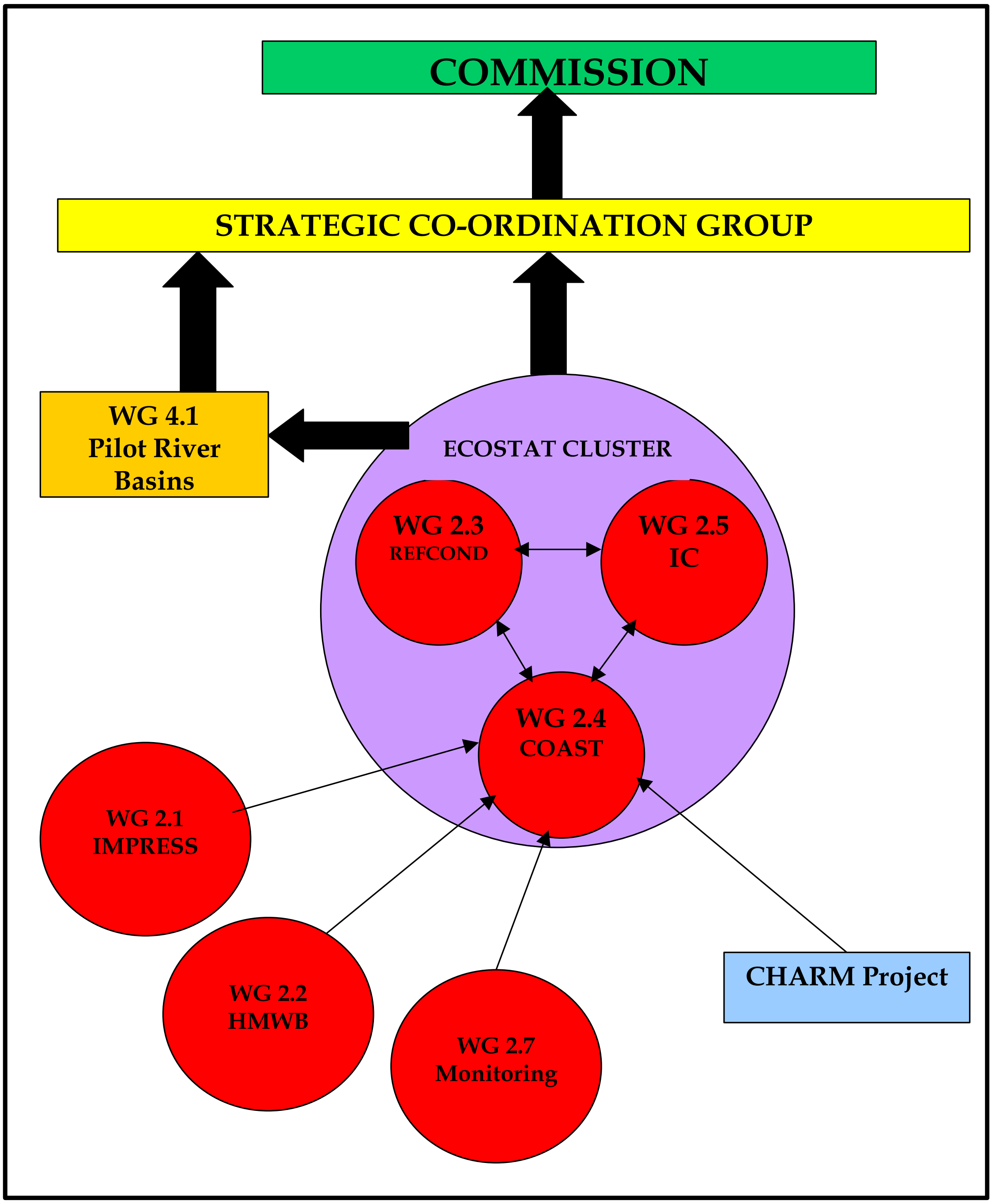


Figure 1.1. **Links between COAST, the Commission, other CIS working groups and European funded projects.**

Section 2 – The Common Understanding of Terms related to Transitional and Coastal Waters.

This Section provides guidance on the language used in the Directive for transitional and coastal waters.

2.1. DEFINITIONS OF TRANSITIONAL AND COASTAL WATERS

2.1.1. The Directive defines **transitional waters** as:

> **Article 2 (6)**
> *"'Transitional waters' are bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows."*

2.1.2. Further guidance is given in Section 2.3 on defining transitional waters.

2.1.3. The Directive defines **coastal waters** as:

> **Article 2 (7)**
> *"'Coastal water' means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters."*

2.1.4. The ecological status of coastal waters should be classified from the landward extent of either the coastal or transitional waters out to one nautical mile from the baseline. According to the United Nations Convention on the Law of the Sea (UNCLOS) the baseline is measured as the low-water line except along the mouths of estuaries and heads of bays where it cuts across open water. Along highly indented coastlines, bays, mouths of estuaries or coastlines with islands, the baseline can be drawn as a straight line. Each Member State has a legislative baseline associated with this definition.

2.1.5. The Directive gives no indication of the landward extent of either transitional or coastal waters. One of the hydromorphological quality elements for both transitional and coastal waters is the structure of the intertidal zone. Since it is likely that some of the quality elements may be monitored within the intertidal area, it is recommended that transitional and coastal water bodies include the intertidal area from the highest to the lowest astronomical tide.

2.2. DEFINING SURFACE WATER BODIES WITHIN TRANSITIONAL AND COASTAL WATERS

Annex II 1.1
"Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies".

2.2.1. The Directive requires surface waters within the River Basin District to be split into water bodies (Figure 2.1). Water bodies represent the classification and management unit of the Directive. A range of factors will determine the identification of water bodies. Some of these will be determined by the requirements of the Directive and others by practical water management considerations.

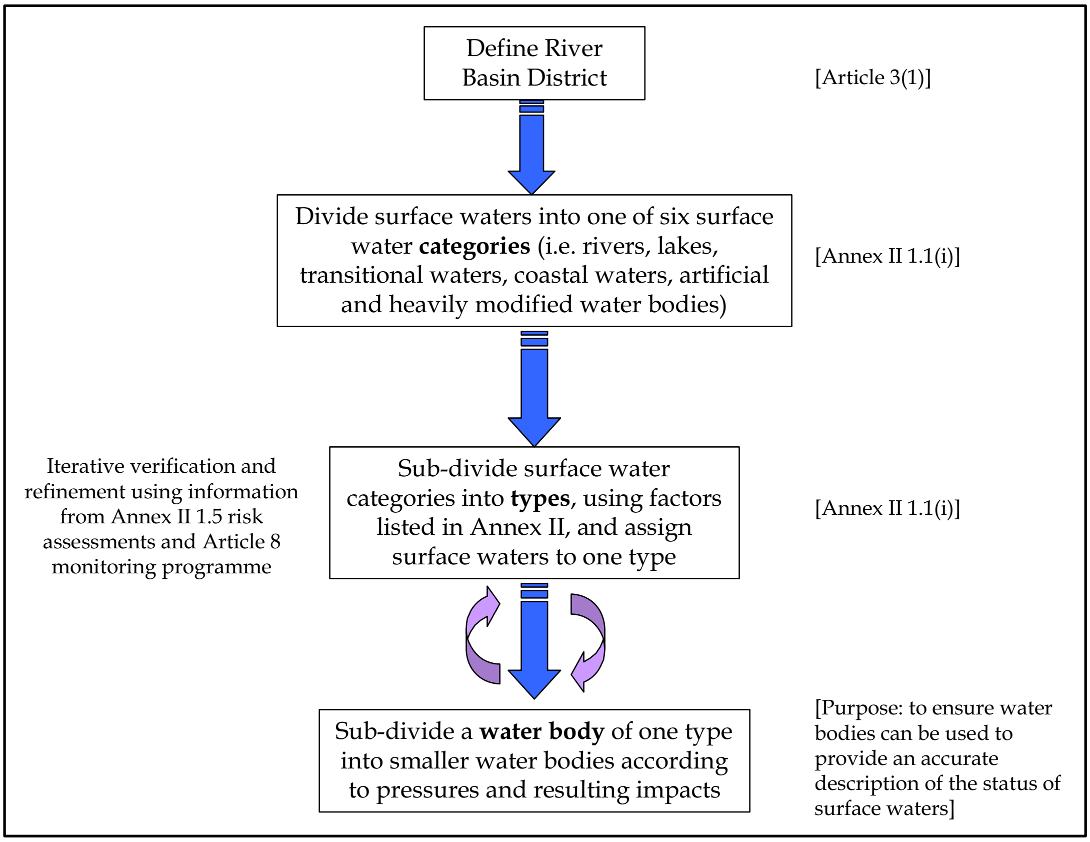


Figure 2.1. Summary of suggested hierarchical approach to the identification of surface water bodies.

2.2.2. This paper provides guidance on defining water bodies specific to coastal and transitional waters. A separate horizontal Guidance Document is available which specifically gives guidance on the term 'water body' and the identification of water bodies (WFD CIS Guidance Document No 2.).

Surface Water Categories

Annex II 1.1(i)
"The surface water bodies within the river basin district shall be identified as falling within either one of the following surface water categories – rivers, lakes, transitional waters or coastal waters – or as artificial surface water bodies or heavily modified surface water bodies."

2.2.3. The first stage in describing surface water bodies is to assign all surface waters to a surface water category – rivers, lakes, transitional waters or coastal waters – or to artificial surface water bodies or heavily modified surface water bodies (Figure 2.2).

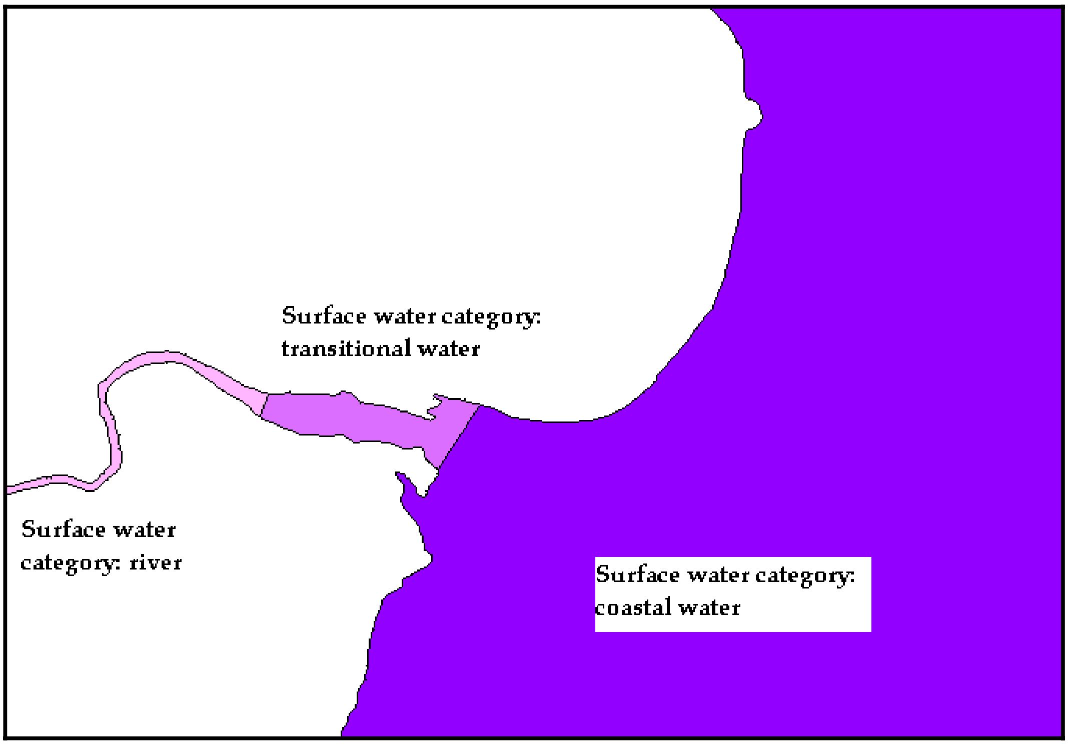


Figure 2.2. Surface Water Categories.

Surface Water Types

Annex II 1.1(ii)
"For each surface water category, the relevant surface water bodies within the river basin district shall be differentiated according to type. These types are those defined using either 'system A' or 'system B'."

2.2.4. The Directive recognises that the ecological character of surface waters will vary according to their different physical regimes. For example, a marine scientist expects to find different biological communities on an exposed Atlantic rocky shore compared to a fjord, a bay in the Baltic or a Mediterranean coastal lagoon. Examples of surface water types are shown in Figure 2.3. The purpose of assigning water bodies to a physical type is to ensure that valid comparisons of its ecological status can be made. For each type reference conditions must also be described, as these form the 'anchor' for classification of the water bodies status or quality. Guidance on how to type surface water bodies is given in Section 3.

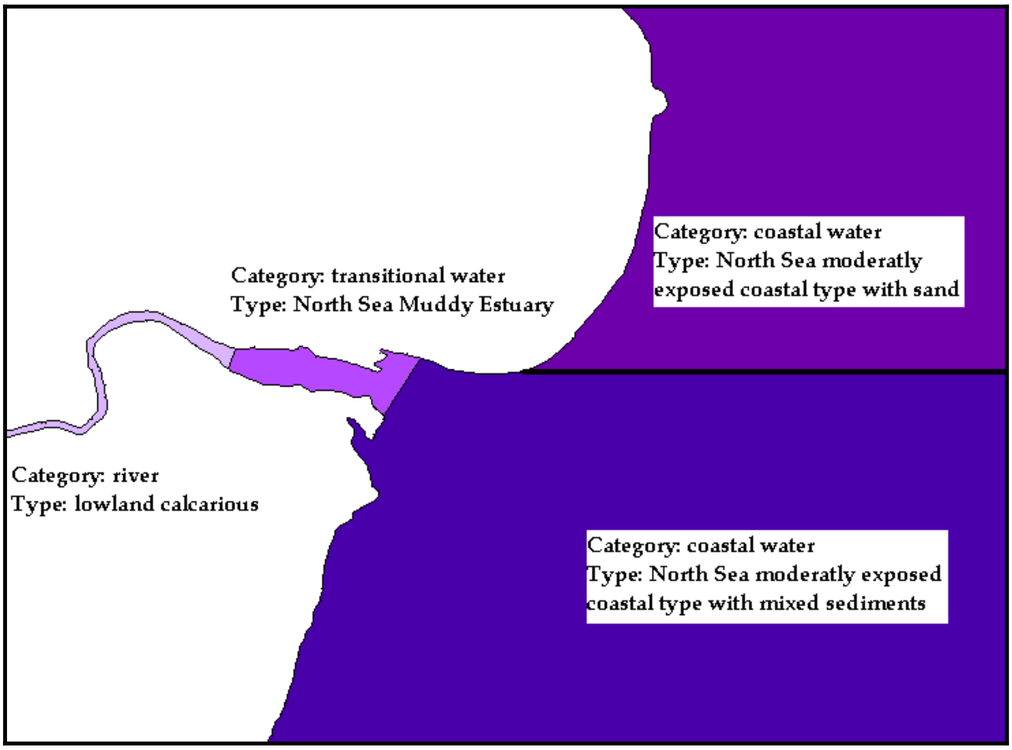


Figure 2.3. Types of surface water.

Surface Water Bodies

> **Article 2(10)**
> *"Body of surface water" means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.*

2.2.5. The water body is the management unit of the Directive.

2.2.6. Water bodies may be identified for all surface waters (natural, heavily modified and artificial waters). This step is of major importance for the implementation process because water bodies represent the units that will be used for reporting and assessing compliance with the Directive's principal environmental objectives.

2.2.7. To assign a single classification and effective environmental objectives to a water body it may be necessary to divide an area which is of one type further into two or more separate water bodies (Figure 2.4.). Water bodies may not spread over two types because reference conditions and hence environmental objectives are type specific.

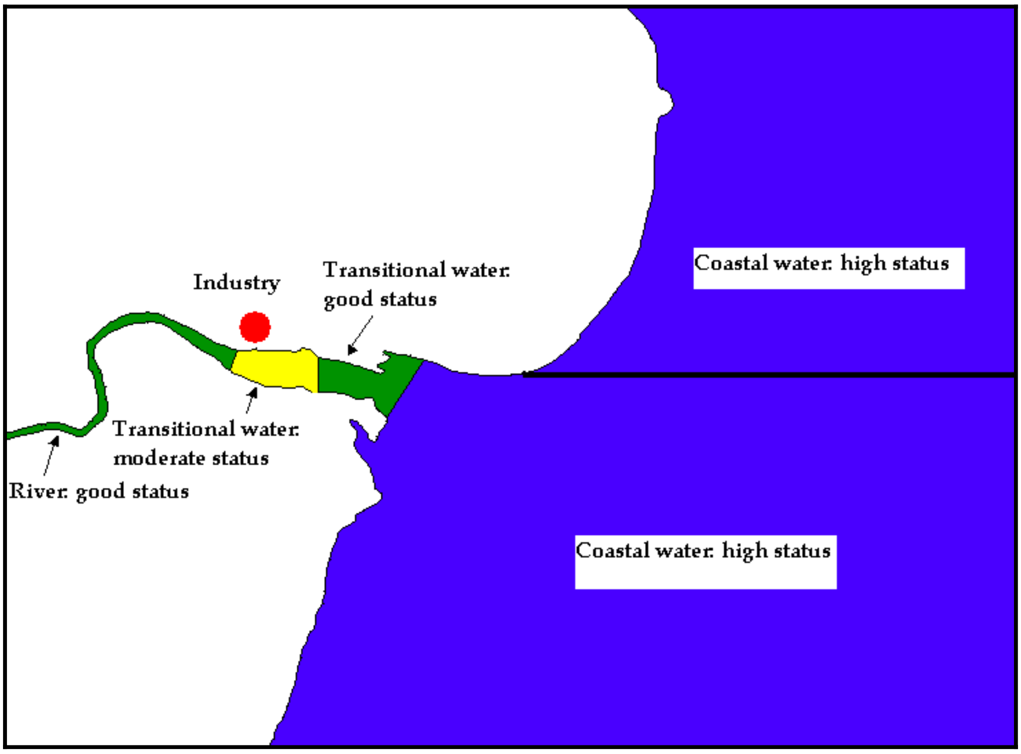


Figure 2.4. Surface water bodies. The colours used relate to those stated in Annex V 1.4.2 for reporting.

2.2.8. According to the definition in the Directive, water bodies must be "discrete and significant". This means that they must not be arbitrary sub-divisions of river basin districts, that they must not overlap with each other, nor be composed of elements of surface water that are not contiguous.

2.2.9. The Directive specifies that rivers and coastal waters may be sub-divided. It is assumed that transitional waters may also be sub-divided as long as the resulting water bodies are discrete and significant (Figure 2.5). In the case of coastal waters, stretches of open coast are often continuous (unless divided by transitional waters); here subdivisions may follow significant changes in substratum, topographies or aspect.

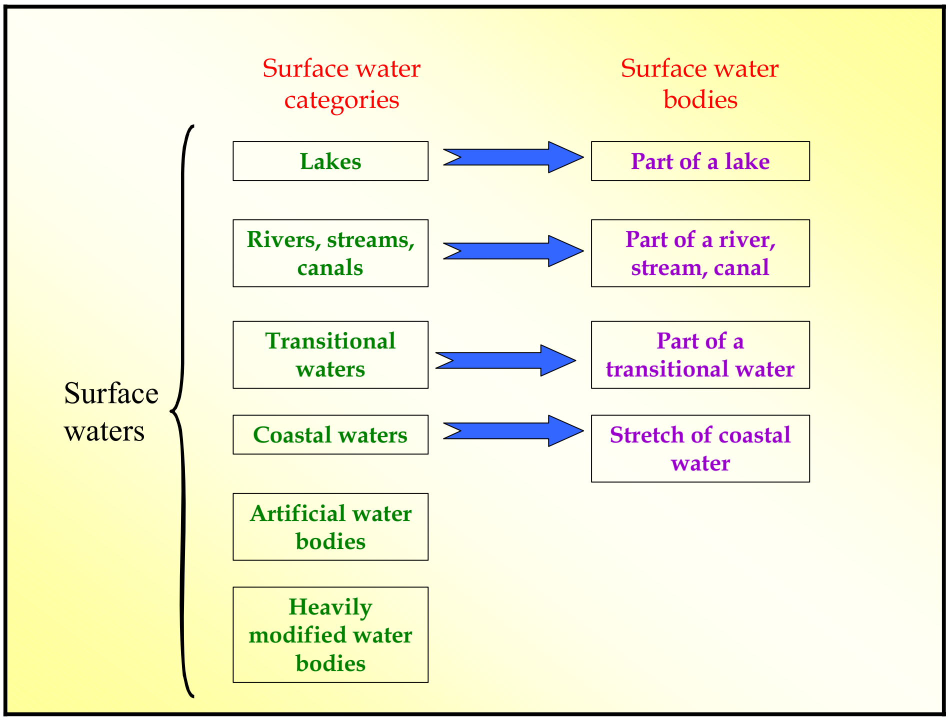
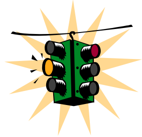


Figure 2.5. The splitting of surface water categories into surface water bodies.

2.2.10. The need to keep separate two or more contiguous water bodies of the same type depends upon the pressures and resulting impacts. For example, a discharge may cause organic enrichment in one water body but not in the other. Such an area of one type could therefore be divided into two separate water bodies with different classifications. If there were no impact from the discharge it would not be necessary to divide the area into two water bodies as it would have the same classification and should be managed as one entity.



Look out! The Directive only requires sub-divisions of surface water that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of coastal and transitional waters into smaller and smaller water bodies that do not support this purpose should be avoided.

2.2.11. Every six years from 2013, Member States must review the characterisation of water bodies, including the type-specific reference conditions, so as to reflect greater understanding and knowledge of the systems and natural variability including climate change. In this review, water bodies whose status changes may be merged with adjacent water bodies of the same status **and** the same type.

> **Article 5(2)**
> *"The analyses and reviews mentioned under"* [Article 5] *"paragraph 1 shall be reviewed, and if necessary updated at the latest 13 years after the date of entry into force of this Directive and every six years thereafter."*

2.3. DEFINING TRANSITIONAL WATERS

2.3.1. The Directive defines transitional waters as:

> **Article 2 (6)**
> *"'Transitional waters' are bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows."*

2.3.2. When defining transitional waters for the purposes of the WFD, it is clear that the setting of boundaries between transitional waters, freshwaters and coastal waters must be ecologically relevant.

2.3.3. Transitional waters are:
(1) "...in the vicinity of a river mouth" meaning close to the end of a river where it mixes with coastal waters;
(2)"...partly saline in character" meaning that the salinity is generally lower than in the adjacent coastal water;
(3)"...substantially influenced by freshwater flow" meaning that there is a change to salinity or flow.

2.3.4. If riverine dynamics occur in a plume outside the coastline because of high and strong freshwater discharge, the transitional water may extend into the sea area (allowed in definition 1).

2.3.5. For the purposes of the Directive, the main difference between transitional and coastal waters is the inclusion of the abundance and composition of fish fauna in the list of biological quality elements for the classification assessment of transitional waters.

2.3.6. Transitional waters are usually characterised by their morphological and chemical features in relation to the size and nature of the inflowing rivers. Many different methods might be used to define them but the method should be relevant ecologically. This will ensure reliable derivation of type-specific biological reference conditions.

2.3.7. In certain areas of the Baltic Sea, such as the Bothnian Bay, the salinity of coastal water is similar to that of fresh water. As a result riverine fresh water life may extend into the adjacent coastal water. However, because of the different physical characteristics (flow dynamics) of a river and coastal water (Article 2(6)), the same biological community falls into two different categories of surface waters (river - coastal) and hence must be separated into two different water bodies, as required by the Directive. In such cases the delimitation of a transitional water might be superfluous.

Defining the seaward boundary of transitional waters

2.3.8. To assist Member States in defining the seaward boundary of transitional waters, four methods are proposed.

1. The use of boundaries defined under other European and national legislation such as the Urban Waste Water Treatment Directive;
2. Salinity gradient;
3. Physiographic features;
4. Modelling.

2.3.9. Member States should select the most ecologically relevant method for their own situation. The use of one or more of these approaches will allow comparisons across all Member States.

The use of boundaries defined under other European and National legislation

2.3.10. Where boundaries of transitional waters were defined for the purposes of existing legislation, they may be used to define transitional waters under the WFD as long as they are consistent with the WFD categories.

2.3.11. Article 17(1) and (2) of the Urban Waste Water Treatment Directive (91/271/EC) gave Member States the task of establishing an implementation programme to include information on discharges into different types of water bodies, which might have implicated defining the outer (seaward) limit of estuaries. Each Member State used its own individual method. These boundaries are likely to have been drawn for most sizeable estuaries and could be used to define transitional waters for the purposes of the WFD.

Salinity gradient

2.3.12. If salinity measurements exist, the outer boundary should be drawn where the salinity of the transitional water is usually substantially lower than the salinity of the adjacent coastal water. By definition, the transitional water must also be substantially influenced by freshwater flows.

2.3.13. For larger rivers the influence of freshwater is likely to extend into coastal waters (Figure 2.6).

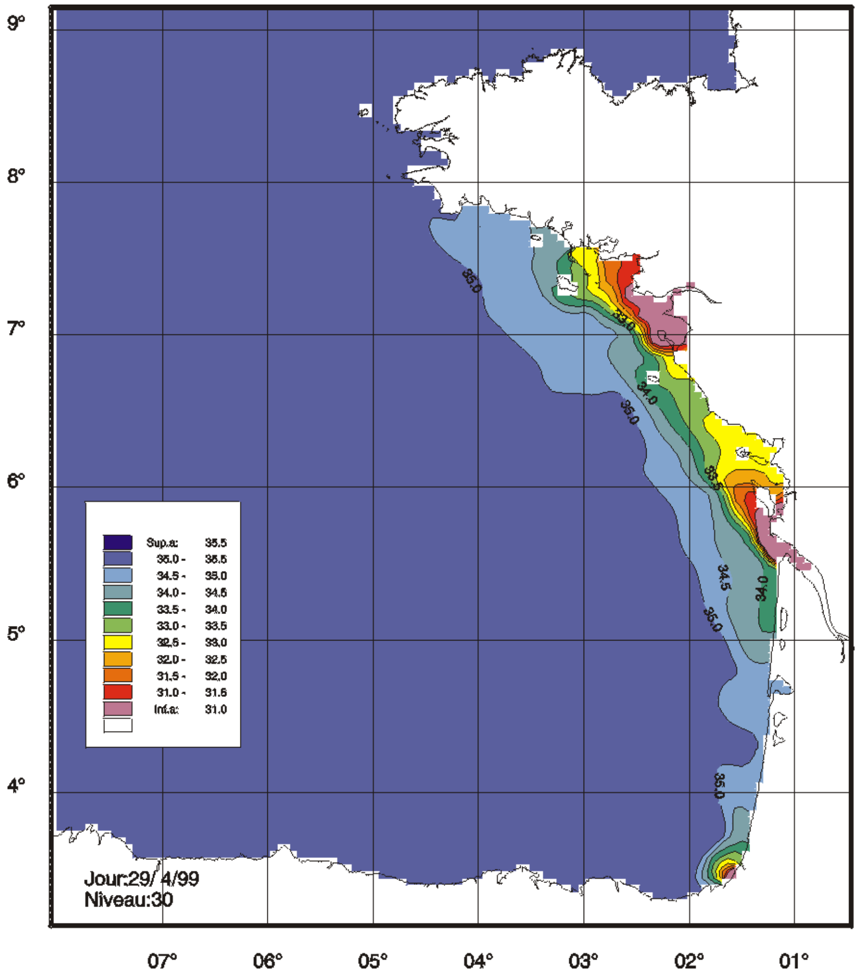


Figure 2.6. **Examples of the plumes of the Loire and Gironde estuaries on the French Atlantic coast. The extension of the plume (salinity gradient) varies according to freshwater flow and tide conditions.**

Physiographic features

2.3.14. Where morphological boundaries lie close to enclosing geographic features such as headlands and islands, such features may be used to define the boundary.

This is acceptable in some cases such as bar-built estuaries (Figure 2.7) whose morphological features may also coincide with biological boundaries.

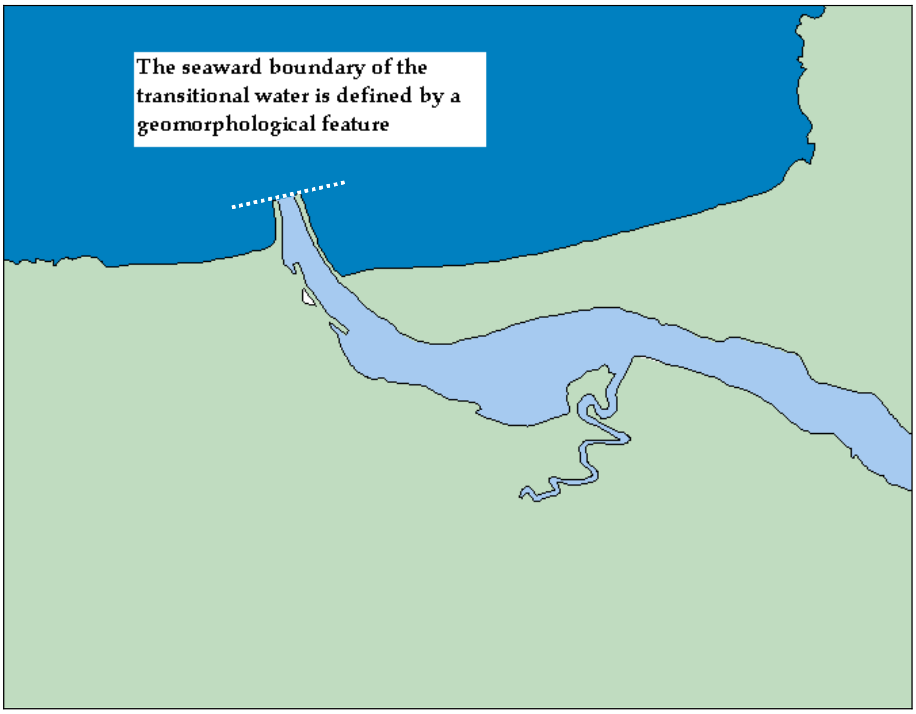


Figure 2.7. Bar-built estuary showing that geomorphological and biological limits of transitional waters can coincide.

Modelling

2.3.15 Models may be designed to predict the size of transitional waters. This method may be applicable where no estuary boundary has been defined for the purpose of existing legislation and where no suitable salinity data are available. Models may be used to estimate the area of water of a salinity substantially less than the salinity of the adjacent coastal water.

Defining the freshwater boundary of transitional waters

2.3.16. Annex II 1.2.3. and 1.2.4 of the Directive defines freshwater as less than 0.5 salinity.

2.3.17. There are two main methods for defining the freshwater boundary of transitional waters: the fresh/salt water boundary or the tidal limit (Figure 2.8). In some large estuaries, the tidal limit can be several tens of kilometres further inland than the freshwater/salt water boundary.

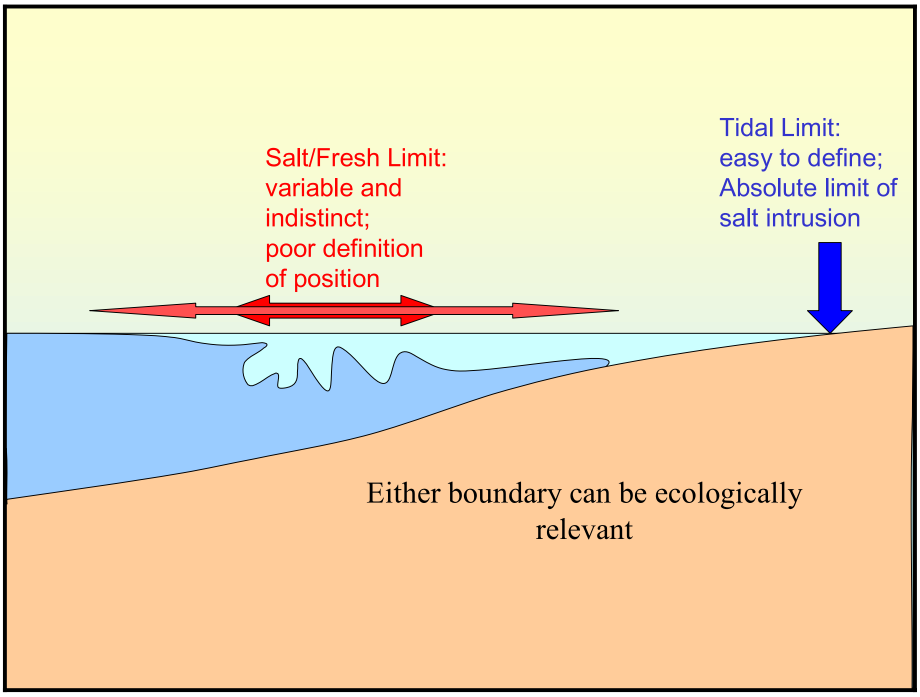


Figure 2.8. Methods for defining the freshwater boundary of transitional waters.

2.3.18. It is suggested that either the fresh /salt boundary or the tidal limit be used to define the freshwater boundary of transitional waters depending upon which method is most suitable to local circumstances. Whichever method is used, it is clear that all transitional waters must abut freshwater, leaving no section of the system unassigned to a surface water category.

The Minimum Size of Transitional Waters

2.3.19. The Directive gives no indication of the minimum size of transitional waters to be identified as separate water bodies. Although catchment size may be used as a guideline for the size of identified transitional waters, it should be considered with other factors such as the size, length, volume, river, discharge and the nature of the mixing zone. Most importantly it must meet the water body definition (Article 2.10) of being a 'discrete and significant' element of surface water. Significant could mean in terms of size or risk of failing to meet good ecological status.

2.3.20. The horizontal Guidance on water bodies (WFD CIS Guidance Document No. 2) gives no guidance on the minimum size for transitional or coastal water bodies. It does however state that Member States have the flexibility to decide whether the purposes of the Directive, which apply to all surface waters, can be achieved without the identification of every minor but discrete element of surface water as a water body**.**

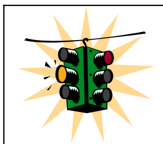
2.4. ASSIGNING COASTAL WATERS WITHIN THE RIVER BASIN DISTRICT

Article 3.1
"Coastal waters shall be identified and assigned to the nearest or most appropriate river basin district or districts."

3.4.1. The free exchange of substances from river basin districts to the open sea takes place in coastal waters. Coastal waters must be assigned to a River Basin District. This may involve the splitting of stretches of coastal water that might otherwise be considered as single water bodies.

2.4.2. When assigning a stretch of coastal water to a River Basin District the objective is to ensure that coastal waters are assigned to the closest possible or the most appropriate natural management unit and to minimise any unnecessary splitting of coastal stretches. To ensure consistency in the approach, the following principles should be applied:

- Where possible, existing administrative boundaries could be used. Examples are, ecoregions defined within the Directive and regions defined in the Marine Conventions;
- The boundaries between two adjacent types should be used wherever possible to minimise unnecessary splitting of the coastline;
- In the general case, the coastline should be split at open coast areas rather than through natural management units such as bays or inlets. However, specific situations may exist where the splitting of natural units for management purposes can not be avoided.



Look out! Further details on assigning coastal stretches to River Basin Districts are given in the Guidance Document "Identification of River Basin Districts in Member States. Overview, criteria and current state of play" produced by working group 2.9.

2.4.3. When managing coastal water bodies it must be recognized that water bodies in different river basin districts may interact to affect water quality in adjacent water bodies or even further away. In this case, the management plans of both river basins should acknowledge the problem and work together to resolve any issues. Where possible the coastal water body should be assigned to the River Basin District most likely to influence its quality, particularly taking into account long-shore influences of any contaminants.

2.5. TERRITORIAL WATERS

Article 2. 1
"'Surface water' means inland waters, except groundwater; transitional and coastal waters, except in respect of chemical status for which it shall also include territorial waters."

2.5.1. The definition of surface waters includes territorial waters. The Directive requires the achievement of good surface water chemical status for all surface water up to 12 nautical miles seaward from the baseline from which territorial waters are measured (i.e. territorial waters).

2.5.2. However, Member States are only required to identify water bodies in coastal waters, not in territorial waters.

Article 2. 10
"'Body of surface water' means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.'"

2.5.3. By protecting these inland surface waters, transitional waters, coastal waters and groundwaters, the Directive *contributes* to the protection of territorial and marine waters.

2.5.4. It is intended that the daughter directives that must be proposed by the Commission for substances on the Priority List by 20 November 2003 will clarify the compliance, assessment and reporting requirements relevant to the classification of good surface water chemical status.

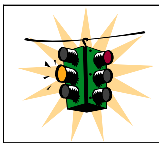
2.5.5. One option for reporting any failures to achieve good surface water chemical status in territorial waters would be to identify territorial water bodies only where needed to delineate contiguous stretches of water in which the required environmental quality standards for good chemical status are not being met.

2.6. MARINE LAGOONS

2.6.1. Coastal lagoons may be either coastal waters or transitional waters, depending on whether the lagoon fits the definition of transitional waters in the Directive *"in the vicinity of river mouths"* and *"substantially influenced by freshwater flows"* *(Article 2(6)).*

2.6.2. All surface waters are covered by the Directive. The minimum size of lagoons to be covered by the Directive is here suggested to be the same as the minimum size of lakes. Within Annex II of the Directive, the smallest size of lakes included in System A is a surface area of 0.5 to 1 km^2. This must not be considered as an absolute value and Member States may wish to include lagoons smaller than 0.5 km^2, particularly if they are at risk of failing to meet good status or are at high status and require a high level of protection. Further information on significant water bodies is given in the horizontal Guidance on water bodies (WFD CIS Guidance Document No. 2).

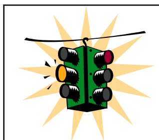
2.7. WETLANDS



Look out! A horizontal Guidance paper (currently under preparation) deals with the role of wetlands in the WFD and should be referred to for more detailed discussion.

Article 1
"The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:
(a) prevents further deterioration and protects and enhances the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems."

2.7.1. It is clear from Article 1 of the Directive that one of the primary objectives of the WFD is to protect and enhance aquatic ecosystems including wetlands directly dependent on aquatic ecosystems. The major strength of the WFD as a management tool is that these interdependencies are recognised, in contrast to previous water pollution control or nature conservation directives.



Look out! Although specific Guidance on marine wetlands is not covered within this Guidance Document, the importance of wetlands associated with coastal and transitional waters, in particular salt marshes, is recognised.

2.7.2. Wetland ecosystems are ecologically and functionally significant elements of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in CIS horizontal Guidance Documents water bodies (WFD CIS Guidance Document No. 2) and further considered in the Guidance Document on wetlands (currently under preparation).

2.7.3. Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

2.7.4. Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal Guidance paper on wetlands (currently under preparation).

Section 3 – Guidance for Typology in Transitional and Coastal Waters.

This Section interprets the requirements of the WFD to define typology as one of the supporting factors in determining ecological status.

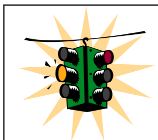
3.1. INTRODUCTION TO TYPOLOGY

Article 5(1).
"Each Member State shall ensure that for each river basin district or for the portion of an international river basin district falling within its territory:
- an analysis of its characteristics"…
…"is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive."

3.1.1. Article 5 of the Directive requires Member States to carry out a characterisation of all water bodies. This exercise is referred to as typology. It is one of the first stages in the implementation of the WFD.

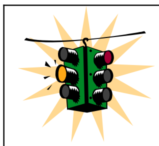
3.1.2. Annex II of the Directive gives instructions on how typology should be carried out and the obligatory and optional factors that can be used.

3.1.3. The purpose of typology is to enable type specific reference conditions to be established. These then become the anchor for classification systems. Typology has consequences for all subsequent operational aspects of the implementation of the Directive including monitoring, assessment and reporting.



Look out! Typology should be completed as soon as possible because all successive steps of Annexes II and V build on typology. In addition, the selection of types and sites for the draft register to form the intercalibration network is needed in 2003.

3.1.4. When carrying out typology Member States should focus on the overall purpose of the Directive outlined in Article 1; to establish a framework for the protection of both water quality and water resources preventing further deterioration and protecting and enhancing ecosystems. Typology is simply a tool to assist this process by comparing like with like.



Look out! The aim of typology is to produce as simple a physical typology as possible that is both ecologically relevant and practical to implement. It is recognised that a simple typology system needs to be complemented by more complex reference conditions that cover ranges of biological conditions.

3.1.5. The final typology should be submitted to the Commission in the form of GIS map(s) by 2004.

Annex II 1.1(vi)
"Member States shall submit to the Commission a map or maps (in a GIS format) of the geographical location of the types".

3.2. THE PROCESS OF TYPING

3.2.1. According to Annex II, Member States shall assign surface water bodies to one of the following categories: rivers, lakes, transitional, coastal, artificial or heavily modified surface water bodies. These categories must then be further divided into types.

Annex II 1.1(ii)
"For each surface water category, the relevant surface water bodies within the river basin district shall be differentiated according to type. These types are those defined using either 'system A' or 'system B'"

3.2.2. Water bodies within each surface water category are differentiated according to type using a system of typology as defined in Annex II of the Directive. Member States may choose to use either System A or System B.

3.2.3. If system A is used the type must first be assigned to an Ecoregion as shown in Map B of the Directive (Figure 3.1). In transitional waters the surface water type is then described according to mean annual salinity and mean tidal range. In coastal waters mean annual salinity and mean depth are used to describe the type. The COAST working group held the opinion that the class limits defined for the various descriptors by system A are not always ecologically relevant for the local environmental conditions.

Annex II 1.1(iv)
"If system B is used, Member States must achieve at least the same degree of differentiation as would be achieved using System A. Accordinly, the surface water bodies within the river basin district shall be differentiated into types using the values for the obligatory descriptors and such optional descriptors, or combinations of descriptors, as are required to ensure that type specific biological reference conditions can be reliably derived."

3.2.4. The Directive states that if Member States choose to use system B at least the same degree of differentiation must be achieved as if system A were used. System B uses a series of obligatory (e.g. tidal range and salinity) and optional factors (e.g. mean substratum composition, current velocity) in order to classify surface waters into types.

3.2.5. Most Member States have expressed the opinion that system B will be applied. This is because the differences in biological compositions and community structures normally depend on more descriptors than those in system A.

3.3. THE DEVELOPMENT OF TYPOLOGY GUIDANCE

3.3.1. The Directive does not prescribe a scientific methodology as to how Member States should type their surface waters.

3.3.2. The ecological approach to assessing the quality of Europe's transitional and coastal waters takes into account biological differences caused by land-ocean interactions and climatic zones. Therefore, the starting point for managing the scientific development of types of water bodies is a separation into broad ecoregions based on accepted marine biological provinces.

3.3.3. On the basis of the 'Obligatory Factors' in system B (latitude, longitude, tidal range and salinity), it is possible to split the maritime area into three basic Ecoregions/Ecoregion Complexes:

- **Atlantic/North Sea Ecoregion Complex** comprises North Atlantic Ocean, North Sea, Norwegian Sea and the Barents Sea Ecoregions. A general physical description shows mostly full salinity regimes and moderate to higher hydrodynamic properties;
- **Baltic Sea Ecoregion** with brackish waters and mostly low hydrodynamic properties;
- **Mediterranean Sea Ecoregion** with euhaline waters and moderate hydrodynamic properties.

3.3.4. These Ecoregions are shown on Map B in the Directive (Figure 3.1).

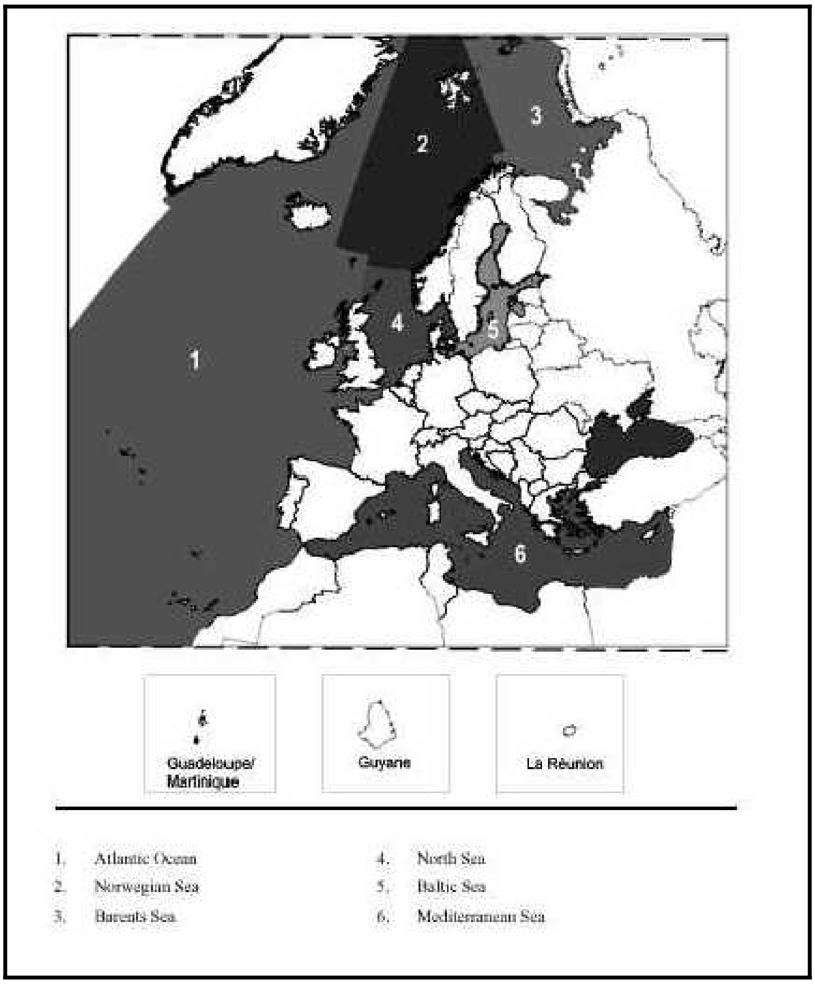


Figure 3.1. Map B from the Directive. System A: Ecoregions for transitional and coastal waters. The North-East Atlantic eco-region complex referred to in this Guidance Document includes the Atlantic Ocean, Norwegian Sea, Barents Sea and North Sea.

3.3.5. The Guidance was developed at three Ecoregion workshops by investigating:

- the common key optional factors within each Ecoregion;
- the order in which optional factors could be used to achieve the appropriate level of differentiation;
- the way in which the optional factors could be used.

3.4. COMMON FRAMEWORK FOR THE USE OF FACTORS FOR SYSTEM B

3.4.1. The factors listed in Annex II for coastal and transitional waters under System B are as follows:

Annex II 1.2.3. Transitional Waters
System B

Alternative Characterisation	***Physical and chemical factors that determine the characteristics of the transitional water and hence the biological population structure and composition***
Obligatory factors	*latitude* *longitude* *tidal range* *salinity*
Optional factors	*depth* *current velocity* *wave exposure* *residence time* *mean water temperature* *mixing characteristics* *turbidity* *mean substratum composition* *shape* *water temperature range*

Annex II 1.2.4. Coastal Waters
System B

Alternative Characterisation	***Physical and chemical factors that determine the characteristics of the coastal water and hence the biological population structure and composition***
Obligatory factors	*latitude* *longitude* *tidal range* *salinity*
Optional factors	*current velocity* *wave exposure* *mean water temperature* *mixing characteristics* *turbidity* *retention time (of enclosed bays)* *mean substratum composition* *water temperature range*

3.4.2. From the set of factors listed in Annex II of the Directive, Member States should use the obligatory factors followed by the optional factors that are most applicable to their own ecological situation.

3.4.3. It is suggested that a hierarchical approach is used for use of the optional factors when using System B.

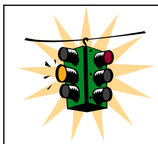
- First use obligatory factors
  - Latitude/Longitude - Ecoregion (c.f. Annex 11 of the Directive, Map B) (Figure 3.1 above);
  - Tidal Range;
  - Salinity.

3.4.4. If ecological separation to define the type specific reference conditions can be achieved by using only the obligatory factors, the use of optional factors is unnecessary.

3.4.5. If ecological separation to define the type specific reference conditions according to types cannot be achieved by using only the obligatory factors, then optional factors should also be used.

3.4.6. In **transitional waters**, the optional factors may be used in the following order if possible:
- Mixing;
- Intertidal Area (as an integrator of depth, tidal range and shape);
- Residence time;
- Other factors until an ecologically relevant type of water body is achieved.

3.4.7. In **coastal waters**, the optional factors may be used in the following order if possible:
- Wave exposure;
- Depth (*not in Annex II list);*
- Other factors until an ecologically relevant type of water body is achieved.

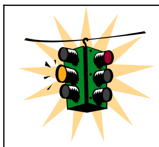


Look out! Even if only several factors are used to describe a type, it is suggested that Member States describe each water body using all factors in order to allow comparison of types between Member States. This will also aid the intercalibration exercise.

3.5. HOW COULD THE FACTORS BE USED?

3.5.1. Each factor has been split into several ranges on the basis of the ecological relevance across the three ecoregions.

3.5.2. Working within the agreed ranges will
- ensure true comparability between Member States on types;
- enable the identification of common types which could be used for intercalibration.



Look out! The Guidance was agreed on the understanding that:
- Member States may further split descriptors within these ranges if this is necessary to achieve an ecologically relevant type;
- Member States may aggregate descriptors within these ranges if there is no biological difference.

3.5.3. **Salinity**
In defining types the ranges of the broadly in line with system A of the Directive should be used.

freshwater	< 0.5 (‰)
oligohaline	0.5 to 5 - 6 (‰)
mesohaline	5 - 6 to 18 - 20 (‰)
polyhaline	18 – 20 to 30 (‰)
euhaline	>higher than 30 (‰)

3.5.4. **Mean Spring Tidal Range** (astronomical)

micro tidal	< 1 m
meso tidal	1 m to 5 m
macro tidal	> 5 m

Tidal Range is irrelevant for the Baltic Sea and the Mediterranean Sea because they have negligible tides. These whole areas are therefore defined as microtidal.

3.5.5. **Exposure (wave)**
It has been agreed that a pan-European scale should be used.

Extremely exposed open coastlines which face into prevailing wind and receive oceanic swell without any offshore breaks (such as islands or shallows) for more than 1000 km and where deep water is close to the shore (50 m depth contour within about 300 m).

Very exposed open coasts which face into prevailing winds and receive oceanic swell without any offshore breaks such as islands, or shallows for at least several hundred kilometres. Shallow water less than 50 m is not within about 300 m of the shore. In some areas exposed sites may also be found

	along open coasts facing away from prevailing winds but where strong winds with a long fetch are frequent.
Exposed	the prevailing wind is onshore although there is a degree of shelter because of extensive shallow areas offshore, offshore obstructions, or a restricted (<90°) window to open water. These stretches of coast are not generally exposed to strong or regular swell. Coasts may also face away from prevailing winds if strong winds with a long fetch are frequent.
Moderately exposed	these sites generally include open coasts facing away from prevailing winds and without a long fetch but where strong winds can be frequent.
Sheltered	at these sites there is a restricted fetch and/or open water window. Coasts can face prevailing winds but with a short fetch e.g. 20 km or extensive shallow areas offshore or may face away from the prevailing winds.
Very sheltered	these sites are unlikely to have a fetch greater than 20 km (the exception being through a narrow channel) and may face away from prevailing winds or have obstructions such as reefs offshore or be fully enclosed.

3.5.6. **Depth**

shallow	< 30 m
intermediate	30 m to 50 m
deep	> 50 m

3.5.7. **Mixing**

permanently fully mixed
partially stratified
permanently stratified

3.5.8. **Proportion of Intertidal Area**

small	< 50%
large	> 50%

The intertidal area integrates other Annex II factors such as depth, tidal range, residence time and shape.

3.5.9. **Residence Time**

short	days
moderate	weeks
long	months to years

3.5.10. **Substratum**

hard (rock, boulders, cobble)
sand-gravel
mud
mixed sediments

In many cases different seabed substrata will occur within one water body type. The dominant substratum should be selected.

3.5.11. **Current Velocity**

weak	<1 knot
moderate	1 knot to 3 knots
strong	>3 knots

Average current velocities should be used from measurements, tidal atlases or modelling. Current velocities throughout the Mediterranean Sea are expected to be <1 knot. Member States may further divide this class into < 0.5 knots and 0.5 – 1 knot.

3.5.12. **Duration of Ice Coverage**

irregular	
short	< 90 days
medium	90 to 150 days
long	> 150 days

In parts of the Baltic Sea ice coverage has an important influence on the ecosystem. It was the expert's advice to include this factor in the set of optional descriptors.

Section 4 – Guidance on the Development of Biological Reference Conditions for Coastal and Transitional Waters.

This Section of the Guidance explains the concepts of biological reference conditions and presents a way to use these concepts in practice.

4.1. INTRODUCTION

4.1.1. The reference condition is a description of the biological quality elements that exist, or would exist, at high status. That is, with no, or very minor disturbance from human activities. The objective of setting reference condition standards is to enable the assessment of ecological quality against these standards.

4.1.2. Within the Directive, reference conditions are described as follows:

> **Annex II 1.3 (i)**
> *"Type specific biological reference conditions shall be established, representing the values of the biological quality elements" … "for that surface water body type at high ecological status".*

4.1.3. In defining biological reference conditions, criteria for the physico-chemical and hydromorphological quality elements at high status must also be established. The reference condition is a description of the **biological** quality elements only. High **ecological status** incorporates the biological, physico-chemical and hydromorphological elements.

> **Annex II 1.3 (i)**
> *"For each surface water body type"….."type-specific hydromorphological and physicochemical conditions shall be established representing the values of the hydromorphological and physico chemical elements"….."for that surface water body type at high ecological status".*

4.1.4. 'Type specific' means that reference conditions are specific to a type as described under Annex II, System A or B (Section 3.2.).

4.1.5. It is recognised that some Member States may have few or no water bodies at high status and may need to use reference conditions established in another Member State for the same type.

4.1.6. Pressures such as diffuse pollution and land-use patterns are indirect pressures that Member States are required to control under the WFD. However, it is unrealistic to base reference conditions upon historic landscapes that no longer exist in modern Europe.

4.1.7. High status provides the direction, not the target, for restoration.

> **Article 4.1 a (ii)**
> *"Member States shall protect, enhance and restore all bodies of surface water" with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive."*

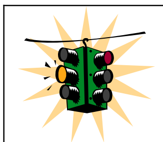
4.1.8. Qualitative and quantitative aspects of reference conditions should be published as part of the River Basin Management Plan and be available to the public.

> **Annex VII, A 1.1.**
> *"River basin management plans shall cover the following elements:*
> *1.1. …for surface waters….identification of reference conditions for the surface water body types;"*

4.1.9. Member States may wish to engage in a consultation process on any reference network of high status sites in the spirit of Article 14. Further Guidance on the Public Participation Process is given in the WFD CIS Technical Report No. 2Identification of river basin districts in Member States, Overview, Criteria and State of play.

4.2. REFERENCE CONDITIONS AND THE RANGE OF NATURAL VARIATION

4.2.1. Reference conditions must summarise the range of possibilities and values for the biological quality elements over periods of time and across the geographical extent of the type. The reference conditions represent part of nature's continuum and must reflect natural variability (Figure 4.1).



Look out! Reference conditions are type specific, and therefore the typology must lead to the reliable derivation of biological reference conditions.

4.2.2. Because reference conditions must incorporate natural variability, in most instances they will be expressed as ranges. Reference conditions should be derived with a view to distinguishing between very minor, slight, and moderate disturbance. 'Very minor' disturbance could be defined as just detectable in the sense that the disturbance is more likely to be anthropogenic than not. Slight disturbance could be defined as anthropogenic at a prescribed level of confidence.

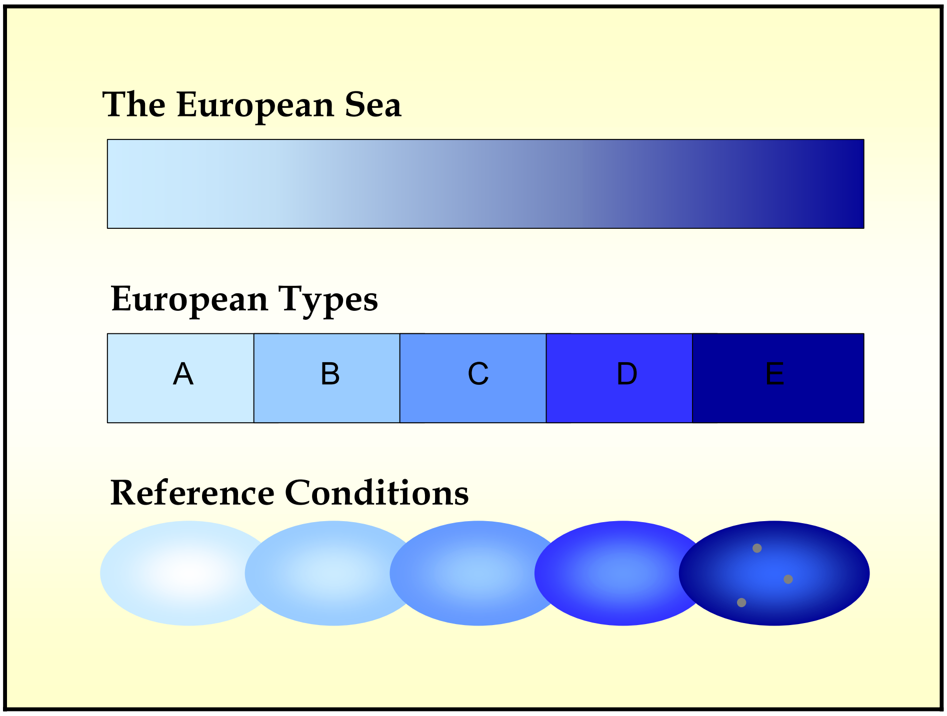


Figure 4.1. **The relationship between all the seas in Europe (the European Sea), typology and type-specific reference conditions. The European sea is a continuum. Typology falsely compartmentalises this continuum into a number of physical types. The reference conditions for a specific water body type must then describe all possible natural variation within that type. In type E, sites are shown. This shows how sites within a type may be used to establish the natural variability within the type.**

4.2.3. It is likely that the natural variability of a quality element within a type may be as large as the natural variability between types. Member States should adopt the spirit of the Directive and attempt to minimise variability by making valid comparisons between biological communities (i.e. compare 'like with like' by selecting comparable parts of the biological communities with the comparable part of the reference condition).

4.3. THE RELATIONSHIP BETWEEN REFERENCE CONDITIONS, HIGH STATUS AND THE ECOLOGICAL QUALITY RATIO

4.3.1. Type specific reference conditions are to be established for the **biological** quality elements for that type of surface water at high status. **Reference conditions are a description of the biological quality elements at high status.**

> **Annex V 1.4.1. (ii)**
> *"the results of the (classification) systems"…"shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero."*

4.3.2. The description of the biological reference conditions must permit the comparison of monitoring results with the reference conditions in order to derive an Ecological Quality Ratio (EQR). The values of the EQR set for each status class must mean that the water body meets the normative definition for that status class given in Annex V Table 1.2. and each biological quality element meets the relevant definition in Annex V Tables 1.2.3. or 1.2.4. The EQRs must be defined in such a way that allows the comparison of high status sites between Member States.

4.3.4. The EQR is not necessarily a simple ratio of two numbers but 'represents the relationship between the values of the biological parameters' in a given water body.

4.3.5. The EQR expresses the relationship between observed values and reference condition values. Its numerical value lies between 0 and 1. At high status, the reference condition may be regarded as an optimum where the EQR is close to, and including one.

4.3.6. Outside the reference condition range, the method of conversion of measurements to a numerical EQR will depend on the quality element and on classification schemes within individual Member States.

4.4. BIOLOGICAL QUALITY ELEMENTS REQUIRING REFERENCE CONDITIONS

4.4.1. Reference conditions should be described according to the definitions of the biological quality elements at high status in Annex V Table 1.2.3 and Table 1.2.4.

Definitions of the biological elements at high status in transitional waters taken from Annex V Table 1.2.3.

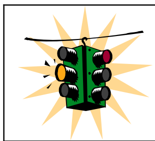
Element	High Status
Biological Quality Elements	
Phytoplankton	*The composition and abundance of the phytoplanktonic taxa are consistent with undisturbed conditions.* *The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions.* *Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physico-chemical conditions.*
Macroalgae	*The composition of macroalgal taxa is consistent with undisturbed conditions.* *There are no detectable changes in macroalgal cover due to anthropogenic activities.*
Angiosperms	*The taxonomic composition corresponds totally or nearly totally to undisturbed conditions.* *There are no detectable changes in angiosperm abundance due to anthropogenic activities*
Benthic Invertebrate Fauna	*The level of diversity and abundance of invertebrate taxa is within the range normally associated with undisturbed conditions.* *All the disturbance-sensitive taxa associated with undisturbed conditions are present.*
Fish Fauna	*Species composition and abundance is consistent with undisturbed conditions.*

Definitions of the biological elements at high status in coastal waters taken from Annex V Table 1.2.4.

Element	High Status
Biological Quality Elements	
Phytoplankton	*The composition and abundance of the phytoplanktonic taxa are consistent with undisturbed conditions.* *The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions.* *Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physico-chemical conditions.*
Macroalgae and Angiosperms	*All disturbance-sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present.* *The levels of macroalgal cover and angiosperm abundance are consistent with undisturbed conditions.*
Benthic Invertebrate Fauna	*The level of diversity and abundance of invertebrate taxa is within the range normally associated with undisturbed conditions.* *All the disturbance-sensitive taxa associated with undisturbed conditions are present.*

4.4.2. There is an urgent need to collect new data to ensure that reference conditions which incorporate natural variability can be derived. The development of reference conditions is likely to be an iterative process until adequate data sets are available. This urgent need is reflected in Annex V 1.3.1. The impact assessment has to be completed by 2004 and reference conditions will be required in order to undertake the intercalibration exercise.

Annex V 1.3.1
"Member States shall establish surveillance monitoring programmes to provide information for:
- supplementing and validating the impact assessment procedure detailed in Annex II."

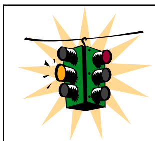


Look out! It is likely that the complete descriptions of reference conditions for transitional and coastal waters will not be possible at this stage as there are few or no data for some of the biological quality elements.

4.5. METHODS FOR DETERMINING REFERENCE CONDITIONS

4.5.1 The WFD identifies four options for deriving reference conditions.

Annex II, 1.3 (iii)
Reference conditions may be *"either spatially based or based on modelling, or may be derived using a combination of these methods. Where it is not possible to use these methods, Member States may use expert judgement to establish such conditions."*



Look out! A hierarchical approach for defining reference conditions is suggested using the various methods in the following order:

1. An existing undisturbed site or a site with only very minor disturbance; or
2. historical data and information; or
3. models; or
4. expert judgement.

4.5.2. Models are generally not well developed or validated for the marine environment and given the problems with using historical data, the reference network of high status sites is the preferred approach for deriving reference conditions for transitional and coastal waters.

Spatial Data

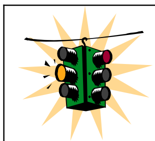
4.5.3. With regard to spatial data, Annex II, 1.3 (iv) states that:

> **Annex II 1.3 (iv)**
> *"Member States shall develop a reference network for each surface water body type. The network shall contain a sufficient number of sites of high status to provide a sufficient level of confidence about the values for the reference conditions, given the variability in the values of the quality elements corresponding to high ecological status for that surface water body type".*

4.5.4. Where a site with 'very minor disturbance' is used to derive reference conditions it should be validated to ensure that it meets the definitions of high status given in Annex V.

4.5.5. It may be possible to use a site to derive biological reference conditions for a biological quality element, even though not all other quality elements at the site are at high status. In this case it must be demonstrated that this biological quality element is not disturbed.

4.5.6. A site with hydromorphological modification may be used to derive biological reference conditions for the quality elements which are not disturbed by the modification (e.g. a slipway or a small jetty will not disturb the phytoplankton community). Although this water body as a whole may not qualify for high status, given the hydromorphological modification, it may be possible to derive biological reference conditions from this site.



Look out! At present there are no reference networks of high status sites for coastal and transitional waters. In addition, there are few reliable models for predicting marine biological communities. The few existing tools which are in existence have generally not been tested outside individual Member States.

Historical data and information

4.5.7. It may be possible to use historical information to derive reference conditions if the historical data are of assured quality. If reference conditions are derived from historical conditions, these should be based upon the condition of water bodies at times of no or very minor anthropogenic influence. No single date can be used to determine the reference conditions, for example, in urbanised estuaries a historical period of low nutrient inputs from agriculture may have corresponded to high industrial discharges and the release of untreated sewage.

4.5.8. A site at which there are historic pressures may still be used to derive biological reference conditions if the pressures are not causing current ecological disturbance to that quality element.

Modelling

4.5.9. A number of different modelling techniques may be used to derive reference conditions.

> **Annex V 1.3 (v)**
> *"Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods. The methods shall use historical, palaeological and other available data and shall provide a sufficient level of confidence about the values for the reference conditions to ensure that the conditions so derived are consistent and valid for each surface water body type."*

Expert Judgement

4.5.10. It is emphasised that expert judgement is required with all the above techniques: for example, use of historical data will require expert judgement in deciding which data are appropriate. In addition, robust predictive models can only be developed using data plus expert judgement. In the early stages of implementation of the Directive, expert judgement will be used alongside the development of classification tools outlined in Section 6 to derive reference conditions consistent with the normative definitions.

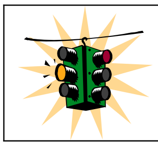
4.6. THE SELECTION OF A REFERENCE NETWORK OF HIGH STATUS SITES

4.6.1. The Directive requires Member States to establish a reference network of high status sites.

4.6.2. A possible starting point for this process is to screen for unimpacted areas using pressure criteria. It is clear that pressure criteria alone cannot be used to define high status areas because something which would be a minor pressure in one water body e.g. a sewage works of 250 population equivalent discharging to the Atlantic Ocean may have a significant impact if discharged to a small lagoon with poor water exchange. However, screening for areas with a lack of pressures is a useful starting point in identifying a reference network of high status sites.

4.6.3. The screening process starts with the identification of areas with no or very minor morphological changes. These areas can be identified from examining sea charts and from obtaining licensing information on the disposal of dredged material, extraction of oil, gas, aggregates or other marine resources. More information would be required to ensure that these areas are not subject to a fishing pressure which would constitute more than a 'very minor disturbance'.

4.6.4. The next step is to identify areas of no or very minor pressures from land based activity (i.e. areas which have no or low intensity agricultural practises and no or few point sources of pollution).



Look out! A German screening tool for identifying significant pressures and evaluating their impacts is included in WFD CIS Guidance Document No. 3 – Analysis of pressures and impacts (Section 4.2)

4.6.5. A detailed examination of the biological status of these areas is required alongside expert judgement to establish if these sites are at high status. In many cases it may be unacceptable to base reference conditions on current land management practice.

4.7. EXCLUSION OF QUALITY ELEMENTS WITH HIGH NATURAL VARIABILITY

Annex II 1.3 (vi)
"Where it is not possible to establish reliable type-specific reference conditions for a quality element in a surface water body type due to high degrees of natural variability in that element, not just as a result of seasonal variations, then that element may be excluded from the assessment of ecological status for that surface water type. In such circumstances Member States shall state the reasons for this exclusion in the river basin management plan".

4.7.1. The WFD allows Member States to exclude a quality element from the assessment of ecological status if its natural variability, other than seasonal, is too high to allow the derivation of reliable reference conditions. In this case reference conditions need not be formulated but the reason for the exclusion along with supporting evidence must be stated in the river basin management plan.

4.7.2. No specific guidance is given within the Directive on the level of natural variability that justifies such exclusion. It is recommended that sufficient reason for exclusion may exist if the range of natural variability within a type overlaps with the range expected in disturbed conditions resulting in a high risk of mis-classification.

4.7.3. When formulating reference conditions it is important to express natural variability as explicitly as possible (e.g. the specific seasonal (spring or summer) range of phytoplankton biomass).

4.8. REFERENCE CONDITIONS AND OTHER SIGNIFICANT ANTHROPOGENIC IMPACTS

Non-indigenous species

4.8.1. The biological quality of water bodies may be impacted by pressures such as the introduction of non-indigenous species or disease-causing organisms. The WFD does not identify them explicitly as pressures but includes them as "*other significant anthropogenic impacts*" (Annex II 1.4.). Such pressures may affect some biological quality elements and must be taken into account when deriving reference conditions.

4.8.2. The mere presence of a non-indigenous species in a water body of high status is acceptable if it does not unduly influence the overall structure and function of the ecosystem and if the normative definitions of high status are not compromised.

Fishing

4.8.3. Where a fishing operation constitutes more than 'a very minor disturbance' on one or more of the biological quality elements, that water body cannot be considered to be at high status (e.g. benthic trawling has a direct impact on the benthic invertebrate fauna). In addition, fishing activities may compromise high hydromorphological status in transitional or coastal waters.

Definitions of the hydromorphological elements at high status in transitional waters taken from Annex V Table 1.2.3.

Element	*High Status*
Hydromorphological Quality Elements	
Morphological	*Depth variation, substrate conditions and both the structure and condition of the intertidal zones correspond totally or nearly totally to undisturbed conditions.*

Definitions of the hydromorphological elements at high status in coastal waters taken from Annex V Table 1.2.4.

Element	*High Status*
Hydromorphological Quality Elements	
Morphological	*Depth variation, structure and substrate of the coastal bed conditions and both the structure and condition of the intertidal zones correspond totally or nearly totally to undisturbed conditions.*

4.8.4. The specification for fish fauna in transitional waters at good status includes impacts due to the physico-chemical or hydromorphological quality elements but does not explicitly include the effects of fishing. Therefore a water body within which fishing takes place can be considered to be at good status if the effects of, for example benthic trawling, lead only to slight disturbance of the quality elements from high status.

Annex V 1.2.3.
Description of fish fauna at high status
"Species composition and abundance is consistent with undisturbed conditions".
Description of fish fauna at good status

"The abundance of the disturbance-sensitive (fish) species shows slight signs of distortion from type specific conditions attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements".

4.9. UPDATING REFERENCE CONDITIONS

4.9.1. Reference conditions are not permanent. Climate, land cover and marine ecosystems vary naturally over many periods relevant to the WFD. Every six years from 2013, Member States must review the characterisation of water bodies, including reference conditions.

4.9.2. Reference conditions must therefore be formulated so as to include natural variability over a period of at least six years, and other factors directly out of the control of Member States. It is accepted that many of these variables are not fully understood in the marine environment.

4.9.3. Over the forthcoming years as understanding increases it may be possible to develop sound predictive models, thus reducing the degree of expert judgement in the process.

4.10. REFERENCE CONDITIONS / HIGH STATUS STUDIES

4.10.1. Through the COAST working group, a number of Member States completed reference condition pilot studies for areas which may be in high status. It cannot be confirmed that these areas are in high status until classification tools are developed and the intercalibration exercise has been completed. Some Members States with no sites considered to be at high status completed 'best of type' studies for types that may be in good or moderate status.

4.10.2. The papers were discussed by the working group and the main lessons learnt through the exercise are listed below:

- It is likely that there will be very few sites across the whole of Europe at high status because of human pressures and impacts.
- The IMPRESS Guidance Document gives guidance on what constitutes a specific pollutant (WFD CIS Guidance Document No. 3). This Guidance will need to be tested to see if the strict requirements for specific pollutants discount sites which are **biologically** in high status.
- In the marine environment there is a lack of biological and chemical data for high status sites as the focus for monitoring programmes has historically been centred on polluted areas.

- At present Member States do not have a full set of data for each quality element. This is particularly true for macroalgae, angiosperms and fish. It is clear that additional studies may be required in order to derive reference conditions.
- Where possible reference conditions should be quantitative rather than qualitative. However it is appreciated that this may not be possible initially, if at all, for all quality elements.
- At least in the short term, expert judgement is essential because of the lack of good data sets. Over the forthcoming years as understanding increases it may be possible to develop sound predictive models, thus reducing the degree of expert judgement.

4.10.3. A table can be found in Annex C which lists the pilot studies that were carried out by various Member States.

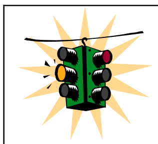
Section 5 – General Guidance on the Classification of Ecological Status within Transitional and Coastal Waters.

This Section of the Guidance introduces the principles underlying classification and the requirements of classification tools and schemes for the purposes of the WFD.

5.1. INTRODUCTION TO CLASSIFICATION

5.1.1. The WFD requires Member States to assess the ecological status of water bodies and then ensure that the appropriate environmental objectives are set for these water bodies through the river basin management process.

5.1.2. At present, there are a limited number of coastal and transitional water classification schemes in Europe. None of the existing schemes meet all the requirements of the WFD. Existing classification schemes do not generally include all of the quality elements given in Annex V 1.2.3 and 1.2.4. Each of the existing schemes has different strengths and weaknesses in relation to WFD implementation.



Look out!
A **classification scheme** is what is used for the overall classification and includes a measure of all appropriate quality elements.
Classification tools are used for assessing the status of each individual quality element against high status.

5.1.3. WFD classification schemes and tools must assess status against the biological reference conditions.

5.1.4. The classification of ecological status is based upon the status of the biological, hydromorphological and physico-chemical quality elements (Figure 5.1). The quality elements to be included in classification are listed in Annex V 1.1.3. and 1.1.4. The hydromorphological and physico-chemical elements are also referred to as the supporting elements.

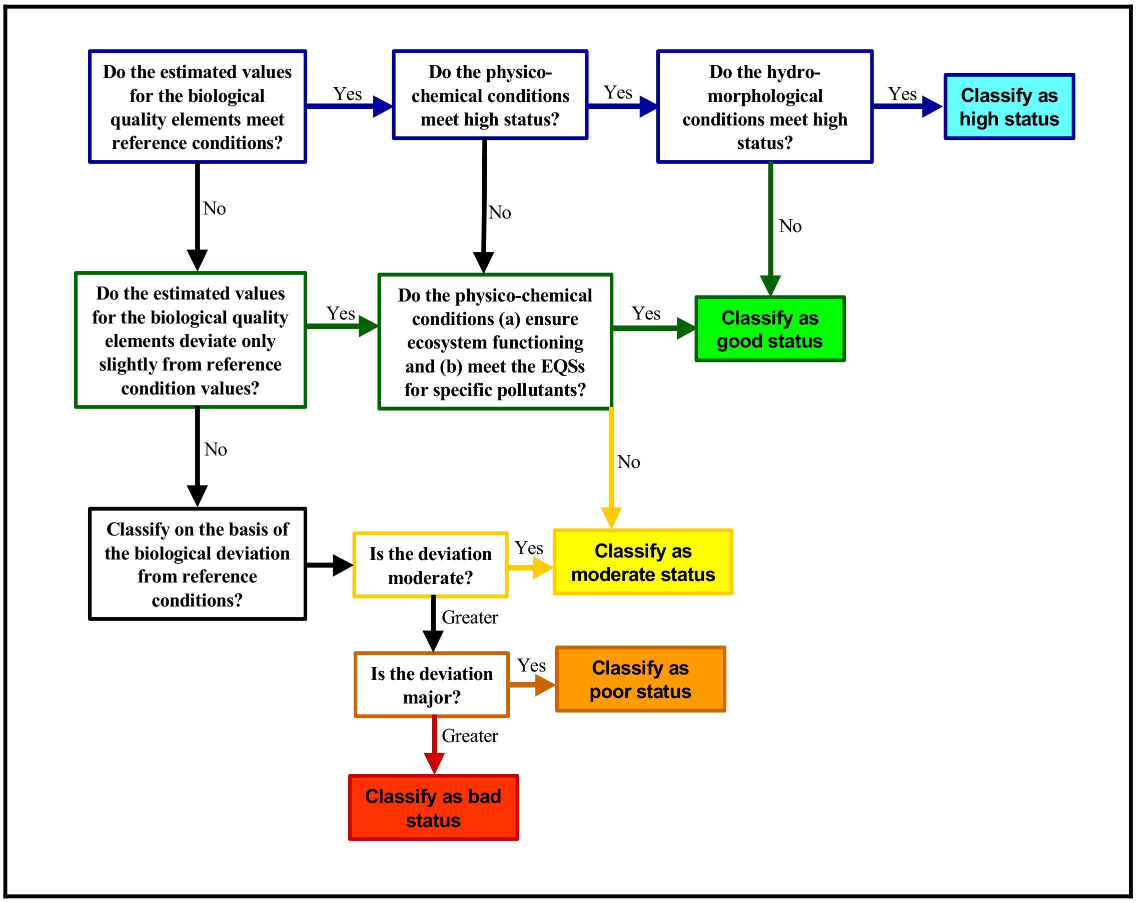


Figure 5.1. **Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according to the normative definitions in Annex V 1.2. A more detailed understanding of the role of physico-chemical parameters in the classification of the ecological status will be developed in specific Guidance on this issue during 2003.**

Annex V 1.1.3. Transitional Waters	**Annex V 1.1.4. Coastal Waters**
Biological elements	
• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna* • *Composition and abundance of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna*
Hydromorphological elements supporting the biological elements:	
Morphological conditions: • *depth variation* • *quantity, structure and substrate of the bed* • *structure of the inter-tidal zone* *Tidal regime:* • *freshwater flow* • *wave exposure*	*Morphological conditions:* • *depth variation* • *structure and substrate of the coastal bed* • *structure of the inter-tidal zone* *Tidal regime:* • *direction of dominant currents* • *wave exposure*
Chemical and physio-chemical elements supporting the biological elements:	
General: • *Transparency* • *Thermal conditions* • *Salinity* • *Oxygenation conditions* • *Nutrient conditions* *Specific Pollutants:* • *Pollution by all priority substances identified as being discharged into the body of water* • *Pollution of other substances identified as being discharged in significant quantities into the body of water.*	*General:* • *Transparency* • *Thermal conditions* • *Salinity* • *Oxygenation conditions* • *Nutrient conditions* *Specific Pollutants:* • *Pollution by all priority substances identified as being discharged into the body of water* • *Pollution of other substances identified as being discharged in significant quantities into the body of water.*

5.2. ECOLOGICAL STATUS CLASSES AND THE ECOLOGICAL QUALITY RATIO

5.2.1. Definitions of the five ecological status classes are given in Annex V Table 1.2. These are referred to as the **normative definitions**.

Annex V Table 1.2. General definition for rivers, lakes, transitional waters and coastal waters

High status

"There are no, or only very minor, anthropogenic alterations to the values of the physicochemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.

The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion.

These are the type specific conditions and communities."

Good status

"The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions."

Moderate status

"The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status."

Poor status

"Water showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor."

Bad status

"Water showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad."

5.2.2. The observed results from the monitoring of the biological quality elements should be compared against the reference conditions for that type and expressed as an Ecological Quality Ratio (Figure 5.2).

Annex V, 1.4.1 (ii)

"In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero."

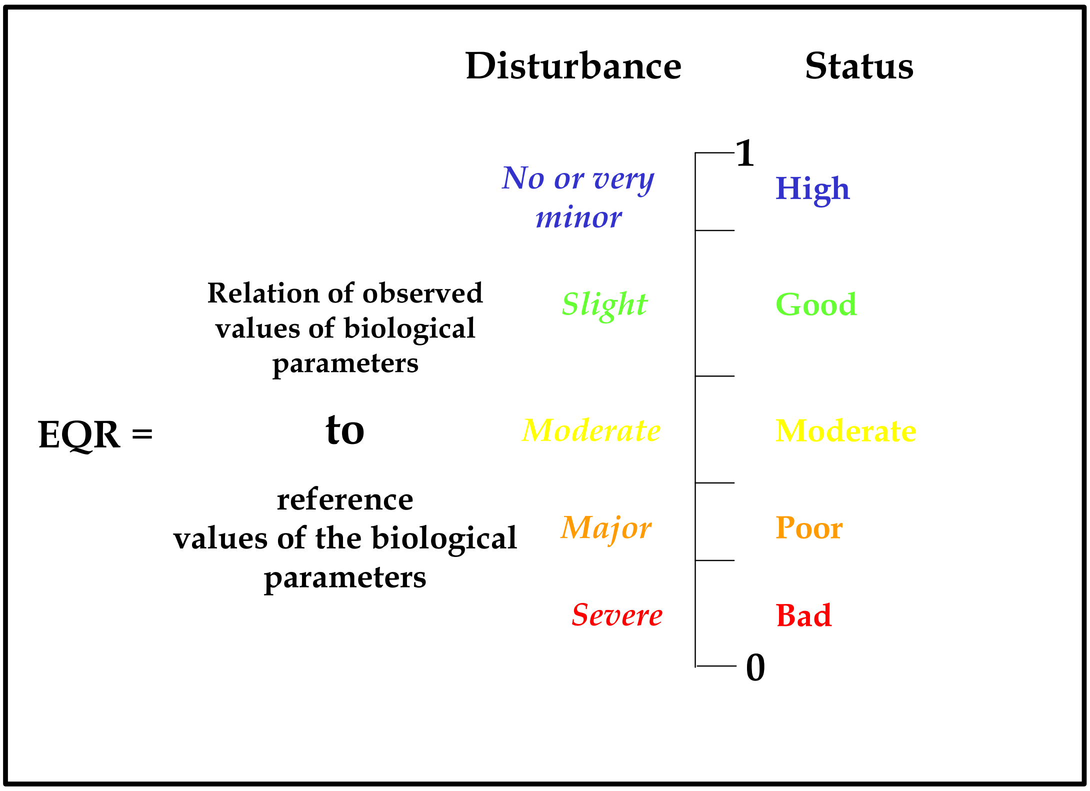
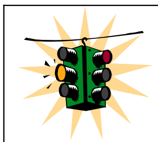


Figure 5.2. **Suggested Ecological Quality Ratio according to Annex V, 1.4.1. The size of the bands differ because the boundaries between classes must align with the normative definitions, not a simple percentage. Note that all the deviations are measured from the reference condition.**

5.2.3. A most critical issue in implementing the WFD will be setting the borders between the high, good and moderate classes, as this determines whether management action is necessary.

Annex V 1.4.1.(iii)
"The value for the boundary between the classes of high and good status, and the value for the boundary between good and moderate status shall be established through the intercalibration exercise…"



Look out! The borders between high and good status and good and moderate status will be set as part of the Intercalibration exercise to be carried out by the Member States. The role of the Commission is to facilitate the information exchange between the Member States. More information on intercalibration can be found in the Intercalibration Guidance (WFD CIS Guidance Document No. 6).

5.2.4. Definitions are given for each of the quality elements at high, good and moderate status in Annex V Tables 1.2.3 and 1.2.4. These definitions can therefore be used to help determine whether a quality element is affected by very minor, slight or moderate anthropogenic influences. The preliminary description of high and good ecological status will, to a large extent, have to rely on existing monitoring data and pressure information in combination with risk assessments. It will be extremely difficult to define the difference between very minor and slight disturbance before the results of monitoring programmes are available.

5.2.5. Environmental objectives are set for water bodies as laid out in Article 4 of the Directive. These are summarised below:

Article 4(1)(a)(i) No Deterioration
"… to prevent deterioration of the status of all bodies of surface water…"

Article 4(1)(a)(ii) Good Status – Default Objective
"Member States shall protect, enhance and restore all bodies of surface water"…"with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive…"

Article 4(1)(a)(iii) Good Ecological Potential
"Member states shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years from the date of entry into force of this Directive….."

Article 4(1)(c) Protected Areas
"for protected areas
Member States shall achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of the Directive, unless otherwise specified in the Community legislation under which the individual protected areas have been established."

Article 4(4) Good Status with an Extended Deadline Derogation
"The deadlines"…"may be extended for the purposes of phased achieved of the objectives for bodies of water, provided that no further deterioration occurs in the status of the affected body of water when all of the following conditions are met…"

Article 4(5) Less Stringent Environmental Objectives Derogation
"Member States shall aim to achieve less stringent environmental objectives"…"when they are so affected by human activity"…"or their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive and all of the following objectives are met…"

5.2.6. The results of classification will be used alongside the requirements of Annex II to evaluate the risk of a water body failing its objectives (Figure 5.3).

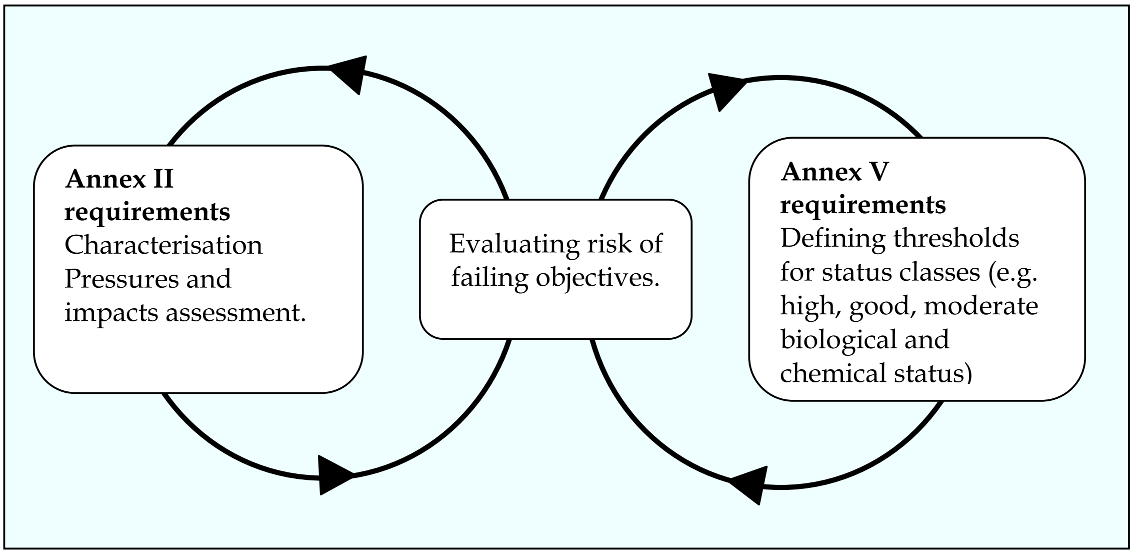


Figure 5.3. The iterative evaluation of the risk of failing objectives.

5.3. BASIC PRINCIPLES UNDERPINNING CLASSIFICATION

Precautionary Principle

> **Preamble (11)**
> *As set out in Article 174 of the Treaty, the Community policy on the environment is to contribute to pursuit of the objectives of preserving, protecting and improving the quality of the environment, in prudent and rational utilisation of natural resources, and to be based on the precautionary principle and on the principles that preventive action should be taken, environmental damage should, as a priority, be rectified at source and that the polluter should pay.*

5.3.1. The EC Treaty sets out the general principles of environmental policy including the precautionary principle. The precautionary principle underpins all environmental legislation.

One Out, All Out Principle

5.3.2. The classification scheme must apply the one-out all-out principle. This means that the ecological status of the water body equates to the lower status of either the biological quality elements or the physico- chemical elements

> **Annex V 1.4.2.(i)**
> *"For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified".*

5.4. QUALITY ASSURANCE AND EXPERT JUDGEMENT

5.4.1. The sources of uncertainty in the classification of ecological status fall into the following categories:

- **Natural Spatial Variability** Within each water body there will be spatial heterogeneity in the microhabitats. This means that, for example, taxonomic richness and composition or the concentration of a contaminant within sediments can vary within the sampling location;
- **Natural Temporal Variability** The taxa present or contaminant in biota at a site will vary naturally over time;
- **Biological Sampling and Analytical Errors.** When e.g. sorting the material in a new macro invertebrate sample and identifying the taxa, some taxa may be missed or misidentified;
- **Chemical Sampling and Analytical Errors.** For chemical quality elements the errors associated with different analytical techniques may vary for the same substance.

5.4.2. Any of these errors or variability may lead to misclassification.

5.4.3. Confidence in the overall classification requires confidence in the

- sampling process;
- analysis; and
- classification.

The Directive gives a clear message on the importance of quality assurance at all stages in the classification process.

Sampling and Analysis

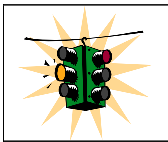
5.4.4. In recognition that different sampling methods and analysis can produce incomparable results, the Directive also specifies the use of ISO/CEN standards, or other national or international standards, where available.

Annex V 1.3.6. Standards for the Monitoring of Quality Elements
"Methods used for the monitoring of type parameters shall conform to the international standards listed below or such other national or international standards which will ensure the provision of data of an equivalent scientific quality and comparability."

5.4.5. To date there are few ISO/CEN standards applicable to the marine environment. However, there is a wealth of international standards, monitoring methods and guidelines available that have been developed by the marine conventions (OSPAR, HELCOM, AMAP, UNEPMAP), or ICES. More information on this is given in the WFD CIS Guidance Document No 7 - Monitoring under the Water Framework Directive.

5.4.6. Quality assurance systems are well developed for some of the marine chemistry determinands through the QUASIMEME Scheme, though not all of the WFD priority substances are covered at present.

5.4.7. BEQUALM is a Europe wide scheme for quality assurance in marine biological effects measurement. The scope of this scheme is being developed further.



Look out! Given the difficulties and expense involved in sampling the marine environment, Member States need to ensure excellent quality assurance and control throughout the sampling and analysis process.

Expert Judgement

5.4.8. In addition to good quality assurance in sampling and analysis, expert judgement will be extremely important in the development of classification tools and in the preliminary 2004 assessment (Figure 5.4).

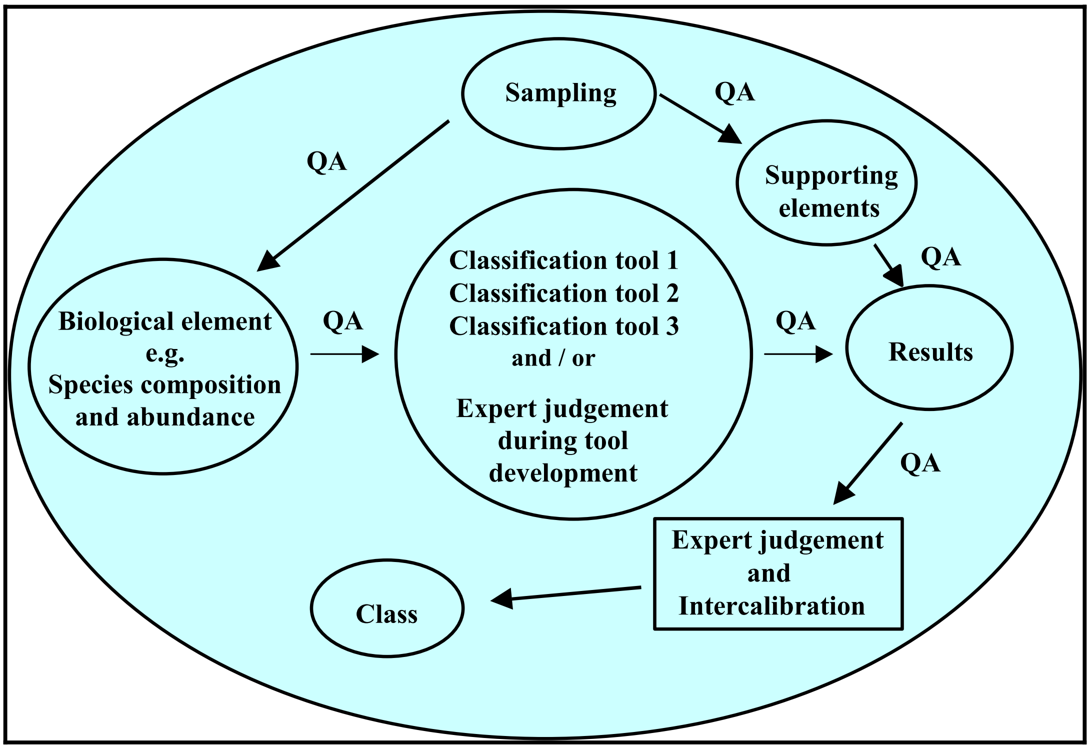


Figure 5.4. The importance of quality assurance and the use of expert judgement through the whole classification process.

Annex V 1.3.4 Frequency of Monitoring
"Frequencies shall be chosen to achieve an acceptable level of confidence and precision. Estimates of confidence and precision attained by the monitoring system shall be stated in the river basin management plan."

5.4.9. In order to quantify the level of confidence, the errors associated with each classification method must be quantified. For some of the biological quality elements there is no or little information on spatial or temporal variability.

5.4.10. Until there is a better understanding of spatial and temporal variability in the marine environment along with adequate marine biological quality control schemes, expert judgement will play an important role in classification.

5.5. CLASSIFICATION OF THE BIOLOGICAL QUALITY ELEMENTS

Phytoplankton

5.5.1. The classification of phytoplankton in transitional and coastal waters must be based upon:
- composition
- abundance
- biomass.

The Directive also mentions transparency conditions and frequency and intensity of blooms.

5.5.2. The WFD presents definitions of phytoplankton at high, good and moderate status.

Transitional Waters Annex V, 1.2.3.

High status	***Good status***	***Moderate Status***
The composition and abundance of the phytoplanktonic taxa are consistent with undisturbed conditions. *The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type specific transparency conditions.* *Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.*	*There are slight changes in the composition and abundance of phytoplanktonic taxa.* *There are slight changes in biomass compared to the type-specific conditions. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water.* *A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.*	*The composition and abundance of phytoplanktonic taxa differ moderately from type specific conditions.* *Biomass is moderately disturbed and may be such as to produce a significant undesirable disturbance in the condition of other biological quality elements.* *A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.*

Coastal Waters Annex V, 1.2.4.

High status	*Good status*	*Moderate Status*
The composition and abundance of the phytoplanktonic taxa are consistent with undisturbed conditions. *The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type specific transparency conditions.* *Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physico-chemical conditions.*	*The composition and abundance of planktonic taxa show slight signs of disturbance.* *There are slight changes in biomass compared to the type-specific conditions. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the quality of the water.* *A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.*	*The composition and abundance of phytoplanktonic taxa show signs of moderate disturbance.* *Algal biomass is substantially outside the range associated with type-specific conditions, and is such as to impact upon other biological quality elements.* *A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.*

Other aquatic flora:

5.5.3. The classification of aquatic fauna in transitional and coastal waters must be based upon:

- composition
- abundance.

The Directive also mentions the presence and absence of disturbance sensitive taxa.

5.5.4. The Directive separates transitional and coastal waters for plants.

5.5.5. The WFD presents separate normative definitions for macroalgae and angiosperms at high, good and moderate status in transitional waters.

Annex V, 1.2.3.

High status	*Good status*	*Moderate status*
Macroalgae:		
The composition of macroalgal taxa is consistent with undisturbed conditions. *There are no detectable changes in macroalgal cover due to anthropogenic activities.*	*There are slight changes in the composition and abundance of macroalgal taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water.*	*The composition of macroalgal taxa differs moderately from type-specific conditions and is significantly more distorted than at good quality.* *Moderate changes in the average macroalgal abundance are evident and may be such as to result in an undesirable disturbance to the balance of organisms present in the water body.*
Angiosperms:		
The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. *There are no detectable changes in angiosperm abundance due to anthropogenic activities.*	*There are slight changes in the composition of angiosperm taxa compared to the type-specific communities.* *Angiosperm abundance shows slight signs of disturbance.*	*The composition of the angiosperm taxa differs moderately from the type-specific communities and is significantly more distorted than at good quality.* *There are moderate distortions in the abundance of angiosperm taxa.*

5.5.6. The WFD presents joint normative definitions for macroalgae and angiosperms in coastal waters at high, good and moderate status.

Annex V 1.2.4.

High status	*Good status*	*Moderate status*
All disturbance sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present. *The levels of macroalgal cover and angiosperm abundance are consistent with undisturbed conditions.*	*Most disturbance sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present.* *The level of macroalgal cover and angiosperm abundance shows slight signs of disturbance.*	*A moderate number of the disturbance sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are absent.* *Macroalgal cover and angiosperm abundance is moderately disturbed and may be such as to result in an undesirable disturbance to the balance of organisms present in the water body.*

Benthic invertebrate fauna

5.5.7. The classification of benthic invertebrate fauna in transitional and coastal waters must be based upon:
- composition;
- abundance.

It also mentions both disturbance sensitive taxa and taxa indicative of pollution.

5.5.8. The WFD presents normative definitions of benthic invertebrate fauna at high, good and moderate status.

Annex V 1.2.3. & 1.2.4.

High status	*Good status*	*Moderate status*
The level of diversity and abundance of invertebrate taxa is within the range normally associated with undisturbed conditions. *All the disturbance-sensitive taxa associated with undisturbed conditions are present.*	*The level of diversity and abundance of invertebrate taxa is slightly outside the range associated with the type-specific conditions.* *Most of the sensitive taxa of the type-specific communities are present.*	*The level of diversity and abundance of invertebrate taxa is moderately outside the range associated with the type-specific conditions.* *Taxa indicative of pollution are present* *Many of the sensitive taxa of the type specific communities are absent.*

Fish fauna

5.5.9. The classification of fish fauna is only required in transitional waters and must be based upon:
- composition
- abundance.

It also mentions disturbance sensitive specie.

5.5.10. The WFD presents normative definitions of the fish fauna at high, good and moderate status for **transitional waters** (Annex V, 1.2.3, 1.2.4).

Annex V 1.2.3.

High status	*Good status*	*Moderate status*
Species composition and abundance is consistent with undisturbed conditions.	*The abundance of the disturbance-sensitive species shows slight signs of distortion from type specific conditions attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements.*	*A moderate proportion of the type-specific disturbance-sensitive species are absent as a result of anthropogenic impacts on physicochemical or hydromorphological quality elements.*

5.6. CLASSIFICATION OF THE HYDROMORPHOLOGICAL AND PHYSICO-CHEMICAL SUPPORTING ELEMENTS

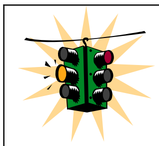
5.6.1. The hydromorphological and physico-chemical elements are supporting elements for the classification of ecological status.

Hydromorphological Elements

5.6.2. The classification of hydromorphological quality elements in transitional and coastal waters must be based upon:

Annex V, 1.1.3. **Annex V,1.1.4.**

Transitional waters (Annex V, 1.1.3)	***Coastal waters (Annex V, 1.1.4)***
Morphological conditions: *depth variation* *quantity, structure and substrate of the bed* *structure of the inter-tidal zone* *Tidal regime:* *freshwater flow* *wave exposure*	*Morphological conditions:* *depth variation* *structure and substrate of the coastal bed* *structure of the inter-tidal zone* *Tidal regime:* *direction of dominant currents* *wave exposure*



Look out! Hydromorphological elements are only included in the classification of high ecological status. For a waterbody to be at high status the biological, hydromorphological and physico-chemical quality elements must be at high status (Figure 5.1).

5.6.3. The WFD presents definitions of the hydromorphological quality elements at high, good and moderate status for **transitional waters** (Annex V, 1.2.3.):

Annex V 1.2.3.

High status	*Good status*	*Moderate status*
Morphological conditions:		
Depth variations, substrate conditions, and both the structure and condition of the inter-tidal zones correspond totally or nearly totally to undisturbed conditions.	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*
Tidal regime:		
The freshwater flow regime corresponds totally or nearly totally to undisturbed conditions.	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*

5.6.4. The WFD presents definitions of the hydrological quality elements at high, good and moderate status for **coastal waters** (Annex V, 1.2.4):

Annex V 1.2.4.

High status	***Good status***	***Moderate status***
Morphological conditions:		
The depth variation, structure and substrate of the coastal bed, and both the structure and condition of the inter-tidal zones correspond totally or nearly totally to the undisturbed conditions.	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*
Tidal regime:		
The freshwater flow regime and the direction and speed of dominant currents correspond totally or nearly totally to undisturbed conditions.	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*

Physico-Chemical Elements

5.6.5. The WFD presents normative definitions of ecological status classifications (Annex V, 1.1.3, 1.1.4). For the purposes of classification of the physico-chemical quality elements in transitional and coastal waters, the following is to be included:

Annex V 1.1.3. and 1.1.4.
General:
- *Transparency*
- *Thermal conditions*
- *Oxygenation conditions*
- *Salinity*
- *Nutrient conditions*

Specific Pollutants:
- *Pollution by all priority substances identified as being discharged into the body of water*
- *Pollution of other substances identified as being discharged in significant quantities into the body of water*

5.6.6. The WFD presents normative definitions of the physico-chemical elements at high, good and moderate status for **transitional** and **coastal waters** (Annex V, 1.2.3, 1.2.4).

Annex V 1.2.3. and 1.2.4.

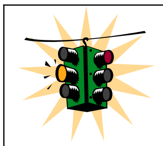
High status	***Good status***	***Moderate status***
General conditions:		
The physico-chemical elements correspond totally or nearly totally to undisturbed conditions. *Nutrient concentrations remain within the range normally associated with undisturbed conditions.* *Temperature, oxygen balance and transparency do not show signs of anthropogenic disturbance and remain within the ranges normally associated with undisturbed conditions.*	*Temperature, oxygenation conditions and transparency do not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.* *Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*
Specific synthetic pollutants:		
Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	*Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<environmental quality standard).*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*
Specific non synthetic pollutants:		
Concentrations remain within the range normally associated with undisturbed conditions (background levels).	*Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6. without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<environmental quality standard).*	*Conditions consistent with the achievement of the values specified above for the biological quality elements.*

Specific Pollutants

5.6.7. Under 'Chemical and physico-chemical elements supporting the biological elements', the Directive refers to specific pollutants. These are understood to mean substances not included in the chemical status assessment i.e. priority substances for which European EQSs have not yet been agreed or other substance identified as being discharged in significant quantities into the body of water. These may be described as:

a) Specific synthetic pollutants.
b) Specific non-synthetic pollutants.

5.6.8. The word "specific" indicates that not all pollutants listed in Annex VIII, points 1-9. (or any others) must be considered.



Look out! The IMPRESS Guidance Document produced by CIS working group 2.1 (WFD CIS Guidance Document No. 3) provides guidance on how specific pollutants are to be identified in the pressures and impacts analysis.

5.6.9. Specific pollutants are included in ecological status and accordingly there are five class categories. The definitions for specific pollutants at high status are stringent (Annex V Tables 1.2.3. and 1.2.4.).

5.6.10. This definition has been subject to a long political debate (*cf.* OSPAR) and it is clear that no scientific specification can be given for terms such as "close to zero". These issues are being examined by a sub-group of the Expert Advisory Forum on Priority Substances (EAF PS) dealing with Analysis and Monitoring (AMPS). It is recommended that the approach adopted by the EAF PS, AMPS group, be adopted for substances for which national detection limits and background concentrations are to be set.

5.7. THE RELATIONSHIP BETWEEN CHEMICAL AND ECOLOGICAL STATUS

5.7.1. Chemical status refers only to those priority substances for which Environmental Quality Standards (EQSs) are set at the European level.

Annex V, 1.4.3
"Where a body of water achieves compliance with all the environmental quality standards established in Annex IX (existing List I substances, Dangerous Substances Directive), Article 16 (Priority Substances, Annex X) and under other relevant Community legislation setting environmental quality standards it shall be recorded as achieving good chemical status. If not, the body shall be recorded as failing to achieve good chemical status."

5.7.2. Chemical status is only divided into 2 classes; good status and bad status and good status is defined as being less than the EQS.

Relationship between Chemical Status and Ecological Status

5.7.3. Once European EQSs have been established, those substances are **NOT** included in ecological status. There are currently 18 of these from the existing Dangerous Substance Directive. More will be added to this list by the end of 2003 for the Annex X. These EQSs are to be agreed by the Expert Advisory Forum on Priority Substances. Until European EQSs have been agreed, priority substances are part of the ecological status.

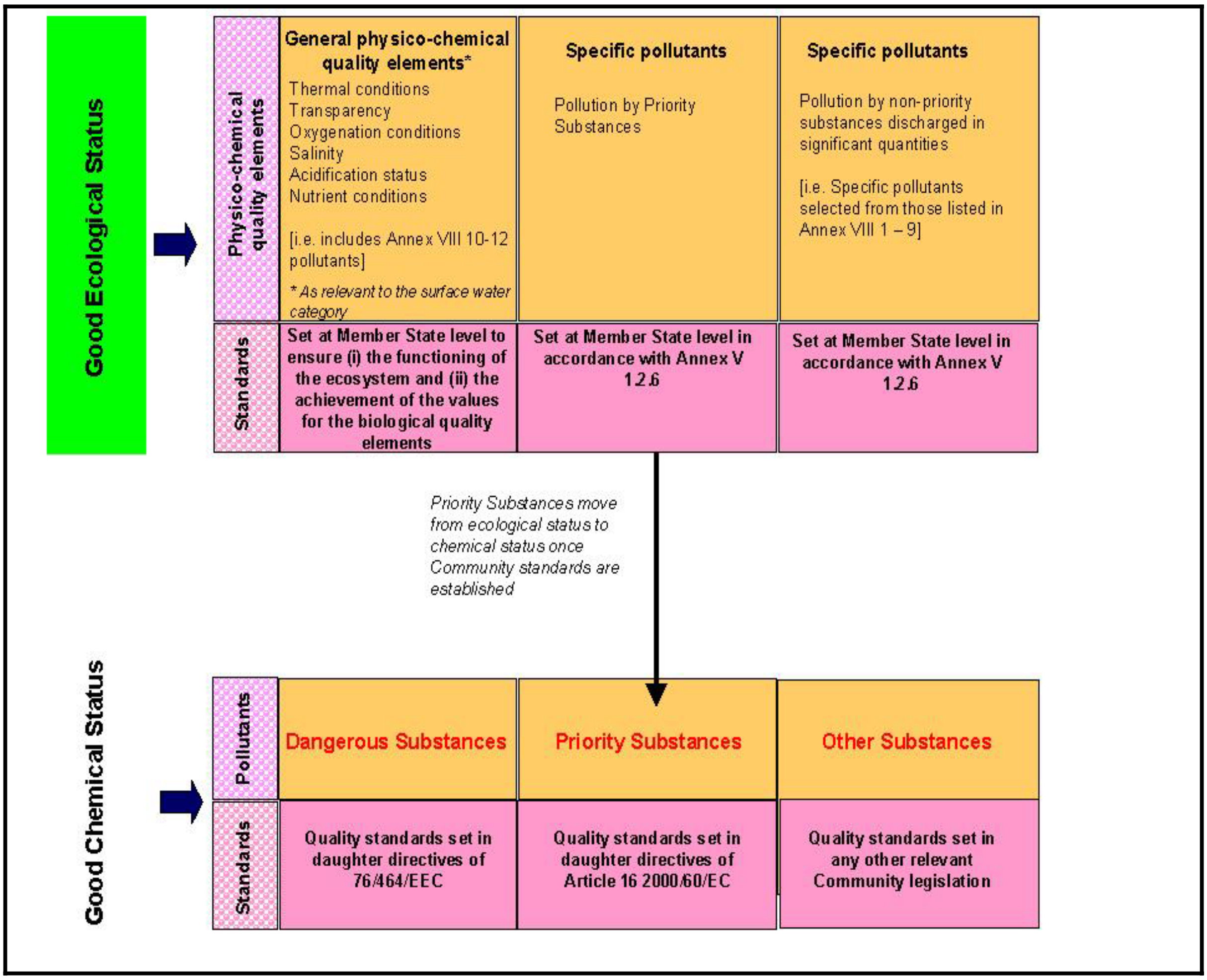


Figure 5.5. The relationship between good ecological status and good chemical status.

Section 6 - Toolbox

6.1. INTRODUCTION

6.1.1. This toolbox contains examples of existing classification schemes and tools for transitional and coastal waters that may be suitable for testing by Member States.

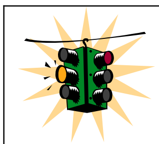
6.1.2. It must be stressed that very little testing of these tools for the purposes of the WFD has been completed yet. Member States are encouraged to test existing classification schemes and tools in their ecoregion and share the results and knowledge gained with experts from other Member States.

6.2. PHYTOPLANKTON

Tools currently available in Member States to assess the ecological status of phytoplankton:

6.2.1. Several tools for classifying the ecological status of phytoplankton in transitional and coastal waters are presented here although no single suggested tool meets all the requirements of the Directive.

6.2.2. **OSPAR – Comprehensive Procedure**
The OSPAR Comprehensive Procedure provides a framework for classifying the trophic status of marine waters into three classes; non-problem, problem and potential problem areas. The criteria include the maximum and mean chlorophyll *a* concentrations (a surrogate for algal biomass) and the presence / concentration of nuisance / toxic algae species, providing some measure of composition and abundance.



Look out! The OSPAR Common Assessment Criteria is an area of study that is still evolving. An example of the agreed criteria at the time of publishing can be found in Section 6.6 of the toolbox. Member States must endeavour to use the latest version of the criteria which at the time of publication of this Guidance Document could be found on the OSPAR website at www.ospar.org/ see Measures, Agreements, Agreement 2002-20.

6.2.3. **Tentative classification tool for phytoplankton under development in France by IFREMER.**

As part of a global classification tool for transitional and coastal waters, France is currently developing a classification tool for phytoplankton, building on the work undertaken for the Shellfish Hygiene Directive.

6.2.4. **EC Shellfish Hygiene Directive: (Council Directive 91/492/EEC of 15 July 1991 laying down the health conditions for the production and the placing on the market of live bivalve molluscs.)**

The purpose of this Directive is to protect public health and includes a requirement to monitor the presence of plankton containing marine biotoxins. Periodic sampling is required to detect changes in the composition and distribution of specific plankton that produce biotoxins. When threshold values are reached, more intensive sampling is undertaken.

<u>Do the available tools available fulfill the requirements of the Directive?</u>

6.2.5. **OSPAR Comprehensive Procedure**

The Comprehensive Procedure is not fully compatible with the requirements of the Directive, but there is the potential to develop the criteria further to fit the Directive's requirements. The procedure includes algae composition but focuses on nuisance and toxic algae rather than the whole community. It also includes a measure of biomass in terms of chlorophyll *a*, which may not be sensitive enough in many areas. The Comprehensive Procedure may have to be adapted for region-specific circumstances, but clearly could be used as a framework for further development of classification tools under the WFD.

6.2.6. **Tentative classification scheme for phytoplankton under development in France by IFREMER**

The threshold values for nuisance/toxic algal species are strongly associated with detecting diarrhetic and paralytic shellfish poisoning species, rather than any measure of ecological status. The links between the two have been the subject of debate among marine scientists for many years. It is clear that the links will need to be further explored. This French classification tool, which is under development, takes into account the abundance of phytoplankton species that are toxic for both human health and flora and fauna as well as those species that are used as an eutrophication indicator. The tool does not include measures of biomass of the population.

6.2.7. Summary of the **tentative classification tool for phytoplankton under development in France by IFREMER**.

1. Phytoplankton species toxic for human health

Species: those species producing DSP, PSP and ASP toxins. *Dinophysis* spp., *Alexandrium minutum, Gymnodinium catenatum, Gymnodinium breve, Prorocentrum minimum.*

Thresholds: DSP negative results of biological tests
PSP 80 µg.100g^{-1}
ASP 20 g. g^{-1} domoic acid

Indicator: Number of weeks of positive results over a 5-year moving period.

Classification:

Table 6.1. Classification of number of positive results of DSP and PSP over a 5 year moving period.

High (blue)	Good (green)	Moderate (yellow)	Poor (orange)	Bad (red)
0	1-5	6-15	16-25	>25

Table 6.2. Classification of number of positive results of ASP over a 5 year moving period.

High (blue)	Good (green)	Moderate (yellow)	Poor (orange)	Bad (red)
0	1	2-3	4-5	>5

2. Phytoplankton species toxic for the flora or the fauna:

Species: *Gymnodinium* cf. *nagasakiense (= G. nagasakiense, G. aureolus, G. mikimotoi), G. splendens (=G. sanguineum), G. breve (=Ptychodiscus brevis), Gyrodinium spirale, Prorocentrum micans (= P. arcuatum = P gibbosum)* (main species) + *P. minimum (= P. balticum = P. cordatum)* (high proportion species), *P. gracile, P. lima (=P marinum); P. triestum (=P. redfieldii)* (low proportion species) + *P. compressum, P. mexicanum* (sporadic species), *Dictyocha* sp., *Heterosigma carterae, Fibrocapsa japonica, Chrysochromulina* spp.

Thresholds: A bloom occurrence means >10^{6} cell.l^{-1}

Indicator: Total number of bloom occurrences over a 5 years moving period.

Classification:

Table 6.3. Classification of the number of blooms of phytoplankton species toxic for the flora or fauna over a 5 year moving period.

High (Blue)	Good (Green)	Moderate (yellow)	Poor (Orange)	Bad (red)
0	1-2	3-5	6-10	>10

3. Phytoplankton species used as a eutrophication indicator

Species: All species

Thresholds: A bloom occurrence means >10^{5} cell.l^{-1}

Indicator: Total number of bloom occurrences over a 5 years moving period.

Classification:

Table 6.4. Classification of the number of blooms of phytoplankton species used as an eutrophication indicator over a five year moving period.

High (Blue)	Good (Green)	Moderate (yellow)	Poor (Orange)	Bad (red)
0-10		11-20	21-40	>40

6.3. OTHER AQUATIC FLORA

Tools currently available in Member States to classify other aquatic flora:

6.3.1. The **OSPAR Comprehensive Procedure** has criteria for macrophytes which are region specific and include a shift from long-lived to short-lived nuisance species. These regional criteria have still to be developed.

6.3.2. **Sweden** has a classification system covering both chemical elements as well as biota. Below is presented some examples from the Swedish classification scheme (angiosperms and rocky shore communities).

6.3.3. **Greece** is developing a classification tool for seaweed and seagrasses.

6.3.4. **Spain** has developed a classification tool for rocky shore communities using multivariate methods.

Do the tools available fulfill the requirements of the Directive?

6.3.5. The OSPAR Criteria for macrophytes could be developed further on a regional basis to take into account WFD requirements.

6.3.6. The Swedish classification tool does not fulfill all the criteria in the WFD, but the tool is being adjusted at the moment and could be tested for the relevant ecoregions.

6.3.7. The Greek tool compares composition and abundance of sensitive and non-sensitive species and could be tested in more areas.

6.3.8. The Spanish tool fulfils the criteria and could be tested in more areas.

6.3.9. Summary of the **Swedish Classification Tool for Angiosperms and Rocky Shore Communities** (Swedish Environmental Protection Agency 2000)**.** A full presentation can be downloaded at: www.environ.se

The term "macrovegetation" refers to plants that are large enough to be readily visible to the naked eye. The species composition of vegetation is affected by two aspects of eutrophication – an increased supply of nutrients, and increased turbidity (increasing number of particles). In some cases, the distribution and species composition of the vegetation can also be influenced by thick layers of ice, other pollutants, wave actions from heavy boat traffic, etc.

The correct interpretation of macrovegetation characteristics requires knowledge of natural variations in the flora associated with various parts of a coast. These variations depend to a large extent on differences in salinity. Also, there are usually important differences between the vegetation of hard bottoms (rocks, boulders, etc.) and that of soft bottoms (sand, clay, mud, etc.). Furthermore, the vegetation of exposed bottoms in outer archipelagos and along open coasts often has a different character from that of more sheltered areas.

The examples below are from the Skagerrak/Kattegat area. The scheme also covers the Baltic proper and the Bothnian Sea.

No special reference values are provided, but the conditions described in class 1 can in most cases be used as a basis for comparisons. Class 1, which is based on data from historical sources and more-or-less pristine areas, is intended to represent natural conditions.

Assessments of the macrovegetation's current conditions should be based on data gathered during the summer.

For the Skagerrak/Kattegat, there are three classifications, which can be used separately or together. A basic precondition for all three is that the salinity of the water must be greater than five parts per thousand.

Table 6.5. Classification of common eelgrass (Zostera marina) beds on soft bottoms in the Skagerrak / Kattegat.

Class	Level	Description
1	Little or none	Dense growth of common eelgrass *(Zostera marina)*, which occurs at depths greater than 6 metres.
2	Moderate	Abundant growth of common eelgrass down to depths of 3 metres, sparse growth to depths of 6 metres.
3	Significant	Common eelgrasses present to depths of 3 metres; loose filamentous algae also common.
4	Serious	Isolated specimens of common eelgrass; loose filamentous algae dominate.
5	Eradication	"Dead" bottom areas, or absence of stationary vegetation. Possibly masses of loose algae and/or bottom layer of luminous white sulphurous bacteria (thread-like or downy substance).

Table 6.6. Classification of sheltered to moderately exposed hard bottom communities in the Skagerrak / Kattegat.

Class	Level	Description
1	Little or none	Dense stands of bladder wrack *(Fucus vesiculosus)* and/or *Ascophyllum nodosum*, (Knobbed or knotted wrack). Epiphytes consist primarily of brown and red algae, and only to a limited extent of green algae or the odd filter feeders. (Green algae may grow more abundantly on cliffs with large quantities of bird droppings.) The undervegetation is varied. In exposed areas, the bladder wrack may lack bladders and may thus be confused with *Fucus evanescens*.
2	Moderate	Dense stands of *Fucus vesiculosus* and/or *Ascophyllum nodosum*, which are partly covered with epiphytic green algae. Also present are *Fucus evanescens* and the red alga *Porphyra purpurea*.
3	Significant	Sparse stands of bladder wrack. *Fucus evanescens* often more abundant, together with belts of green algae. *Porphyra purpurea* may also be common. The bladder wrack is covered with thick growths of green algae and/or filtering animal species.
4	Serious	Sparsely distributed specimens of *Fucus vesiculosus* or *Fucus evanescens*, often covered with thick growths of green algae and/or filtering animal species. Loose drifting algae may also be common.
5	Eradication	Perennial brown algae such as bladder wrack are lacking entirely. Vegetation is dominated by stands of green algae or drifting carpets of algae, usually of the genera *Enteromorpha* (grass kelp) and *Blidingia*, but also *Cladophora*. Alternatively, no algae larger than 1 cm are present; instead, there are "blue-green algae" (cyanobacteria) and other bacteria.

This classification applies to the vegetation of rocky bottoms to depths of 0–1 metre. Inventories should be made during the period 1 June–31 August. Areas affected by heavy layers of ice or intensive boat traffic should not be used.

Table 6.7. Classification of exposed hard bottom communities in the Skagerrak / Kattegat.

Class	Level	Description
1	Little or none	Macroalgae grow at depths greater than 25 metres
2	Moderate	Macroalgae grow at depths of at least 20 metres.
3	Significant	Macroalgae grow at depths of up to 10–25 metres
4	Serious	Macroalgae grow at depths of up to 5 metres. Perennial species are present, but short-lived species dominate.
5	Eradication	Macroalgae grow at maximum depths of up to 1–2 metres. Perennial species are completely lacking.

This classification applies to the vegetation of hard bottoms to depths of 0–20 metres. Inventories require diving, and should be taken during the period 1 April–31 October. Class 1 requires sites that are at least 25 metres deep or have well-developed vegetation at 20 metres.

6.3.10. Summary of the **Greek classification tool for seaweed and seagrasses** (Orfanidis *et al.*, 2002)**.**

A model to estimate the ecological status and identify restoration targets of transitional and coastal waters was developed. Marine benthic macrophytic species (seaweeds, seagrasses) were used to indicate shifts in the aquatic ecosystem from the pristine state with late-successional species (Ecological State Group (ESG) I) to the degraded state with opportunistic (ESG II) species. The first group comprises species with a thick or calcareous thallus, low growth rates and long life cycles (perennials) whereas the second group includes sheet-like and filamentous species with high growth rates and short life cycles (annuals). Seagrasses were included in the first group, whereas Cyanophyceae and species with a coarsely branched thallus were included in the second group.

The evaluation of ecological status into five categories from high to bad includes a cross comparison in a matrix of the ESG and a numerical scoring system. The model could allow comparisons, ranking and setting of priorities at regional and national levels fulfilling the requirements of the WFD. A successful application of the model was realised in selected lagoons of the Macedonian & Thrace region (North Greece) and in the Saronikos coastal ecosystems (Central Greece).

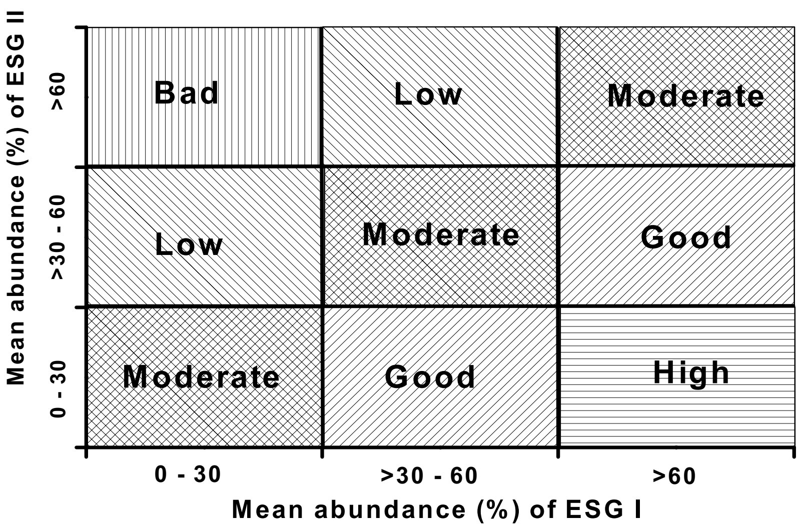


Figure 6.1. A matrix based on the mean abundance (%) of ESGs to determine the ecological status of transitional and coastal waters.

6.3.11. Summary of the **Spanish classification tool for littoral benthic communities using multivariate analysis (**Agència Catalana de l'Aigua and Centre d'Estudis Avançats de Blanes 2002)**.**

A combination of sampling information, the species-coverage and species-biomass data matrices are developed, prior to carrying out the two- or three-dimensional cluster aggregation ordering analyses. Numerous multivariate analyses and hierarchical classification systems can be used. Each of them has advantages and weaknesses and it is up to each researcher to select the method that can best help to interpret the data. One of the multivariate analyses is the PCA (Principal Components Analysis), which uses the Euclidean metric distance, giving too much importance to the abundance/biomass of the species and is useful only if the samples are very similar. The AC (Analysis of Correspondences) uses the X^2 distance, which solves the problem since it gives relatively greater importance to the species with little representation. But it has a double weakness. On one side, the species that appear in very few samples but are very abundant distort the representation, and, on the other, if the samples are located along a strong gradient, the second axis is often a function of the first and then the samples are distributed in the factorial space in the form of an arc (Guttman effect). The DCA (Detrended Correspondence Analysis) has the advantages of the AC (uses the X^2 distance) but avoids the relationship between the second and the first axes, avoiding the Guttman effect. Hence, we have considered that it is the method that best suits our data. Another of the methods in use is the MDS (Multidimensional Scaling) and, more specifically, the non-parametric MDS, recently applied to biological data. One of the advantages of this method is that it requires very few assumptions about the data and the interrelation among samples to apply it effectively. It is a very flexible method that uses ranges of similarity among samples. This new method has not yet been applied to the environmental quality data on the Catalan coast.

The statistics packages that can be used to apply the various multivariate analyses are the CANOCO (Ter Braak, 1988) and the PRIMER (Clark & Warwick, 1994). The objective of hierarchical classification systems is to group the objects in classes or homogenous groups, so that each group is differentiated from the rest with measurements of similarity or of distance among samples. The process builds up increasingly larger groups that include some classes within others. It is presented in the form of a classification tree or dendrogram. The statistical package that will be used to apply this type of classification system will be the PRIMER (Clark & Warwick, 1994). All the analyses have considered the overall set of species (flora and fauna) and have eliminated all those species that appear in less than 2% of the samples, considering that they are hardly representative of the community.

6.4. BENTHIC INVERTEBRATE FAUNA

Tools currently available in Member States to classify benthic invertebrate fauna

6.4.1. **Norway has** a classification tool covering both chemical elements as well as biota.

6.4.2. **Greece** is developing a classification tool for benthic invertebrate fauna.

6.4.3. **Spain** has developed a biotic index to establish the ecological quality of soft bottom benthos. The index has been designed for use with in European estuarine and coastal environments.

6.4.4. The **UK** has started to test the Spanish classification tool within a number of estuaries and this work is to be continued over the forthcoming year.

6.4.5. The **OSPAR Comprehensive Procedure** includes benthic invertebrate fauna as a possible indirect effect of eutrophication in relation to zoobenthos kills from oxygen depletion and / or long-term changes in zoo-benthos biomass and species composition due to nutrient enrichment (see Section 6.6).

Do the tools available fulfill the requirements of the Directive?

6.4.6. All of the existing methods either have limitations to areas they can be used or are not yet widely tested. Methods combining composition, abundance and sensitivity may be the most promising.

6.4.7. Summary of the **Norwegian Classification tool for soft bottom macrofauna and chemical elements (Molvær *et al.*, 1997).**

This Norwegian classification tool uses the faunal diversity of soft bottom macrofauna to assess ecological status. The present form of the system has been used since 1997 and a former version was used from 1993. The system also includes chemical elements and harmful substances in biota and will be adjusted to fit the requirements of the WFD.

The faunal diversity is measured by the Shannon-Wiener index (H') (Shannon and Weaver 1963) and the Hurlbert rarefaction method (Hurlbert 1971). Samples must be quantitative, usually taken with a 0.1 m^2 grab and the samples are sieved on 1 mm screens. Calculations are carried out using four or five pooled samples representing 0.4-0.5 m^2 bottom surface, but is also used for single samples as well.

In addition to fauna the organic content of the sediment is measured in terms of total organic carbon (TOC) using an elemental analyser. The measured values are adjusted for the content of silt and clay (fine fraction) in the sediments. This part of the tool has to be developed further as it does not fit in all areas.

The classification is shown in Table 6.8. The class limits have been set using a large number of samples (> 500) from Norwegian waters taken under different environmental conditions as a reference basis. The limit between class II (good conditions) and class III (fair conditions) has been set at the median value for the indices, i.e. such that classes I and II encompass 50 % of the samples and classes III, IV and V the other 50 %. The further separation between classes has been based on the calculation of percentiles. In addition, expert judgement is used to adjust the values according to the environmental conditions.

Table 6.8. The Norwegian system for classification of environmental status with regard to fauna and total organic content (TOC) of soft sediments.

		Classes				
	Parameters	**I Very Good**	**II Good**	**III Fair**	**IV Bad**	**V Very bad**
Diversity of soft-bottom fauna	Shannon-Wiener index (H'_{log2})					
	Hurlbert's index $ES_{n=100}$					
Sediments	TOC (mg/g)					

6.4.8. Summary of the **Greek classification tool for benthic invertebrate fauna** (Simboura and Zenetos 2002).

The general scheme proposed for the implementation of WFD requirements into Greek coastal waters with the use of macrozoobenthic quality element, comprises three steps leading to the typological justification of water body types and the classification of ecological quality (Simboura & Zenetos, 2002). These steps are briefly described bellow:

a) Definition of habitat types. The outline of the major benthic habitat types occurring in the Mediterranean is essential for linking water body types and benthic habitat types and also for the implementation of classical classification tools as the diversity indices.

b) Definition of benthic indicator species. These are species which according to the literature are either sensitive and characterise a given habitat type by their dominance or exclusive presence in the specific habitat, or are tolerant and indicate instability or pollution. Linking sensitive indicator species to a habitat type serves as a biological justification of the typological definition of a given water body.

c) Development of a new Biotic index (BENTIX). The new index was developed on the basis of former indices which combine the relative percentages of five ecological groups of species with varying degree of sensitivity to disturbance factors, into a single formula. The innovation of the new index lies in the reduction of the ecological groups from five to three and finally to two as described below. Reducing the number of groups has the advantage of avoiding uncertainty regarding the grouping (two groups instead of five) and also of increasing the simplicity of its calculation.

Ecological groups:

Group 1 (GI). Species belonging to this group are very sensitive to disturbance conditions in general. This group correspond to the k-strategy species, with relatively long life, slow growth and high biomass. Also species indifferent to disturbance always present in low densities with non-significant variations with time are included in this group, as they cannot be considered as tolerant by any degree.

Group 2 (GII). This group includes species tolerant to disturbance or stress whose populations may respond to enrichment or other sources of pollution by an increase in density (slightly unbalanced situations). This group also includes second-order opportunistic species, or late successional colonisers with r-strategy: species with short life span, fast growth, early sexual maturation and larvae throughout the year.

Group 3 (GIII). First order opportunistic species (pronounced unbalanced situations), pioneers, colonisers, species tolerant to hypoxia.

The derived formula gives a series of continuous values from 2 to 6, being 0 when the sediment is azoic. By assigning the factor 2 to both groups GII and GIII, the ecological groups are finally reduced to two: the sensitive and the tolerant.

Bentix Index = {6 X %GI + 2 X (% GII + % GIII)}/100

A classification system appears as a function of the Bentix Index including five levels of ecological quality. The Bentix Index is independent from the habitat type and the sample size, does not require exhaustive taxonomic effort and is easy in its calculation and use.

Table 6.9. Pollution Classification, Bentix Index and Ecological Status.

Pollution Classification	BC	Ecological Status
Normal	$4.5 \leq BC < 6$	High
Slightly polluted, transitional	$3.5 \leq BC < 4.5$	Good
Moderately polluted	$2.5 \leq BC < 3.5$	Moderate
Heavily polluted	$2 \leq BC < 2.5$	Poor
Azoic	0	Bad

6.4.9. Summary of the **Spanish marine Biotic Index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments** (Borja *et al.*, 2000).

The index developed is based on that first used by Glémarec and Hily (1981) and then by Hily (1984), which utilises soft-bottom benthos to construct a biotic index. Hily (1984) and Glémarec (1986) stated that the soft-bottom macrofauna could be ordered in five groups, according to their sensitivity to an increasing stress gradient (i.e. increasing organic matter enrichment). These groups have been summarized by Grall and Glémarec (1997), as outlined below.

Group I: Species very sensitive to organic enrichment and present under unpolluted conditions (initial state).
Group II: Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance).
Group III: Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations).
Group IV: Second-order opportunistic species (slight to pronounced unbalanced situations). Mainly small sized polychaetes: subsurface deposit-feeders, such as cirratulids.
Group V: First-order opportunistic species (pronounced unbalanced situations). These are deposit-feeders, which proliferate in reduced sediments.

The distribution of these ecological groups, according to their sensitivity to pollution stress, provides a biotic index with eight levels, from 0 to 7 (Hily, 1984, Hily *et al.*, 1986; Majeed, 1987). Based upon Hily's model (Hily, 1984; Hily *et al.*, 1986, Majeed, 1987), and in order to improve the index, a single formula was proposed. This is based upon the percentages of abundance of each ecological group, within each sample, to obtain a continuous index (the Biotic Coefficient, BC), where:

$$BC = \{(0 \times \%GI) + (1.5 \times \%GII) + (3 \times \%GIII) + (4.5 \times \%GIV) + (6 \times \%GV)\}/100$$

In this way, use of the Biotic Coefficient can derive a series of continuous values, from 0 to 6, being 7 when the sediment is azoic. The result obtained is a "pollution classification" of a site which is a function of the Biotic Coefficient. Consequently, this represents the benthic community "health", represented by the entire numbers of the Biotic Index.

Table 6.10. Site Pollution classes derived from the Biotic Coefficient.

Site Pollution Classification	Biotic Coefficient	Biotic Index	Dominating Ecological Group	Benthic Community Health
Unpolluted	$0.0 < BC \leq 0.2$	0	I	Normal
Unpolluted	$0.2 < BC \leq 1.2$	1		Impoverished
Slightly Polluted	$1.2 < BC \leq 3.3$	2	III	Unbalanced
Meanly Polluted	$3.3 < BC \leq 4.3$	3		Transitional to pollution
Meanly Polluted	$4.3 < BC \leq 5.0$	4	IV-V	Polluted
Heavily Polluted	$5.0 < BC \leq 5.5$	5		Transitional to heavy pollution
Heavily Polluted	$5.5 < BC \leq 6.0$	6	V	Heavy polluted
Extremely Polluted	Azoic	7	Azoic	Azoic

The index has been validated and has been shown to be able to detect differences between control and contaminated stations (based on the oxygenation at bottom waters, and organic matter and heavy metal content of the sediments). The results were published in Marine Pollution Bulletin (Borja *et al.*, 2000). This index could comply with the requirements of the WFD if combined with measures of abundance and diversity.

6.5. FISH

Tools currently available in Member States to classify fish fauna

6.5.1. No tools are commonly used at the moment in Europe.

6.5.2. Within the **UK** a fish classification tool that was developed for assessing the status of fish communities in estuaries within South Africa is currently being tested.

6.5.3. **Belgium** has developed an estuarine fish index for the Scheldt estuary in Flanders.

Do the available tools fulfill the requirements of the Directive?

6.5.4. The **South African tool being tested by the UK**: includes a measure of both the composition and abundance of the fish fauna.

6.5.5. The **Belgium** classification tool considers the composition of the fish community. The tool does not include a direct measure of abundance.

6.5.6. Summary of the **South African Fish Classification System currently being tested within the UK.**

Introduction
The UK is currently testing a fish classification system developed in South Africa. It is believed that although this approach was developed to assess the status of fish communities in estuaries in South Africa, it could also be applied to European estuaries. Until adequate datasets are available, full testing and refinement of the categories in Table 6.11 to ensure alignment with the normative definitions in the Directive will not be possible.

The approach described below was developed in order to provide a state of the environment indicator and monitoring tool within South Africa. Research was based on a 7-year intensive field sampling program during which 257 estuaries were visited. Using fisheries data and typological classification, biogeographic regions were identified and characterised in order to form six basic estuary types (Harrison et al., 2000).
The fish community structure within each estuary type was investigated, with each estuary type being found to contain a fairly distinctive fish assemblage. From this an Estuarine Classification Scheme was developed. The fish community structure (species richness, composition & relative abundance) of each estuary type within a biogeographic region is described and used as a reference against which each estuary is assessed.

Methods
A multi-method sampling approach was used including seine netting and gill netting. Sampling was generally carried out until no new species were encountered or until all representative habitats within the estuary had been sampled.

The fisheries data was then analysed using the Bray-Curtis similarity co-efficient which was essential for standardisation of sampling effort. The Bray-Curtis coefficient reflects the differences between two samples due to differing community composition and/or differing total abundance. Standardisation removes any effect of the latter.

These results showed that estuarine fish communities within each geomorphological type formed groups which were related to their geographical position & biogeography.

Classification
Having determined the biogeographic boundaries along the South African coast the fish community structure was investigated in relation to estuary type. Data analysis used a combination of hierarchical agglomerative clustering and non-metric multi-dimensional scaling (MDS) using PRIMER (Clark and Warwick 1994).

The concept of biological community health (in relation to the ecosystem) was used and termed 'Fish Community Status (Health)'. It uses the 'Community Degradation Index (CDI)' which measures the degree of dissimilarity (degradation) between a potential fish assemblage and the actual measured fish assemblages. This was then modified into the 'Biological Health Index' (BHI) to provide a measure of the similarity between the potential and actual fish assemblages (Cooper *et al.*, 1994). The index ranges from 0 (poor) to 10 (good). Although the BHI is a useful tool in condensing information on estuarine fish assemblages into a single value (the index is based on presence/absence data) it does not take into account the relative proportions of the species present.

Whitfield and Elliott (2002) give examples of indexes which can be used to condense biological community data and suggest how these parameters could be used to determine the degree of human induced change within an estuary (Table 6.11).

Table 6.11. Fish-based parameters that could be used in a single or composite scoring system (the higher the score, the more natural the system) for monitoring human induced changes within an estuary. Some of the indicators are subjective and qualitative whereas others are more objective and quantitative.

Level	Indicator	Value	Score
1. Fish species	1(a). Species abundance/ biomass	Artificially low	1
		Medium/high	3
	1(b). Keystone/indicator species	Present	3
		Absent	1
	1(c). Alien/introduced species	Presence of alien/introduced species	1
		Absence of alien/introduced species	3
	1(d). Fish species health	Toxic accumulations present	1
		Toxic accumulations absent	3
2. Fish community	2(a). Harrison et al. (2000) Species richness index	Similarity with mean number of taxa:	
		>95% upper confidence interval	5
		Within 95% confidence intervals	3
		<95% lower confidence interval	1
	2(b). Harrison et al. (2000) Bray-Curtis presence/absence similarity index	Similarity with reference condition:	
		>50th percentile similarity	5
		10th – 50th percentile similarity	3
		<10th percentile similarity	1
	2(c). Harrison et al. (2000) Bray-Curtis percentage abundance similarity index	Similarity with reference condition:	
		>50th percentile similarity	5
		10th – 50th percentile similarity	3
		<10th percentile similarity	1
	2(d). Deegan et al. (1997) Estuarine Biotic Integrity Index (number and/or biomass)	EBI value (eight metrics used):	
		Score 31 – 40	5
		Score 21 – 30	3
		Score 0 – 20	1

6.5.7. Summary of the **of an estuarine fish index (EFI) for the Scheldt estuary in Flanders (Belgium)** (Goethals *et al.*, 2002, Adriaenssens *et al.*, 2002a, Adriaenssens *et al.*, 2002b).

The Estuarine Fish Index consists of seven metrics, which each aim to assess a different functional aspect of the estuarine fish assemblages and the integrated quality of the ecosystem.

Description of the score system

Application area: Schelde estuary between Burcht and the Dutch Belgian border, based on salinity measurements

Description of reference conditions: a combination of historical data, data from similar European Estuaries (e.g. Eems-Dollard), expert knowledge and recent data collections.

Data collection: double fykes (type 120/80). Fykes were emptied every three days. Data were based on averaging data collected during one month, recalculated as average catch per day per fyke for a particular month.

Table 6.12. Metrics, variables and scoring system:

Parameter	**Score**				
	1	2	3	4	5
Total number of species	>=4	5-14	15-19	20-24	>24
Type species*					
% Flounder	<=5	>5-10 >50-80			>10-50
% Smelt	<=5	>5-10 >50-80			>10-50
Trophic composition*					
% omnivores	<=1 >80	>1-2.5 >20-80			>2.5-20
% piscivores	<=5 >80	>5-10 >50-80			>10-50
♦**Tolerance**	<1.20	1.20-1.59	1.60-1.99	2-3	>3
Estuarine resident species*					
Number E.R.S.	<2	2	3	4	>4
% E.R.S.	<5 >50	5-10 40-50			>10-<40
% diadromous species	<=5 >80	5-10 >70-80			>10-70
% marine juvenile migrating species	<=10 >90	5-10 >80-90	>20-30 >70-80		>30-70

*adding missing scores 3, 4 (and 5) would be of no ecological relevance, presence of extremely low as well as extreme high number reflect deterioration
♦A tolerance score was attributed to each fish species present.

Overall classification of the estuarine fish index, is the average of the seven metric sores as shown in Table 6.13.

Table 6.13. Estuarine Fish Index quality classes.

colorcode	EFI-value	Classification
	>4,5	excellent
	4-<4,5	good
	3-<4	moderate
	2-<3	bad
	<2	very bad

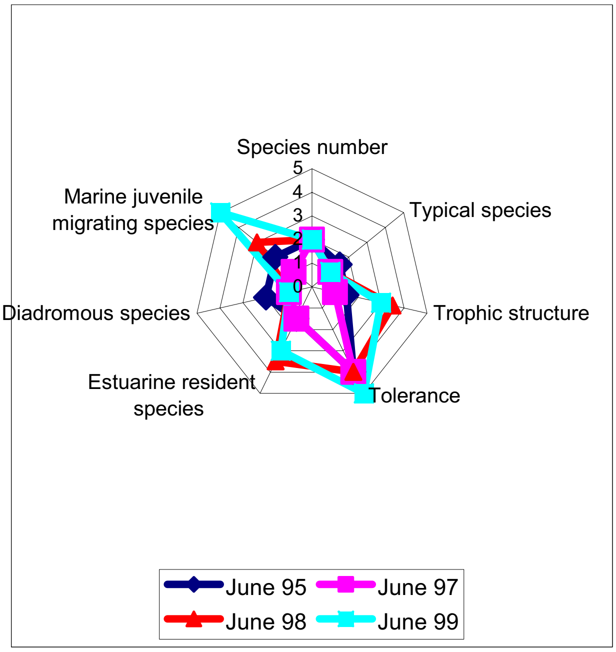


Figure 6.2. Visual presentation of the evolution for the 7 metric scores at Bath.

6.6. CLASSIFICATION SCHEMES FOR BIOLOGICAL QUALITY ELEMENTS

The OSPAR Comprehensive Procedure.

6.6.1. Marine eutrophication is one of the main issues that has been dealt with for over 10 years in the context of the North Sea Conferences (Declarations of London 1987, den Hague 1990, Esbjerg 1995) and OSPAR. Consequently, PARCOM Recommendation 88/2 recommends that OSPAR Contracting Parties:

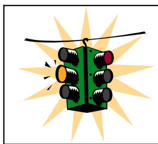
(i) take effective national steps in order to reduce nutrient inputs into areas where these inputs are likely, directly or indirectly, to cause pollution;

(ii) aim to achieve a substantial reduction (in the order of 50 %) in the inputs of phosphorus and nitrogen into these areas between 1985 and 1995, or earlier if possible.

6.6.2. The Comprehensive Procedure for the Identification of the Eutrophication Status of the Maritime Area is a main element of that strategy. The Strategy has the aim of identifying the eutrophication status of all parts of the maritime area by the year 2002 and asks for every effort to be made to combat eutrophication in order to achieve, by the year 2010, a healthy marine environment where eutrophication does not occur.

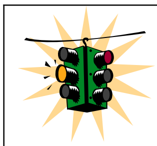
6.6.3. The Comprehensive Procedure consists of a set of assessment criteria that may be linked to form a holistic and common assessment of the eutrophication status of the maritime area. Through this process the OSPAR maritime area is classified into areas which are considered to be problem, potential problem, or non-problem areas with regard to eutrophication. Repeated application of the Comprehensive Procedure should identify any change in the eutrophication status of a particular area.

6.6.4. The Comprehensive Procedure comprises two steps. The first step is the screening procedure which is a broad-brush process to identify obvious non-problem areas with regard to eutrophication. Following that step, all areas not identified as non-problem areas shall be subject to the Comprehensive Procedure.



The Comprehensive Procedure is specifically designed to assess the effects of eutrophication within the North-East Atlantic. This is just one of the pressures that a classification scheme for the WFD should be able to detect.

6.6.5. The following is a summary of the **Comprehensive Procedure** (OSPAR 1997).



Look out! The OSPAR Common Assessment Criteria is an area of study that is still evolving. An example of the agreed criteria at the time of publishing can be found in Section 6.6 of the toolbox. Member States must endeavour to use the latest version of the criteria which at the time of publication of this Guidance Document could be found on the OSPAR website at www.ospar.org/ see Measures, Agreements, Agreement 2002-20.

Assessment criteria and their assessment levels within the Comprehensive Procedure

In order to enable Contracting Parties to undertake a harmonised assessment of their waters subject to the Comprehensive Procedure it was necessary to develop a number of the qualitative assessment criteria into quantitative criteria that could be applied in a harmonised way. On the basis of common denominators within a wide range of qualitative and quantitative information provided by Contracting Parties on the criteria and assessment levels already used, a set of assessment criteria were selected and further developed into quantitative criteria for use in a harmonised assessment. It should also be noted that, although the levels against which assessment is made may be region-specific, the methodology for applying these assessment criteria is based on a common approach.

The assessment criteria selected for further development fall into the following categories (Table 6.14):

Category I ***Degree of nutrient enrichment;***
Category II ***Direct effects of nutrient enrichment;***
Category III ***Indirect effects of nutrient enrichment;***
Category IV ***Other possible effects of nutrient enrichment.***

The main interrelationships between the assessment parameters and their categories are shown in Figure 6.3.

Agreed harmonised assessment criteria and their assessment levels

For each criterion an assessment level has been derived (based on a level of elevation) with the exception of nutrient inputs for which there should also be an examination of trends. The level of elevation is defined, in general terms, as a certain percentage above a background concentration. The background concentration is, in general terms, defined as a salinity related and/or region specific derived spatial (offshore) and/or historical background concentration.

In order to allow for natural variability in the assessment, the level of elevation is generally defined as the concentration of more than 50 % above the salinity related and/or region specific background level (e.g. DIN and DIP concentrations).

Table 6.14. The agreed Harmonised Assessment Criteria and their respective assessment levels of the Comprehensive Procedure.

Assessment parameters		
Category I	**Degree of Nutrient Enrichment**	
	1	**Riverine total N and total P inputs and direct discharges (RID)** Elevated inputs and/or increased trends (compared with previous years)
	2	**Winter DIN- and/or DIP concentrations**[1] Elevated level(s) (defined as concentration > 50% above[2] salinity related and/or region specific natural background concentration)
	3	**Increased winter N/P ratio (Redfield N/P = 16)** Elevated cf. Redfield (> 25)
Category II	**Direct Effects of Nutrient Enrichment (during growing season)**	
	1	**Maximum and mean Chlorophyll a concentration** Elevated level (defined as concentration > 50% above[2] spatial (offshore) / historical background concentrations)
	2	**Region/area specific phytoplankton indicator species** Elevated levels (and increased duration)
	3	**Macrophytes including macroalgae (region specific)** Shift from long-lived to short-lived nuisance species (e.g. *Ulva*)
Category III	**Indirect Effects of Nutrient Enrichment (during growing season)**	
	1	**Degree of oxygen deficiency** Decreased levels (< 2 mg/l: acute toxicity; 2 - 6 mg/l: deficiency)
	2	**Changes/kills in Zoobenthos and fish kills** Kills (in relation to oxygen deficiency and/or toxic algae) Long term changes in zoobenthos biomass and species composition
	3	**Organic Carbon/Organic Matter** Elevated levels (in relation to III.1) (relevant in sedimentation areas)
Category IV	**Other Possible Effects of Nutrient Enrichment (during growing season)**	
	1	**Algal toxins (DSP/PSP mussel infection events)** Incidence (related to II.2)

[1] *Maps, figures and mixing diagrams are available in OSPAR EUC 01/11/1 Annex 5 Appendix 4*
[2] *Other values less than 50 % can be used if justified*

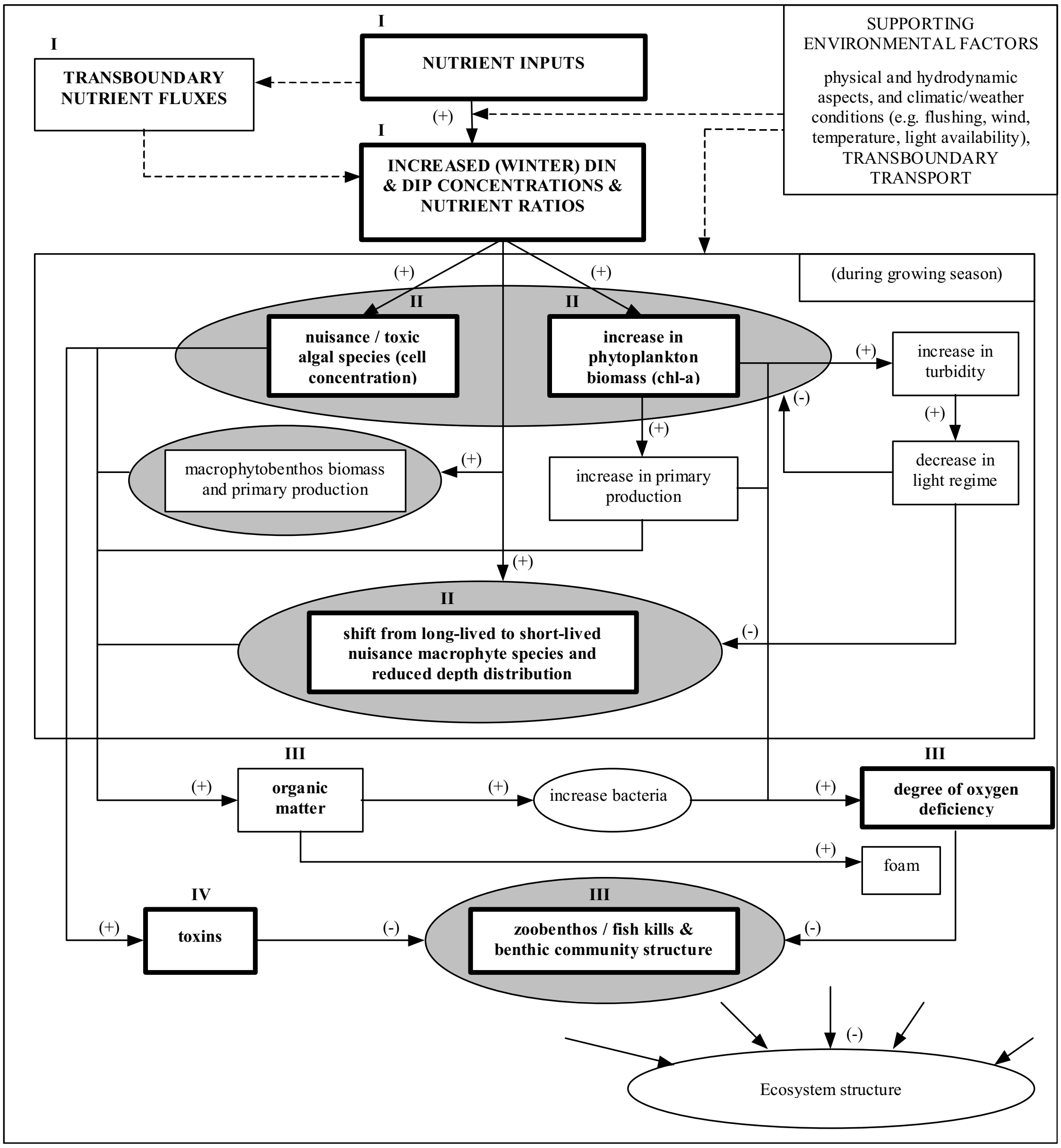


Figure 6.3. Main Interrelationships between the Assessment Parameters (in bold) of the OSPAR Comprehensive Procedure (COMPP).

Parameters for which Assessment Criteria and their assessment levels are identified are shown in boxes with bold lines. Biological elements are shaded. Continuous arrow lines with (+) and (-) indicate 'having stimulating effect upon', and 'having inhibiting effect upon', respectively. Dashed arrow lines indicate 'having influence upon'.

Key:	I	=	Category I	Degree of Nutrient Enrichment (Causative factors)
	II	=	Category II	Direct Effects of Nutrient Enrichment
	III	=	Category III	Indirect Effects of Nutrient Enrichment
	IV	=	Category IV	Other Possible Effects of Nutrient Enrichment

Classification on the basis of the harmonised assessment criteria and their respective assessment levels

For a harmonised holistic assessment of eutrophication status of an area one needs at least to address the common assessment parameters listed in the four categories of the assessment procedure.

To carry out the classification of the eutrophication status of areas of the maritime region each Contracting Party should undertake a number of steps, which are outlined below. The first step is to provide a score for each of the harmonised assessment criteria being applied according to Table 6.14. The second step will bring these scores together according to Table 6.15 to provide a classification of the area. The third step is to make an appraisal of all relevant information (concerning the harmonised assessment criteria their respective assessment levels and the supporting environmental factors), to provide a transparent and sound account of the reasons for establishing a particular status for the area.

Finally this process should enable the classification of the maritime area in terms of problem areas, potential problem areas, and non-problem areas.

Integration of Categorised Assessment Parameters for Classification

The assessment levels of the agreed harmonised assessment criteria form the basis of the first step of the classification.

The next step is the integration of the categorised assessment parameters mentioned in Table 6.14 to obtain a more coherent classification. For each assessment parameter of Categories I, II, III and IV mentioned in Table 6.14 it can be indicated whether its measured concentration relates to a problem area, a potential problem area or a non-problem area as defined in the OSPAR Strategy to Combat Eutrophication. The results of this step are summarised in Table 6.15 and explained below:

a. Areas showing an increased degree of nutrient enrichment accompanied by direct and/or indirect/other possible effects are regarded as **'problem areas**;
b. Areas may show direct effects and/or indirect or other possible effects when there is no evident increased nutrient enrichment, e.g. as a result of transboundary transport of (toxic) algae and/or organic matter arising from adjacent/remote areas. These areas could be classified as **'problem areas'**;
c. Areas with an increased degree of nutrient enrichment, but without showing direct, indirect/ other possible effects, are initially classified as **'potential problem areas'**;
d. Areas without nutrient enrichment and related (in) direct/other possible effects are considered to be **'non-problem areas'**.

Table 6.15. Integration of Categorised Assessment Parameters for Classification (see also Table 6.14.)

	Category I Degree of nutrient enrichment	Category II Direct Effects	Category III and IV Indirect effects/ other possible effects	Classification
A	+	+ and/or	+	problem area
B	-	+ and/or	+	problem area[3]
C	+	-	-	potential problem area
D	-	-	-	non-problem area

(+) = Increased trends, elevated levels, shifts or changes in the respective assessment parameters in Table 6.14.
(-) = Neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters in Table 6.14.

Note: Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated level, shift or change.

Supporting Environmental Factors

3.6 Region specific characteristics should be taken into account, such as physical and hydrodynamical aspects, and weather/climate conditions (see Figure 6.3.). These region specific characteristics may play a role in explaining the results of the classification.

[3] *Caused by transport from other parts of the maritime area.*

6.7. SUPPORTING ELEMENTS (HYDROMORPHOLOGICAL AND PHYSICO-CHEMICAL)

Tools currently available in Member States to classify the general elements:

6.7.1. A number of Member States have or are developing classification tools for all or most of the general supporting elements.

6.7.2. In the context of the Marine Strategy, the Commission will initiate action to prepare in collaboration with the regional marine conventions by 2006 a comprehensive assessment of the extent of marine eutrophication on the basis of a harmonised classification tool.

6.7.3. The OSPAR Common Procedure includes nutrients and could be tested by non-OSPAR Contracting Parties. One challenge is how to handle nutrients because the Comprehensive Procedure only handles winter values and has been developed for open seas.

Section 7 – Summary and Conclusions

7.1. Typology

7.1.1. Many Member States have started to develop a typology for transitional and coastal waters. This Guidance Document promotes the development of a harmonised European typology for transitional and coastal waters through the use of the factors for system B.

7.1.2. It is important to establish good links between typing experts in Member States with similar types. Collaboration is the most important process in reaching a harmonised elaboration of a pan-European basis for the implementation of the Water Framework Directive with regard to monitoring and assessment. Communication between experts in different Member States at the typology stage could aid with the implementation of the successive stages of the Directive such as the establishment of reference conditions and the intercalibration exercise.

7.1.3. In cases where Member States of an Ecoregion have similar coastlines experts should work together to develop a common set of surface water body types where possible. This process should result in a smaller number of water body types than if Member States work independently.

7.1.4. In addition, harmonisation of types between Member States should be encouraged to avoid:

- the same surface water body type having different names; or
- different surface water body types having the same name.

Such collaboration should also prevent disharmony in water body types at the borders between neighbouring Member States.

7.2. Reference conditions

7.2.1. At present no reference networks of high status sites for transitional and coastal waters are known to exist within Europe that meet the requirements of the WFD.

7.2.2. To date the majority of monitoring within transitional and coastal waters has concentrated upon polluted areas rather than areas that will meet the definition of high status for the WFD. Data are not always available for all quality elements. Therefore, there is a need to start collecting data as soon as possible for the purposes of deriving biological reference conditions.

7.2.3. It should be emphasised that the derivation of reference conditions that encompass the full natural variability found within a water body type is likely to take many years. It will be an iterative process and will be assisted by the collection of monitoring data for the purposes of the Directive over the forthcoming years.

7.2.4. Member States with similar types should work together where possible in order to enable the sharing of reference conditions.

7.2.5. Member States should collaborate as soon as possible to start developing a European reference network of high status sites.

7.3. CLASSIFICATION

7.3.1. Section 6 of this Guidance is a toolbox which contains existing classification schemes and tools that may be suitable for testing by Member States. Those classification tools which currently exist have generally not been tested against the normative definitions (Annex V Tables 1.2.) and descriptions of high, good and moderate status for each of the quality elements in transitional and coastal waters (Annex V Tables 1.2.3. and 1.2.4.).

7.3.2. As classification tools are developed within Member States, experts are encouraged to exchange information and knowledge gained from testing. It is likely that Member States with similar types may find that they can use the same classification tools.

7.3.3. Once classification tools have been developed and tested it will be possible to develop further guidance on the setting of EQRs and the boundaries between high/good, and good/moderate status.

7.3.4. It is recognised that this Guidance does not give specific advice on setting EQR values and on the statistical issues surrounding classification. It is suggested that this work needs to be taken further. The development of classification tools will require the gathering of data from a wide range of sites at different status. It should be noted that robust classification tools require many years of data, for example, the South African Fish Classification tool in Section 6.5.6. was developed after seven years of intensive data collection.

7.4. THE PROMOTION OF COMMUNICATION

7.4.1. The establishment of the COAST working group has brought together experts from across Europe who are involved in the implementation of the WFD with regard to transitional and coastal waters.

7.4.2. The establishment of the COAST working group has highlighted that communication and collaboration between experts from different Member States is an important and integral part in the implementation of all parts of the Directive. Communication and collaboration between those people who are implementing the Directive both within and between Member States is essential to ensure the effective and integrated implementation of the Directive both within Member States and across Europe and to exchange knowledge and experience.

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Annex A – Key Activities and the Working Groups of the Common Implementation Strategy

Key Activity 1: Information Sharing

1.1. Tools for Information sharing
1.2. Raising Awareness

Key Activity 2: Develop Guidance on Technical Issues

2.1. Guidance on the analysis of pressures and impacts
2.2. Guidance on the designation of heavily modified bodies of water
2.3. Guidance on classification of inland surface water status and identification of reference conditions
2.4. Guidance on the development of typology and classification systems of transitional and coastal waters
2.5. Guidance for establishing the intercalibration network and intercalibration exercise
2.6. Guidance on economic analysis
2.7. Guidance on monitoring
2.8. Guidance on tools on assessment and classification of groundwater
2.9. Guidance on best practices in river basin management planning

Key Activity 3: Information and Data Management

3.1. Development of a shared Geographical Information System

Key Activity 4: Application, testing and validation

4.1. Integrated testing of guidelines in pilot river basins

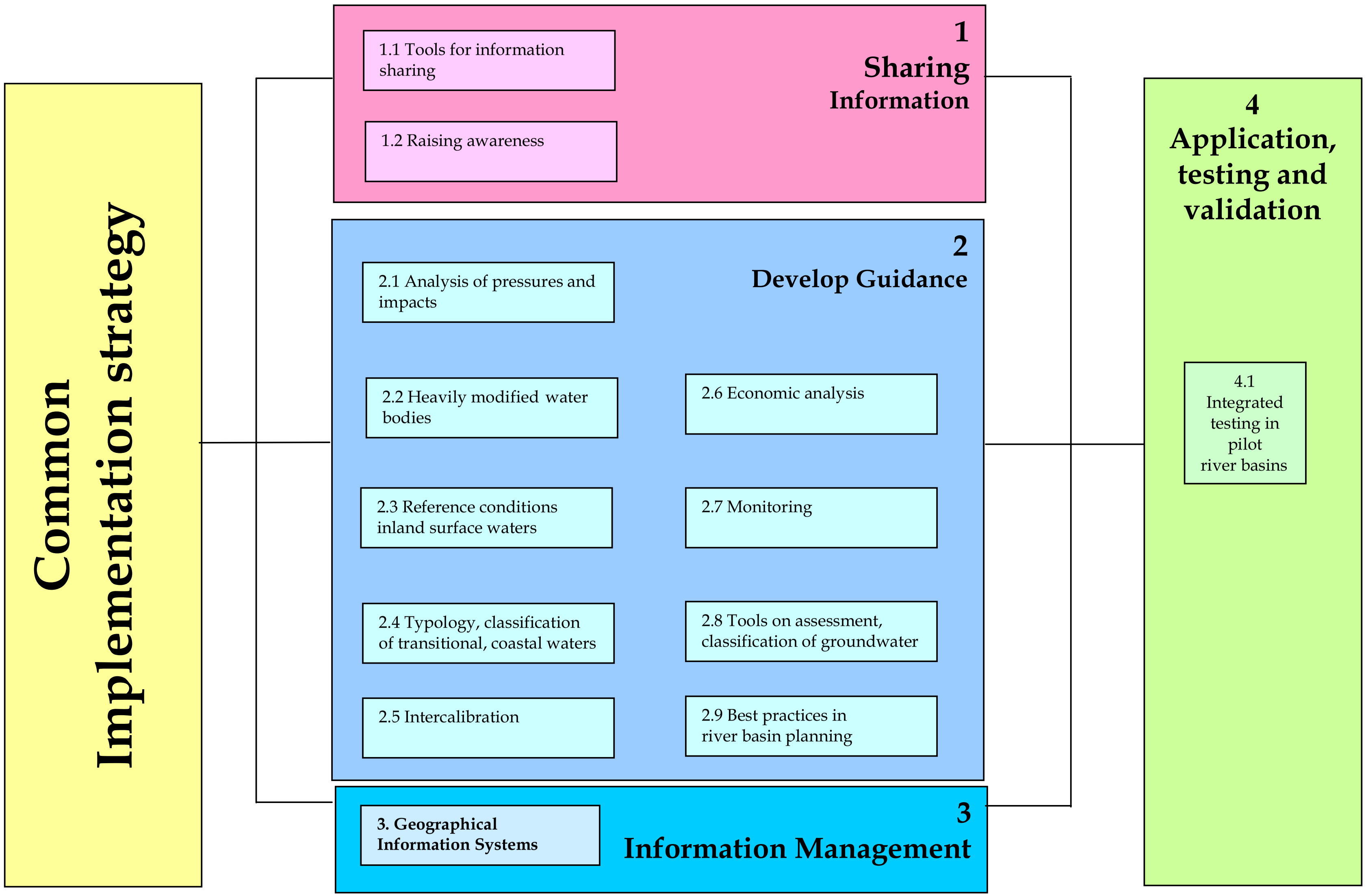

Figure A.1. Overall structure of the Common Implementation Strategy.

Annex B – Members of the COAST Working Group

This list is by no means exhaustive. There were many other people who had an input to the writing of the Guidance Document.

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Annex C – List of Reference Conditions Studies

The following table lists all the pilot studies that were carried out within the COAST working group. It is recognised that not all of these areas are in high status. Some are 'best of type' and may equate to good status.

For further information regarding these pilot studies please contact one of the COAST representatives from the respective Member State.

Table C.1. List of Pilot Studies.

Site	Member State	Coastal or Transitional
Randers Fjord	Denmark	Coastal
Rio Formosa, (mesotidal shallow ria)	Portugal	Coastal
Mira Estuary, (Mesotidal torrential estuary)	Portugal	Transitional
Loch Creran and Loch Ardbhair, Scotland	United Kingdom	Coastal
Strangford Lough, Northern Ireland	United Kingdom	Coastal
Northern part of South Evvoikos Gulf	Greece	Coastal
Southern part of South Evvoikos Gulf	Greece	Coastal
Tsoukalio, Rhodia and Tsopeli lagoon complex	Greece	Transitional
North Sea Skagerrak Open Rocky Coast	Norway	Coastal

Annex D - Glossary

Term	Definition
AMAP	Arctic Monitoring and Assessment Programme established in 1991 to implement certain components of the Arctic Environmental Protection Strategy.
Angiosperm	Flowering plant.
Bar-built estuary	An estuary characterised by a bar across the mouth. Usually associated with the availability of large volumes of sediment and a restricted tidal range.
Barcelona Convention	Convention for the Protection of the Mediterranean Sea against Pollution adopted in Barcelona on 16 February 1976.
Baseline for Territorial Waters	According to the United Nations Convention on the Law of the Sea the baseline is measured as the low-water line except along the mouths of estuaries and heads of bays where it cuts across open water. Along highly indented coastlines, bays, mouths of estuaries or coastlines with islands, the baseline can be drawn as a straight line. Each Member State has a legislative baseline associated with this definition.
Benthic Invertebrate Fauna	Invertebrate animals living at least for part of their lifecycles on or in the benthic substrates of rivers, lakes, transitional waters or coastal waters
BEQUALM	Biological Effects Quality Assurance in Monitoring Programmes.
Birds Directive	Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds
Catchment	Refer to definition of 'River Basin' in Article 2 of the WFD (2000/60/EC)
Deterioration	A reduction in quality of one or more of the quality elements.
Diffuse Source Pollution[4]	Pollution which originates from various activities, and which cannot be traced to a single source and originates from a spatially extensive land use (e.g. agriculture, settlements, transport, industry). Examples for diffuse source pollution are atmospheric deposition, run-off from agriculture, erosion, drainage and groundwater flow.
Discharge[5]	The release of polluting substances from individual or diffuse sources in the installation through effluent directly or indirectly into water bodies as defined under Article 2 (1) of Directive 2000/60/EC.
Diurnal tidal cycle	Tide which has a period or cycle of approximately one tidal day (about 25 hours). Diurnal tides usually have one high and one low tide each day.

[4] *Interim working definition. Discussions in the context of the WFD implementation are ongoing.*
[5] *Interim working definition. Discussions in the context of the WFD implementation are ongoing.*

Term	Definition
Ecological Quality Ratio	Ratio representing the relationship between the values of the biological parameters observed for a given body of surface water and values for these parameters in the reference conditions applicable to that body. The ratio shall be represented as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero (Annex V 1.4(ii)).
Eco-region	The geographical areas illustrated in Annex XI Maps A (rivers and lakes) and B (transitional waters and coastal waters).
EU Marine Strategy	Part of the 6th Environment Plan in order to develop a strategy for the marine environment in collaboration with all major stakeholders. The aim is for a joint Europe wide assessment to be published by 2010.
Habitats Directive	Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
HELCOM Convention	Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992 which entered into force on 17 January 2000 (otherwise known as the Helsinki Convention).
Hydromorphology	The physical characteristics of the shape, the boundaries and the content of a water body. The hydromorphological quality elements for classification of ecological status are listed in Annex V.1.1 and are further defined in Annex V.1.2 of the Water Framework Directive.
ICES	International Council for the Exploration of the Sea which coordinates and promotes marine research in the North Atlantic.
Impact	The environmental effect of a pressure (e.g. fish killed, ecosystem modified).
Intercalibration	An exercise facilitated by the Commission to ensure that the high/good and good/moderate class boundaries are consistent with the normative definitions in Annex V Section 1.2 of the Directive and are comparable between Member States (see Guidance produced by WG 2.5) (Annex V 1.4. (iv)).
Isohaline	A line connecting points of equal salinity (OSPAR QSR 2000 North Sea).
Lagoon	Isolated saline water. Enclosed bodies of water, separated or partially separated from the sea.
Macrophyte[6]	All aquatic higher plants, mosses and characean algae, but excluding single celled phytoplankton or diatoms.
Non-Indigenous Species	An introduced species that would not naturally occur in that water body.
OSPAR Common Procedure	The Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area.
OSPAR Convention	The Convention for the Protection of the Marine Environment of the North-East Atlantic which replaces the former Oslo and Paris Conventions. The Convention entered into force on 25 March 1998.

[6] *Interim working definition. Discussions in the context of the WFD implementation are ongoing.*

Term	Definition
Phytoplankton	Unicellular algae and cyanobacteria, both solitary and colonial, that live, at least for part of their lifecycle, in the water column of surface water bodies.
Point source pollution	Pollution arising from a discrete source , e.g. the discharge from a sewage treatment works
Pressure[7]	The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry of surface and groundwater bodies.
QUASIMEME	Quality Assurance in Marine Environmental Monitoring in Europe.
RAMSAR Convention	The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
RDM – INSPIRE	Reference Data and Metadata - Inspire Working Group
Reference conditions	For any surface water body type reference conditions or high ecological status is a state in the present or in the past where there are no, or only very minor, changes to the values of the hydromorphological, physico-chemical, and biological quality elements which would be found in the absence of anthropogenic disturbance. Reference conditions should be represented by values of the biological quality elements in calculation of ecological quality ratios and the subsequent classification of ecological status.
Register of Protected Areas	A register of areas lying within the river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater, or for the conservation of habitats and species directly depending on water (see Annex IV). This register must be completed by December 2004 (Art 6, 7 and Annex IV).
River Basin Management Plan	A plan that must be produced for each River Basin District within a Member State in accordance with Article 13. The plan shall include the information detailed in Annex VIII.
Salt marsh	An area of coastal grassland that is regularly flooded by seawater.
Shellfish Waters Directive	Council Directive of 30 October 1979 on the quality required of shellfish waters (79/923/EEC).
Specific Pollutants	Pollution by all priority substances defined as being discharged into the body of water; and pollution by other substances identified as being discharged in significant quantities into the body of water (Annex V, 1.1)
Specific Non-Synthetic Pollutants	Naturally occurring priority substances identified as being discharged into the body of water and other substances identified as being discharged in significant quantities into the body of water (Annex V 1.1).

[7] *Interim working definition. Discussions in the context of the WFD implementation are ongoing.*

Term	Definition
Specific Synthetic Pollutants	Man-made priority substances identified as being discharged into the body of water and other substances identified as being discharged in significant quantities into the body of water (Annex V 1.1)
Strategic Co-ordination Group	A group led by the Commission with participants from all Member States which was established to co-ordinate the work of the different working groups of the Common Implementation Strategy.
Taxa	Taxonomic groups of any rank.
Territorial waters	The breadth of waters extending out to 12 nautical miles from the baseline defined under the United Nations Convention on the Law of the Sea, 1982.
Toxic Algae	Species of algae that produce harmful toxins.
Transboundary	Crossing the boundary between Member States, River Basin Districts etc.
UNEPMAP	United Nations Environment Programme Mediterranean Action Plan.
Unit cost	The cost of producing one unit of a product.**
Urban Waste Water Treatment Directive	Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC).
Wetland	Refer to Guidance on wetlands currently under preparation.

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European Commission

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.º 6

Towards a guidance on establishment of the intercalibration network and the process on the intercalibration exercise

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 6

Towards a Guidance on Establishment of the Intercalibration Network and the Process on the Intercalibration Exercise

Produced by Working Group 2.5 - Intercalibration

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In the context of this strategy, an informal working group dedicated to prepare guidance for the technical protocol of the Intercalibration required in the Directive has been set up. The main (short-term) objective of this working group, launched in June 2001, was the development of a non-legally binding and practical Guidance Document on the technical protocol for the establishment of the intercalibration network and the intercalibration exercise of the Water Framework Directive. The Commission's Directorate General, Joint Research Centre (Institute of Environment and Sustainability) has the responsibility of the leadership and co-ordination of the working group that is composed of technical experts from governmental and non-governmental organisations.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the INTERCALIBRATION working group activities and discussions that have taken place since June 2001. It builds on the input and feedback from a wide range of experts and stakeholders from both EU Member States and candidate countries that have been involved throughout the process of guidance development through meetings, workshops, conferences or electronic communication media, without binding them in any way to its content.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined this guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders of the Joint Research Centre, for preparing this high quality document.

We recognise that the Guidance Document represents a significant first step towards the elaboration of a comprehensive approach for intercalibration as required under the directive.

The Water Directors agreed that the document must be developed further during 2003 and beyond. It was stressed that the elaboration of an intercalibration system in line with the requirements of the Water Framework Directive was a major challenge. Pragmatic solutions need to be developed which bridge the gap between the technical and scientific possibilities and the formal requirements. As expressed in the guidance, a step-wise approach should be developed with improvements and refinements being introduced in the light of experience and new information.

The Water Directors highlighted that the status of the document is as an interim product, still under active development.

We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work. Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the guidance is applicable in practice. We also invite the Working Group to come forward with a further developed document by the end of 2003 taking account of the above comments.

Table of Contents

Introduction - A Guidance Document: What for?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the guidance for the procedure of establishment of the intercalibration network and the execution of the intercalibration exercise ensuring comparability of biological monitoring results between the Member States, as required by the Directive.

To whom is this Guidance Document addressed?

If this is your task, we believe the guidance will help you in doing the job, whether you are:

- **Carrying out the analysis for ecological quality classification of surface waters yourself;**
- **Leading and managing experts undertaking the ecological quality classification;**
- **Using the results of the classification for selection of the intercalibration sites**, **or**
- **Reporting on the results of the classification of the ecological quality of the intercalibration sites to the European Union, as required by the Directive.**

What can you find in this Guidance Document?

- **Common understanding of Water Framework Directive intercalibration requirements**
- Extraction and description of the relevant text concerning intercalibration from the Directive, Annex V;
- Agreement on what this text means in practical terms.

- **Synthesis of the intercalibration process: problems and possible solution**
- Description of the timetable of the intercalibration process;
- Description of practical problems in requirements of the Directive in relation to the implementation timetable in Member States;
- Possible solutions to these problems on short-term and long term basis;
- Possible implications of limited intercalibration.

- **Description of a practical procedure of the intercalibration process (Figure 1)**

- **Practical organization for the selection of intercalibration sites**
- Roles of Member States and the Commission in the site selection process;
- Procedure, timetable, and criteria for the selection of water body types for intercalibration;
- Procedure, timetable and criteria for the selection of intercalibration sites;
- Deliverables and milestones of the intercalibration process;
- Artificial and heavily modified water bodies and the intercalibration network;
- Criteria for the selection of intercalibration sites.

- **Preliminary technical protocol for the intercalibation exercise**
- Stepwise description of the intercalibration exercise and the tasks of the participants;
- Guidance on data collection and data exchange;
- Reporting of the classification results;
- Expected outcome of the intercalibration exercise.

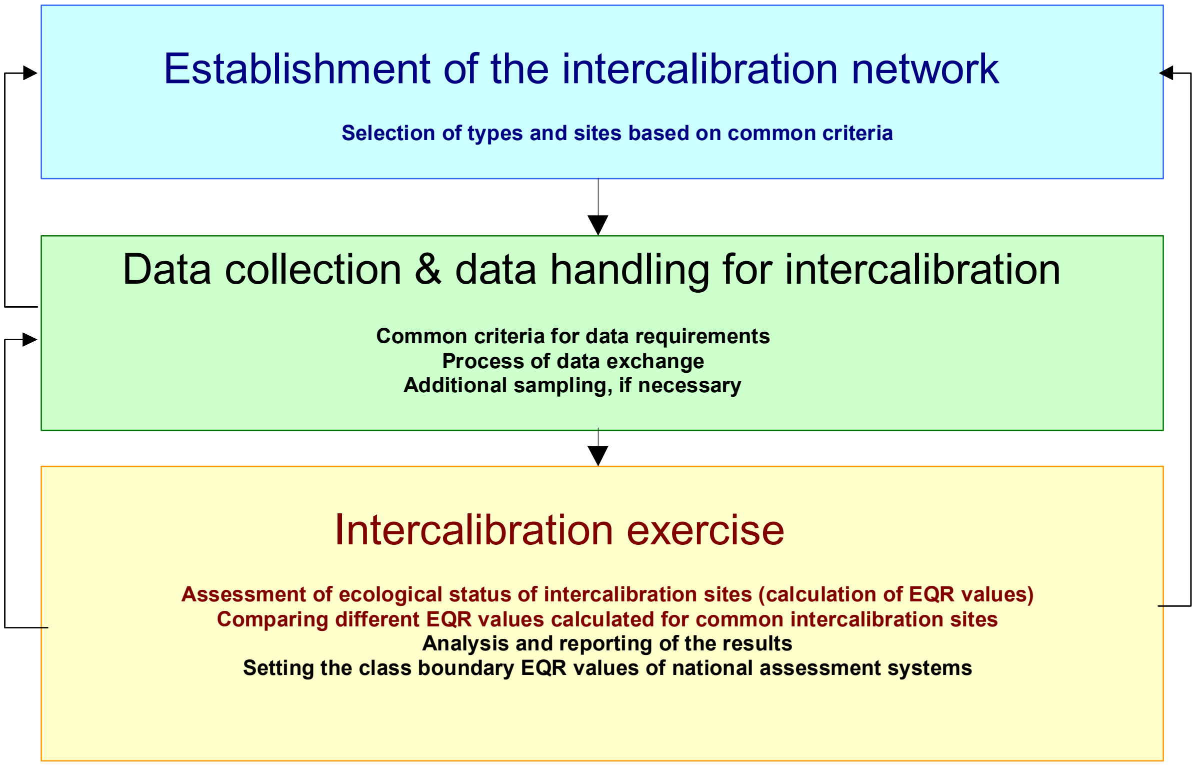
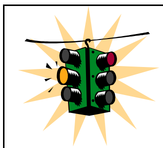
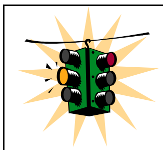


Figure 1 Structure of the guidance for the process of Intercalibration

	***Look out! The methodology from this Guidance Document must be adapted to regional and surface water category specific circumstances*** *The Guidance Document describes an overall approach for the selection of intercalibration sites and the intercalibration process. Because of the diversity of the surface waters and their natural conditions in the European Union, the intercalibration process needs to be tailored for the different ecoregions and surface water categories. To achieve this, a procedure is proposed involving experts from all Member States.*

	***Look out! What you will not find in this Guidance Document*** • *Guidance on how to calculate Ecological Quality Ratios for different quality elements is not included, because:* - *This will depend on the assessment method and metrics that each MS chooses for the assessment of their surface water quality (this is addressed in the WFD CIS Guidance Document No. 7 - Monitoring);* - *This will depend on the method that each MS chooses for establishing reference conditions (this is addressed in the WFD CIS Guidance Document No.s 10 and 5 - REFCOND and COAST).* • *Guidance on a common understanding and more specific interpretations of the normative definitions of the quality classes given in the Directive is not included, because:* - *The REFCOND and COAST working groups have started to address these issues, and (to a certain extent) will address these in their Guidance Documents (WFD CIS Guidance Documents No. 10 and 5 respectively).*

	- *It is proposed that water category and type specific criteria for the normative definitions of the high-good and good-moderate class boundaries will be developed by expert groups as a part of the continuation of the ECOSTAT cluster (REFCOND, COAST, and Intercalibration WGs), building on the present Guidance Documents.*

Section 1 – Implementing the Directive: Setting the scene

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

December 2000: A milestone for water policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the Water Framework Directive.

The Water Framework Directive: New challenges in EU water policy

What is the purpose of the Directive?

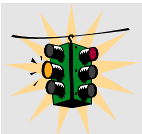
The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out intercalibration of the surface water ecological quality status assessment systems by 2006 (*Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).



Look out!
Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin management including those which are beyond the scope of the Water Framework Directive such as flood protection and flood prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

What is being done to support implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include public consultation , development of national guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding guidance (see *Annex A*). A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision body for the Common Implementation Strategy.

The working group 2.5. Guidance for establishing the intercalibration network and intercalibration exercise

A working group was created for dealing specifically with the issue of the intercalibration process. The main short-term objective of this working group (named shortly: Intercalibration) has been the development of a non-legally binding and practical guidance for the process of intercalibration of the surface water ecological quality assessment systems required by the Water Framework Directive. The members of the working group are environmental officers, technical experts, and researchers from European Union Member States, from a limited number of candidate countries to the European Union and from organisations involved in the standardisation, assessment and reporting of the ecological status of surface waters (European Environment Agency, European Water Topic Centre, and CEN).

To ensure an adequate input and feedback during the guidance development phase and to evaluate earlier versions of the Guidance Document, interaction with other working groups and relevant research projects has been an integral part of the activities (Fig. 2). The Intercalibration working group has organised three workshops, including a joint workshop with REFCOND[1],. Representatives from the working groups COAST[2], IMPRESS[3], MONITORING[4], HMWB[5], and Pilot River Basins[6], participated in the workshops.

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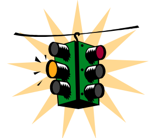
[1] *Working group 2.3 Guidance on classification of inland surface water status and identification of reference conditions*
[2] *Working group 2.4 Guidance on the development of typology and classification systems of transitional and coastal waters*
[3] *Working group 2.1 Guidance on the analysis of pressures and impacts*
[4] *Working group 2.7 Guidance on monitoring*
[5] *Working group 2.2 Guidance on designation of heavily modified bodies of water*
[6] *Working group 4.1 Integrated testing of guidelines in pilot river basins*

Additionally, expert drafting group meetings were held with the aim to draft and define criteria of selection of types and sites for the intercalibration network for rivers, lakes, and coastal & transitional waters.



Look out! You can contact the experts involved in the planning and execution of the Intercalibration process
*The list of Intercalibration Working Group members with full contact details can be found in Annex **B**, if you want to know the status is the intercalibration process in your country.*

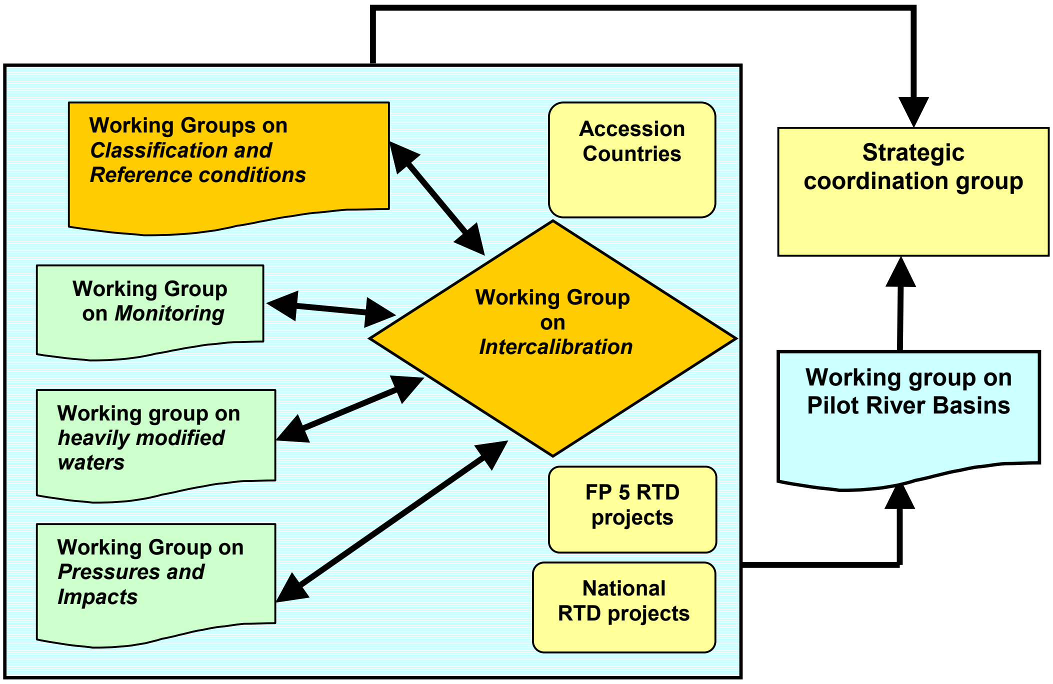


Figure 2 *Links between Common Implementation Strategy Working Groups and other research activities, relevant for the information needs of the Working Group on Intercalibration.*

Developing the Guidance Document: an interactive process

Within a very short time period, a large number of experts have been involved in the different stages of the development of this Guidance Document. The process has included the following activities:

- **Regular communication through internet and emails** of the 30+ members of the Intercalibration Working Group;
- Organisation of **three workshops** to present and discuss the intermediate draft documents and activities:
  - Kick-off meeting with participation of REFCOND, IMPRESS, and HMWB working groups (June 2001, JRC-Ispra, Italy);
  - Jointly with the REFCOND, with participation of COAST working group and WWF representatives (December 2001 – JRC, Ispra, Italy);
  - Workshop for discussing and evaluating the draft Guidance Document, including experts from interested candidate countries (June 2002 – JRC, Ispra, Italy).
- A series of three **expert drafting group meetings** to establish more specific criteria for selection of types and sites for the intercalibration network for rivers, lakes and coastal and transitional waters, and discussion of obstacles and potential solutions of the intercalibration process (March and April 2002 – JRC, Ispra, Italy); you can find the papers produced by the expert drafting groups on CIRCA[7];
- Interactions with relevant **5th Framework Programme RTD-projects**; participation of their experts in workshops and expert drafting group meetings, and presentations of WFD Intercalibration issues in the meetings of research projects (AQUEM[8], STAR[9], FAME[10], CHARM[11]);
- Regular **interactions with experts from other working groups of the Common Implementation Strategy**, including joint drafting of documents, regular email exchange of documents and participation in relevant workshops of the other working groups (mainly with REFCOND & COAST, IMPRESS, HMWB, Monitoring and Integrated testing of guidance in pilot river basins). In spring 2002, an Ecological Status Cluster was formed of the three working groups closely linked to each other (Intercalibration, REFCOND and COAST).

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[7]*http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/intercalibration/drafts/expert_drafting&vm=detailed&sb=Title*

[8] *Development and testing of an integrated assessment system for the ecological quality of streams and rivers throughout Europe using benthic macroinvertebrates*

[9] *Standardisation of river classifications: Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive*

[10] *Development, Evaluation and Implementation of Standardised Fish-based Assessment method for the Ecological status of European rivers – A contribution to the Water Framework Directive*

[11] *Characterisation of the Baltic Sea Ecosystem: Dynamics and Function of Coastal Types*

Section 2 – Common understanding of the text and terms related to intercalibration requirements

In this Section the common understanding and the implications of the relevant parts of the Annex V and Article 21 of the Directive, concerning Intercalibration, and other relevant legal texts[12] are presented and briefly discussed.

Water Framework Directive, Annex V:

1.4. Classification and presentation of ecological status

1.4.1. Comparability of biological monitoring results

WFD Annex V, 1.4.1 only deals with **biological** monitoring results, implying that the intercalibration exercise described below includes only the biological quality elements, not ecological status as a whole.

(i) Member States shall establish monitoring systems for the purpose of estimating the values of the biological quality elements specified for each surface water category or for heavily modified and artificial bodies of surface water.

Monitoring systems should estimate "values" for the category-specific **biological** quality elements (example: aquatic flora, benthos, and fish for rivers). For artificial and heavily modified water bodies biological quality elements to be monitored should be those used in the most applicable category (example: lake quality elements for reservoirs).

In applying the procedure set out below to heavily modified or artificial water bodies, references to ecological status should be construed as references to ecological potential.

"Applying the procedure set out below" implies that **artificial or heavily modified water bodies should be considered in the intercalibration (but not as a separate category)**, using maximum ecological potential as reference (see Section 4.3).

Such systems may utilise particular species or groups of species which are representative of the quality element as a whole.

In order to assess which particular species or groups are "representative" for the quality element as a whole one should take into account the definitions for high, good and moderate status for the different quality elements (WFD Annex V, 1.2.1). (Example: benthic invertebrate fauna indicators in rivers must be able to show changes in composition/abundance, the ratio of disturbance sensitive taxa to insensitive taxa, and diversity).

Monitoring systems should be able to detect anthropogenic impact from different kinds of pressures (Example: a saprobic index that is very sensitive to eutrophication pressures could be insensitive to heavy metal pollution).

[12] *Decision 1999/468/EC, Article 205(2) of the Treaty (see Annex C).*

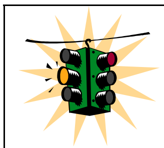
(ii) In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status.

These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.

> The monitoring results for the biological quality elements are expressed as EQRs - ratios derived from observed values and reference values.
>
> Intercalibration of individual parameters is difficult because different Member States may measure different parameters for a given biological quality element. ***The biological quality elements should be the level for intercalibration***.

(iii) Each Member State shall divide the ecological quality ratio scale for their monitoring system for each surface water category into five classes ranging from high to bad ecological status, as defined in Section 1.2, by assigning a numerical value to each of the boundaries between the classes. The value for the boundary between the classes of high and good status, and the value for the boundary between good and moderate status shall be established through the intercalibration exercise described below.

> The results of the intercalibration exercise will determine the numerical (EQR) values for the high-good and the good-moderate boundaries in each Member State's classification system. Values for the other two class boundaries are established by the Member States themselves.

	What will be intercalibrated is ***not*** ecological status, but the outcome (as status classes) of the numerical (EQR) values for the biological quality elements in Member State's assessment systems. The ecological status is determined by the lower of the values (high/good/moderate/poor/bad) of the relevant biological and physico-chemical monitoring results for the relevant quality elements[13].

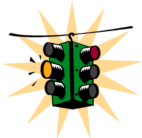
(iv) The Commission shall facilitate this intercalibration exercise in order to ensure that these class boundaries are established consistent with the normative definitions in Section 1.2 and are comparable between Member States.

(v) As part of this exercise the Commission shall facilitate an exchange of information between Members States leading to the identification of a range of sites in each ecoregion in the Community; these sites will form an intercalibration network.

> As a first step in this information exchange it should be decided **what information (including biological and other data) is needed to identify intercalibration sites**.

[13] *WFD Annex V, Article 1.4.2 (i)*

The network shall consist of sites selected from a range of surface water body types present within each ecoregion.

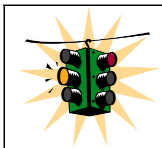


'Sites' for the intercalibration network refer to whole water bodies, because the water body is the unit of ecological status classification (i.e. each water body has only one classification status)[14].

Not all types distinguished by member States (and shared by other Member States) need to be included in the intercalibration network, but a subset of common types will be selected. For intercalibration purposes, common types between Member States sharing same ecoregion(s) need to be agreed.

Criteria and a process for the selection of water body types for the intercalibration network are presented in Section 4.2.

For each surface water body type selected, the network shall consist of at least two sites corresponding to the boundary between the normative definitions of high and good status, and at least two sites corresponding to the boundary between the normative definitions of good and moderate status.



In the opinion of the Intercalibration working group, the sites included in the intercalibration network should be selected by the Member States, representing the interpretations by the respective Member States of the normative class boundary definitions. Harmonised class boundaries should be the outcome of the intercalibration exercise – not the starting point.

More than 2 sites per boundary can be selected for each surface water type included in the intercalibration network (number of sites recommended is presented in Section 4.7).

The normative definitions of the different quality classes are formulated in terms of the biological quality elements; the values of these should not deviate too much from reference conditions (i.e. the least "*slight deviations*" within the good status range, and the least "*moderate deviations*" within the moderate status range).

The information required for the selection of intercalibration sites is presented in Section 4.6.

The sites shall be selected by expert judgement based on joint inspections and all other available information.

Regional expert groups will evaluate the information from the sites proposed by the Member States and make recommendations for the Commission.

The process to carry out the selection of intercalibration sites is presented in Section 4.1 of this guidance.

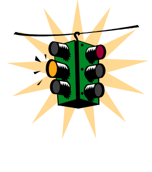
[14] See "WFD CIS Guidance Document No. 2 on the application of the term "water body" in the context of the Water Framework Directive".

(vi) Each Member State monitoring system shall be applied to those sites in the intercalibration network which are both in the ecoregion and of a surface water body type to which the system will be applied pursuant to the requirements of this Directive.

For each Member State monitoring system it must be determined to which ecoregion(s) and water body type(s) the system will be applied.

If the ecoregions presented in Annex XI (as a part the System-A typology) are used as the sole basis for intercalibration there will be limited possibilities for comparison of monitoring and assessment systems of inland waters for many Member States (example: ES-P, IRL-GB), or even no possibility at all (I, GR).

The directive does not prescribe the use of the Annex XI ecoregions. The intercalibration would benefit from using larger ecoregions, as long as the same surface water body types are found within those regions. This would better enable intercalibration between larger numbers of Member States.



"Ecoregions" for intercalibration are not necessarily the ecoregions for System A typology presented in Annex XI, but should be as large as possible to enable intercalibration between a maximum number of Member States. Preliminary proposals for intercalibration ecoregions are presented in Section 4.5 of this Guidance Document.

The results of this application shall be used to set the numerical values for the relevant class boundaries in each Member State monitoring system.

The EQR values of the boundaries will be established through the intercalibration exercise.

Member States define the numerical values for the relevant class boundaries using their monitoring systems. Intercalibration compares the outcome (as status classes) of the numerical values "measured" according to the methodology adopted by Member States.

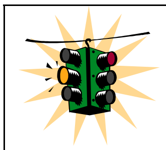
In order to allow comparison of Member States' classification results from the same intercalibration sites, information of data and assessment methods will need to be brought together.

Guidance how to translate the results of the intercalibration exercise into numerical values for the class boundaries will be developed in the next phase of the Common Implementation Strategy when there will be metadata (information about the availability of data) available from the potential intercalibration sites (i.e. during 2003; see Section 5.7.

(vii) Within three years of the date of entry into force of the Directive, the Commission shall prepare a draft register of sites to form the intercalibration network which may be adapted in accordance with the procedures laid down in Article 21. The final register of sites shall be established within four years of the date of entry into force of the Directive and shall be published by the Commission.

The procedures laid down in Article 21[15] concern the regulatory committee, referring to Decision 1999/468/EC[16]. The regulatory committee consists of representatives of the Member States and is chaired by the Commission.

The Commission shall submit to the committee a draft of the measures to be taken (in this case the draft register of intercalibration sites together with a plan how to finalise it). The committee shall deliver its opinion on the draft, by qualified majority (Article 205(2) of the Treaty[17]). The Commission shall adopt the measures if they are in accordance with the opinion of the committee. If this is not the case, the Commission shall submit to the Council a proposal relating to the measures to be taken and inform the European Parliament.



This procedure should allow for the amendment of the draft register of the intercalibration network after it has been proposed by the Commission (December 2003 at the latest) and before the final register is published (December 2004).

(viii) The Commission and Member States shall complete the intercalibration exercise within 18 months of the date on which the finalised register is published.

(ix) The results of the intercalibration exercise and the values established for the Member State monitoring system classifications shall be published by the Commission within six months of the completion of the intercalibration exercise.

[15] *WFD art. 21: Regulatory committee.(1) A committee, hereinafter referred to as "the Committee", shall assist the Commission; (2) Where reference is made to this Article, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof. The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three month; (3) The Committee shall adopt its rules of procedure.*
[16] *See Annex C of this document.*
[17] *See Annex C of this document.*

Section 3 – Synthesis of the intercalibration process: problems and possible solution

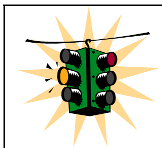
In this Section a synthesis of the intercalibration process is presented, key steps of the critical path and the bottlenecks in the fulfilment of the requirements of the Directive are presented and discussed. The potential implications of a limited intercalibration and the possible short and long-term solutions are also presented.

3.1. Formal requirements and the timetable of intercalibration

The Directive requires that the boundaries between the ecological quality classes high - good and good - moderate will be established through an intercalibration exercise (WFD Annex V, 1.4.1, iii). An intercalibration network, consisting of selected sites, will be established representing Member States' interpretations of the normative definitions of surface water status (defined in WFD Annex V, Section 1.2) in relation to reference conditions.

The purpose of the Intercalibration exercise is to ensure comparable ecological quality assessment systems and harmonised ecological quality criteria for surface waters in the Member States. This ensures a harmonised approach to define one of the main environmental objectives of the WFD, the "***good ecological status***", by establishing:

- Agreed ecological quality criteria for good quality sites, setting the targets for protection and restoration;
- Agreed numerical Ecological Quality Ratio (EQR) values for two quality class boundaries (high/good and good/moderate).



This means that the normative definitions for the high and good surface water quality need to be interpreted equally regardless of differences in ecological quality assessment systems between Member States (i.e. good ecological quality should have the same meaning all over the EU).

Intercalibration is carried out by the Member States. The role of the Commission is to facilitate the information exchange between the Member States.

An intercalibration exercise shall be carried out in 2005 and 2006 between the Member States to ensure the comparability of the biological monitoring results. Prior to this an intercalibration network should be established by the end of 2004 (Figure 3). The draft register of the Intercalibration network, published by the Commission may be adapted in accordance with the procedures laid down in Article 21 of the Directive.

The intercalibration network will be established for a limited number of water body types with two or more sites corresponding to both boundaries between quality classes *High-Good* and *Good-Moderate* according to each Member States' classification. The selection of water body types and intercalibration sites needs to be carried out using expert judgement based on joint inspections and all available information. In the intercalibration exercise, Member State's ecological quality assessment systems are then applied to classify these sites in the ecoregions where their classification systems are applicable. The results are used to set the boundary '*Ecological Quality Ratio*' (EQR) values of the classification systems and published by the Commission.

The Directive requires the following timetable for the intercalibration:

- establishment of draft register of the intercalibration network – December 2003;
- establishment of final register of intercalibration network – December 2004;
- Intercalibration exercise completed – June 2006;
- Results of intercalibration exercise published by Commission – December 2006;

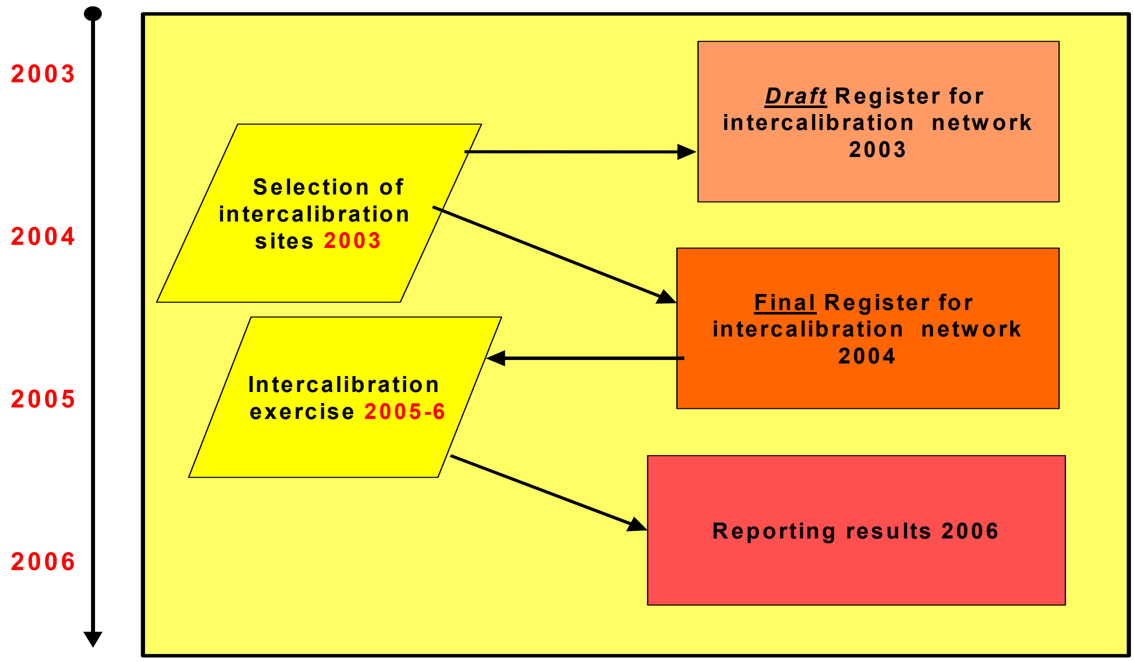


Figure 3 *Task phases and time-table of the formal Intercalibration exercise.*

3.2. Obstacles in the timetable of the intercalibration process

In the fulfillment of the formal requirements of the intercalibration exercise, as described in Annex V of the Directive, certain difficulties are foreseen. The main reason is that the intercalibration timetable does not completely match with the implementation timetable in the Member States. As a consequence, crucial information for the intercalibration will only be available during the progress in implementation (Table 1).

Table 1 Comparison of the Member States' implementation timetable and the intercalibration timetable, as required by Annex V of the Directive.

Year	MS implementation timetable	Intercalibration timetable
2003		Draft register of the Intercalibration network
2004	Analysis of characteristics (typology and reference conditions) and pressures & impacts	Final register of the Intercalibration network
2005		Intercalibration exercise
2006	Monitoring programs operational	Intercalibration exercise completed: harmonized class boundaries

The major obstacles for the intercalibration process due to the differences in timetables are presented below.

3.3. *Problem of typology incompatibility*

It will be difficult to select intercalibration types that are compliant with water body types differentiated by the Member States, because:

- Different Member States may use different typology systems;
- Member States do not need to differentiate surface water body types (needed for the 'analysis of the characteristics' of each River Basin District) before December 2004[18] (cf. Table 1);
- Before that (in 2003) the sites for the draft register of the intercalibration network should already be selected and the draft register submitted to the Article 21 Committee for adoption. In absence of a common typology, this selection can only be made on an *ad hoc* basis and using expert judgement.

Implications:

- Water body types selected for the intercalibration network on an *ad hoc* basis in 2003 may not be compliant with water body types that will be differentiated by the Member States when their typologies are completed in 2004;
- It will be difficult to select and agree upon intercalibration sites representing class boundaries, since type-specific reference conditions are needed for classification of the ecological quality.

Potential solutions on a short term basis:

- Member States should start to carry out implementation of typology and reference conditions as soon as possible;
- Member States should agree on compatible typology systems (still allowing regional refinements) and, if possible, a common basis for reference conditions

[18] *WFD, Art. 5, Annex II, 1.1. (i-vi)*

within (eco)regional intercalibration groups as soon as possible or latest in early 2003;

- If the solutions above are not practically possible, the *ad hoc* selection of common types using expert judgement in 2003 should be designed so that it would allow further division into ecologically relevant subtypes that will be later differentiated by Member States.

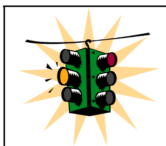
3.4. *Problem of data availability*

The selection of sites for the intercalibration network by the Member States requires that they have adequate and reliable information on all relevant pressures and impacts. Furthermore, reference conditions must be specified for the intercalibration types. At present it is foreseen that this information will only partially be available at the time when the sites have to be selected (in 2003 and 2004), because:

- At present **no** Member States have monitoring systems that are compliant with the requirements of WFD. Data from the on-going monitoring systems are in many cases incomplete or not applicable for the intercalibration;
- There is practically no possibility to collect new data to be available for the site selection in 2003 and 2004. Thus the site selection (i.e. the setting of the ecological quality class boundaries *high-good* and *good-moderate*) can only be based on data presently available;
- The monitoring systems of the Member States do not need be operational before December 2006[19]. By that time the intercalibration exercise should be already completed and the results should be published (Table 1).

Implications:

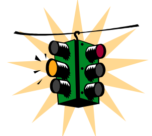
- Site selection can only be based on limited data, not covering all biological quality elements, meaning that the intercalibration network will reflect impacts of pressures on some quality elements only[20];
- Establishment of the class boundaries (*high-good* and *good-moderate*) will be based mostly on expert judgement;
- Limited data availability will limit the number of water body types that can be included in the intercalibration network;
- Once new monitoring data, including other biological quality elements, is available (i.e. after 2006), the intercalibration network may no longer adequately represent the ecological quality class boundaries (i.e. *high-good*, and *good-moderate*) presumed during the site selection in 2003 and 2004.



The WFD foresees a single intercalibration exercise in 2005 and 2006. It is inevitable that this exercise will be based on results from monitoring systems that are still under development, with limited data available and practically no possibility to collect additional data.

[19] *WFD, Art. 8, Annex V, 1.3.*

[20] *For example, the intercalibration of rivers would mainly have to use data on macroinvertebrates, because for the other quality elements there is not sufficient data available at this stage.*



The objectives of the intercalibration exercise – agreement on class boundaries and harmonised classification systems – can be only partially met in the single intercalibration exercise that is required by the WFD.

Potential solutions on a short term basis:

A number of potential solutions on a short term basis exist, including:

- The site selection in 2003 and 2004 should be targeted for water body types where most data is available, recognising that the intercalibration network established will not reflect the impacts of all pressures, and all biological quality elements;
- Member States should voluntarily start WFD compatible monitoring programs as soon as possible, in order to obtain as much as possible of the data required to carry out the intercalibration exercise;
- The intercalibration exercise in 2005 and 2006 could be limited to comparison of classification methods on sites where most data concerning selected pressures would be available.

Table 2 ***Key steps and bottlenecks of the INTERCALIBRATION process.***

Red (marked "WFD-req." indicate WFD requirements, blue (marked "Bottleneck" indicate bottlenecks in the planning.

Key activities	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Register of Intercalibration network													
> Site selection on available data													
> Article 21 Committee evaluates and adopts Register													
> Set preliminary class-boundaries (establish reference conditions) with available data on biological quality elements [links to WG REFCOND & COAST]													
> Choose typology system, water types for each ecoregion [links to WG REFCOND & COAST]													
> Monitoring programmes operational													
> Establish criteria for high and good ecological status [links to WG IMPRESS, REFCOND, COAST)]													
> Select potential high and good status sites [links to WG REFCOND, COAST] depending on type-specific pressures and impacts [link to WG REFCOND]													
> Choose quality elements and method(s) for establishing reference conditions and ecological quality class boundaries [links to WG Monitoring, WG REFCOND]													
> Establish type- or site-specific RC and calculate EQR-values for all relevant quality elements [links to WG REFCOND& Monitoring]													
> Establish ecological quality class boundaries [WG Intercal.]													
Intercalibration Exercise													
> **optional:** refining the status of intercalibration sites (revision of the Register) when new monitoring data becomes available													
> **optional:** adjusting EQR values													
> **Potential** revision of ecological quality classifications of all surface waters due to review and update of analyses mentioned in Article 5.1													

WFD-req. Submit Draft Register of Intercalibration Network

WFD-req. Final establishment of Register

Bottleneck 1-3. Typology, reference conditions and class boundaries not available. Draft register based on expert judgement and (little available data)

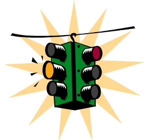
Bottleneck 4. Need to start monitoring potential Reference condition and Intercalibration sites before monitoring programmes are operational

Bottleneck 5. Finishing intercalibration exercise and setting EQR values for good-high, good-moderate borders before monitoring programmes are operational

WFD-req. Intercalibration exercise completed, reporting of results

3.5. *Problems of 'limited' intercalibration*

Member States select intercalibration sites using information on pressures and the impact of these pressures on the biological quality elements (compared with reference conditions). Intercalibration sites represent their judgement of what is a "slight" or a "moderate" impact.



There is no guarantee that different Member States will have the same views on how the normative definitions of the quality class boundaries should be interpreted. Differences in interpretation will be reflected in the draft intercalibration network.

Member States may, or may not, have monitoring data on biological quality elements sensitive to the pressures identified as the most significant for the water bodies proposed for the intercalibration network.

Since EQR values will be established based on biological quality data (using relevant quality elements), sites where there is no biological data collected and available before 2005, cannot be used in the intercalibration exercise (Fig. 4).

The prerequisite to use any site in the intercalibration exercise requires that there will be **biological monitoring data** (of relevant quality elements) available latest in 2005.

An intercalibration network including only sites impacted by the most widespread pressures (such as eutrophication in lakes and coastal waters), as proposed in Section 4.4, would imply that:

- Only those parts of the classification systems targeted to detect impacts of such pressures on the selected quality elements would be intercalibrated (Fig. 4);
- Agreed ecological quality criteria for good quality sites, setting the targets for protection and restoration of water bodies would be set only for most widespread pressures, while impacts of other pressures would not be considered;
- In 2006, there will be no verified and comparable targets for 'good ecological status' as a whole.

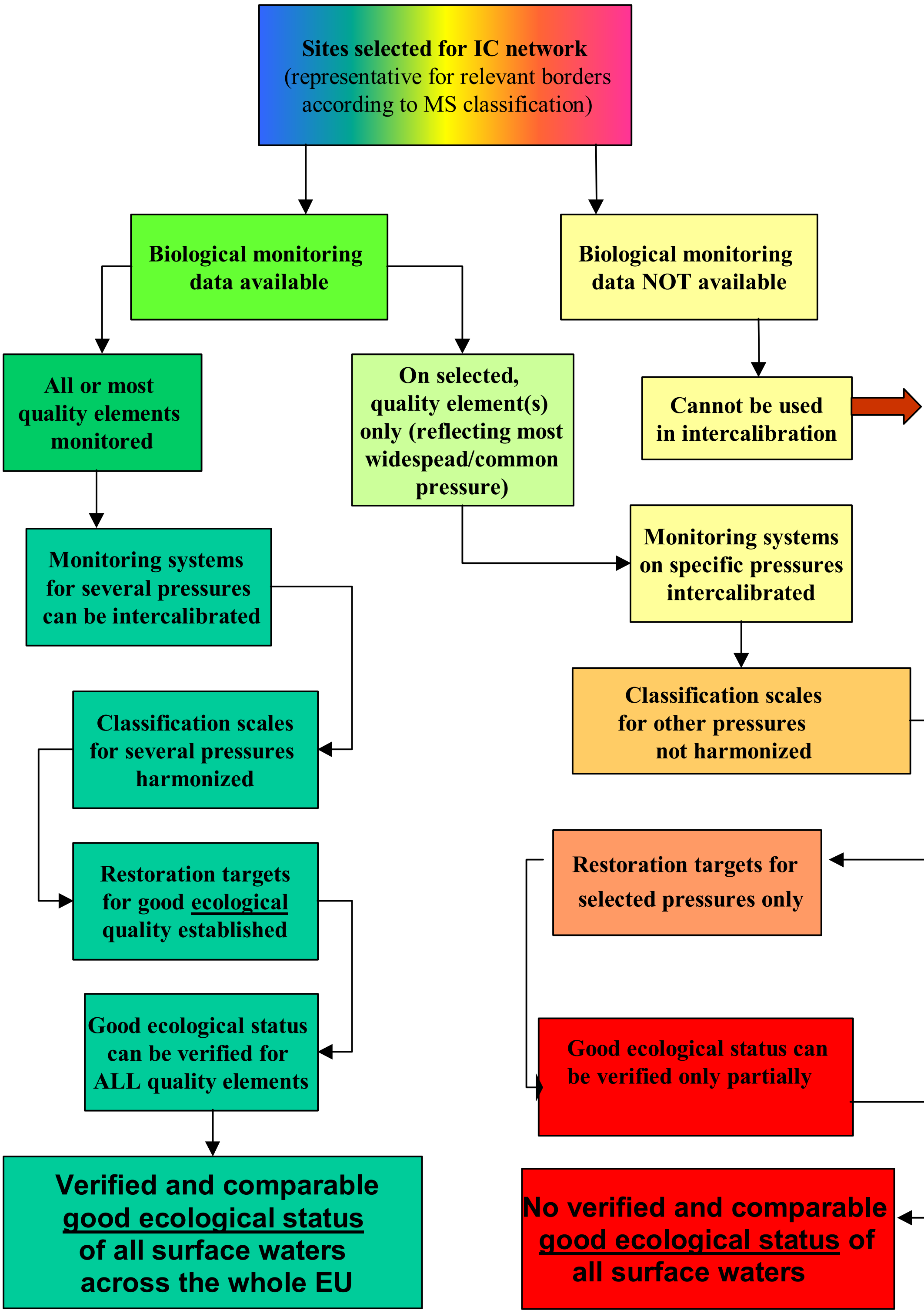
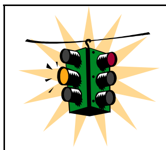


Figure 4 *Flow chart of the benefits of complete intercalibration (not possible in present implementation time schedule) vs. risks of limited intercalibration that will be carried out during 2005 and 2006.*

3.6. Long-term strategy to overcome the problems of intercalibration

It is anticipated that a voluntary commitment of the Member States could improve the outcome of the intercalibration exercise in 2003-2006. However, due to practical problems in establishing WFD compatible monitoring systems in time it is anticipated that the objectives of the intercalibration exercise – agreement on class boundaries and harmonised classification systems – can be only partially met in the single intercalibration exercise that is required by the WFD. In order to establish reliable and comparable ecological quality class boundaries, a review mechanism for the intercalibration network at a time when more data with better quality and compatible with WFD requirements will be available (i.e. after 2006) is strongly recommended. In principle, a revision of the intercalibration network is implicit due to the timetable for revision of the analysis of river basin district characterisation – including typology and reference conditions – provided for in Article 5 of the WFD.



A long-term strategy allowing a mechanism for the revision of the intercalibration network after 2006 is strongly recommended by the Intercalibration working group. The practical implications[21] and the legal possibilities[22] for such revisions should be clarified as soon as possible in the continuation of the Common Implementation Strategy.

The establishment of a long-term strategy and a review mechanism for the intercalibration register in specific guidelines would allow:

- Assessment of the possible changes in the quality of the intercalibration sites;
- Intercalibration and harmonisation of new assessment methods (i.e. development of new indicators, new assessment tools, approval of new standards, etc.);
- Addition of new sites impacted by other significant pressures (which were not represented in the intercalibration network in 2004);
- Addition of further water body types in the intercalibration network as a consequence of verification of the typology systems in Member States when new biological monitoring data is available;
- Intercalibration and harmonisation of the monitoring and classification systems of the new Member States.

[21] *Taking into account the consequences for preparing programmes of measures, river basin management plans and establishing classification systems*
[22] *Taking into account the possibilities given in WFD Art. 19, 20 and 21*

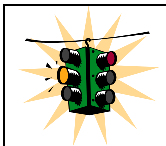
Section 4 – Guidance for the establishment of the intercalibration network

This Section provides practical guidance for the establishment of the intercalibration network:

1) How to carry out site selection process for the intercalibration network in practise;
2) Criteria for selection of types for the intercalibration network;
3) Criteria for selection of sites for the intercalibration network.

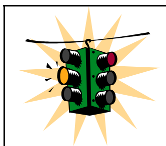
The guidance is based on the common understanding of the Directive's requirements concerning intercalibration (*Section 2*) and the Synthesis of the intercalibration process (*Section 3*). It is to a large extent the result of the work of three temporary expert drafting groups that were established by the Working Group on Intercalibration to address issues specific to the major categories of water bodies – rivers, lakes, and coastal and transitional waters.

The WFD intercalibration will harmonise results of the biological assessment systems implemented by the Member States. All obligatory quality elements and all relevant pressures should be taken into account to completely accomplish this task.



The intercalibration working group concludes that **the intercalibration has to be limited** to water body types and quality elements where sufficient data will be available in time.

The intercalibration working group concludes that the **Member States select intercalibration sites** using information on selected pressures and the impact of these pressures on the biological quality elements (compared with reference conditions).



Thus **the sites of the Intercalibration network represent the respective Member State's interpretations of the normative definitions of Annex V (1.2.)** including their judgement what is a "slight" or a "moderate" impact.

4.1. *Procedure for the establishment of the intercalibration network*

The selection of intercalibration sites for the intercalibration network needs to be carried out in two steps.

1. Firstly, selection of the surface water body types for each of the surface water categories (rivers, lakes, transitional and coastal waters), and possibly the artificial and heavily modified waters in each ecoregion, which will be included in the intercalibration network;
2. Secondly, within these types a minimum number of intercalibration sites have to be selected by the Member States following the requirements described in the Annex V of

the Directive (Fig. 5). The intercalibration network must consist of sites selected from a range of surface water body types present within each ecoregion (WFD Annex V).

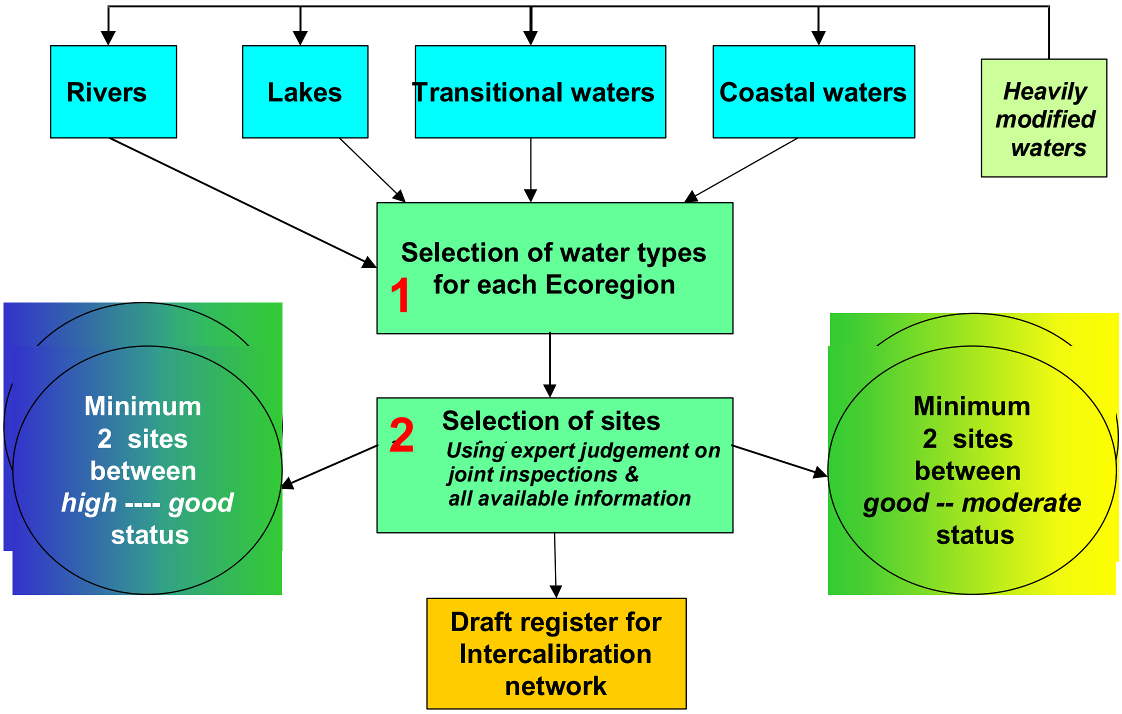
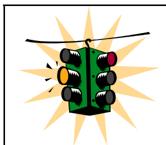


Figure 5 *Selection of intercalibration sites for the intercalibration network.*

	Intercalibration is carried out by the Member States. The role of the Commission is to facilitate the information exchange between the Member States.

The technical work of the Commission is carried out by the ***European Centre of Ecological Water Quality & Intercalibration – EEWAI*** *(hosted by EC-JRC)* which is the organisation responsible for facilitating the intercalibration exercise and organising the work of the expert groups. The Ecological Status Cluster will co-ordinate the work of the expert groups.

4.1.1 *How to carry out the site selection process for the intercalibration network in practice*

The following is a stepwise description of the proposed procedure for the selection of sites for the intercalibration network. Flowcharts of the process are presented in Figure 6a and 6b.

Step 1. Establishment of the Expert groups:

- Expert groups will be established for all main water body categories (rivers, lakes, and transitional and coastal waters);
- The experts are proposed and selected by the Member States. Their work will be co-ordinated through the Ecological Status Cluster;
- Each Member State should be represented in the expert groups relevant for their surface waters;
- Expert groups can be subdivided into (eco)regional groups, or further into geographical intercalibration groups (*Section 4.5.*) when necessary;
- A platform for the communication within/between the expert groups (information exchange, meetings, www-page, etc.) will be organised by the Commission.

Step 2. Proposal of water body types:

- The expert groups will propose the ***water body types*** for each surface water category and (eco)region included in the intercalibration network, taking into account the output of working groups REFCOND and COAST (refer to WFD CIS Guidance Documents No.s 10 and 5, respectively). Preliminary proposals of common intercalibration types for each surface water category have been prepared by the expert drafting groups[23].

Step 3. Proposal of pressures and biological quality elements:

- For each selected intercalibration type, the expert groups need to agree on the pressures and the biological quality elements, where the intercalibration exercise should focus on, taking into account guidance from the IMPRESS and MONITORING working groups (WFD CIS Guidance Document No.s 3 and 7, respectively). Preliminary proposals for the focus and information requirements for the site selection have been prepared by the expert drafting groups[22].

Step 4. Selection of types, pressures, and quality elements for the intercalibration network:

- The proposals of the expert groups will be discussed and finalised by the Intercalibration working group.

Step 5. Selection of sites for the draft intercalibration register:

- Each Member State will select sites for the draft intercalibration register;
- The sites selected should represent high-good and good-moderate class boundaries according to each Member States' interpretation of the

[23]*drafting expert group reports are available on CIRCA: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/intercalibration/drafts/expert_drafting&vm=detailed&sb=Title*

normative definitions, taking into account the Guidance Documents of REFCOND and COAST (WFD Guidance document No.s 10 and 5);

The selection process should follow these steps:

i. Member States identify which types in the Member State's typology system correspond to the intercalibration types relevant for the Member State, and identify the reference conditions for those types;

ii. Bring together all available information necessary for the site selection (pressures, impacts, biological data for the sites that will be considered for the sites selection - ranging from high to moderate status);

iii. If there is not sufficient biological data, site selection should be partially based on pressure criteria, and the Member State should plan to acquire biological data to be available for the intercalibration exercise in 2005-6;

iv. Based on the available information, Member States select sites representing the high-good and good-moderate boundary, according to their interpretation of the normative definitions specified in Annex V (1.2.) of the Directive, motivating their choice.

Step 6. Metadata analysis:

- The Commission will set up a database holding metadata (information about the availability of data) for all intercalibration sites as selected by the Member States;
- Member States will provide metadata on typology, reference conditions and biological and physico-chemical monitoring results (step 5.1-5.3 above). If essential information is lacking at the time of the site selection, they should indicate if, when and in what form the data will become available;
- Additionally, information should be provided on the criteria for classification of the sites (step 5(iv) above). This information is necessary for the evaluation of the choices of the Member States by the expert groups in the next step;
- The metadata analysis will be the basis for the compilation of the draft register for the intercalibration network providing an overview of the information available for each intercalibration site;
- The metadata analysis will be the basis for a realistic planning for the intercalibration exercise and for the preparation of the database for this purpose.

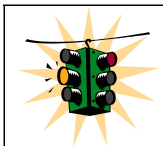
Step 7. Evaluation of the proposed intercalibration sites by expert groups:

- The Commission will compile the results of the metadata analysis and make them available to the expert groups;

- The expert groups evaluate the selection by the Member States and point out possible inconsistencies (including differences in Member State's interpretations of the normative definitions);
- The expert groups review the metadata and propose what data should be collected / made available for the intercalibration exercise – allowing Member States to start collecting data which is still not available.

Step 8. Finalisation of the draft register:

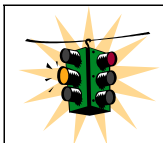
- The evaluation of the different expert groups of the proposed selections of the Member States will be presented, discussed and approved by the Intercalibration working group;
- The draft register of the intercalibration network will be discussed in a joint workshop of Member State representatives (Intercalibration WG) and the Commission, to evaluate consistency with the normative definitions of the class boundaries and comparability between Member States[24]. Where possible, proposals are made how inconsistencies should be resolved;
- The draft register will be the list of sites selected by the Member States, together with the approved summary of the metadata analysis including information of the criteria for the quality classification of those sites.



The sites selected for the draft intercalibration register represent high-good and good-moderate class boundaries according to each Member State's interpretation of the normative definitions in the WFD Annex V (1.2.).

Step 9. Presentation of the draft register to the Article 21 Committee:

- The Commission will finalise the draft register of the Intercalibration network, and submit it to the Article 21 Committee before 22 December, 2003;
- Together with the draft register, the Commission will submit the results of the evaluation made in step 8.



The procedure for revising the draft intercalibration register will depend on the decisions of the Article 21 Committee.

Step 10. Revision of the draft intercalibration register:

- If a revision of the draft intercalibration is decided, ***Member States should reconsider and possibly expand their selection*** (based on the decisions of the Article 21 Committee);

[24] *WFD Annex V, 1.4.1 (iv)*

- If new sites are selected by the Member States they should be included in the metadata analysis;
- For the final register, it is recommended to follow the same procedure should be followed as for the draft intercalibration register (see steps 7-9 above):
  - Evaluation of the proposed intercalibration sites by expert groups;
  - Finalisation of the (proposed) register;
  - Presentation of the (proposed) register to the Article 21 Committee;
  - Approval of the final intercalibration register by the Article 21 Committee.

Table 3 ***Summary and proposed timetable of the site selection for the intercalibration network in 2003 and 2004.***

Month	Actions		Actors
Jan-03	Establishment of expert groups (for rivers, lakes, transitional and coastal waters); subdivision in (eco)regional groups		Member States, Commission
Feb-Mar-03	Selection of surface water body types. Selection of pressures and biological quality elements.		Expert groups, Intercalibration working group.
Apr-Jun-03	Selection of sites for the draft intercalibration register. Delivery of metadata to the Commission.		Member States
Apr-Oct-03	Metadata evaluation, possible checking of sites, preliminary draft register.		Expert groups and Commission .
Oct-03	**Workshop**	Approval of draft register	Intercalibration working group, Expert groups, Commission
Nov-03	Compilation of the draft register		Commission
Dec-03	Draft register submitted to the Art. 21 Committee		Commission
Jan-Jun-04	Submission of new information, if possible & available		Member States
Jan-Sep-04	Revision of the draft register, if possible		Expert groups
Sep-Nov-04	Compilation of the final register		Commission
Nov-Dec-04	Adaptation and publication of the final register		Committee

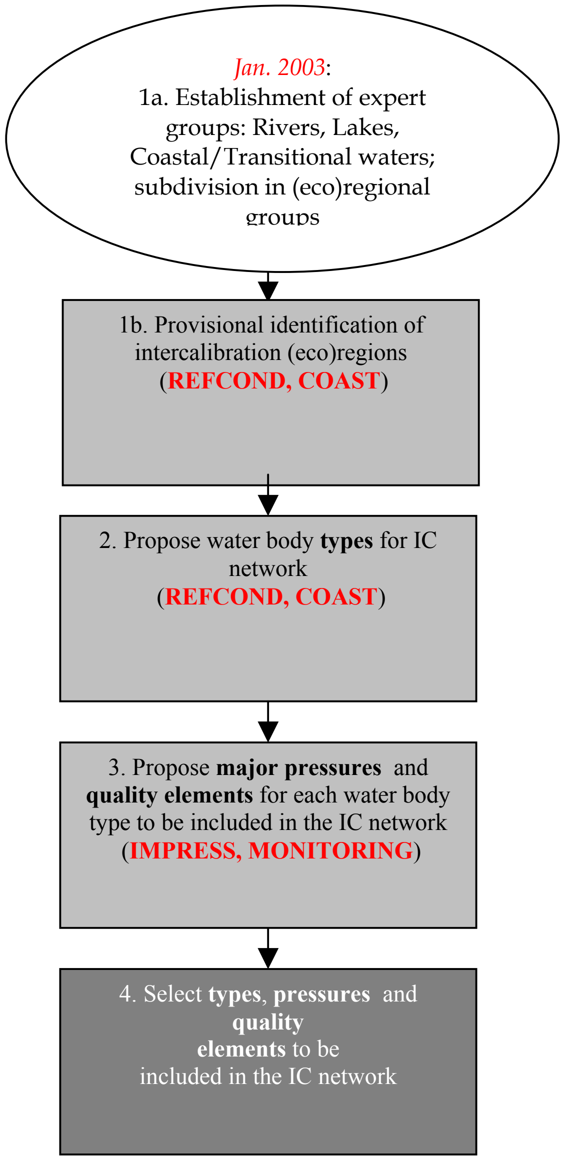


Figure 6a *Flow chart of the proposed process for the selection of types, pressures, and quality elements for the intercalibration network in 2003. Steps where guidance is required from other WFD CIS working groups are indicated. The colours of the boxes indicate the actors that have to carry out the steps: White – Ecological Status Cluster, Light grey – expert groups, Dark grey– Intercalibration working group.*

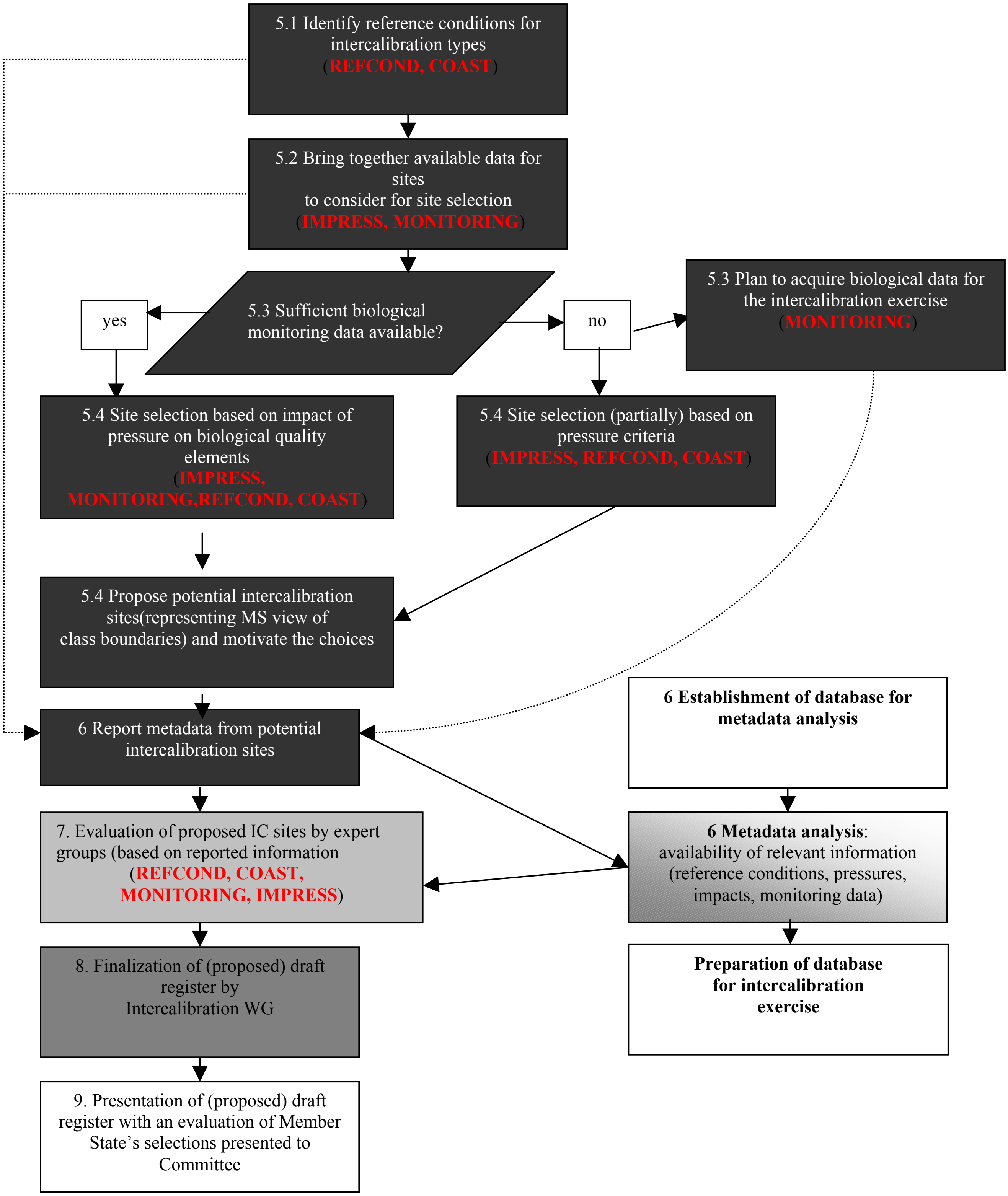
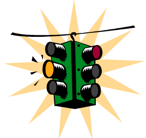


Figure 6b *Flow chart of the proposed process for the selection of sites for the draft intercalibration register. Steps where guidance compiled by other WFD CIS working groups is needed are indicated. The colours of the boxes indicate the actors that have to carry out the steps: Black - Member States, Light grey – expert groups, Dark grey – Intercalibration working group, White – Commission.*

4.2. *Criteria for the selection of water body types for the intercalibration network*

The intercalibration network must consist of sites selected from a range of surface water body types present within each ecoregion[25].



Different Member States will not always use the same typology for the characterisation of water bodies[26]. For intercalibration it is necessary to agree on common types between countries of the same ecoregion.

The following points should be considered in the selection of ***typology system(s) for intercalibration***:

- Guidance for characterisation of the surface water types is prepared by REFCOND and COAST working groups (WFD CIS Guidance Document No.s 10 and 5, respectively). Based on this guidance, Member States may decide to implement a common typology framework throughout Europe or within certain (eco)regions, for certain water body categories. In these cases the intercalibration types should fit in this common typology framework;
- For water body categories and/or (eco)regions where no common typology will be used in the Member States implementation, it will still be necessary to agree on a common typological framework. In the absence of any other common classification system, the selection of types for the intercalibration network could be based on the factors of System A;
- During the process of type selection, the experts should have this information from their Member States in order to be evaluate the potential types to be selected.

The most important requirements for the selected intercalibration types are:

- *Are* ***common*** (found in at least 2 or more Member States, and covering sufficiently large geographical areas (or ecoregions) to enable comparison of different (national) assessment systems, and all ecoregions should be covered);
- *Are* ***sensitive to and impacted by different pressures*** (e.g., organic pollution, physical alterations, acidification, eutrophication; habitat degradation, discharge or exposure to toxic substances);
- allow Member States to identify ***reference conditions*** at the time of the site selection;
- Should have ***potential intercalibration sites*** corresponding to the boundary between high/good and good/moderate available, but accepting that in some ecoregions/types there might be only sites representative for the moderate/ good boundary.

[25] *WFD Annex V, 1.4.1(v)*
[26] *as required in WFD Art. 5*

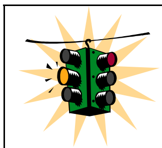
4.3. Artificial and heavily modified water bodies

In the common understanding (*Section 2*) it is concluded that **artificial or heavily modified water bodies should be considered** in the intercalibration, but **not as a separate category.**

Some artificial or heavily modified water bodies could be considered to be included in the intercalibration network, if they fit into one of the **natural water body types** selected for the intercalibration network.

Artificial and heavily modified water bodies that are not comparable with any natural water bodies should only be included in the intercalibration network if they are **dominant within a water category in one or more Member States**. In that case they should be treated as one or several separate water body types.

Final designation of heavily modified water bodies and definition of maximum ecological potential will be established in 2009.



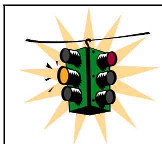
Heavily modified water bodies, which are provisionally identified in 2003 (i.e. water bodies that are at risk of failing 'good' status due to physical modification), can only be included in the intercalibration network, if they fulfil the same selection criteria as natural water bodies. This needs to be evaluated by the expert groups during the selection process (*Section 4.1*.)

4.4. Pressures

The intercalibration exercise has to deal with pressures separately because of the different ecological impact of different pressures, and because different indicators or assessment methods are used to assess different impacts.

For each selected intercalibration type it should be agreed which pressure(s) to focus on. The working group on intercalibration recommends that these should be the pressures that are most widespread in Europe.

The preliminary recommendation[27] is to focus the lake intercalibration on eutrophication and acidification, the river intercalibration on organic pollution and stream modification, as well as acidification and nutrient pollution for some types only, and intercalibration of coastal and transitional waters on eutrophication and habitat degradation (Table 4).



For practical reasons the intercalibration has to focus on specific pressures. However, pressures hardly ever come alone, and it will be difficult to find sites, which are impacted only by one pressure.

Eventually, if a revision of the intercalibration exercise will be possible, the other significant pressures could be included, in order to come to a harmonised classification of **good ecological status**, rather than harmonised indicators for specific pressures.

[27] *based on drafting expert group reports available on CIRCA: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/intercalibration/drafts/expert_drafting&vm=detailed&sb=Title*

Table 4 Preliminary recommendation of the pressures for different surface water categories that should be in focus in the selection of the intercalibration network. Further specification should be considered on the level of selected types for each surface water category.

Surface water category	Pressures
Lakes	Eutrophication, Acidification
River	Organic pollution, stream modification, acidification (selected types only), nutrient pollution (selected types only)
Coastal and transitional waters	Eutrophication, habitat degradation

4.5. Geographical intercalibration groups

The intercalibration network must be confined to "ecoregions"[28]. "Ecoregions" can either be interpreted as those specified in Annex XI of the Directive (the Illies ecoregions for lakes and rivers, and much wider regions for coastal and transitional waters), or can be defined in a wider sense.

It is recommended that for rivers and lakes the geographical intercalibration groups of Member States should be larger than proposed by Illies ecoregional division, consisting of at least two or more countries sharing a similar climate.

Groups of Member States that share the same water body types in different sub-regions or ecoregions should carry out intercalibration using the same intercalibration sites.

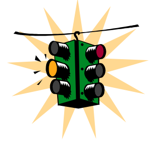
Some Member States will have to join two or more such intercalibration groups, thus acting as links between the different sub-regions or ecoregions, allowing intercalibration to take place across different ecoregions.

Preliminary proposals for intercalibration groups[29] are:

- For **rivers:** three intercalibration groups (Northern, Middle latitude, Mediterranean);
- For **lakes**: five intercalibration groups (Northern, Atlantic, Central, Alpine, Mediterranean);
- For **coastal and transitional waters** it is recommended to use the ecoregions of System A[30] (Baltic, North Sea, Northeast Atlantic, and Mediterranean).

If needed, each of the intercalibration groups may be further divided to smaller geographic regions.

[28] *WFD Annex V, 1.4.1 (vi)*
[29] *based on drafting expert group reports available on CIRCA: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/intercalibration/drafts/expert_drafting&vm=detailed&sb=Title*
[30] *WFD Annex XI, Map B*



In this example the regional intercalibration groups for **rivers and lakes** are slightly different. It is recommended that when finalising the proposals, the expert groups and the Intercalibration working group should resolve this, and agree on the same geographical groups for lakes and rivers.

4.6. *Selection of intercalibration sites*

Member States should carry out the selection process (following steps 5.1.-5.4. in *Figure 6b, Section 4.1.*) and propose intercalibration sites for the draft register.

Selection should be based on the Member States' interpretation of the normative definitions of class boundaries (Annex V, 1.2).

A helpful tool (for the Member States) in the selection process could be ranking of water bodies (within the type selected for intercalibration) across a range of quantified pressure criteria (refer to WFD CIS Guidance Document No. 10) for identifying sites that are provisionally representative for the high-good and the good-moderate class boundaries (Figure 7). This could be done either on national or on (eco)regional level.

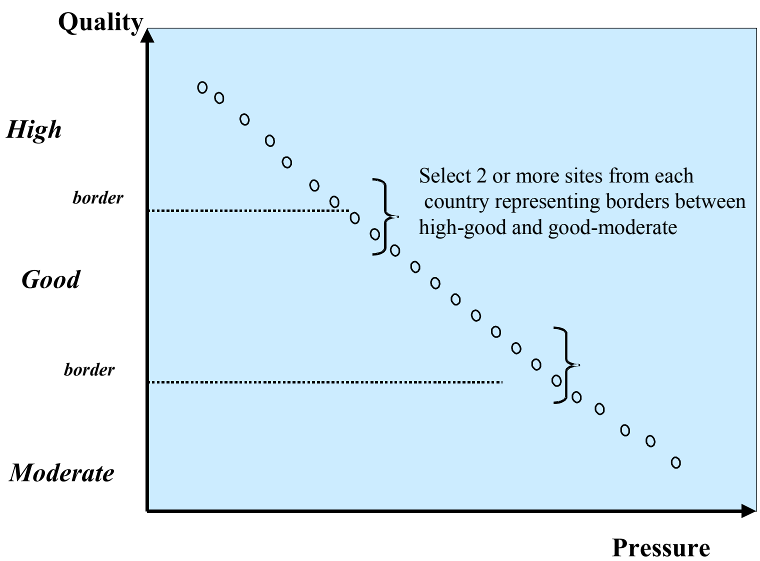


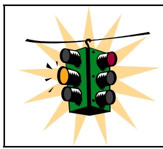
Figure 7 *Illustration of the ranking of the estimated ecological quality of the sites (varying as a function of certain pressure). The Member States evaluate their data, and select 2 or more sites provisionally representative for the borders between high-good and good-moderate from each country for each type selected for the intercalibration network.*

Member States should consider all available data for site selection. Ideally data should originate from national or regional monitoring systems, but national and international research projects should be considered as potential sources of information as well.

Member States should provide metadata and other information from the proposed sites to the Commission. The Commission will facilitate evaluation of the site selections by collecting metadata and making it available to the expert groups for evaluation (see *Section 4.8.*).

The following information of the proposed intercalibration sites should be reported:

- Information of the biological data (metadata);
- Information of the supporting hydromorphological, physico-chemical, and chemical data (metadata);
- If essential information is lacking at the time of the site selection, indication when and in what form the data will become available;
- A description of the pressures and an evaluation of their importance;
- Description of the type according to the national typology of the site;
- Type-specific reference conditions *at least* for the biological quality elements chosen for intercalibration, and the method used to obtain the reference conditions (if available);
- Description on the criteria and methodology for the provisional classification of the sites referring to normative definitions.

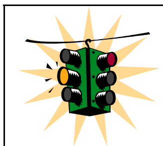
	Because of lack of data and absence of final assessment systems in 2003, the selected sites can in many cases only approximate the relevant class borders.

4.7. Number of intercalibration sites needed

The Directive requires that at least two (2) sites representative for each (provisional) quality status class boundaries (good- moderate, and high-good) for each type should be included in the intercalibration network.

In order to allow flexibility in the process Member States should consider proposing several sites (more than 2+2 for each type) provisionally classified representative for the relevant quality status class boundaries and provide metadata and other information from these sites to the Commission.

It is recommended that the draft intercalibration register should contain at least 5 sites at each of the quality status boundaries for each water body type and for each geographical intercalibration group.

	The total number of sites included in the final draft register will depend on the availability of sites provisionally matching the required status classification within each type and each Member State. Also the number of proposed intercalibration sites may be different in each Member State depending on their surface area and hydrological characteristics.

4.8. Metadatabase for establishment of the intercalibration network

A metadatabase (hosted and maintained by the Commission/EEWAI) will be established to contain all metadata and other relevant information from the sites proposed for the intercalibration network.

The purpose of this database is to provide consistent information of the selected intercalibration sites for the evaluation of the expert groups, and to allow maximum transparency in the selection process.

The metadatabase and analysis of metadata and other information will form the basis for the compilation of the draft register.

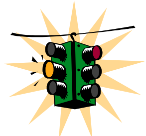
A clear format needs to be agreed how the metadata from the intercalibration sites will be organised and submitted for the metadatabase for the purpose of the expert evaluation and compilation of the draft register.

If possible, the planning for the metadata collection should be initiated in autumn 2002, in order to have an overview of the data in spring (April – June, 2003) (see Table 3).

The metadatabase will be further developed to hold all necessary information for the intercalibration exercise ('intercalibration database', see *Section 5.1.*).

Section 5 - Preliminary technical protocol for the intercalibration exercise

In this Section the preliminary description of the process during the intercalibration exercise in 2005 and 2006 is presented. This Section is not complete and further development will be required in 2003.



At present it is not possible to provide more detailed guidance, since there is not a clear overview what kind of data can be expected from the provisional intercalibration sites.

Such information will be obtained in the metadata analysis carried out during site selection process in 2003.

5.1. *Stepwise description of the intercalibration exercise and the tasks of the participants*

Intercalibration is carried out by the Member States. Co-operation between Member States belonging to the same geographical intercalibration group (*Section 4.6*) is needed. The role of the Commission is to facilitate the information exchange between the Member States.

Step 1. After adaptation and publication of the register for the intercalibration sites in December 2004, the intercalibration exercise will be initiated. All data from the selected intercalibration sites will be made available for Member States through an Intercalibration database[31] hosted by the Commission (EEWAI);

Step 2. Member States will use data from the sites, which are within the ecoregion/geographical area where their national assessment systems are applicable. For practical purposes, Member States belonging to the same geographical intercalibration group (*Section 4.6.*) will share data from the common intercalibration sites;

Step 3. Using this data and possibly carrying out voluntary additional sampling[32], the Member States will assess the Ecological Quality Ratio (EQR) values of the intercalibration sites representing the relationship of observed values with the type-specific reference conditions;

Step 4. If additional sampling is carried out, Member States will use this data for intercalibration and report this data to the Intercalibration database;

Step 5. Member States will report the results of the intercalibration exercise to the Commission;

Step 6. The Commission is assisted by the expert groups (selected following the procedure described in *Section 4.1.*) in the analysis and evaluation of the results;

[31] The intercalibration database can either hold all necessary data, or provide links to databases at the Member States where actual data would be available in structured form to be downloaded for the use of other Member States in the same intercalibration group.
[32] The Member States that need more data for assessment than available in the database for the particular site, may carry out additional sampling. This may not be needed if the available monitoring data would be compatible with WFD.

Step 7. The Commission will publish the results of the intercalibration exercise within six months after the completion of the intercalibration exercise. The report should at least include:

- ✓ An evaluation of the factors affecting comparability of the EQR values established by the Member States' monitoring and classification systems;
- ✓ proposals for the numerical values to set harmonised EQR–scales for the same water body types.

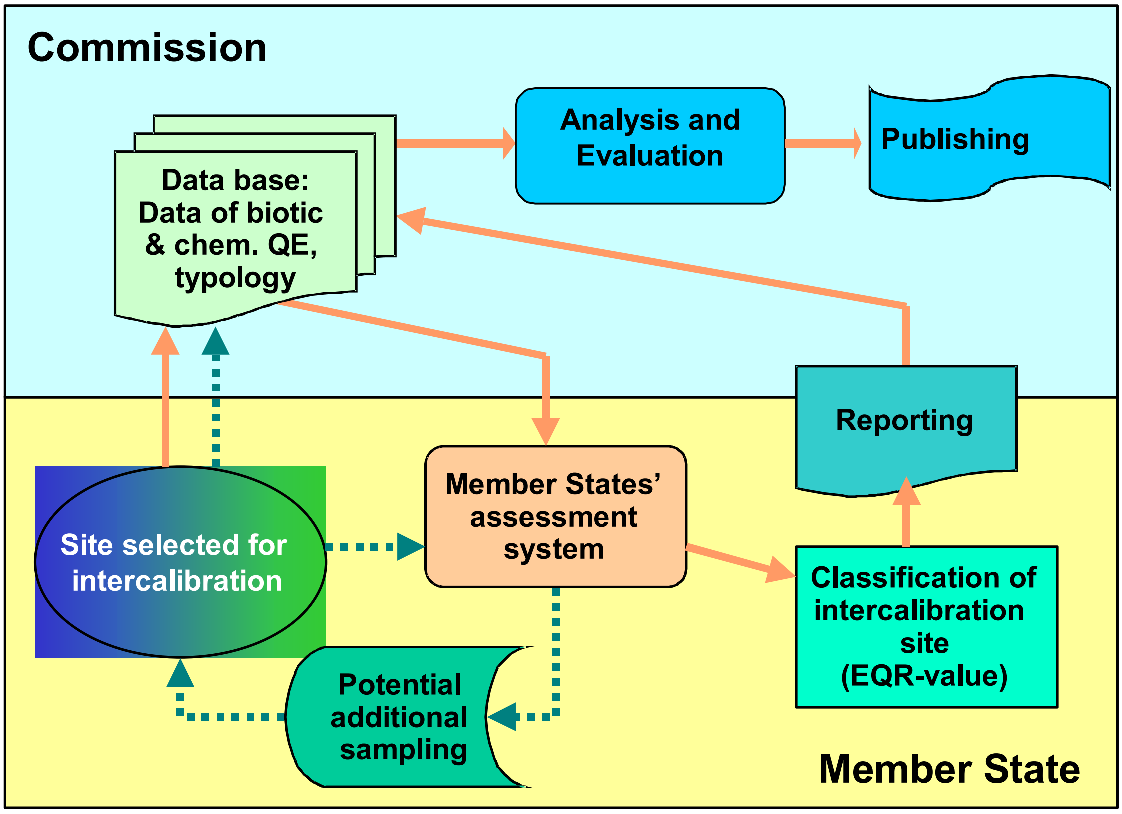


Figure 8 *Process of intercalibration showing the tasks of the Member States and the Commission (stippled green arrow: Flow of data in case, if additional sampling is carried out).*

Table 5 Summary and [tentative] timetable of the intercalibration exercise in 2005 and 2006.

Month	Actions	Actors
Jan-05	Establish intercalibration database	Commission
Jan-05-Jun-06	Reporting data from intercalibration sites to database; assessing EQR of applicable sites	Member States, assisted by Expert Groups
Jun-06	Reporting the results to Commission	Member States
Jul-Oct-06	Analysis and evaluation of the results	Commission , Expert Groups
Oct-Dec-06	Publication of the results	Commission

5.2. Geographical scope/ applicability of different national assessment systems

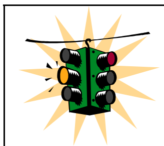
The intercalibration types should be as widespread and common as possible, thus allowing ***true intercalibration between the Member States belonging to the same geographical intercalibration groups*** as presented in *Section 4.5.*

Member States should apply their national assessment systems to all sites in the Intercalibration network within their national borders and all comparable sites within the geographical intercalibration groups where they belong.

5.3. Criteria for selection of biological quality elements.

The Directive (Annex V, 1.4.2) requires that the final ecological status (of a water body) is determined by the lower of the values of the relevant biological and physico-chemical monitoring results. ***Thus the relevant biological quality elements should be the level for intercalibration.*** This requires that it is clear which of the quality elements are the relevant ones for different types of waters.

It is the responsibility of Member States to select the biological quality elements most sensitive to impacts (e.g. depending on their ecological assessment system)



Refer to WFD CIS Guidance Document No.s 7, 5 and 10 for guidance on the selection of relevant biological elements (indicators) with regard to pressures relevant for intercalibration (i.e. elements/indices, which are sensitive for different pressures).

5.4. Guidance for additional sampling in the intercalibration sites.

Sampling and analysis methods for each biological quality element and parameter to be measured should be carried out following the relevant ISO/CEN standards, or if not existing, the best practice/guidelines approved by the expert groups and recommended by the MONITORING working group, and/or international conventions or other international organisations.

Guidance on reporting results of the additional sampling needs to be harmonised with the reporting process of existing data for the Intercalibration database.

5.5. Execution of (voluntary) intercalibration field campaigns

Intercalibration on the level of sampling and analysis methods for different ecological/biological parameters, which have low comparability and where there is little consensus on methods, could be carried out in selected water body types. Such experiments could be done between the countries, which will carry out intercalibration using the same sites. Bearing in mind the tight deadlines to be faced, it is questionable whether it will be possible to carry out this kind of voluntary intercalibration of methods before the 'official' intercalibration in 2005-6.

5.6. Reporting of the final classification results

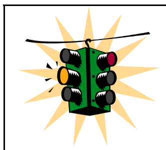
The results of the classification of intercalibration sites based on each Member States' assessment system are reported as Ecological Quality Ratio (EQR) values for each intercalibration site.

Member States should report the results to the Commission.

Commission will be assisted by the expert groups (selected following the procedure described in *Section 4.1.*) in the evaluation of the results.

The results must be reported in detail and as transparently as possible. The following information should be included in reporting:

- Data and parameters of the biological quality elements, which were used in assessment and calculation of the EQR values;
- Details of assessment methods, including statistical methods, confidence limits of the estimates, etc;
- The method used for determination of the reference conditions of each intercalibration site should described in detail (for each biotic quality element), also taking into account statistical uncertainty in reference values[33];
- In case that additional sampling has been carried out, sampling and analytical methods should be reported in detail (see above, *Section 5.4*).

	It is not possible to give guidance how to calculate the EQR ratio in this stage, since this is dependent on Member States monitoring and assessment systems which they are using currently, or planning to adapt after guidance for Monitoring is completed. Further as EQR is calculated as a ratio, it is dependent on the method Member States choose to use for determination of the reference conditions. This guidance is prepared by REFCOND and COAST (WFD CIS Guidance Documents No's 10 and 5 respectively).

5.7. Expected outcome of the intercalibration exercise

Intercalibration sites selected in 2003 and 2004 represent Member States' interpretations of the normative definitions for the high-good and the good-moderate class boundaries - **not** common European "yard sticks" for those boundaries. There is no guarantee that different

[33] *The results of the intercalibration exercise are very much dependent on how the Member States define the reference conditions for each water body type. The reporting should include detailed description of the method (modelling, hindcasting, paleaoecological reconstruction, or site-dependent, etc.).*

Member States will have the same view on how the normative definitions of the quality class boundaries should be interpreted.

> Differences in interpretation of the normative definitions of the ecological quality class boundaries between Member States will be reflected in the intercalibration network, and therefore in the results of the intercalibration exercise.

If there is no agreement about which sites in the intercalibration network represent the boundaries, monitoring results (EQR values) can only be compared between Member States.

However, the WFD requires that the (EQR) values in the different Member State's classification systems representing the high-good and the good-moderate class boundaries shall be set through the intercalibration exercise.

> The intercalibration exercise will be able to set EQR values for Member States classification systems representing class boundaries, if an agreement can be reached which of the intercalibration sites represent those borders.

Annex A: Key activities and the Working Groups of the Common Implementation Strategy

Key activity 1: Information sharing

1.1 Tools for information sharing
1.2 Raising awareness

Key activity 2: Develop guidance on technical issues

2.1 Guidance on the analysis of pressures and impacts
2.2 Guidance on designation of heavily modified bodies of water
2.3 Guidance on classification of inland surface water status and identification of reference conditions
2.4 Guidance on the development of typology and classification systems of transitional and coastal waters
2.5 Guidance for establishing the inter-calibration network and inter-calibration exercise
2.6 Guidance on economic analysis
2.7 Guidance on monitoring
2.8 Guidance on tools on assessment and classification of groundwater
2.9 Guidance on best practices in river basin planning

Key activity 3: Information and data management

3.1 Development of a shared Geographical Information System

Key activity 4: Application, testing and validation

4.1 Integrated testing of guidelines in pilot river basins

Annex B: Members of the Working Group 2.5

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Annex C: Legal texts related to committee procedure

Relevant articles of Decision 1999/468/EC:

***Article** 5,*
Regulatory procedure:
1. The Commission shall be assisted by a regulatory committee composed of the representatives of the Member States and chaired by the representative of the Commission.
2. The representative of the Commission shall submit to the committee a draft of the measures to be taken. The committee shall deliver its opinion on the draft within a time-limit which the chairman may lay down according to the urgency of the matter. The opinion shall be delivered by the majority laid down in Article 205(2) of the Treaty in the case of decisions which the Council is required to adopt on a proposal from the Commission. The votes of the representatives of the Member States within the Committee shall be weighted in the manner set out in that Article. The chairman shall not vote.
3. The Commission shall, without prejudice to Article 8, adopt the measures envisaged if they are in accordance with the opinion of the committee.
4. If the measures envisaged are not in accordance with the opinion of the committee, or if no opinion is delivered, the Commission shall, without delay, submit to the Council a proposal relating to the measures to be taken and shall inform the European Parliament.
5. If the European Parliament considers that a proposal submitted by the Commission pursuant to a basic instrument adopted in accordance with the procedure laid down in Article 251 of the Treaty exceeds the implementing powers provided for in that basic instrument, it shall inform the Council of its position.
6. The Council may, where appropriate in view of any such position, act by qualified majority on the proposal, within a period to be laid down in each basic instrument but which shall in no case exceed three months from the date of referral to the Council.
If within that period the Council has indicated by qualified majority that it opposes the proposal, the Commission shall re-examine it. It may submit an amended proposal to the Council, re-submit its proposal or present a legislative proposal on the basis of the Treaty.
If on the expiry of that period the Council has neither adopted the proposed implementing act nor indicated its opposition to the proposal for implementing measures, the proposed implementing act shall be adopted by the Commission.

Article 7
1. Each committee shall adopt its own rules of procedure on the proposal of its chairman, on the basis of standard rules of procedure, which shall be published in the Official Journal of the European Communities.
Insofar as necessary existing committees shall adapt their rules of procedure to the standard rules of procedure.
2. The principles and conditions on public access to documents applicable to the Commission shall apply to the committees.
3. The European Parliament shall be informed by the Commission of committee proceedings on a regular basis. To that end, it shall receive agendas for committee meetings, draft measures submitted to the committees for the implementation of instruments adopted by the procedure provided for by Article 251 of the Treaty, and the results of voting and summary records of the meetings and lists of the authorities and organisations to which the persons designated by the Member States to represent them belong. The European Parliament shall also be kept informed whenever the Commission transmits to the Council measures or proposals for measures to be taken.
4. The Commission shall, within six months of the date on which this Decision takes effect, publish in the Official Journal of the European Communities, a list of all committees which assist the Commission in the exercise of implementing powers. This list shall specify, in relation to each committee, the basic instrument(s) under which the committee is established. From 2000 onwards, the Commission shall also publish an annual report on the working of committees.
5. The references of all documents sent to the European Parliament pursuant to paragraph 3 shall be made public in a register to be set up by the Commission in 2001.

Article 8
If the European Parliament indicates, in a Resolution setting out the grounds on which it is based, that draft implementing measures, the adoption of which is contemplated and which have been submitted to a committee

pursuant to a basic instrument adopted under Article 251 of the Treaty, would exceed the implementing powers provided for in the basic instrument, the Commission shall re-examine the draft measures. Taking the Resolution into account and within the time-limits of the procedure under way, the Commission may submit new draft measures to the committee, continue with the procedure or submit a proposal to the European Parliament and the Council on the basis of the Treaty. The Commission shall inform the European Parliament and the committee of the action which it intends to take on the Resolution of the European Parliament and of its reasons for doing so.

Article 205 (2) of Treaty establishing the European Community:
Where the Council is required to act by a qualified majority, the votes of its members shall be weighted as follows:
Belgium 5, Denmark 3, Germany 10, Greece 5, Spain 8, France 10, Ireland 3, Italy 10, Luxembourg 2, Netherlands 5, Austria 4, Portugal 5, Finland 3, Sweden 4, United Kingdom 10.
For their adoption, acts of the Council shall require at least:
- 62 votes in favour where this Treaty requires them to be adopted on a proposal from the Commission,
- 62 votes in favour, cast by at least 10 members, in other cases.

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Guidance document n.° 7

Monitoring under the Water Framework Directive

COMMON IMPLEMENTATION STRATEGY

FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 7

Monitoring under the Water Framework Directive

Produced by Working Group 2.7 - Monitoring

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. The focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, project 2.7 "Development of Guidance on monitoring" was launched in December 2000. An informal working group (working group 2.7) was established to facilitate the production of this Guidance. Project 2.7 was initiated to provide Member States with Guidance on monitoring of inland surface water, transitional waters, coastal waters and groundwater, based on the criteria provided in Annex V of the Water Framework Directive. Italy and the European Environment Agency have the joint responsibility, as co-leaders of Working Group 2.7, for the co-ordination of the working group that is composed of scientists and technical experts from governmental and non-governmental organisations.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the Working Group 2.7 activities and discussions that have taken place since December 2000. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the procedure of Guidance development through meetings, workshops, conferences and electronic media, without binding them in any way to this content.

"We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders, Italy and the European Environment Agency, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation."

Table of Contents

1 Introduction

A Guidance Document: What For?

1.1 Purpose of this Guidance Document

The 26 articles of the Directive 2000/60/EC – establishing a framework for Community action in the field of water policy (The Water Framework Directive) describe what shall be done to implement the Directive and the annexes have been developed to assist Member States in ensuring that the articles are implemented in accordance with the requirements of the Directive. However, the complex nature of the Directive means that the annexes may not provide sufficient Guidance to provide Member States with the assistance they require.

The purpose of this document, along with the other Guidance Documents published by the Commission, is to provide experts and stakeholders with Guidance in the implementation of the Directive. The focus of the document is on providing Guidance on establishing programmes of measures with specific emphasis on the appropriate selection of quality elements and design of monitoring programmes in accordance with Articles 8 and 11 and Annex V.

1.2 To whom is this Guidance Document addressed?

If this is your task, we believe the Guidance will help you in doing the job, whether you are:

- Undertaking the monitoring programmes yourself;
- Leading and managing experts undertaking the monitoring;
- Using the results of the monitoring for taking part in the policy making process; or,
- Reporting on the results of monitoring to the European Union as required by the Directive.

1.3 What you can find in this Guidance document?

1.3.1 Common understanding of concepts and terms

Chapter 2 provides clarification of key concepts and terms of the Directive. This has been developed through an extensive process of review and represents, as far as possible, a common understanding between Member States who have been involved in Working Group 2.7. Clarification is provided on the following terms and concepts:

- The term 'supporting';
- The term 'water body';
- The concepts of risk, precision and confidence;
- Monitoring of wetlands;
- Surveillance, operational and investigative monitoring of surface waters;
- Surveillance, operational and quantitative status monitoring of groundwater;
- Surface water monitoring for protected areas; and,
- Other monitoring considerations such as intercalibration exercises and monitoring of heavily modified water bodies.

1.3.2 Guidance on the selection of Quality Elements

Chapter 3 provides a number of tables summarising the key features of each quality element for surface waters and how each of the quality elements are monitored in Member States. In addition Guidance is provided on the appropriate selection of mandatory and recommended quality elements and parameters that are most representative of catchment pressures for each surface water body type.

Guidance on the selection of groundwater parameters is provided in Chapter 4.

1.3.3 Best Practices and Tool Box

Chapter 5 provides Guidance on the design and implementation of monitoring programmes. Guidance is given on the appropriate selection of water bodies and monitoring sites within water bodies and sampling frequencies required for implementation of surveillance, operational, investigative and quantitative status monitoring programmes and for the monitoring of protected areas.

The chapter provides an overview of the process of establishing a monitoring programme based on the identified objectives and required outcomes of the Directive, with particular emphasis on achieving acceptable levels of risk, precision and confidence.

1.3.4 Best practice examples of current national monitoring

Chapter 6 provides an overview of national monitoring contributions received from Member States. A list of monitoring fact sheets, including the title of the programme, Member State who proposes the method and website link is provided in Annex IV.

1.4 Guidance on monitoring – a framework approach

This Guidance document proposes an overall methodological approach to monitoring for the implementation of the WFD. Because of the diversity of catchment pressures, water-body types, biological communities and hydromorphological and physico-chemical characteristics within the Europena Union the appropriate implementation of programmes of measures in accordance with the requirements of the Directive will vary between Member States and river basins. This proposed methodology will need to be tailored to specific circumstances.

It is not the intention of this Guidance to define prescriptive methods for the assessment and classification of ecological status. This is due to the following factors:

- There are a number of existing classification systems already in use throughout the EU that are potentially suitable for adaptation to meet the requirements of the WFD, some of which have been incorporated into National Standards;
- Individual Member States generally understand local natural variations in biological communities, hydromorphological conditions and physico-chemical variables;
- The level of habitat detail required varies for different indicators depending on their sensitivity to natural variation in habitat conditions; and
- There are existing international, European and national standards for a number of the required quality elements.

This Guidance, therefore, provides a framework within which Member States can either use/modify their existing methods, or where no appropriate monitoring and assessment systems exists, develop new systems that will incorporate all the requirements of the WFD.

Look Out! The methodology from this Guidance Document must be adapted to regional and national circumstances

The Guidance Document proposes an overall methodological approach. Because of the diversity of circumstances within the European Union, the way to apply a logical approach and answer questions will vary from one river basin to the next. This proposed methodology will therefore need to be tailored to specific circumstances.

While monitoring for surface and groundwater status will require the development/adaptation of specific assessment systems, it is critical that Member States ensure that the following key criteria are incorporated into the programmes of measures:

- An assessment on the deviation of observed conditions to those that would normally be found under reference conditions;
- Provides for natural and artificial physical habitat variation;
- Accounts for the range of natural variability and variability arising from anthropogenic activities of all quality elements in all water-body types;
- Accounts for interactions between surface and groundwaters; and,
- Provides for detection of the full range of potential impacts to enable a robust classification of ecological status.

Incorporation of the above key criteria into the assessment systems of each Member State will ensure that ecological quality is reported to the Commission using a unit-less classification scale based on ratios or fractions of reference values. This will enable Member States to continue using existing national assessment systems (where they exist), whilst reporting ecological status to the Commission on a common European scale.

Look Out! What you will not find in this Guidance Document

The Guidance Document focuses on the monitoring requirements of the Directive. The Guidance does not focus on:

- *Determination of reference conditions;*
- *Development of assessment and classification Systems;*
- *Monitoring wetlands; or,*
- *Data analysis and reporting.*

Implementing the Directive: Setting the Scene

1.5 December 2000: A Milestone for Water Policy

1.5.1 A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that today form the foundation of the Water Framework Directive.

1.6 The water Framework Directive: new challenges in EU water policy

1.6.1 What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

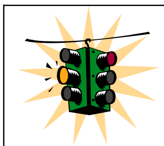
- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

1.6.2 …and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

1.7 What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (Article 3, Article 24);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (Article 5, Article 6, Annex II, Annex III);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (Article 2 (22), Annex V);
- To make the monitoring networks operational by 2006 (Article 8);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (Article 11, Annex III);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- To make the programme of measures operational by 2012 (Article 11); and,
- To implement the programmes of measures and achieve the environmental objectives by 2015 (Article 4).



Look Out!

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

1.8 Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007; and,
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of integration that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives,** combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general 'good' status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology, engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Freshwater Fish Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and civil society in decision making,** by promoting transparency and making information accessible to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;

- **Integration of different decision-making levels that influence water resources and water status** (these could be at a local, regional or national level), for an effective management of all waters;
- **Integration of water management by different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

1.9 What is being done to support implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

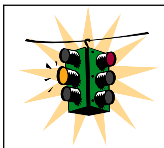
May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and Guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, and involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance. A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision body for the Common Implementation Strategy.

A working group has been created for dealing specifically with monitoring issues. The main short-term objective of this working group was the development of a non-legally binding and practical Guidance for supporting the implementation of the monitoring requirements of the Water Framework Directive. The members of this working group on monitoring are scientists, technical experts and stakeholders from European Union Member States, from a limited number of candidate countries to the European Union and from focal point organisations involved in water and environmental policy in candidate countries.

The working group on monitoring has organised several discussions and feedback events such as meetings and workshops, to ensure an adequate input and feedback from a wider audience during the Guidance development phase, and to evaluate earlier versions of the Guidance Document,. You will find the synthesis of key discussions and events in Annex VII.



Look Out! You can contact the experts involved in the working group on monitoring

The list of working group 2.7 (monitoring) members with full contact details can be found in Annex V. If you need input into your own activities, contact a member from the working group in your country. If you want more information on specific scoping and testing pilot studies, you can also contact directly the persons in charge of carrying out these studies.

Developing the Guidance Document: an interactive process

Within a very short time period, a large number of experts and stakeholders have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- Regular meetings of the 40-plus experts and stakeholder members of working group 2.7;
- Organisation of four workshops to present and discuss the activities and preliminary output of Working group 2.7:
  - Working Group Meeting No. 1 June 2001 - Rome, Italy. Discussion of proposed work schedule and member state contributions;
  - Working group co-ordination team meeting November 2001 – Brussels, Belgium. Meeting held with small group of experts from lead countries to discuss progress on the work plan and agree on the next phases;
  - Working Group Meeting No. 2 January 2002 - Rome, Italy. Presentation and discussion of the first draft. Identification of areas for comment and Member State contributions;
  - Working Group Meeting No. 3 June 2002 - Brussels, Belgium. Revised draft presented and discussed;
  - Working Group Meeting No. 4 September 2002 – Copenhagen, Denmark. Presentation of final draft for comment and discussion.
- Regular interactions with experts from other working groups of the Common Implementation Strategy, mainly those dealing with the assessment of pressures and impacts, intercalibration, reference conditions, groundwater, coastal waters and river basin planning. Three events for discussing and evaluating the Guidance Document; and,
- A final evaluation of the draft Guidance (content and format) was undertaken following the Copenhagen working group meeting. Criteria for evaluating the Guidance were completeness, rigour, practicality, ease of use, ease of understanding and usefulness, and integration with other disciplines and elements of the Directive.

2 Common Understanding of the Monitoring Requirements of the Water Framework Directive

2.1 Monitoring requirements for the Directive

Article 8 of the Directive establishes the requirements for the monitoring of surface water status, groundwater status and protected areas. Monitoring programmes are required to establish a coherent and comprehensive overview of water status within each river basin district. The programmes have to be operational at the latest by 22 December 2006, and must be in accordance with the requirements of Annex V.

Annex V indicates that monitoring information from **surface waters** is required for:

- The classification of status. (*Note: Member States must provide a map for each river basin district in their territory illustrating the classification of the ecological and chemical status of each body of water using the colour-coding system specified by the Directive.)*
- Supplementing and validating the Annex II risk assessment procedure;
- The efficient and effective design of future monitoring programmes;
- The assessment of long-term changes in natural conditions;
- The assessment of long-term changes resulting from widespread anthropogenic activity;
- Estimating pollutants loads transferred across international boundaries or discharging into seas;
- Assessing changes in status of those bodies identified as being at risk in response to the application of measures for improvement or prevention of deterioration;
- Ascertaining causes of water bodies failing to achieve environmental objectives where the reason for failure has not been identified;
- Ascertaining the magnitude and impacts of accidental pollution;
- Use in the intercalibration exercise *(Note this is not an Article 8 requirement)*;
- Assessing compliance with the standards and objectives of Protected Areas; and,
- Quantifying reference conditions (where they exist) for surface water bodies. (*Note that this is an Annex II requirement).*

Annex V also indicates that monitoring information from **groundwater** is required for:

- Providing a reliable assessment of quantitative status of all groundwater bodies or groups of bodies; *(Note: Member States must provide maps illustrating the quantitative status of all groundwater bodies or groups of bodies using the colour-coding scheme set out in the Directive);*
- Estimating the direction and rate of flow in groundwater bodies that cross Member States boundaries;
- Supplementing and validating the impact assessment procedure;
- Use in the assessment of long term trends both as a result of changes in natural conditions and through anthropogenic activity;
- Establishing the chemical status of all groundwater bodies or groups of bodies determined to be at risk. *(Note: Member States must provide maps illustrating the*

chemical status of all groundwater bodies or groups of bodies using the colour-coding scheme set out in the Directive.);

- Establishing the presence of significant and sustained upwards trends in the concentrations of pollutants. *(Note: Member States must indicate on the maps of chemical status using a black-dot, those groundwater bodies in which there is a significant upward trend);* and,
- Assessing the reversal of such trends in the concentration of pollutants in groundwater *(Note: Member States must indicate on the maps of chemical status using a blue-dot, those groundwater bodies in which a significant upward trend has been reversed).*

2.1.1 Reporting

The following must be reported in the River Basin Management Plans:

- Maps of the monitoring networks;
- Maps of water status;
- An indication on the maps of the bodies of groundwater which are subject to a significant upward trend in concentration of pollutants and an indication of the bodies of groundwater in which such trends have been reversed; and,
- Estimates of the confidence and precision attained by the monitoring systems.

Three types of monitoring[1] for surface waters are described in Annex V: surveillance, operational and investigative monitoring. For groundwater a water level monitoring network is required which will provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies including an assessment of the available groundwater resource. It should be noted that the water level network alone will not be able to achieve this assessment. In terms of groundwater chemical status, surveillance and operational monitoring are required. An additional objective of groundwater surveillance and operational monitoring is to provide information that can be used in the assessment and in establishing the presence of long term trends in pollutant concentrations. Surveillance monitoring data should also be used to assess long term trends in natural conditions.

These types are to be supplemented by monitoring programmes required for Protected Areas registered under Article 6. Annex V only describes requirements for Drinking Water Protected Areas in surface water and for Protected Areas for habitats and species. Member States may wish to integrate monitoring programmes established for other Protected Areas within the programmes established under the Directive. This is likely to improve the cost-effectiveness of the various programmes.

2.2 What Water bodies should be monitored

The Water Framework Directive covers **all** waters[2] including inland waters (surface water and groundwater) and transitional and coastal waters up to one sea mile (and for the chemical status also territorial waters which may extend to 12 sea miles) from the territorial baseline of a Member State independent of the size and the characteristics[3].

This totality of waters is, for the purpose of the implementation of the directive, attributed to geographical or administrative units, in particular the **river basin**, the **river basin district**,

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[1] *In the context of the Directive monitoring means the gathering of data and information on the status of water, and does not include the direct measurement of emissions and discharges to water. The latter is being dealt with by WG 2.1, IMPRESS*

[2] *Taken from horizontal Guidance on the application of the term "water body", version 7.0*

[3] *Articles 2 (1), (2) and (3)*

and the "**water body**"[4]. In addition, groundwaters and stretches of coastal waters must be associated with a river basin (district).

Whereas the river basin is the geographical area related to the hydrological system, the river basin district must be designated by the Member States in accordance to the directive as the "**main unit for management of river basins**"[5].

One key purpose of the Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems. The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of "water bodies". "Water bodies" are therefore the units that will be used for reporting and assessing compliance with the Directive's principal environmental objectives. However, it should be emphasised that the identification of a "water body" is a tool not an objective in itself.

Monitoring is a cross-cutting activity within the Directive and as such there are important interrelationships with other Articles and Annexes of the Directive. A key Article in relation to monitoring and the design of appropriate programmes for surface waters and groundwater is Article 5. Figures 2.1 and 2.2 summarise the relationship between articles 5 and 8 for surface waters and groundwater, respectively. Article 5 requires river basin districts to be characterised and the environmental impact of human activities to be reviewed in accordance with Annex II. The first assessments must be completed by 22 December 2004. Risk assessments will be on-going as they will be required for subsequent River Basin Management Plans. The first assessments must be completed 2 years before monitoring programmes have to be operational.

Annex II describes a process by which surface water bodies are identified, categorised and then typified according to one of two systems A or B given in section 1.2 of the Annex. Type-specific reference conditions have to be identified for each surface water body type. It is the type specific reference conditions from each surface water body type that the monitoring results will be compared with to give an assessment of the status of a water body categorised in the water body type. Information on the type and magnitude of the significant anthropogenic pressures to which the surface water bodies in each river basin district are subject has to be collected and maintained. There must then be an assessment of the susceptibility of the surface water status of bodies to the pressures identified, and of the likelihood that surface water bodies within the river basin district will fail to meet the environmental quality objectives set under Article 4. This assessment will use any available existing monitoring data: the extent of existing data will vary greatly from country to country. Also expert judgement and /or modelling approach (i.e. risk assessment) can be used. For the first assessment there will not be data arising from the Article 8 monitoring programmes as they do not have to be operational until the end of 2006: data should be available for subsequent assessments for future RBMPs. However, many countries already have extensive monitoring programmes.

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[4] *Articles 2 (13), (15), (10), and (12) respectively*
[5] *Article 2 (15)*

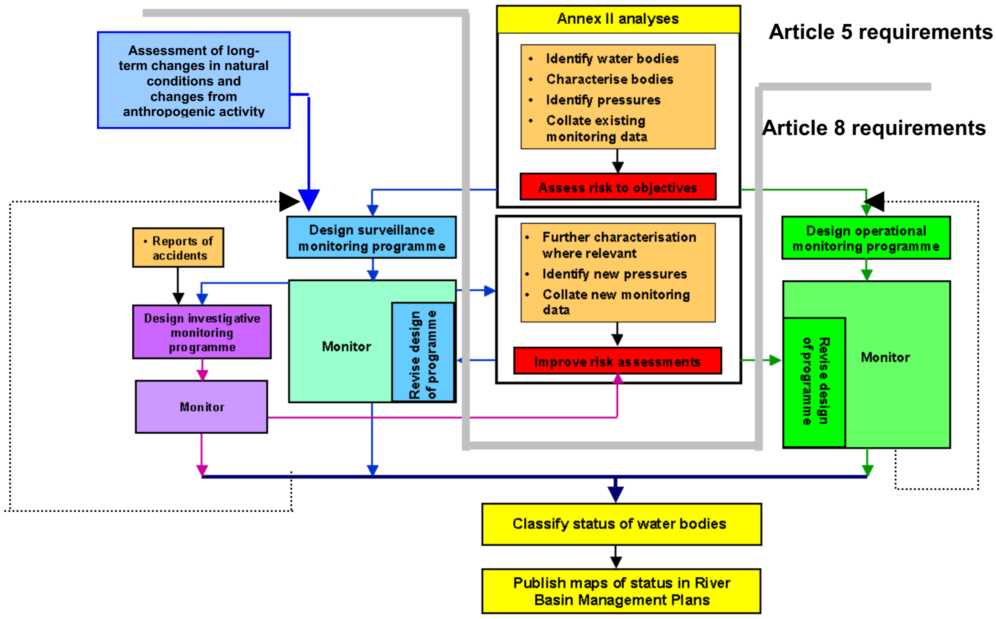


Figure 2.1 **Schematic diagram illustrating the relationship between Article 5 and Article 8 in the design of surface water monitoring programmes**

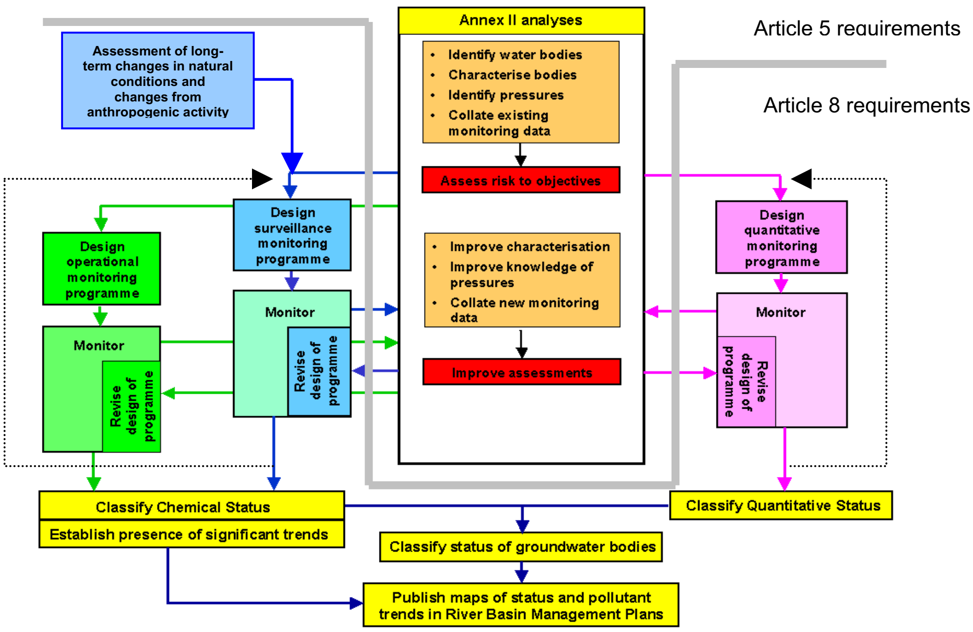
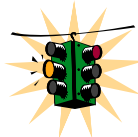


Figure 2.2 **Schematic diagram illustrating the relationship between Article 5 and Article 8 in the design of groundwater monitoring programmes**

Thus the Annex II risk assessments play a key role in the initial design and subsequent revision of the monitoring programmes required by the Directive.

The Directive introduces a flexible hierarchical system for monitoring the very many different types of water body across Europe reflecting the fact that natural physical and geological conditions and anthropogenic pressures vary greatly across Europe. Because of this, a monitoring system designed for one part of Europe may not be entirely applicable in another. The Directive seeks ways of harmonising the results of monitoring systems and ecological assessments rather than imposing a common ecological quality assessment system in each country.



Look Out! The methodology from this Guidance Document must be adapted to regional and national circumstances
The Guidance Document proposes an overall pragmatic approach. Because of the diversity of circumstances within the European Union, Member States may apply this Guidance in a flexible way in answer to problems that will vary from one river basin to the next. This proposed Guidance will therefore need to be tailored to specific circumstances. However, these adaptations should be justified and should be reported in a transparent way.

The objective of monitoring is to establish a coherent and comprehensive overview of water status within each River Basin District and must permit the classification of all surface water bodies into one of five classes[6] and groundwater into one of two classes[7]. However, this does not mean that monitoring stations will be needed in each and every water body. Member States will have to ensure that enough individual water bodies of each water body type are monitored. They will also have to determine how many stations are required in each individual water body to determine its ecological and chemical status. This process of selecting water bodies and monitoring stations should entail statistical assessment techniques, and should ensure that the overview of water status has an acceptable level of confidence and precision.

There is flexibility in terms of monitoring frequencies reflecting that some determinands and quality elements (in terms of surface waters) will be more variable than others. Member States can also plan their monitoring programmes and resources so that not all the selected quality elements (for surface waters) and chemical parameters (for groundwater) have to be monitored every year at every station. This should prevent a situation where countries have to monitor for chemical substances even though they are known not to be present in the catchment, except where validation of the risk assessments is required. In short, cost-effective and targeted monitoring programmes can be designed.

An important aspect in the design of monitoring programmes is quantifying the temporal and spatial variability of quality elements and the parameters indicative of the quality elements in the surface water bodies being considered. Those that are very variable may require more sampling (and hence cost) than those that are more stable or predictable. Alternatively, variability might be reduced or managed by an appropriate targeted or stratified sampling programme which collects data in a limited but well-defined sampling window.

For surface water bodies, the Directive requires that sufficient surface water bodies are monitored in surveillance programmes to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. Operational monitoring is to establish the status of those water bodies identified as being at risk of failing their environmental objectives, and to assess any changes in their status from the programmes of measures. Operational monitoring programmes must use parameters indicative of the quality element or elements most sensitive to the pressure or pressures to which the body or group of bodies is subject. This means that the least number of estimated quality element values may be used in status classification. This will help reduce the errors in the assessment of status. It will therefore be inherently less error prone than surveillance

[6] *Annex V 1.3*
[7] *Annex V 2.2.4 and 2.4.5*

monitoring which uses estimates of all quality elements (i.e. the chance of a water body being wrongly classified will in theory be lower in operational monitoring, everything else being equal).

Indicators must be used in monitoring to estimate the value for the relevant biological quality element. Where the confidence in the estimate provided by one indicator is considered unacceptable, several indicators may be used and a weighting procedure adopted to obtain an acceptable confidence in the estimated value of the quality element. This will also help reduce errors in the assessment of status. Indicators can also be chosen for which reference conditions can be most reliably established and for which errors in monitoring are small and well known.

The purpose of delineating water bodies is to provide for an accurate description of the status of surface water and groundwater and provide a sound basis for management of the water environment. The number of water bodies required in monitoring programmes will, therefore, be strongly dependent on the degree of variation in the status of the water environment as well as on the extent and characteristics of surface waters in a Member State's territory (e.g. number of lakes, whether the State has a coast, etc). Where there are numerous and significant differences in status, water bodies will be equally numerous to reflect those differences. Where status is similar, water bodies will tend to be larger and therefore fewer in number. The scale of monitoring programmes will be dependent to some degree on the numbers of water bodies – or more accurately on the extent of, and variability in, impacts on the water environment. However, the amount of monitoring required will also depend on the degree to which the characteristics of, and range of pressures on, a Member State's water bodies allow them to be grouped for monitoring purposes.

2.3 Clarification of the term "supporting"

The Directive specifies quality elements for the classification of ecological status[8] that include hydromorphological elements supporting the biological elements and chemical and physico-chemical elements supporting the biological elements. For surveillance monitoring, parameters indicative of all the biological, hydromorphological and all general and specific physico-chemical quality elements are required to be monitored. For operational monitoring, the parameters used should be those indicative of the biological and hydromorphological quality elements most sensitive to the pressures to which the body is subject, all priority substances discharged and other substances discharged in significant quantities. The ecological status classification[9] of a body of water is to be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the normative definitions[10].

Supporting means that the values of the physico-chemical and hydromorphological quality elements are such as to support a biological community of a certain ecological status, as this recognises the fact that biological communities are products of their physical and chemical environment. The latter 2 aspects fundamentally determine the type of water body and habitat, and hence the type-specific biological community. It is not intended that these supporting elements can be used as surrogates for the biological elements in surveillance and operational monitoring. The monitoring or assessment of the physical and physico-chemical quality elements will support the interpretation assessment and classification of the results arising from the monitoring of the biological quality elements.

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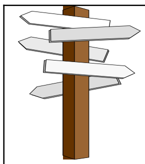
[8] *Annex V.1.1*
[9] *Annex V.1.4.2*
[10] *Annex V.1.2*



The classification of ecological status is being considered by Working Group 2.3 on *"establishing reference conditions and ecological status class boundaries for inland surface waters*", and Working Group 2.4 on *"typology, reference conditions and classification systems for transitional and coastal waters"* .The reader should refer to the Guidance Documents produced by these 2 Working Groups (WFD CIS Guidance Document Nos. 10 and 5). for information on the use of quality elements for the classification of ecological status.

The Directive permits Member States to make estimates of the values of the biological quality elements using monitoring data for parameters indicative of the biological quality elements. The use of indicator parameters should facilitate reliable and cost-effective assessments:

1. Monitoring whole biological quality elements, such as the abundance of all fish species, in each water body could be a very onerous task. The Directive therefore provides that Member States may use species or groups of species representative of the quality element as a whole in their monitoring systems[11].
2. Second, the possibility of using more than one indicator to estimate the value for a biological quality element could provide an important means of avoiding unacceptable risks of misclassification. This is because the results for different indicators can be cross-checked. If the result for one is at odds with the result for another, this may suggest that more data is needed to achieve the required confidence in the estimated value of the quality element.

In some situations, one or more of the indicators used may need to be non-biological. For example, where the pressure to which a water body is subject results in hydromorphological changes, such as a reduction in habitat area, estimates of the values for the abundance of biological elements in the remaining habitat could be made using biological indicators. However, to provide the necessary estimate of the effect of the loss of habitat on the abundance of the quality elements in the water body as a whole, these estimates would need to be combined with a non-biological measure of the reduction in habitat area.

In another situation, a biological indicator is able to provide an estimate of the value of a biological quality element, such as phytoplankton abundance, but the errors in that estimate do not provide for an acceptable level of confidence in status classification. The pressure to which the water body is subject also affects a non-biological parameter; phosphorous concentration. Monitoring information on this parameter could therefore be used to improve confidence in the value of the biological quality element estimated by the biological indicator.

Key Principal

The use of non-biological indicators for estimating the condition of a biological quality element may complement the use of biological indicators but it cannot replace it. Without comprehensive knowledge of all the pressures on a water body and their combined biological effects, direct measures of the condition of the biological quality elements using biological indicators will always be necessary to validate any biological impacts suggested by non-biological indicators.

2.4 Horizontal Guidance on the application of the term "water body"

Article 2.10 of the Directive provides the following definition of a body of surface water: *"Body of surface water" means a* ***discrete and significant element*** *of surface water such as a*

[11] *Annex V 1.4.1(i)*

lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.

Article 2.12 defines a groundwater body as: "*Body of groundwater" means a distinct volume of groundwater within an aquifer or aquifers*.

The Commission, at the request of many of the Working Groups, is developing a horizontal Guidance Document on the identification of water bodies under the Water Framework Directive[12]. Some key aspects with regards to the design and implementation of appropriate monitoring programmes are reproduced below.

Key Principal

The "water body" should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying "water bodies" is to enable the status to be accurately described and compared to environmental objectives[13].

It should be clear that the identification of water bodies is, first and foremost, based on geographical and hydrological determinants. However, the identification and subsequent classification of water bodies must provide for a sufficiently accurate description of this defined geographic area to enable an unambiguous comparison with the objectives of the Directive. This is because the environmental objectives of the Directive, and the measures needed to achieve them, apply to "water bodies". A key descriptor in this context is the "status" of those bodies. If water bodies are identified that do not permit an accurate description of the status of aquatic ecosystems, Member States will be unable to apply the Directive's objectives correctly. At the same time, an endless sub-division of water bodies should be avoided in order to reduce administrative burden if it does not fulfil any purpose as regards the proper implementation of the Directive. In addition, the aggregation of water bodies may, under certain circumstances, also help to reduce meaningless administrative burden, in particular for smaller water bodies.

However, identifying water bodies that will provide for an accurate description of the status of surface water and groundwater will require information from the Article 5 analyses and reviews, and the Article 8 monitoring programmes. Some of the necessary information will not be available before 2004. The information that is available is likely to be updated and improved in the period prior to the publication of each river basin management plan.

Geographical or hydromorphological features can significantly influence surface water ecosystems and their vulnerability to human activities. These features can also differentiate discrete elements of surface water. For example, the confluence of one part of a river with another could clearly demarcate a geographically and hydromorphologically distinct boundary to a water body.

However, the Directive does not exclude other elements, such as a part of a lake or part of transitional water, from being considered as water bodies. For example, if part of a lake is of a different type to the rest of the lake, the lake must be sub-divided into more than one surface water body.

A requirement that is implicit in the Directive is that the purpose of identifying "water bodies" is to enable the **status** of surface waters and groundwater to be accurately described.

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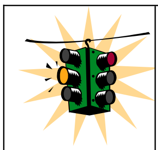
[12] *Version 8.0, 31 October 2002*

[13] *An estimate of the status of water bodies will be required to assess the likelihood that they will fail to meet the environmental quality objectives set for them under Article 4 [Article 5; Annex II 1.5 & 2]. The status of water bodies must be classified using information from the monitoring programmes [Article 8, Annex V 1.3, 2.2 & 2.4]. The status of water bodies must be reported in the river basin management plans [Article 13, Annex VII] and, where necessary, measures must be prepared [Article 11, Annex VI].*

A discrete element of surface water should not contain significant elements of different status. A "water body" must be capable of being assigned to a single ecological status class with sufficient confidence and precision through the Directive's monitoring programmes.

The delineation of bodies of groundwater must ensure that the relevant objectives of the Directive can be achieved. This does not mean that a body of groundwater must be delineated so that it is homogeneous in terms of its natural characteristics, or the concentrations of pollutants or level alterations within it. However, bodies should be delineated in a way that enables an appropriate description of the quantitative and chemical status of groundwater.

It is clearly possible to progressively subdivide waters into smaller and smaller units that would impose significant logistic burdens. However, it is not possible to define the scale below which subdivision is inappropriate. It will be necessary to balance the requirement to adequately describe water status with the need to avoid the fragmentation of surface waters into unmanageable numbers of water bodies. In addition, it may be appropriate to aggregate water bodies under certain circumstances, to reduce meaningless administrative burden. In the end, it is a matter for Members States to decide on the basis of the characteristics of each River Basin District.



Look Out!
The Directive only requires sub-divisions of surface water and groundwater that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of surface water and groundwater into smaller and smaller water bodies that do not support this purpose should be avoided.

Key Principal
Surface water bodies or bodies of groundwater may each be grouped for the purposes of assessing the risk of failing to achieve the objectives set for them under Article 4 (pressures and impacts). They may also be grouped for monitoring purposes where monitoring sufficient indicative or representative water bodies in the sub-groups of surface water or groundwater bodies provides for an acceptable level of confidence and precision in the results of monitoring, and in particular the classification of water body status.

2.5 Risk, precision and confidence

Risk[14] and confidence[15] are words used in Annex II[16] (in terms of risk of failing environmental objectives, and confidence in the values of reference conditions), and risk, confidence and also precision[17] are words used in Annex V[18] (design of monitoring programmes). Their interpretation will affect the scale and extent of the monitoring required to assess status at any particular time and changes in status with time. What are considered to be "acceptable", "adequate" and "sufficient" levels of precision and confidence, and a "significant" risk, will determine aspects such as the:

- number of water bodies included in the various types of monitoring;
- number of stations that will be required to assess the status of each water body; and

[14] *At the simplest level, a risk can be thought of as the chance of an event happening. It has two aspects: the chance, and the event that might happen. These are conventionally called the probability and the consequence.*
[15] *The probability (expressed as a percentage) that the answer obtained (e.g. by the monitoring programme) does in fact lie within calculated and quoted limits, or within the desired or designed precision.*
[16] *Annex II.1.1.5, 2.1 and 1.3*
[17] *The discrepancy between the answer (e.g. a mean) given by the monitoring and sampling programme and the true value.*
[18] *Annex V 1.3, 2.3 and 2.4*

- frequency at which parameters indicative of surface water quality elements will have to be monitored.

Choosing levels of precision and confidence would set limits on how much uncertainty (arising from natural and anthropogenic variability) can be tolerated in the results of monitoring programmes. In terms of monitoring for the Directive, it will be necessary to estimate the status of water bodies and in particular to identify those that are not of 'good' status or good ecological potential or are deteriorating in status. Thus status will have to be estimated from the sampled data. This estimate will almost always differ from the true value (i.e. the status which would be calculated if all water bodies were monitored and sampled continuously for all components that define quality).

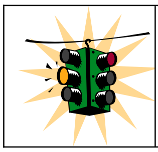
The level of acceptable risk will affect the amount of monitoring required to estimate a water body's status. In general terms, the lower the desired risk of misclassification, the more monitoring (and hence costs) required to assess the status of a water body. It is likely that there will have to be a balance between the costs of monitoring against the risk of a water body being misclassified. Misclassification implies that measures to improve status could be inefficiently and inappropriately targeted. It should also be borne in mind that in general the cost of measures for improvement in water status would be orders of magnitude greater than the costs of monitoring. The extra costs of monitoring to reduce the risk of misclassification might therefore be justified in terms of ensuring that decisions to spend larger sums of money required for improvements are based on reliable information on status. Further, from an economics point of view, stronger criteria should be applied to avoid a situation where water bodies fulfilling the objective are misjudged and new measures applied. Also it should be noted that for surface water surveillance monitoring, and all groundwater monitoring, sufficient monitoring should be done to validate risk assessments and test assumptions made.

The Directive has not specified the levels of precision and confidence required from monitoring programmes and status assessments. This perhaps recognises that achievement of too rigorous precision and confidence requirements would entail a much-increased level of monitoring for some, if not all, Member States.

Key Principal
On the other hand the actual precision and confidence levels achieved should enable meaningful assessments of status in time and space to be made. Member States will have to quote these levels in RBMPs and will thus be open to scrutiny and comment by others. This should serve to highlight any obvious deficiencies or inadequacies in the future.

The starting point for many Member States will probably be an assessment of existing stations and samples to see what level of precision and confidence can be achieved by those resources. It is likely that this will have to be an iterative process with modification and revision of monitoring programmes to achieve levels of precision and confidence that allow meaningful assessments and classification.

It is also likely that Member States will use expert judgement to some extent in assessing the risk of misclassification. For example in the case of a misclassifying bodies "at risk" the persons responsible for making the decision to implement expensive measures will clearly secure their decisions by further assessments before implementing the measures. In the case of misclassifying bodies as "not being at risk" there will be much local experience and expert judgement (by water managers or public persons) to doubt the monitoring results and assessment and look for further clarification.



Look Out!
Guidance on the level of precision required for classification is being discussed by WG 2.3 Reference conditions inland surface water and WG 2.4 Typology, classification of transitional, coastal waters.

2.6 Inclusion of wetlands within the monitoring requirements of the Directive

“Wetland ecosystems are ecologically and functionally significant elements of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in CIS horizontal Guidance Documents water bodies (WFD CIS Guidance Document No. 2) and further considered in the Guidance Document on wetlands (currently under development).

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal Guidance Document on wetlands (currently under development).

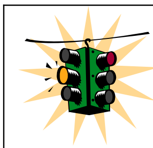
Wetlands are not defined as a separate water category or water body type within the Directive. There are, however, explicit references to wetlands within the Directive[19]. Wetlands could be considered as relevant under the Directive in three contexts:

1. As part of the structure and condition of riparian zones of rivers, shore zones of lakes and intertidal zones of transitional and coastal waters. The structure and condition of these zones is one of the hydromorphological quality elements specified in Annex V 1.1 – 1.2;
2. As directly dependent terrestrial ecosystems in the definition of good groundwater quantitative status and good groundwater chemical status (Annex V 2.1.2 and 2.3.2); and
3. For use in supplementary measures, which MSs may use where cost-effective, to achieve the Directive’s objectives (Annex VI B vii).

"Wetlands" are defined by Articles 1.1 and 2.1 of the Ramsar Convention (Ramsar, Iran, 1971) as shown below:

Article 1.1: *".. Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."*

Article 2.1, wetlands: *"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands".*



Look Out!
The inclusion of wetlands in the monitoring requirements of the Directive is a matter of discussion between Members States, NGOs and other stakeholders. As a result the EEB and WWF prepared a draft paper regarding wetlands and WFD. It was presented at the Strategic Co-ordination Group (SCG) (30.09.0 -01.10.02) meeting in order to determine what actions are required. At this meeting it was agreed that the SCG should take the issue of wetlands under the umbrella of the CIS and to prepare a ‘horizontal guidance’ within 2003.

[19] *e.g. Article 1(a), Preamble (8), (23)*

2.7 Surveillance monitoring of surface waters

2.7.1 Objectives and timing

The objectives[20] of surveillance monitoring of surface waters are to provide information for:

- Supplementing and validating the impact assessment procedure detailed in Annex II;
- The efficient and effective design of future monitoring programmes;
- The assessment of long term changes in natural conditions; and
- The assessment of long term changes resulting from widespread anthropogenic activity.

The results of such monitoring should be reviewed and used, in combination with the impact assessment procedure described in Annex II, to determine requirements for monitoring programmes in the current and subsequent River Basin Management Plans (RBMP).

As has already been described, there will be no information arising from surveillance monitoring for the first risk assessment undertaken under Article 5 – monitoring programmes have to be operational by December 2006, and the first Article 5 characterisation/risk assessment completed by December 2004. However, any existing monitoring data should be used in the assessment. Many countries have already established extensive monitoring programmes.

Surveillance monitoring has to be undertaken for at least a period of one year during the period of a RBMP. The deadline for the first RBMP is 22 December 2009. The monitoring programmes must start by 22 December 2006. The first results will be needed for the first draft RBMP to be published at the end of 2008[21], and then for the finalised RBMPs at the end of 2009. These plans must include status maps.

2.7.2 Selection of monitoring points

The Directive requires that sufficient water bodies should be included in the surveillance monitoring programme to provide an assessment of the overall surface water status within each catchment and sub-catchment of the river basin district. This would imply that more water bodies would have to be monitored in a heterogeneous river basin district in terms of types of water body characteristics and anthropogenic pressures than in a more homogenous catchment. In both cases a statistically representative sub sample would be adequate. A good example of representative sub sampling is in some Nordic lake monitoring programmes where only relatively few of the many thousands of lakes are monitored and directly assessed. The results from the 'few' lakes are then extrapolated to the whole 'population' of lakes being assessed.

If there is low confidence in the Annex II risk assessments (e.g. because of limited existing monitoring data), more surveillance monitoring will be required initially to supplement and validate the assessments than will be the case where existing information is extensive.

Surveillance monitoring may also initially need to be more extensive in terms of the number of water bodies included, monitoring stations within bodies and the range of quality elements. This is because:

- of the probable lack of appropriate existing monitoring information and data;
- the Directive requires Member States to consider a different range of quality elements and a different range of pressures than have previous Directives.

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[20] *Annex V.1.3.1*
[21] *Article 14.1.c*

Member States may also wish or have the need to (depending on the amount of existing information and the confidence in the first Annex II risk assessments) undertake surveillance monitoring each year, at least during the first three years (2006-2008).

For subsequent surveillance monitoring programmes the same principles, outlined above, of validating the risk assessment (which may well have changed) etc, should be used to develop the programme but, depending on the additional information provided from the other monitoring programmes, such as the operational monitoring programmes, the extent of the surveillance monitoring programme will change with time.

Annex II risk assessments are to identify those water bodies at risk of failing EQOs. If confidence in the identification of water bodies at risk is still low after both the Annex II risk assessments and their supplementation and validation using surveillance monitoring data, bodies that are actually not at risk should be assumed to be at risk. Consequently, a larger operational monitoring network will be required than would be the case if water bodies at risk and not at risk were more reliably differentiated by the risk assessments.

Key Question

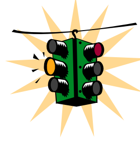
For risk assessments, and therefore surveillance monitoring what is the acceptable risk of a body being described as not at risk of failing the objectives when it is in fact at risk of such a failure?

The Directive also stipulates that monitoring should be carried out at points where:

- The rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment is greater than 2 500 km^2;
- The volume of water present is significant within the river basin district, including large lakes and reservoirs;
- Significant bodies of water cross a Member State boundary;
- Sites are identified under the Information Exchange Decision 77/795/EEC; and
- At such other sites as are required to estimate the pollutant load which is transferred across Member States boundaries, and which is transferred into the marine environment.

The size typology given in Annex II (System A) implies that rivers with catchment areas greater than 10 km^2 and (b) lakes greater than 0.5 km^2 in surface area are water bodies that fall under the requirements of the Directive and might need to be included within the water status assessment and monitoring. Surface waters below the System A typology size thresholds could be Protected Areas, be important to the ecology of the river basin as a whole (e.g. important spawning and breeding grounds), or be subject to pressures that have significant consequences elsewhere in the river basin district. In the System B typology no such size limits are implied, though the typology used must achieve at least the same degree of differentiation as would be achieved using System A. Member States may thus wish or need to include small water bodies within the monitoring and assessment requirements of the Directive.

In practice Member States will determine the size of water body that needs to be included in monitoring programmes. It will depend on the nature (natural and anthropogenic) of each River Basin District being characterised and the attainment of the objective to obtain a coherent and comprehensive overview of water status within the River Basin District.

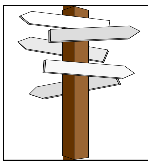


Look Out!

The horizontal guidance on water bodies (see section 3) indicates that Member States have flexibility to decide whether the purposes of the Directive, which apply to all surface waters, can be achieved without the identification of every minor but discrete element of surface water as a water body.

Surveillance monitoring is also required to provide information on long-term natural changes and long-term changes resulting from widespread anthropogenic activity. Information on the first will be important if such changes are likely to affect reference conditions. Monitoring for long-term natural changes is likely to be focused on high and maybe 'good' status water bodies. This is because such changes (possibly relatively small and gradual) are more likely to be detectable in the absence of the impact of anthropogenic activities which may mask natural changes. In terms of changes resulting from widespread anthropogenic activity, monitoring will be important to determine or confirm the impact of, for example, long range transport and deposition of pollutants from the atmosphere. If this is likely to lead to a risk of water bodies deteriorating in status (any status level down to poor) then those water bodies or groups of bodies will have to be included in operational monitoring programmes.

The first surveillance programme should also seek to establish a quantitative baseline for future assessments of long-term natural or anthropogenically induced changes, and also against which reductions in pollution from Priority Substances (PH), and cessation and phasing out of emissions of Priority Hazardous Substances (PHS) will be judged. This will be important in supplementing and validating the assessment of whether water bodies are at risk of failing Article 4 EQOs[22] or not.



The EAF Expert Group on the Analysis and Monitoring of Priority Substances will also be considering the assessment of compliance of PS and PHS in terms of the WFD.

2.7.3 Selection of quality elements

For surveillance monitoring, Member States must monitor at least for a period of a year parameters indicative of all biological, hydromorphological and general physico-chemical quality elements. The relevant quality elements for each type of water are given in Annex V.1.1. Thus for rivers, the biological parameters chosen to be indicative of the status of each biological element such as the aquatic flora, macro-invertebrates and fish must be monitored for. For example, in the case of the aquatic flora, the parameters might be presence or absence of indicator species or the population structure. The Directive indicates that monitoring of the biological quality elements must be at an appropriate taxonomic level to achieve adequate confidence and precision in the classification of the quality elements. This applies equally to the three types of surface water monitoring.

Those priority list substances discharged into the river basin or sub-basins must be monitored. Other pollutants[23] also need to be monitored if they are discharged in significant quantities in the river basin or sub-basin. No definition of 'significance' is given but quantities that could compromise the achievement of one of the Directive's objectives are clearly significant, and as examples, one might assume that a discharge that impacted a Protected Area, or caused exceedence of any national standard set under Annex V 1.2.6 of the Directive or caused a biological or ecotoxicological effect in a water body would be expected to be significant.

A structured approach should be used to inform the process of selecting which chemical should be monitored for in the surveillance monitoring programme. This should be based on a combination of knowledge of use patterns (quantity and locations), pathways for inputs (diffuse and/or point source) and existing information on potential ecological impacts. This is a basis for the risk assessment required under Annex II of the Directive.

Additionally the selection should be informed by information on the ecological status where indications of toxic impacts are found or from ecotoxicological evidence. This will help to

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[22] *Article 4.1.a.i and 4.1.a.iv*
[23] *Annex VIII*

identify situations where unknown chemicals are entering the environment which need investigative monitoring.

Further guidance on the selection of chemicals is being provided by the IMPRESS working group (WFD CIS Guidance Document No. 3).

In the case of transboundary river basins, pollution may originate from sources which cannot be identified by the Member State. For example, it may originate from a country not covered by the requirements of the WFD. In these cases there would be no Annex II assessments on which to base the monitoring (unless the effects of the pollution have been detected through existing monitoring programmes). For this reason, a Member State might decide to monitor parameters indicative of all priority substances and all other relevant pollutants at a selection of surveillance sites established to detect possible transboundary pollution problems. In addition, Member States may suitably decide to monitor for all priority substances and other relevant pollutants during the first year of surveillance, especially in the case of transboundary water bodies or pollutants with long-range mobility.

2.8 Operational monitoring of surface waters

2.8.1 Objectives

The objectives of operational monitoring[24] are to:

- Establish the status of those bodies identified as being at risk of failing to meet their environmental objectives; and
- Assess any changes in the status of such bodies resulting from the programmes of measures.

Operational monitoring (or in some cases investigative monitoring) will be used to establish or confirm the status of bodies thought to be at risk. Therefore, it is operational monitoring that will produce the environmental quality ratios used for status classification for those water bodies included in operational monitoring. It is highly focused on parameters indicative of the quality elements most sensitive to the pressures to which the water body or bodies are subject.

Key Question

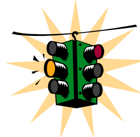
For operational monitoring, what is the acceptable level of risk of a body being wrongly classified?

The answer partly depends on what action is likely to be required if the objective is failed. Expensive measures would require higher certainty of failure to obtain EQOs to justify them than would low cost measures. Because the implications of misclassification could be serious for water users, there should be a high level of confidence in the estimates produced from operational monitoring data. In some cases failing objectives can be serious for water users, but in many cases implementation of unnecessary measures have more serious consequences for the community and therefore it is important to judge whether or not a water body is fulfilling its objectives.

Thus the required confidence in establishing the status of a water body will be highest where the implications of a misclassification to below ‘good’ status are high with costs potentially being wrongly imposed on a water user. Similarly there needs to be high confidence in ensuring that water bodies of less than ‘good’ status are not misclassified as good. In short a high level of confidence will be required close to the boundary of good/moderate status.

[24] *Annex V.1.3.2*

The more water bodies identified as being at risk of failing to achieve an environmental objective, the more operational monitoring will be required. Put more accurately: the more significant pressures there are upon the water environment, the more monitoring will be required to provide the information for managing those pressures. Generally it should be easier to achieve high levels of confidence in status classification where the pressure is very high and well identified, than at sites that lie close to the good/moderate status boundary.



Look Out!
Outputs from the Working Group on Pressures and Impacts will influence the monitoring programmes for environmental pressures such as the Priority Substances.

2.8.2 Selection of monitoring sites

Operational monitoring has to be undertaken for all water bodies that have been identified, by the review of the environmental impact of human activities (Annex II) and/or from the results of the surveillance monitoring, as being at risk of failing the relevant environmental objectives under Article 4. Monitoring must also be carried out for all bodies into which priority substances are discharged. This implies that monitoring in all such bodies will not necessarily be required as the Directive allows similar[25] water bodies to be grouped and representatively monitored.

In addition, monitoring sites for those priority list substances with environmental quality standards should be selected according to the requirements of the legislation establishing the standards.

The Directive gives further guidance on the selection of monitoring sites for other water bodies and those receiving discharges of priority list substances without specific guidance in legislation. The guidance differentiates between bodies at risk (of failing EOs) from significant point source, diffuse source and hydromorphological pressures. The number of monitoring stations selected needs to be sufficient to assess the magnitude and impact of the three specified pressures:

- In terms of all significant pressures more than one station per water body may be required to do this;
- In cases where a body of water is subject to more than one point source, stations may be selected to represent the magnitude and impact of the sources as a whole. In theory, it may sometimes be sufficient to have no monitoring points in a body where information from adjacent similar bodies, for example, allows an adequate assessment of the magnitude and impact of the point source. The confidence in any judgement of 'sufficiency' must be set out in the RBMP;
- In terms of diffuse sources and hydromorphological pressures, stations may be required in a number of those water bodies at risk;
- For diffuse sources, the selected water bodies need to be representative of the relative risks of the occurrence of the diffuse source pressures, and of the relative risks of the failure to achieve good surface water status. However, in selecting the representative water bodies for operational monitoring it should be taken into account that water bodies can only be grouped, for example, where the ecological conditions are similar or almost similar in terms of the magnitude and type pressure as well as in terms of hydrological and biological conditions such as retention time and food web structure. In all cases grouping must be technically or scientifically justifiable;

[25] *For example, in terms of type, pressures to which they are subject and sensitivity to those pressures.*

- For hydromorphological pressures, the selected water bodies should be indicative of the overall impact of the pressure to which all the bodies are subject;
- If only one source of pollutant is present in a water body included in the operational monitoring programme, the monitoring station should be selected according to what is judged to be the most sensitive location. If there are several sources of pollution or other pressures, it might be desirable or necessary (from the management perspective) for the operational monitoring system to be able to discriminate between the different pressures and sources. This could, for example, help in the apportionment of reduction measures relative to the impact of the pressures. Thus more than one monitoring station and different quality elements might be considered. It should also be noted that in many cases it will not be possible to measure the impact of each source of pressure, and that the impact of groups of pressures will have to be considered.

2.8.3 Selection of quality elements

For operational monitoring, Member States are required to monitor for those biological and hydromorphological quality elements most sensitive to the pressures to which the body or bodies are subject. For example, if organic pollution is a significant pressure on a river then benthic invertebrates might be the most sensitive and appropriate indicator of that pressure. Thus in the absence of other pressures, aquatic flora and fish populations may not need to be monitored in those bodies of water. However, the monitoring and assessment system must still be based on the concept of ecological status and not just reflect degrees of organic pollution without comparison to the appropriate reference conditions. This is because its ecological status must be defined.

As discussed in section 3, the use of non-biological indicators for estimating the condition of a biological quality element may complement the use of biological indicators but it cannot replace it. This does not exclude the use of non-biological indicators (such as physico-chemical parameters) when it is operationally appropriate, for example when measures to reduce pressures (e.g. discharges from Urban Waste Water Treatment Works) are related to specific physico-chemical parameters (e.g. total organic carbon, BOD or nutrients). In this case it might be appropriate to monitor non-biological indicators and biological indicators (e.g. macrozoobenthos) at different frequencies with the results from the physico-chemical monitoring being periodically validated by the results of the biological monitoring. This would be necessary because non-biological indicators cannot be relied on without checking their inference using biological indicators because we do not have perfect knowledge of cause-effect relationships, pressures, the effects of pressure combinations etc.

If a body is not identified as being at risk because of discharges of priority substances or other pollutants, no operational monitoring for these substances is required. A pollutant is defined[26] as ‘any substance liable to cause pollution in particular those listed in Annex VIII’. As such nutrients and substances that have an unfavourable influence on oxygen balance must also be considered as well as metals and organic micropollutants. Operational monitoring must use parameters relevant to the assessment of the effects of the pressures placing the body at risk.

2.9 Investigative monitoring

Investigative monitoring[27] may also be required in specified cases. These are given as:

- where the reason for any exceedences (of Environmental Objectives) is unknown;

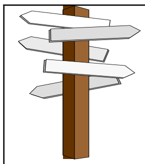
[26] *Article 2.31*
[27] *Annex V.1.3.3*

- where surveillance monitoring indicates that the objectives set under Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; or
- to ascertain the magnitude and impacts of accidental pollution.

The results of the monitoring would then be used to inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution.

Investigative monitoring will thus be designed to the specific case or problem being investigated. In some cases it will be more intensive in terms of monitoring frequencies and focused on particular water bodies or parts of water bodies, and on relevant quality elements. Ecotoxicological monitoring and assessment methods would in some cases be appropriate for investigative monitoring.

Investigative monitoring might also include alarm or early warning monitoring, for example, for the protection of drinking water intakes against accidental pollution. This type of monitoring could be considered as part of the programmes of measures required by Article 11.3.1 and could include continuous or semi-continuous measurements of a few chemical (such as dissolved oxygen) and/or biological (such as fish) determinands. Such monitors are used on the River Rhine, for example.



Information on the use of bioassays to support implementation of the Directive is provided in the document:
“The potential role of bioassays in meeting the monitoring needs of the Water Framework Directive” < http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/bioassays >.

2.10 Frequency of monitoring for surface waters

2.10.1 General aspects

Some determinands and quality elements will be very variable (natural, anthropogenically caused and due to sampling error) in particular water bodies. A lot of monitoring in terms of numbers of sites and frequency of monitoring might thus be required to obtain high or sufficient levels of confidence and precision in a water body’s status. There will of course be a cost implication for Member States for the required monitoring. It is likely therefore, that the levels of confidence and precision achievable will be balanced against the costs, i.e. an assessment of the cost-effectiveness of the monitoring programme may be undertaken. In short the provision of reliable information from monitoring programmes will allow measures to be effectively and efficiently targeted.

The actual confidence and precision achieved by monitoring at any particular monitoring site will depend partly on the variability (both natural and resulting from anthropogenic activities) of the determinand being measured, and the frequency of monitoring. Member States are able to target their monitoring to particular times of year to take into account variability due to seasonal factors. An example would be the sampling for nutrients in marine waters in winter when uptake by biota is at its minimum. Seasonal sampling to reflect seasonal human pressures is also permitted.

Thus the Directive allows Member States to tailor their monitoring frequencies according to the conditions and variability within their own waters. These are likely to differ greatly from determinand to determinand, from water body type to water body type, from area to area and from country to country, recognising that a frequency adequate in one country may not be so in another. However, the key is to ensure that a reliable assessment of the status of all water bodies can be achieved, and the reliability of that assessment in terms of confidence and precision must be provided. The latter will have to be published in RBMPs and will therefore, be open to review and scrutiny by other experts, members of the public and the Commission.

As already described, lower monitoring frequencies and on some occasions even no monitoring may be justified when previous monitoring reveals/has revealed that concentrations of substances are below detection limits, declining or stable and there is no obvious risk of increase. An increase will not be likely for instance when the substance is not used in catchment and there is no atmospheric deposition. This corresponds with the thoughts to the principles used by OSPAR/HELCOM in their monitoring and assessment programmes

The minimum monitoring frequencies quoted in the Directive[28] may also not be adequate or realistic for transitional and coastal waters. There will generally be a lower level of confidence in most marine systems because of the much higher natural variability and heterogeneity. Natural variability can be reduced by targeting monitoring to specific seasons such as measuring nutrient concentrations in transitional and coastal waters during winter. Similarly the OSPAR guidelines for the monitoring of biota help programme managers to reduce variability by avoiding the spawning season, sampling pre-spawning for a worst-case scenario etc.

2.10.2 Surveillance monitoring

Surveillance monitoring must be carried out for each monitoring site for a period of one year during the period covered by a RBMP for parameters indicative of all biological quality elements, all hydromorphological quality elements and all general physico-chemical quality elements. Annex V[29] provides tabulated guidelines in terms of the minimum monitoring frequencies for all the quality elements. The suggested minimum frequencies are generally lower than currently applied in some countries. More frequent samples will be necessary to obtain sufficient precision in supplementing and validating Annex II assessments in many cases, for example phytoplankton and nutrients in lakes. Less frequent samples for the general physico-chemical quality elements are permissible if technically justified and based on expert judgement. In addition not all quality elements need to be monitored during the same year, there can be phased monitoring from year to year as long as all are monitored at least once over a year during the lifetime of the RBMP.

There is also an additional clause in Annex V that allows Member States to only undertake surveillance monitoring in specific water bodies once every three river basin management plans (RBMPs) (i.e. once in 18 years) when that body has reached ‘good’ status and when there is no evidence that impacts on that body have changed.

An objective of surveillance monitoring is to assess the long term changes in natural conditions and long term changes resulting from widespread anthropogenic activity. The minimum frequencies given in the Directive may not be adequate to achieve an acceptable level of confidence and precision in this assessment. It may therefore be necessary to increase the frequencies of at least some surveillance monitoring parameters and monitor more than once every sixth year at those surveillance sites designed to detect long-term changes.

2.10.3 Operational monitoring

In terms of operational monitoring Member States are required to determine monitoring frequencies that will provide a reliable assessment of the status of the relevant quality element. The same guidance given on minimum monitoring frequencies for surveillance

[28] *Annex V.1.3.4*
[29] *Annex V.1.3.4*

monitoring is also used for operational monitoring. Again more frequent monitoring will mostly likely be necessary in many cases, but also less frequent monitoring is justified when based on technical knowledge and expert judgement.

The statistical interpretation of results from monitoring is an important topic to ensure a reliable assessment of status etc. Data arising from traditional sampling programmes (e.g. regular monthly sampling) and from more targeted sampling, as might be used in operational monitoring, must be treated in an appropriate manner. These statistical issues are discussed in more detail in the Tool Box, chapter 5.

Member States can also amend their operational monitoring programmes (particularly the monitoring frequency) during the duration of a RBMP where an impact is found not to be significant or the relevant pressure is removed, and the ecological status is no longer less than good.

2.10.4 Summary

In summary, sampling frequencies for surveillance and operational monitoring should be critically assessed in terms of the confidence in the estimates they will provide. For example, Member States may have to undertake additional surveillance monitoring at least during the first 3 years from 2006 to 2008. Also, it may be that data needs to be gathered in every year of subsequent RBMP periods in order to get enough to meet adequate confidence targets in assessing compliance with monitoring objectives and associated Environmental Objectives.

2.11 Monitoring for Protected Areas

There are additional monitoring requirements for protected areas[30]. Protected Areas include bodies of surface water and groundwater used for the abstraction of drinking water and habitat and species protection areas identified under the Birds Directive or the Habitats Directive. Thus for the former areas monitoring sites must be designated in bodies of surface water which provide more than 100 m^3 a day as an average. For groundwater there appears to be no additional monitoring requirements.

In terms of drinking water protected areas, all priority list substances discharged into the water body and all other substances discharged in significant quantities which could affect the status of the body of water and which are included in the requirements of the Drinking Water Directive should be monitored.

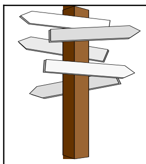
In other words, the monitoring requirements appear to be the same as for other water bodies at risk, except that grouping may not usually be permitted if the body supplies more than 100 m^3 per day. There may be special cases where there is a high number of small mosaic groundwater body types where grouping may be permitted. One of the objectives for Drinking Water Protected Areas is to aim to prevent deterioration in quality in order to reduce the level of purification treatment required. This objective was added to the Directive after the Annex V requirements had been effectively finalised. This means that there are no explicit monitoring requirements designed to provide information for the purposes of assessing and securing achievement of this Protected Area objective. The provisions quoted above do not cover it because they focus on risks to status rather than risks to the relevant quality parameters.

Monitoring frequencies are also given for certain Drinking Water Protected Areas[31] and relate to the size of the population that the Protected Area serves – the greater the population the greater the frequency.

In terms of habitat and species protection areas, bodies of water forming these areas must be included in operational monitoring if they are identified (by the Annex II risk assessment

[30] *Annex V.1.3.5*
[31] *Annex V.1.3.5*

and surveillance monitoring) as being at risk of not meeting their environmental objectives. Monitoring must be carried out to assess the magnitude and impact of all relevant significant pressures on these bodies, and where necessary, to assess changes in the status of such bodies resulting from the programmes of measures. Monitoring should also continue until the areas satisfy the water-related requirements of the legislation under which they are designated and met their objectives under Article 4.



Additional monitoring is required for drinking water abstraction points and habitat and species protection areas. However the register or registers of protected areas also includes areas designated as bathing waters under Directive 76/160/EEC, as vulnerable zones under Directive 91/676/EEC and areas as sensitive under Directive 91/271/EEC. These latter Directives also have monitoring and reporting requirements. The EAF on Reporting is considering not only the reporting required under the WFD but also existing reporting requirements with the aim of 'streamlining' the reporting process. The Working Group on Monitoring also recommends that ways of integrating, rationalising and streamlining the monitoring requirements under the other Directives should also be considered in future work that might revise this Guidance Document.

2.12 Other requirements for surface water monitoring

2.12.1 Reference conditions

Member States have the opportunity of establishing reference conditions based on existing high status water bodies where they still exist. In this case monitoring will be required to define the values of the biological quality elements. Type-specific hydromorphological and physico-chemical conditions have also to be established for each type at high ecological status. Reference conditions can also be derived from modelling approaches. These could utilise data from existing water bodies in which the relevant quality element is subject to no more than very minor anthropogenic disturbance. As high status is the anchor point for the classification of ecological status, it would be expected that the results from the monitoring would have a high level of confidence and precision. In particular, the natural variability (e.g. diurnal, monthly, seasonal and inter-annual) of the quality elements needs to be quantified and understood if the impact of anthropogenic pressures on water bodies of lesser status is to be determined. Thus more stations per water body and a higher sampling frequency per station over a number of years may be required.

It should also be noted that the errors in reference conditions and in estimates of the actual conditions will sum. Making sure the errors in the reference conditions are small will be beneficial only if the errors in the estimates of current conditions are not large.

In addition, reference stations, for which there are long time series of data, which indicate stable conditions under the present conditions, may not need high sampling frequencies.

There are linkages here with Working Groups 2.3 on reference conditions for inland surface waters (WFD CIS Guidance Document No. 10) and 2.4 on typology and classification of transitional and coastal water (WFD CIS Guidance Document No. 5). Thus this subsection may be modified to reflect conclusions reached by these other groups.

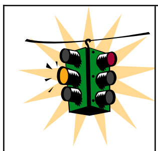
2.12.2 Intercalibration

Annex V.1.4.1 deals with the comparability of biological monitoring results and the intercalibration exercise between countries. Monitoring of the biological quality elements will be undertaken at those sites included in an intercalibration network. The network will consist of sites selected from a range of surface water body types present within each ecoregion. The sites shall be selected by expert judgement based on joint inspections and all other available information. A Member State's monitoring and assessment system will also be applied to the appropriate identified sites and water bodies in one or more other Member States. It would be valuable also to intercalibrate other monitoring results and methodologies.

The results from the monitoring of the biological quality elements will then be formulated as Ecological Quality Ratios (EQRs) for the purpose of classification and comparison with the results from other appropriate Member States.

It has been proposed in the Intercalibration working group 2.5, and supported by different Member States, that monitoring methods of the different Member States sharing the same natural water body should undertake measurements simultaneously, to permit a real comparison of the assessment of 'good' status.

The intercalibration exercise is intended to be a one-off exercise and should be completed within 5.5 years of the entry into force of the Directive (22 June 2006).



Look Out!

However, it has been proposed in the Intercalibration group, and supported by different Member States, that the intercalibration exercise should be repeated. An intercalibration exercise will also be required once the Accession countries have joined the EU. This will by necessity involve at least some of the existing EU Member States.

Its purpose is to define the boundary between high and good and between good and moderate status. The achievement of 'good' status is one of the major Environmental Objectives of the Directive and hence its level will determine how many water bodies require measures to be applied to achieve 'good' status. The definition of this boundary is thus a crucial aspect of the implementation of the Directive.

It is stated that at least two sites corresponding to the boundary between good and high status and two sites corresponding to the boundary between good and moderate status should be selected for an intercalibration network for each water body type within each ecoregion. In practise, because of the natural variability between the same types of water bodies, the number of sites may have to be much larger to be able to define the borderlines between the status groups and the variability of this borderline.

Key issue

The issues surrounding the intercalibration exercise are being discussed with Working Group 2.5 on intercalibration. Thus this subsection may be modified to reflect conclusions reached by this other group.

2.12.3 Heavily Modified and Artificial Water Bodies

According to the WFD, the biological status of surface water is to be assessed using the elements phytoplankton, other aquatic flora, macroinvertebrates and fish fauna. It is suggested that the preliminary assessments of ecological status should be based on the most sensitive quality elements with respect to the existing physical alterations. Effects resulting from other impacts (e.g. toxic effects on macroinvertebrates, eutrophication concerning macrophytes) should be excluded as far as possible. Some suggestions on the suitability of biological elements as indicators for physical alterations can be made:

- Benthic invertebrate fauna and fish are the most relevant groups for the assessment of hydropower generation impacts;
- Long distance migrating fish species can serve as a criterion for the assessment of disruption in river continuum;

- Macrophytes are good indicators of changes in flow downstream of reservoirs as well as for the assessment of regulated lakes because they are sensitive to water level fluctuation; and,
- For linear physical alterations such as flood works, benthic invertebrate fauna and macrophytes/phytobenthos are most appropriate indicators.

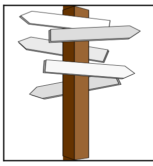
Annex VI of the Guidance Document provides an overview of the key issues for each water body and should be referred to for more details.

Key issue

The issues surrounding the heavily modified water bodies are covered by Working Group 2.2. Thus this subsection may be modified to reflect conclusions reached by this other group.

2.12.4 Standards for monitoring of surface water quality elements

The Directive also indicates that the monitoring of type parameters for surface waters should conform to appropriate international standards (such as those developed by CEN and ISO) which should ensure the provision of data of an equivalent scientific quality and comparability.



It is recommended that appropriate standards are developed as a matter of priority and urgency for those aspects of monitoring for which there are no internationally agreed standards or techniques/methods

The use and development of standards and quality assurance in sampling and laboratory work is further elaborated in Chapter 5.

2.13 Monitoring of groundwater

The Water Framework Directive requires the establishment of monitoring programmes covering groundwater quantitative status, chemical status[32] and the assessment of significant, long-term pollutant trends resulting from human activity[33] by 22 December 2006 at the latest. The programmes must also provide for any additional monitoring requirements relevant to Protected Areas. The programmes must provide the information necessary to validate the Annex II risk assessment procedure and to assess the achievement of the Directive's objectives for groundwater. The relevant objectives are:

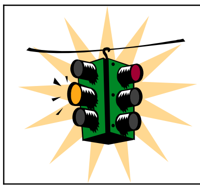
- To prevent deterioration in the status of all bodies of groundwater [Article 4.1(b)(i)];
- To prevent or limit the input of pollutants into groundwater [Article 4.1(b)(i)];
- To protect, enhance and restore all bodies of groundwater and ensure a balance between abstraction and recharge with the aim of achieving good groundwater status [Article 4.1(b)(ii)];
- To reverse any significant and sustained upward trend in the concentration of any pollutant in groundwater in order to progressively reduce pollution of groundwater [Article 4.1(b)(iii)];
- To achieve compliance with any standards and objectives for Protected Areas [Article 4.1(c)]. Relevant Protected Areas include areas designated for the abstraction of water intended for human consumption under Article 7 (Drinking Water Protected Areas),

[32] *Article 8*
[33] *Annex V*

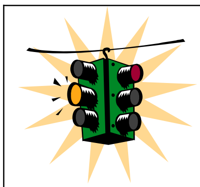
Nitrate Vulnerable Zones established under Directive 91/676/EEC, and areas designated for the protection of habitats and species in which the status of water is an important factor in their protection;

Key principle

The monitoring programmes must provide the information necessary to assess whether the Directive's environmental objectives will be achieved. This means that a clear understanding of the environmental conditions required for the achievement of the objectives, and of how these could be affected by human activities, is essential to the design of effective monitoring programmes.



Look Out!
The Article 17 Daughter Directive may establish additional criteria for the assessment of groundwater status. This guidance may need to be updated once such criteria have been established.



Look Out!
The Article 17 Daughter Directive is expected to establish criteria for the identification of significant and sustained upward trends. Until such criteria have been established, Member States must decide whether a trend in pollutant concentrations is significant and sustained according to their own criteria. In developing such criteria, Member States should take into account the objective to progressively reduce pollution of groundwater [Article 4.1(b)(iii)].

The monitoring programmes should be designed on the basis of the results of the Annex II[2] characterisation and risk assessment procedure. Guidance on characterisation and risk assessment for bodies and groups of bodies of groundwater can be found in the WFD CIS Guidance Document No. 3 - IMPRESS. The results of the assessments should provide the necessary information on, and understanding of, the groundwater system and the potential effects of human activities on it with which to design the monitoring programmes. In particular, monitoring programme design will require:

- Estimated boundaries of all bodies of groundwater;
- Information on the natural characteristics, and a conceptual understanding, of all bodies or groups of bodies of groundwater;
- Information on how bodies may be grouped because of similar hydrogeological characteristics and therefore similar responses to the identified pressures;
- Identification of those bodies, or groups of bodies, of groundwater at risk of failing to achieve Directive's objectives, including the reasons why those are considered to be at risk;
- Information on (a) the level of confidence in the risk assessments (e.g. in the conceptual understanding of the groundwater system, the identification of pressures, etc), and (b) what monitoring data would be required to validate the risk assessments.

To ensure the targeted and cost-effective development of the groundwater monitoring programmes, this information and understanding should serve as the basis for identifying (see Figure 2.3):

- The bodies, or groups of bodies relevant to each monitoring programme;
- The appropriate monitoring sites in those bodies, or groups of bodies;
- The appropriate parameters for monitoring at each site; and
- The monitoring frequencies for those parameters at each site.

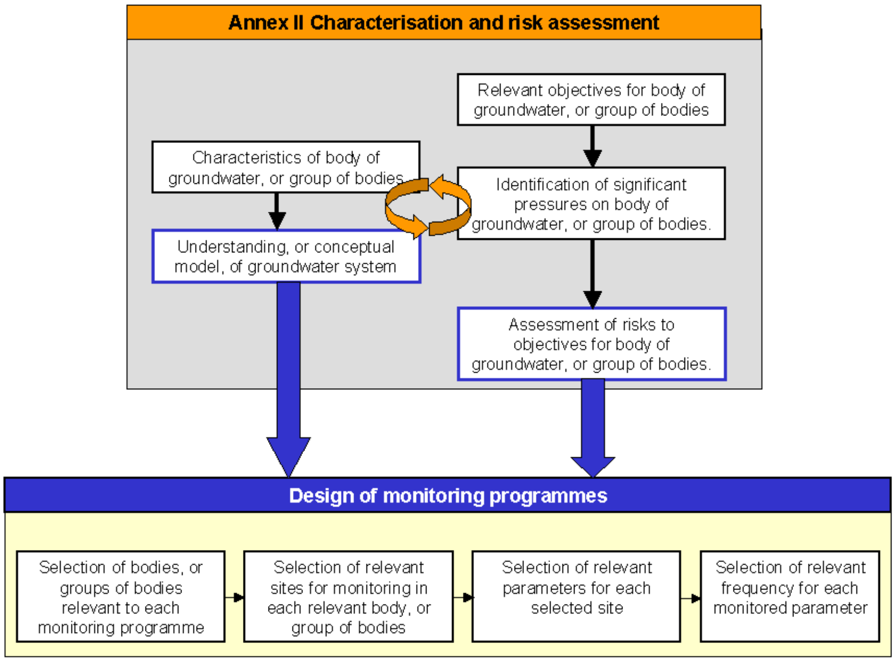
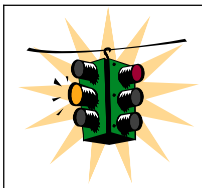


Figure 2.3 The basic information necessary for the design of groundwater monitoring programmes

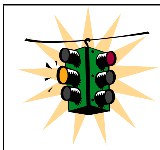
The Directive sets out its requirements for the different groundwater monitoring programmes in Annex V (2.2 and 2.4). The monitoring programmes must include:

A 'groundwater level monitoring' network to supplement and validate the Annex II characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater quantitative status in all bodies or groups of bodies of groundwater. Good groundwater quantitative status requires that: (a) the available groundwater resource for the body as a whole is not exceeded by the long-term annual average rate of abstraction; (b) abstractions and other anthropogenic alterations to groundwater levels have not caused, and are not such as will cause, significant diminution in the status of associated surface water bodies or significant damage to directly dependent terrestrial ecosystems; and (c) anthropogenic alterations to flow direction have not caused, and are not likely to cause, saltwater or other intrusions.

A 'surveillance monitoring' network to: (a) supplement and validate the Annex II characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater chemical status; (b) establish the status of all groundwater bodies, or groups of bodies, determined as not being at risk on the basis of the risk assessments; and (c) provide information for use in the assessment of long term trends in natural conditions and in pollutant concentrations resulting from human activity. Surveillance monitoring should be undertaken in each plan period and to the extent necessary to adequately supplement and validate the risk assessment procedure for each body or group of bodies of groundwater. The programmes should be operational from the beginning of the plan period where necessary to provide information for the design of the operational monitoring programmes, and may operate for the duration of the planning period if required. The programmes should be designed to help ensure that all significant risks to the achievement of the Directive's objectives have been identified. Where confidence in the Annex II risk assessments is inadequate, parameters indicative of pressures from human activities, which may be affecting bodies of groundwater but which have not been identified as causing a risk to the objectives, should be included in the surveillance monitoring programmes in order to supplement and validate the risk assessments.



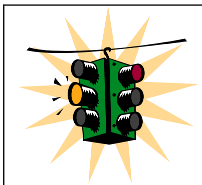
Look Out!
No minimum duration for the surveillance programme is specified. For the first river basin planning period, Member States that already have extensive groundwater monitoring networks may only need a short period of surveillance monitoring to help design their operational monitoring programmes. However, Member States whose existing networks are more limited may require more information from surveillance programmes before the design of their operational programmes can be completed.



Look Out!
Surveillance monitoring is only specified in the Directive for bodies at risk or which cross a boundary between Member States. However, to adequately supplement and validate the Annex II risk assessment procedure, validation monitoring will also be needed for bodies, or groups of bodies, not identified as being at risk. The amount and frequency of monitoring undertaken for these bodies, or groups of bodies, must be sufficient to enable Member States to be adequately confident that the bodies are at 'good' status and that there are no significant and sustained upward trends.

An 'operational monitoring' network to: (a) establish the status of all groundwater bodies, or groups of bodies, determined as being at risk; and (b) establish the presence of significant and sustained upward trends in the concentration of any pollutant. Operational monitoring has to be carried out for the periods between surveillance monitoring. In contrast to surveillance monitoring, operational monitoring is highly focused on assessing the specific, identified risks to the achievement of the Directive's objectives.

The results of monitoring must be used to estimate the chemical and quantitative status of bodies of groundwater. Colour-coded maps[34] of the status of bodies of groundwater, or groups of bodies, and an indication on the maps of which bodies are subject to a significant and sustained upward trend in pollutant concentrations and in which bodies such trends have been reversed must be included in the draft river basin management plans and in the finalised river basin management plans. The first of these plans must be published by 22 December 2008[35] and 22 December 2009[36] respectively. The results of monitoring should also assist in designing programmes of measures, testing the effectiveness of these measures and informing the setting of objectives. Later on monitoring results should be used in the reviews of the Annex II risk assessment procedure, the first of which must be complete by 22 December 2013.



Look Out!
For many Member States, the estimates of groundwater body status included in the first draft river basin management plans at the end of 2008 will have to be based more on surveillance monitoring results and less on operational monitoring data than will be the case in the finalised plan published at the end of 2009 and in subsequent river basin management plans. Accordingly, the confidence in the status classifications included in the first plan may be lower than will be the case in subsequent plans. Member States must report the confidence and precision achieved in the results of monitoring in each plan.

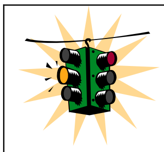
The detailed purposes of, and requirements for, each of the groundwater monitoring programmes are discussed in Chapter 4. Chapter 5.3 contains a toolbox of good practice examples illustrating how the guidelines could be implemented. The tools developed by CIS

[34] *Annex V 2.5*
[35] *Article 14*
[36] *Article 15*

2.8, Statistical aspects of groundwater trends and aggregation of monitoring results, should also be taken into account when designing the monitoring programmes.

3 What Quality Elements should be monitored for Surface Waters?

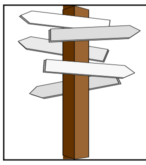
The following sections provide guidance on the appropriate selection of quality elements and parameters for rivers, lakes, transitional waters and coastal waters to support the implementation of the WFD. The selection of quality elements has been based primarily on Annex V.1.1 and Annex V.1.2 of the WFD. Guidance on the selection of quality elements and parameters for rivers, lakes, transitional and coastal waters are summarised in Figures 3.1 - 3.4. These figures show the quality elements as specified in Annex V, and additional recommended quality elements which have been identified by Member States for that particular water body type.



Look Out!

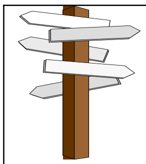
The proposed selection of recommended quality elements and parameters is intended as a guide only. Member States should use their own discretion based on local knowledge and expertise as to what specific sub-element or parameter will provide the best representation of catchment pressures for each quality element.

The key features of each quality element, their existing use in classification systems throughout the EU and their relevance to the Directive are summarised in Tables 3.1-3.12.



Quality Element Descriptions

An overview of the key issues for surface waters description of each of the Quality Elements and sub-elements identified in this chapter, and their relevance for each water body type are provided in Annex VI.



For further details on monitoring guidance for surface waters refer to the full contributions received from Member States:

- Rivers: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/rivers&vm=detailed&sb=Title
- Lakes: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/lakes&vm=detailed&sb=Title
- Transitional and coastal waters: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/transitional_coastal&vm=detailed&sb=Title

3.1 Selection of Quality Elements for Rivers

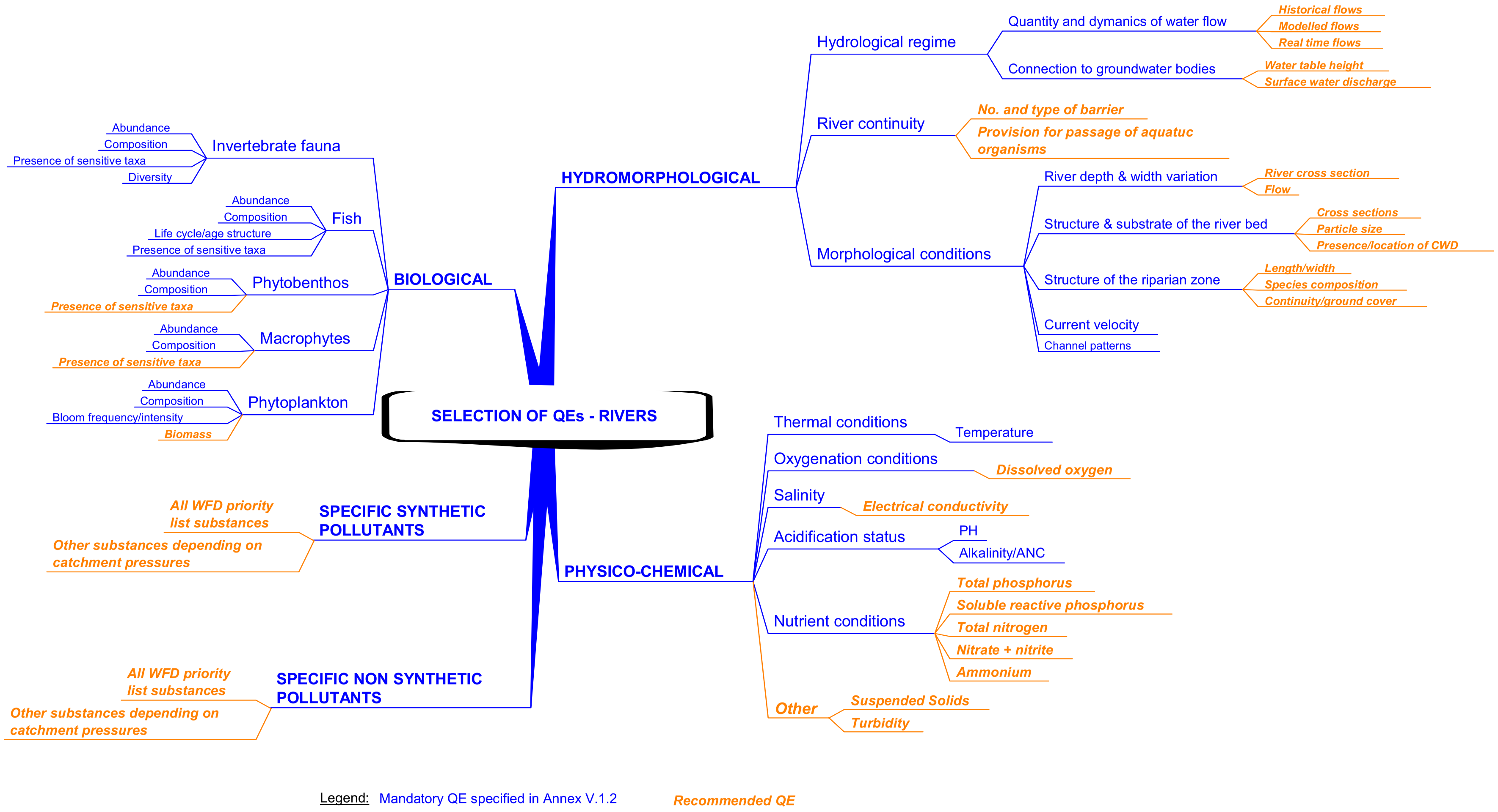


Figure 3.1 Selection of quality elements for rivers

Table 3.1 Key features of each biological quality element (QE) for rivers

Aspect/feature	Benthic invertebrates	Macrophytes	Benthic Algae	Fish	Phytoplankton
Measured parameters indicative of QE	Composition, abundance diversity, and presence of sensitive taxa.	Composition and abundance , and presence of sensitive taxa	Composition and abundance, , and presence of sensitive taxa	Composition and abundance, sensitive species diversity, age structure,	Composition, abundance and planktonic blooms, and presence of sensitive taxa
Supportive/interpretative parameters measured or sampled at the same time	Morphology, physico-chemical parameters (e.g. Temp/DO, nutrients, pH etc), river flow, substrate/habitat sampled	Morphology, river flow, depth, transparency	Substrate/habitat sampled, morphology, nutrients (N, P, Si), TOC, pH, hydrological regime, light conditions	Substrate/habitat sampled, river size (depth/width), river flow, temp, oxygen	Chlorophyll *a,* flow, physico-chemical parameters (e.g. temp, DO, N, P, Si)
Pressures to which QE responds	Mainly developed to detect organic pollution or acidity, can be modified to detect full range of impacts.	Mainly used to detect eutrophication, river dynamics including hydropower effects.	Mainly used as an indicator of productivity. Can be used to detect eutrophication, acidification, river dynamics.	Can be used to detect habitat and morphological changes, acidification and eutrophication.	Used as indicator of productivity/eutrophication.
Mobility of QE	Low, although unfavourable conditions may cause drift	Low. Generally fixed position.	Low	High. Tendency to avoid undesirable conditions (e.g. low oxygen conditions).	High. Drifting with river water
Level and sources of variability of QE	High seasonal variation in community structure. Influenced by climatic events e.g. rainfall/flooding	High seasonal variation in community structure and abundance.	High seasonal variation in community structure. Limited by light and nutrient availability and available substrate for colonisation. Influenced by climatic events	High seasonal variation in community structure (e.g. spawning/migration) and abundance. High interannual variation due to age structure.	High inter and intra-seasonal variation in community structure and biomass. Influenced by climatic events, light, nutrient availability, stability and residence time
Presence in rivers	Abundant	Abundant if suitable habitat. Limited in fast flowing streams.	Abundant if suitable habitat. Limited in large, deep rivers with poor habitat	Abundant	Generally low. May be abundant if conditions conducive to growth
Sampling methodology	ISO 8265, 7828, 9391 (surber sampler, handnet, grab)	CEN –standard under development	CEN –standard under development	Depending on habitats – nets, electrofisher	Integrated sample (3-4m), depth sampler
Habitats sampled	Riffle, pool (rocks/logs), edge (littoral), macrophytes,	Littoral, deposition areas (e.g. pools)	Benthic substrate/artificial substrate	All habitats	Water column
Typical sampling frequency	6 monthly/Annual	Annual/6 monthly	Quarterly/6 monthly	Annual	Monthly/Quarterly
Time of year of sampling	Summer and winter. Spring and autumn in Scandinavia.	Mid to late summer.	All seasons/summer and winter. Summer & autumn in Nordic countries.	Varied	Should cover all seasons. Only during ice free periods in Nordic countries.
Typical sample size	Variable depending on sampling methodology and habitat	Variable, may be standardised	Variable, may be standardised	Variable, may be standardised	Single integrated sample
Ease of sampling	Relatively simple. Difficulties in deep or fast flowing rivers.	Simple due to fixed position and general proximity to banks	Relatively simple. Difficulties in deep or fast flowing rivers. Observations and % cover	Requires specialised sampling equipment (e.g. electrofisher).	Simple using integrated hosepipe (or grab sample in shallow water)
Laboratory or field measurement	Field collection and sorting. Microscopic identification in laboratory	Field collection and identification	Field collection, microscopic identification in laboratory	Field collection, measurement and identification	Field collection, laboratory preparation followed by microscopic identification
Ease and level of Identification	Relatively simple to Genus. Requires expert identification to species level for some (e.g. chironomids). May be damaged during sampling/preservation	Simple to identify to species, except some genera (e.g. potamogeton)	Requires expert identification for majority of species (see phytoplankton)	Simple to identify to species, except some cyprinids which require expert knowledge	Requires expert identification of majority of genera and species. Some small unicellular species (e.g. unicellular greens) difficult to identify unless under high power microscopy

Aspect/feature	Benthic invertebrates	Macrophytes	Benthic Algae	Fish	Phytoplankton
Nature of reference for comparison of quality/samples/stations	Yes: UK, France, Germany, Austria, Denmark, Sweden, Norway	No but underway in some European institutions	No	Yes: UK (HABSCORE) and France.	No
Methodology consistent across EU?	No	No	No	No	No
Current use in biological monitoring or classification in EU	Austria, Belgium, Denmark, Finland, France, Spain, Germany, Italy, Ireland, Luxembourg, Portugal Netherlands, Sweden, Norway and the UK	Austria, Belgium, France, Germany, Ireland, Netherlands and the UK	Austria, Belgium, France, Germany, Ireland, Norway, Sweden, Finland, Spain, Netherlands and the UK	Austria, France, Belgium, Ireland, Norway and the UK	None
Current use of biotic indices/scores	Yes. UK (BMWP), France (IBGN), Germany (Saprobic), Austria (Saprobic), Spain (SBMWP), Belgium (BBI), Netherlands (K-value)	No but some indices under development/calibration (Austria)	Yes. Sweden (developing). Norway and Germany – Index of occurrence of sensitive taxa	Yes. UK (HABSCORE).	No
Existing monitoring system meets requirements of WFD?	No	No	No	No	No
ISO/CEN standards	ISO 7828:1985 ISO 9391:1993 ISO 8265: 1988	CEN-Standard under development	CEN-Standard under development	CEN-Standard under development	
Applicability to rivers	High	Moderate	High	High	Low-Moderate
Main advantages	• Currently most common biological indicator used for ecological classification. • Existing classification systems in place • Possibility of adapting existing systems to incorporate requirements of WFD. • Less variable than physico-chemical elements	• Easy to sample and identify. • Low interannual variability	• Easy to sample (in shallow water) • Some existing methods developed • Less variable than physico-chemical elements • Responds quickly to changes in environmental and anthropogenic conditions • Possibility of adapting existing systems to incorporate requirements of WFD.	• Existing river classification systems in place • Possibility of adapting existing classification systems to incorporate requirements of WFD.	• Easy to sample • May be relevant in rivers where residence times enough to sustain growth (e.g. lowland rivers, upstream of impoundments)

Aspect/feature	Benthic invertebrates	Macrophytes	Benthic Algae	Fish	Phytoplankton
Main disadvantages	• Methods require adaptation to meet requirements of WFD • Some require specialist expertise to identify to species • High substrate-related spatial variability and high temporal variability due to hatching of insects and variation of water flow • Time consuming and expensive • Presence of exotic species in some EU rivers.	• Not commonly used in EU • Lack of information for comparison to reference • Methodology needs to be adapted to incorporate requirements of WFD	• Not commonly used in EU • Lack in information for comparison to reference • Methodology needs to be adapted to incorporate requirements of WFD. • Difficult to sample in deep rivers • High substrate related spatial variability • High seasonal variation • Requires specialist expertise for species identification	• Requires specialist sampling equipment • High mobility • Horizontal and vertical distribution patters (differs between species)	• Not routinely used in river quality assessment in EU • Not generally present in flowing rivers • High variability requires frequent sampling • Difficult to establish dose-response relationships due to flow-related variability.
Conclusions/ Recommendations	This QE is best developed in EU and hence it is recommended as one of the key elements for monitoring especially for organic pollution.	Under certain hydrological conditions this QE is not suitable. However, in good conditions it can give a robust assessment.	Recommended, particularly for assessment of trophic status.	It is recommended as one of the key elements for monitoring for habitat and morphological changes. Further work required for assessing the impact of pollution on fish populations.	Only recommended for large, slow flowing rivers.

Table 3.2 Key features of each hydromorphological quality elements for rivers

Aspect/feature	Quantity and dynamics of water flow	Connection to groundwater bodies	River Continuity	River depth and width variation	Structure and substrate of the river bed	Structure of the riparian zone
Measured parameters indicative of QE	Historical flows, modelled flows, real-time flow, current velocity	Water table height, surface water discharge	No and type of barrier and associated provision for fish passage	River cross section, flow	Cross section, particle size, presence and location of CWD	Length, width, species present, continuity, ground cover
Pressures to which QE responds	Used to detect impact of water storage, abstraction and discharge on biota, hydropower regulation	Provides information on surface-groundwater relationship	Used to detect impact on upstream migration of fish	Used to detect impact on biota from changing flows and habitat availability	Determines impact on biota from changing habitat availability	Influences structure of banks, provides habitat and shading for biota, filters diffuse runoff
Level and sources of variability of QE	Highly variable depending on geographical and climatic conditions. Variations reduced as response to barriers	Moderate variability	Low variability. Based on presence/modification of infrastructure	Moderate variability. Influenced by hydropower regulation	Variable depending on particle size and flow (e.g. gravel/sand scour/sedimentation prevalent following high flows)	Variable. Possibility of physical clearing, accessibility from livestock, erosion etc
Sampling methodology	ISO standard for current velocity. No common methodology for dynamics	No common methodology	No common methodology	No common methodology	No common methodology	No common methodology
Typical sampling frequency	In-situ, real time	6 monthly, depending on climatology and geology	Every 5-6 years	Annual	Annual	Annual
Time of year of sampling	All year	Winter and summer	varied	varied	varied	varied
Typical "sample" size or survey area	Common standard for No of monitoring points in cross sections developed	Not defined	Entire reach	No common agreement	No common agreement	50m in headwaters 100m in middle and lower reaches
Ease of sampling /measurements	Simple using in-situ flow gauging stations in small rivers. Greater effort required for large rivers.	Simple. Measurement of groundwater height (boreholes) and river flow	Simple. Survey to determine location and type of structures and abstraction sites/volumes	Can be simple using observation and measurement or detailed using laser survey equipment	Simple following minimal training	Simple following minimal training. Collection and laboratory identification of species may be required
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality	No	No	No	No	No	No
Methodology consistent across EU?	No	No	No	No	No	No
Current use in monitoring programmes or for classification in EU	Yes. Belgium, France, Sweden, UK, Finland and Norway	Yes. Belgium, UK	Yes. Belgium, Germany, France	Yes. Belgium, Germany, France, UK and Norway	Yes. Belgium, Germany, France, UK and Norway	Yes. Belgium, Germany, France, Italy , UK
Existing monitoring systems meet requirements of WFD?						

Aspect/feature	Quantity and dynamics of water flow	Connection to groundwater bodies	River Continuity	River depth and width variation	Structure and substrate of the river bed	Structure of the riparian zone
Existing classification systems meet requirements of WFD?	No	No	No	No	No	No
ISO/CEN standards	ISO/TC 113 CEN?TC 318 under development	No	No	No	No	No
Applicability to rivers	High	High	High	High	High	High
Main Advantages	• Possibility of adapting existing systems to incorporate requirements of WFD.	•	• Methodology needs to be developed to incorporate requirements of WFD.	• Methodology needs to be developed to incorporate requirements of WFD.	•	•
Main disadvantages	• Not commonly used	• Not commonly used	• Not commonly used	• Not commonly used	• Not commonly used	• Not commonly used
Conclusions/ recommendations	Simple to monitor. Key supporting parameter for interpretation	Can not be commonly used. Only relevant under certain conditions when groundwater plays a major role in water balance. Methodology must be elaborated.	Very relevant for some species. One extensive survey is sufficient – supplied when necessary	Not applicable for all rivers such as rivers with high natural variation. Methodology needs further elaboration	Essential for interpreting the biological quality elements and possibility of sediment accumulation	Applicability depends on the shape, size etc. of the riparian zone. Methodology must be further elaborated

Table 3.3 Key features of each chemical and physico-chemical quality element for rivers

Aspect/feature	Thermal Conditions	Oxygenation Conditions	Salinity	Acidification Status	Nutrients
Measured parameters indicative of QE	Temperature	Dissolved oxygen (mg/L and % sat)	Conductivity, ca concentration	pH, ANC, Alkalinity	TP, TN, SRP, NO_3 + NO_2, NH_4
Pressures to which QE responds	Inflows, water releases, industrial discharges	Organic pollution, industrial discharges	Agricultural runoff, industrial discharges	Industrial discharges, acid rain	Agricultural, domestic and industrial discharges
Level and sources of variability of QE	Variable. Influence d by climatic conditions	Moderate. Diel changes due to respiration. Lower variation in fast flowing rivers.	Low variability although influenced by water flow	Variable depending on buffer capacity, water flow etc	Variable depending on landuse, buffer capacity, temp/DO, presence of binding metals etc
Monitoring considerations	Seasonal stratification and mixing (in deep water), cold water releases	Diel/diurnal variations	Seasonal stratification and mixing in deep waters	Seasonal variations	Sources (diffuse/point), sufficient speciation to enable source discrimination
Sampling methodology	In-situ using submersible probe	In-situ using submersible probe, or sample collection and Winklers titration	In-situ using submersible probe	In-situ using submersible probe, sample collection	Sample collection in field followed by laboratory analysis
Typical sampling frequency	Fortnightly-monthly	Fortnightly-monthly	Fortnightly-monthly	Fortnightly-monthly	Fortnightly-monthly. More frequently during flooding.
Time of year of sampling	All seasons.	All seasons	All seasons	All seasons. Special attention when sea salt or snow melt episodes.	All seasons. Particularly following inflow events. Not during ice cover.
Typical "sample" size	Single measurement or water column profile	Single measurement or water column profile	Single measurement	Single measurement	Single sample, or profile in deep waters
Ease of sampling /measurements	Simple using in-situ submersible probe	Simple using in-situ submersible probe, or sample collection followed by Winklers titration	Simple using in-situ submersible probe	Simple using in-situ submersible probe. Sample collection followed by laboratory analysis	Simple. Surface water sample or profile using depth sampler (e.g. van dorn)
Methodology consistent across EU?	No	No	No	No	No
Current use in monitoring programmes or for classification in EU	All	All	All	All	All
Existing monitoring systems meet requirements of WFD?	Yes	Yes	Yes	Yes	Yes
Existing classification system meets requirements of WFD?	No	No	No	No	No
ISO/CEN standards	Yes	Yes	Yes	Yes	Yes
Applicability to rivers	Moderate. Stratification may be present in deep, slow flowing rivers. Can help detect thermal pollution.	Moderate. Oxygen depletion may be present in deep, slow flowing rivers or upstream of impoundments	High	Low. Problem in stagnant waters.	High

Aspect/feature	Thermal Conditions	Oxygenation Conditions	Salinity	Acidification Status	Nutrients
Main advantages	• Simple to sample in-situ • Able to implement standard methodology	• Simple to sample in-situ • Able to implement standard methodology	• Simple to sample in-situ • Able to implement standard methodology	• Simple to sample in-situ • Able to implement standard methodology	• Can provide information as to pollutant sources • Simple to sample in-situ • Able to implement standard methodology
Main disadvantages	• Does not provide long-term indication	• Diel variations may require frequent monitoring • Does not provide long-term indication	• Does not provide long-term indication	• Does not provide long-term indication • May require intensive monitoring following rainfall events	• Does not provide long-term indication • May require intensive monitoring following rainfall events
Recommendations	Basic determinand for assessment of biocenosis.	Basic determinand for assessment of biocenosis.	Recommended in rivers in semi-arid climate and/or with high salinity.	Recommended in rivers with risk of acidification	Very important indicator for human activity/ eutrophication. Total N and P, nitrate and orthophosphate should be monitored as a minimum. Ammonia monitored where concentrations are expected to be problematic e.g. exceedences of limit values over a specific limit.

3.2 Selection of Quality Elements for Lakes

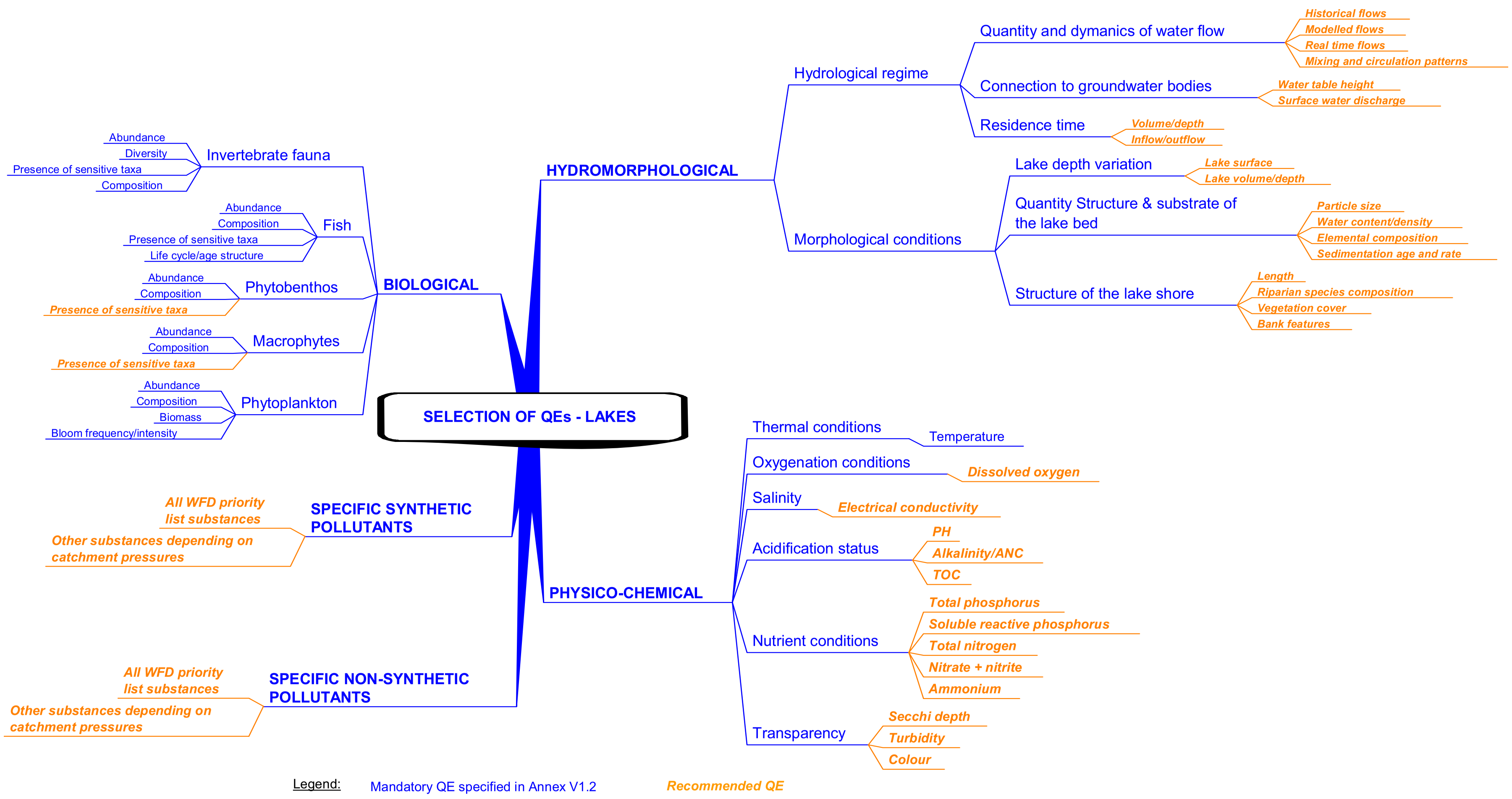


Figure 3.2 Selection of quality elements for lakes

Table 3.4 Key features of each biological quality element (QE) for lakes

Aspect/feature	Phytoplankton	Macrophytes	Phytobenthos	Benthic invertebrates	Fish
Measured parameters indicative of QE	Composition, abundance biomass (Chla), blooms	Composition and abundance	Composition and abundance	Composition, abundance, diversity and sensitive taxa	Composition, abundance, sensitive species and age structure
Supportive/interpretative parameters often/typically measured or sampled at the same time	Nutrient concentrations (total/soluble), chlorophyll, DO, POC, TOC, pH, alkalinity, temperature, transparency, Fluorometric in-situ monitoring	Nutrient concentrations (total/soluble) in lake water, sediment and pore water, substrate type, pH, alkalinity, conductivity, transparency, Secchi disc, ca concentration	Nutrient concentrations (total/soluble) in lake water, sediment and pore water, substrate type, pH, alkalinity, conductivity, transparency, Secchi disc, ca concentration	Nutrient concentrations (total/soluble), DO, pH, alkalinity, sediment analysis, toxicity bioassays	Nutrient concentrations (total/soluble), DO, pH, alkalinity, temperature, toxicity bioassays, trophic condition, Zooplankton dynamics, ANC, TOC
Pressures to which QE responds	Eutrophication, organic pollution, acidification, toxic contamination	Eutrophication, acidification, toxic contamination, siltation, river regulation, lake water level, introduction of exotic species	Eutrophication, acidification, toxic contamination, siltation, river regulation, lake water level, introduction of exotic species	Eutrophication, organic pollution, acidification, toxic contamination, siltation, river regulation, hydro-morphological alteration (littoral)	Eutrophication, acidification, toxic contamination, fisheries, hydro-morphological alteration, Introduction of exotic species
Mobility of QE	Medium	non-mobile	non-mobile	Low to Medium, high when hatching	High
Level and sources of variability of QE	High inter and intra seasonal variation in community structure and biomass Medium to high spatial variability	Medium-high seasonal variability in community structure and biomass High spatial variability	Medium-high seasonal variability in community structure and biomass, Low interannual variability High spatial variability	Medium-high seasonal variability in community structure and biomass High spatial variability	High spatial and seasonal variability Populations clumped in respect to habitat variables
Presence in lakes	Abundant	Abundant, rare in reservoirs	Abundant, rare in reservoirs	Abundant	Abundant
Sampling methodology	Integrated or discrete samples in the water column 1-5 sites per lake A number of sampling gears are commonly used such as hand-held bottles or flexible hose	Aerial photography or/and transect sampling perpendicular to the shore line	In-situ observations of occurrence of natural substrate in littoral zone and/or among macrophyte beds and scraping of sub-strata	Qualitative or semi-quantitative hand net or kick-sampling; Ekman grab or core sampling Gear type depends on type of substrate, e.g. submerged aquatic vegetation – dip net; sand and clay - Peterson, Van Veen grabs; mud – Ponar, Ekman grabs	Electrofishing Net captures, several types (e.g. gill nets, trammel net) Trawls Acoustic
Habitats sampled	Water column (i.e. epilimnion, euphotic zone, metalimnion)	Macrophytes: littoral zone	benthic substrata/ artificial substrata	Littoral, sub-littoral and profundal	Littoral, open waters
Typical sampling frequency	Monthly/ quarterly In Nordic countries 6 times/summer	Yearly (late summer in Nordic countries), in natural lakes every 3-6 years	Varied from several times during the growing season to once a year	Yearly, in natural lakes every 3-6 years Twice yearly in littoral	Depend upon water body physical characteristics and objective, yearly
Time of year of sampling	All seasons, at least twice a year during spring overturn and summer stratification In Nordic countries no sampling during ice coverage. More stations required if high spatial variation.	Late summer, decided through expert judgement	Quarterly/ 6 monthly/ several times during the growing season In Nordic countries no sampling during ice coverage	Early spring and late summer	Late Spring through to early Autumn

Aspect/feature	Phytoplankton	Macrophytes	Phytobenthos	Benthic invertebrates	Fish
Typical sample effort	Often 1 station located in the centre of the lake	3-10 transects per lake with 2-3 quadrats on each transect should be sufficient for the majority of the lakes	Lake wide, 3-10 transects, littoral to sub-littoral	Lakewide composite samples of 2/ 3 grabs at each of 3-5 sub-littoral sites (7-15 grabs total	Dependent on type of sampling gear: For electrofishing multiple habitats are selected in littoral areas based on the substrate and cover. CEN-standard in preparation In shallow lakes fish can be sampled with multimesh gillnets and random sampling. Sampling time 10-12 h overnight. Time less in small lakes and those where fish densities are high. In deeper lakes stratification related to depth zones is recommended. CEN standard under development
Ease of sampling	Relatively simple	Variable, requires specialised sampling equipment and relatively specialised personal with diving qualifications Alternative methods can be used such as drop cameras/ROV/Rakes.	Relatively simple, some difficulty in deep lakes, boat required and expert knowledge of potential hazards in specific lakes	Relatively simple, some difficulty in deep lakes, boat required and expert knowledge of potential hazards in specific lakes	Difficult, requires specialised sampling equipment
Laboratory or field measurement	Laboratory sample preparation followed by identification, counting and biomass determination under microscopy. Algal toxin determinations in laboratory, chla.	Field measurements through aerial photography; samples from transects, laboratory identification to species; analysis of chl-a content, fresh, dry and ash free dry biomass (AFDM), organic content		Sample processing in the laboratory, at least 100 organisms per sub-sample (if possible) are identified to the appropriated taxonomic level frequently to species	Sampling duration and area or distance sampled are recorded in order to determine the level of effort. In the laboratory the specimens are identified to species, enumerated, measured, weighted and examined for the incidence of external abnormalities
Ease and level of Identification	Relatively simple for measures based on high taxonomic levels (e.g. family), difficult for identification to lower taxonomic levels (i.e. genus and species) Biomass evaluation is difficult	Identification to species relatively easy with exception of vegetative stages of certain genera (e.g. Potamogeton)	Identification to species relatively easy for high taxonomic groups (e.g. family), difficult for genus or species. Biomass evaluation difficult.	Relatively simple for measures based on high taxonomic levels, difficult for identification to lower taxonomic levels (i.e. species)	Relatively easy, some difficulties may appear with rare specimens and early fry
Nature of reference for comparison of quality/samples/stations	Estimates of phytoplankton indicators/ indices (e.g. cell density, biovolume) to be expected in the absence of significant anthropogenic pressures	Reference values refer to typical indicator values (TRS) and species diversity of flora in lakes not significantly affected by human activities	Little knowledge of reference conditions for phytobenthos in lakes. No established methodology	Reference values for the diversity, abundance and distribution indices indicate expected conditions if the lakes are not significantly affected by human activities. References set using the 25 percentile of sites considered unimpaired-Sweden.	Difficult to determine because only impacts of the physico-chemical and hydromorphological pressures are to be addressed not fisheries/ stocking/ species introductions

Aspect/feature	Phytoplankton	Macrophytes	Phytobenthos	Benthic invertebrates	Fish
Methodology consistent across EU?	No	No	No	No	No
Current use in biological monitoring or classification in EU	Denmark, Finland, Ireland, Netherlands, Sweden, UK and Norway	Denmark, Netherlands, Sweden, UK for conservation and Norway	No	Finland, Netherlands, Sweden and Norway	Finland, Netherlands, Sweden and Norway
Current use of biotic indicators and indices/scores	Taxonomic analyses (e.g. diversity indices, taxa richness, indicators species) Phytoplankton total volume, presence of spring diatom blooms, occurrence of harmful algae, number and proportion of toxin- producing cyanobacteria (blue-greens)	Trophic Ranking Score (TRS), species with low TRS values occur primarily in waters poor in nutrients, while high values are associated with eutrophic waters); level of diversity. Relative occurrence of functional groups. Macrophyte Trophic Index (TIM)	No	Shannon's diversity index (measure of variation and dominance within animal communities); ASPT index (Average Score Per Taxa, related to the occurrence of sensitive (high index value) and tolerant (low value) species); Danish fauna index (evaluation of the effects of eutrophication and organic pollution in the exposed littoral zone of lakes); Benthic Quality Index (BQI, to evaluate eutrophication and organic pollution in the deep bottom areas); O/C Index (complementary or alternative to BQI); acidity index (reflects the presence of species with varying pH tolerances)	Index of Biotic Integrity (IBI) incorporates measurements of fish assemblage composition and relative abundance; % of piscivore/ zooplanktivore (a surrogate for age structure of fish community); % of invertevore/ omnivore
Existing monitoring system meets requirements of WFD?	No	No	No	No	No
ISO/CEN standards	Under development	Under development	Under development	Under development	Under development
Applicability to lakes	High	High (very low in reservoirs)	High (moderate in reservoirs, depending on water management)	Moderate	High (moderate to low in reservoirs).
Main advantages	• Easy to sample • Relevant for water quality and trophic state • Used in many countries to evaluate eutrophication • Easy to standardise	• Easy to sample and identify (especially in shallow water) • Good indicator of a broad range of impacts, especially eutrophication and siltation	• Easy to identify to family level • Good indicator of eutrophication	• Easy to sample (particularly in shallow waters) • Relatively simple to analyse • Some existing methods developed • Combines chemical and biological features	• Possibility of adapting classification systems to incorporate requirements of WFD

Aspect/feature	Phytoplankton	Macrophytes	Phytobenthos	Benthic invertebrates	Fish
Main disadvantages	• Requires taxonomic expertise for species identification; • High temporal variability requires frequent sampling • Vertical and horizontal sample profiles required due to spatial heterogeneity	• Difficult to sample in deep waters • Not commonly used in EU • Lack of information for comparison to reference • Methodology needs to be developed to incorporate requirements of WFD	• No standard methods • Lack of information for comparison to reference conditions • Not commonly used in EU • Methodology needs to be developed to incorporate requirements of WFD	• Not commonly used in EU • Lack of information for comparison to reference • Methodology needs to be developed to incorporate requirements of WFD • Time consuming and expensive to analyse	• Requires specialised sampling equipment • Methodology needs to be developed to incorporate requirements of WFD
Conclusions/ recommendations	Responds rapidly to changes in phosphorus concentration levels. Identification to order or genus are suitable/ recommended levels for monitoring phytoplankton taxonomic composition. While at present it is not clear that identification to species represents a substantial improvement of the information value of the data. More work required in this area.	Key parameter for evaluating other biological components in lakes. Macrophytes hold an important role in the metabolism of lakes. However their monitoring is not frequently used in the assessment of ecological quality.	The phytobenthos holds an important role in the metabolism of lakes. However there is very little experience and information on the use of phytobenthos. Further work is required in this area.	Important parameter for evaluating other biological components. Their use is at an early stage of development. It is required to develop meaningful methodologies. The drafting of a suitable guideline is the part of method development of CEN. The CEN group recommends that the identification of benthic invertebrate fauna should be carried out to the species level.	Key biological quality element. Can be difficult to interpret (fishery, biomanipulation etc.) Integrate all anthropogenic and natural impacts. The composition, abundance and structure of fish communities can be very useful indicators of ecological quality. Fish are only included in monitoring systems of very few EU member states

Table 3.5 Key features of each hydromorphological quality element for lakes

Aspect/feature	Quantity and dynamics of water flow	Residence time	Connection to the groundwater body	Lake depth variation (water level variation)	Quantity, structure and substrate of lake bed	Structure of lake shore
Measured parameters indicative of QE	Inflow and outflow rates. Water level, spillway and bottom outlets discharges (reservoirs), mixing and circulation patterns	volume, depth, inflow and outflow	Lake surface, lake volume	Lake surface, lake volume, lake depth	Grain size, water content, density, LOI, elemental composition, sedimentation rate, sediment age (Cs 137), microfossils in paleolimnological studies	Length, riparian vegetation cover, species present, bank features and composition
Pressures to which QE responds	Climate variability, flood control, man made activities	Climate variability, man made activities	Climate variability, man made activities	Climate variability, siltation, water use, flow discharges	Siltation	Man-made modifications, erosion, run-off Water level fluctuations in reservoirs
Level and sources of variability of QE	Med variability	Low but may vary under extreme climatic conditions	High variability	Generally low variability, high variability in reservoirs (epilimnetic/ hypolimnetic discharges)	Highly variable, dependent on spread patterns and pollution by historical development	Variable
Sampling methodology	Water level gauge, flow meters, and current meters. In situ using scales or submersible probes associated or not to teletransmission	Echo sounding necessary for depth-volume curves, hypsographic curves	Depth-volume curves, hypsographic curves. Water level gauge.	Sonar device (echosounder), phathometer, Transect methodology with metered sounding poles	Core and grab samplers depending on study objectives 3 main sampling types may be distinguished: deterministic, stochastic and regular grid systems	Transects, aerial photography, planimetry
Typical sampling frequency	Weekly/monthly. Hourly/daily (reservoirs)	Every 5/ 10 year, or less frequently if no changes are suspected. Once per year for reservoirs.	variable	Natural lakes: every 15 yr. Reservoirs: variable	Mostly once a year, or less frequently if no changes expected (reference conditions), in polluted lakes every 3rd to 5th year	Every 6 years
Time of year of sampling	All seasons	All seasons, not during ice cover	All seasons	Reservoirs: generally during operational functioning, spring/ begin fall	Usually winter (from ice in Nordic countries)/ summer	Varied. Spring/summer during growing period
Typical "sample" size or survey area	Inflowing/outflowing waters; gauging stations	Entire lake	Entire lake	Entire lake	Varied depending on study objective	Entire lake shore habitat
Ease of sampling /measurements	Simple following minimal practical training	Easy for theoretical residence time estimation Difficult for the evaluation of effective residence time	difficult	Relatively easy following minimal training	Relatively easy following minimal practical training	
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality	Historical data	Historical data	Historical data	Historical data	Paleolimnology/ sediment core studies	Historical data
Methodology consistent across EU?	Yes, according to other countries practices	No	No	No	No	No

Aspect/feature	**Quantity and dynamics of water flow**	**Residence time**	**Connection to the groundwater body**	**Lake depth variation (water level variation)**	**Quantity, structure and substrate of lake bed**	**Structure of lake shore**
Current use in monitoring programmes or for classification in EU	No/yes (reservoirs)	No	No	No, France, UK, Spain	No	No
Existing monitoring systems meet requirements of WFD?	no	No	No	No	No	No
Existing classification systems meet requirements of WFD?	no	No	No	No	No	No
ISO/CEN standards	Yes, refer to ISO/TC 113, CEN/TC 318	No	No	No	No	No
Applicability to lakes	high	High	High	High	High	High
Main Advantages	• Hydrological measurements are essential for the interpretation of water quality data and for water resource management	• Lake hydrology forms the basis for water quality assessment; • Water residence time influences nutrient retention and development of anoxia in deep, stratified water bodies	• Lake hydrology forms the basis for water quality assessment.	• Water level fluctuation has a direct impact on littoral aquatic life • Lake basin morphology influences lake hydrodynamics and sensitivity to nutrient loading	• Can be regarded as environmental tachometers. The paleolimnological study is often the only tool to gather knowledge of past reference conditions. • The contaminants accumulate often in sediments, the contents are high and the sampling frequency may be quite low.	• Indicators in protection of biological integrity
Main disadvantages	Time consuming and costly	Time consuming and costly	Time consuming and costly	Accurate Hydrographic maps of lakes are rarely available in sufficient detail for ecological analysis even if bathymetric maps are available their accuracy should be checked carefully *	Paleolimnological examinations are often relative expensive and the result depends on the undisturbed state of the sedimental archive. The preservation of microfossils may vary.	Methodology needs to be developed to incorporate requirements of the WFD

Aspect/feature	Quantity and dynamics of water flow	Residence time	Connection to the groundwater body	Lake depth variation (water level variation)	Quantity, structure and substrate of lake bed	Structure of lake shore
Conclusions/ recommendations	Important for calculating mass balances etc. A basic element for use with other relevant parameters	Important for characterising and assessing lake quality data.	Only relevant where groundwater constitutes a major part of the lake water balance. Methodology needs further development	Only relevant where it is of ecological significance. Important consideration in the design of monitoring programmes. Very important in reservoirs. As a supporting elements the measurement of depth over time and space are both important. Thus recommended that both are used.	Not generally used in monitoring programmes. Exchange processes between sediment and water are important in determining the quality of many lakes.	Necessary for interpretation of biological parameters (e.g. macrophytes, some fish species) especially for shallow lakes or lakes with an extensive shallow littoral zone.

Only limited monitoring of hydrological features is currently included in existing classification systems in Europe
With the exception of lake depth variation, monitoring for morphological features is not included in any existing classification system in the EU

Table 3.6 Key features of each chemical and physico-chemical quality element for lakes

Aspect/feature	Transparency	Thermal Conditions	Oxygenation Conditions	Salinity	Acidification	Nutrients
Measured parameters indicative of QE	Secchi depth, turbidity, colour, TSS	Temperature	DO, TOC, BOD, COD DOC	Conductivity	Alkalinity, pH, ANC	Total P, SRP, Total N, N-NO3, N-NO2, N-NH4
Relevance of quality element	Eutrophication, acidification	Hydrological cycle, biological activity	Production, respiration, mineralisation		Buffering capacity, sensitivity to acidification	Eutrophication
Pressures to which QE responds	Agricultural, domestic and industrial discharges	Thermal discharges. Water management in reservoirs.	Eutrophication, organic pollution, industrial discharges	Industrial discharges, run-off	Acid rain, industrial discharges	Agricultural, domestic and industrial discharges
Level and sources of variability of QE	High, influenced by allocthonous and autocthonous material	High, influenced by climate conditions, topography, morphology and waterbody dimensions	Variable, diel changes due to respiration/ photosynthesis	Low-medium, influenced by climatic events	Low-medium, influenced by climatic events	Low-medium, influenced by climatic events
Monitoring considerations	Seasonal variation	Seasonal variation (mixing and stratification)	Diel variation High gradient in stratified lakes	Seasonal variation	Seasonal variation	Sufficient speciation to enable discrimination (point and diffuse)
Sampling methodology	*In situ* using Secchi disc TSS: field sample collection followed by laboratory analysis Turbidity: *in situ* turbidimeters, nephelometers Colour: *in situ* comparison to Forel-Ule scale or in lab.	*In situ* using thermistor probes or reversing type Hg thermometer	On-line data acquisition; *in situ* submersible probes; field sample collection followed by laboratory Winkler titration	*In situ* using submersible probes	*In situ* measurement of pH with probe. Sample collection followed by laboratory analysis	Sample collection in the field followed by laboratory analysis
Typical sampling frequency	Monthly/ quarterly related to the biological elements sampling periodicity. Fortnightly of monthly during growth season in Nordic countries.	Monthly/ quarterly	Depends on morphological characteristics of lake: daily/monthly, or at the end of stratification periods (late winter if ice cover or late summer.	Monthly/ quarterly. Should be measured during snow melt or heavy rainfall events	Monthly/ quarterly. Should be measured during snow melt or heavy rainfall events	Monthly/ quarterly Fortnightly of monthly during growth season in Nordic countries.
Time of year of sampling	All seasons.	All seasons	All seasons	All seasons	All seasons	All seasons, or mainly during growth season, SRP also measured during late winter in bottom waters
Typical "sample" size	In-situ observations. Sample collections for chemical analyses (turb, TSS)	Water column profile	Single measurements, water column profiles. 100mL for Winkler titration	In-situ water column profile, integrated epilimnion or single sample from outlet (depending on monitoring purpose)	Single sample from outlet of lake or water column profile	integrated epilimnion, single samples or water column profile (100-500mL)
Ease of sampling /measurements	Simple , using *in situ* probes or surface water sample	Simple, using *in situ* probes or water samplers	Simple, using *in situ* submersible probes or sample collection followed by titration	Simple, using *in situ* probe	Simple	Relatively easy, depth sampler need for deep lakes

Aspect/feature	Transparency	Thermal Conditions	Oxygenation Conditions	Salinity	Acidification	Nutrients
Basis of any comparison of results/quality/statio ns e.g. reference conditions/best quality	Historical data or data from comparable pristine lakes	Historical data or data from comparable pristine lakes	Historical data or data from comparable pristine lakes	Historical data or data from comparable pristine lakes	Historical data or data from comparable pristine lakes	Statistical methods: MEI index for total phosphorus Historical data or data from comparable pristine lakes
Methodology consistent across EU?	No	No	No	No	No	No
Current use in monitoring programmes or for classification in EU	Yes	Finland, France, Italy, Norway	Finland, France, Italy, Norway Sweden	Finland, Belgium, France, Italy	Belgium, Finland, France, Italy, Norway, Sweden, UK	Germany, Spain, Finland, France, Italy, Ireland, Netherlands, Norway, Sweden, UK
Existing monitoring systems meet requirements of WFD?	No	No	No	No	No	No
Existing classification system meets requirements of WFD?	No	No	No	No	No	No
ISO/CEN standards	No	No	ISO 5813:1983 DO ISO 5815:1989 BOD_5	Yes	Yes, no standard for ANC	Yes, several ISO standards exist
Applicability to lakes	high	High	High	Moderate	High	High
Main advantages	• Simple to sample • It is possible the most universally used parameter in limnology: it is a simple and powerful tool for tracking long-term trends	• Simple to measure • Fundamental to understand the hydrological cycle and lake ecology	• Simple to sample and to measure • Extremely useful because it can act as an integrator of the lake health	• Simple to measure • Conductivity is little influenced by anthropogenic inputs. A good correlation was found with the MEI cond and P concentration allowing the determination of natural background (reference) concentrations for P	• Simple to measure • Provides long term trends in acidification • Alkalinity is little influenced by anthropogenic inputs(except in acidified and limed lakes). A good correlation was found with the MEI alk and P concentration allowing the determination of natural background (reference) concentrations for P	• Provide information and long-term information on the trophic state
Main disadvantages	• No disadvantages	• May require intensive monitoring for appropriate description of thermal conditions	• May require intensive monitoring following depletion events in stratified lakes	• Does not provide long term information on trends	• None	• Need for standardisation of analytical techniques

Aspect/feature	Transparency	Thermal Conditions	Oxygenation Conditions	Salinity	Acidification	Nutrients
Conclusions/ recommendations	Easy to monitor. Secchi disc is widely used in limnology for assessing the biological condition of lakes. However, in humic lakes Secchi disc is not useful for assessment of eutrophication..	Important supporting parameter for interpreting ecological conditions. Seasonal variation, variation with depth and in large lakes horizontal variation should be monitored.	Recommended, and particularly important in deep/stratified lakes and lakes with ice cover.	Important for at characterisation of a lake. For example, it gives an indication of lake mixing processes and of metabolic activity of the lake.	Important for lake characterisation. Acidity is important because it governs the chemical form which metals occur in water body. Alkalinity and Its related variables, pH and conductivity are important classification parameters	Very important indicator for human activity/eutrophication. Total N and P, nitrate and orthophosphate should be monitored as a minimum. Ammonia monitored where concentrations are expected to be problematic e.g. exceedences of limit values over a specific limit. Phosphorus is most often considered to be the nutrient that determines algal production in lakes Thus the focus is mainly on P with regards to lake eutrophication. Nutrients should be monitored not only in water but also in sediments where sediment water interchange processes are expected to be important

3.3 Selection of Quality Elements for Transitional Waters

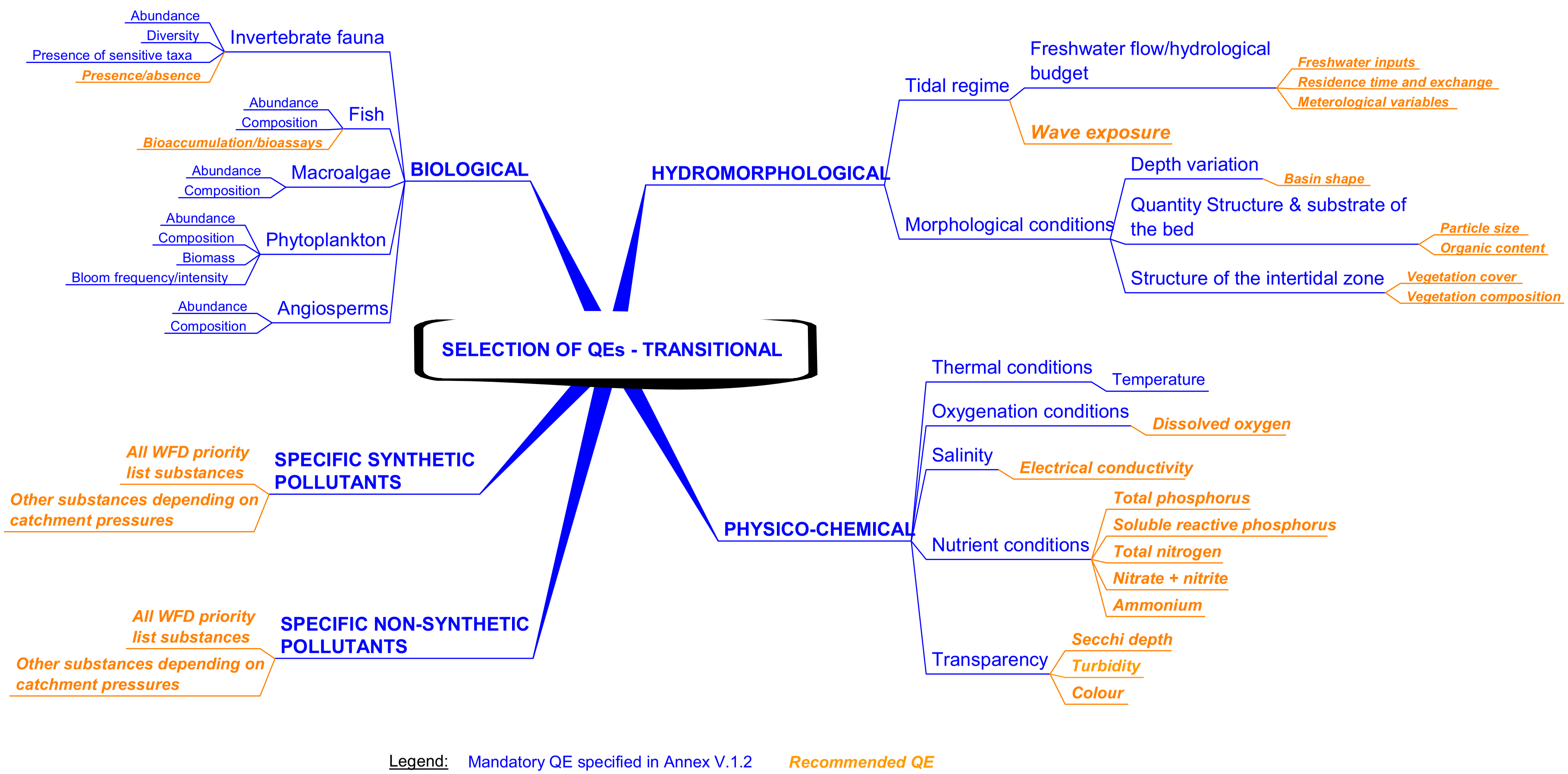


Figure 3.3 Selection of quality elements for transitional waters

Table 3.7. Key features of each biological quality element for transitional waters

Aspect/feature	Phytoplankton	Macroalgae	Angiosperms	Benthic invertebrate fauna	Fish fauna
Measured parameters indicative of QE	Composition, abundance, biomass (biomass as Chl. a), blooms.	Composition, abundance and cover	Composition and abundance	Diversity, abundance and sensitive taxa	Composition, abundance [37], sensitive species.
Supportive/interpretative parameters measured or sampled at the same time (optional parameters)	Transparency, currents, clorophyll "a", Physics-chemical parameters (e.g. temperature, salinity, oxygen, nutrients) Metereological factors Seston	Biomass, density, depth distribu-tion. Physic-chemical (temperature, salinity, nutrients, light/transpa-rency, waves, tides) Sediment and nature of substratum Metereological factors Seston	Biomass, density, depth distribution Physic-chemical (temperature, salinity, nutrients, light/transparency, waves, tides) Sediment and nature of substratum Meteoreological factors Seston	Biomass Characteristics of the habitat (topographic complexity, nature of the substratum, redox, organic matter, etc.) Physico-chemical parameters	Dissolved oxygen, salinity, temperature, pH, tide. Fish biometry and body condition.
Pressures to which QE responds	Environmental pressures such as water temperature, salinity and others have strong influence on phytoplankton composition and abundance; eutrophication; Other impacts affecting nutrient loading	Nitrogen and phosphorus loadings Human exploitation from fishery, aquaculture, tourism, power plants River/land use changes	Nitrogen and phosphorus loadings Human exploitation from fishery, aquaculture, tourism, power plants River/land use changes	Many types of anthropogenic disturbances (i.e. eutrophication, organic pollution and mechanical pollution or sediment disturbance)	Can be used to detect impacts like dams, water regulation measures, lack of natural habitats like rubble beds for spawning etc.
Mobility of QE	Moderate-high at the small scale at which the dynamic processes mainly occur	Low	Low	Low (sessile/semisessile species) to moderate/high (meroplanctic larvae, migratory gammarid species)	Very high (also, transitional waters are transient habitats of migrating species)
Level and sources of variability of QE	Highly variable on a short term temporal scale (i.e., hours-days) affected by : - trophic conditions - phisico-chemical features - hydrodynamics	High to intermediate variability due to: - chemical-physical and biological variables - hydrodynamics and meteo conditions - anthropogenic impacts	Intermediate to low variability due to: - chemical-physical and biological variables - hydrodynamics and meteo conditions - anthropogenic impacts	Highly variable on spatial and temporal scales caused by both natural and anthropogenic processes (i.e., seasonality, trophic conditions, chemical stress, land use, substrate features)	High seasonal variation. Anthropogenic and natural impacts determine changes/absences of species
Presence in transitional waters	Yes	Yes	Yes	Yes	Yes

[37] *Contaminant bioaccumulation and bioassays are not required for monitoring of ecological quality, only composition and abundance of fish fauna required; only relevant for chemical status if Quality Standards are set for transitional water fish*

Aspect/feature	Phytoplankton	Macroalgae	Angiosperms	Benthic invertebrate fauna	Fish fauna
Sampling methodology	Water sampling	Destructive: bottom sampler(hand corer , benthic grabs, etc.) Non-destructive (counts in quadrats or photographic/video methods, including aerial photography for larger species)	Destructive: bottom sampler(hand corer, benthic grabs, etc.) Non-destructive (counts in quadrats or photographic/video methods, including aerial photography)	Destructive: bottom sampler(hand corer, Van Veen grabs, etc.); use 500 micron sieve instead of or together with 1 mm sieve Non-destructive (counts in quadrats or photographic method) Litter bag or leaf pack techniques (in brackish transitional waters?), artificial substrates Use expert knowledge and pilot studies to determine best regional/type-specific sampling design Remote video techniques (ROV, towed sledge) where appropriate Acoustic methods for biogenic structures from a small boat	Fish-Net sampling (stationary: stake net fishery covering full tidal cycle; supported by trap/fixed net fishing and bottom trawls; mesh 8 mm at cod end) Use expert knowledge and pilot studies to determine best regional/type-specific sampling design
Habitats sampled	Water column	Hard and soft bottom	Hard and soft bottom	Hard and soft bottom in eulittoral and sublittoral zone	All main habitats in transitional waters
Typical sampling frequency	Seasonal sampling Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	Seasonally preferable At least twice per year (max/min cover) Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	Seasonally preferable Once or twice per year (max/min cover) Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	Preferable every three months At least twice per year Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	Twice per year Use expert knowledge and pilot studies to determine best regional/type-specific sampling design
Time of year of sampling		Seasonally preferable At least twice per year (max/min cover) Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	Seasonally preferable At least once per year at max cover Use expert knowledge and pilot studies to determine best regional/type-specific sampling design	During peak growth period; sampling in spring and autumn with several days of sampling each to find growth peak As recommended in OSPAR/HELCOM/ICES guidelines	. Spring and autumn; cover full tidal cycle

Aspect/feature	Phytoplankton	Macroalgae	Angiosperms	Benthic invertebrate fauna	Fish fauna
Typical sample size	50-250 ml of water	50x50 cm		0.1 m^2 for soft bottom; for hard bottom use standard sampling time of 20-30 minutes	. [38]
Ease of sampling	Easy	Intermediate to low	Intermediate to low	Intermediate	Intermediate
Laboratory or field measurement	Field collection, laboratory preparation followed by microscopic identification and photo/video documentation	Field collection, laboratory preparation and identification, photo/video documentation, and storage of type material	Field collection, laboratory preparation and identification, photo/video documentation and storage of type material	Field collection, laboratory preparation and identification, photo/video documentation; storage of type material	Field collection, identification and documentation Optional, not mandatory:: assessment of biometry parameters and body weight
Ease and level of Identification	Difficult at the species level. Usually simple to identify to genus	Simple after adequate training, but requires taxonomic experts, particularly for some groups of macroalgae.	Simple after adequate training but requires taxonomic experts, particularly for some groups of macroalgae.	Requires expert identification to species level and for some groups	Easy for experts
Nature of reference for comparison of quality/samples/stations and quality assurance	No. BEQUALM Reference type material partly available at universities and research institutions; quality assurance acc. to national and international programmes	No Reference type material partly available at universities and research institutions; quality assurance acc. to national and international programmes	No Reference type material partly available at universities and research institutions; quality assurance acc. to national and international programmes	Reference type material partly available at universities and research institutions; quality assurance acc. to national and international programmes (OSPAR/HELCOM/ICES, BEQUALM)	No. usually not necessary. If needed, reference type material partly available at universities and research institutions. Quality assurance acc. to national and international programmes (HELCOM Guidelines for coastal fish monitoring might be adapted)
Methodology consistent across EU?	No, but consistent among HELCOM and OSPAR countries for Baltic Sea and North East Atlantic BEQUALM scheme under development.	No, but consistent in Baltic countries (HELCOM Guidelines for phytobenthos monitoring)	No, but consistent in Baltic countries (HELCOM Guidelines for phytobenthos monitoring)	HELCOM/OSPAR Guidelines for macrozoobenthos, to be adapted to transitional waters if necessary; BEQUALM scheme under development	. Use expert knowledge and pilot studies to determine best regional/type-specific methodology

[38] *OSPAR Guidelines for fish are for contaminant analysis, not relevant for abundance and composition*

Aspect/feature	**Phytoplankton**	**Macroalgae**	**Angiosperms**	**Benthic invertebrate fauna**	**Fish fauna**
Current use in biological monitoring or classification in EU	Part of national monitoring in different EU countries	Part of national monitoring in different EU countries	Part of national monitoring in different EU countries	Part of national monitoring in different EU countries	Part of national monitoring in different EU countries
Current use of biotic indices/scores	No	No, but ratio of fast-growing opportunistic versus slowly growing perennial species can be used (shifts due to eutrophication)	No	No	No
Existing monitoring system meets requirements of WFD?	No	No	No	No	No
ISO/CEN standards **Other standards**	OSPAR JAMP Eutrophi-cation Monitoring Guide-lines: Phytoplankton Species Composition; HELCOM COMBINE Monitoring Guidelines *i)* for phytoplankton species composition, abundance and biomass and *ii*) for phytoplankton Chlorophyll a ISO 10260 (1992) for the determination of chlorophyll a	ISO/CEN: No HELCOM COMBINE Guidelines on Phytobenthos Monitoring	ISO/CEN: No HELCOM COMBINE Guidelines on Phytobenthos Monitoring	ISO 7828:1985 (Guidance on handnet sampling of aquatic benthic macro-invertebrates) ISO 9391:1993 (Sampling in deep waters for macro-invertebrates – Guidance on the use of colonization, qualitative and quantitative samplers) ISO 16665 (marine soft-bottom macrofauna; in preparation) HELCOM/OSPAR Guidelines for macrozoobenthos, to be adapted to transitional waters if necessary;	No
Applicability to Transitional waters	low	High	High	High	with restrictions

Aspect/feature	Phytoplankton	Macroalgae	Angiosperms	Benthic invertebrate fauna	Fish fauna
Main advantages	Ease of sampling	Identify potential disturbance phenomena Evaluation of community evolution Cost-effective, objective and amenable to optimisation through statistical procedures	Identify potential disturbance phenomena Evaluation of community evolution Cost-effective, objective and amenable to optimisation through statistical procedures	Identify potential disturbance phenomena Evaluation of community evolution Cost-effective, objective and amenable to optimisation through statistical procedures	Relatively easy to compare fish fauna at "pristine state" by use of historical list of fish species with list in actual condition. Identifies natural and anthropogenic impacts from a wide range of sources. [Passage of migratory fish is an excellent indicator of good water quality in freshwater part of river only; in trans. water indicative of good hydromorphological conditions – no dams/constructions or sufficient number of fish passages]
Main disadvantages	High spatial-temporal variability, occurrence of freshwater, marine and brackish species in varying physiological state (brackish water zone as "graveyard" of freshwater and marine species), high influence of temperature and salinity fluctuations on phytoplankton composition Taxonomic identification can be difficult and time-consuming. Lack of quality assurance protocols	No standardized method except in HELCOM countries Lack of taxonomic detail (looping of tiny species into morphological groups). Lack of quality assurance protocols	No standardized method except in HELCOM countries Lack of taxonomic detail (looping of tiny species into morphological groups). Lack of quality assurance protocols	High spatial-temporal variability Lack of taxonomic detail (looping of tiny species into morphological groups). Lack of quality assurance protocols High taxonomic expertise required. High sampling frequency and high number of samples required due to variability in time and space	The high mobility, occurrence of eurytolerant marine and freshwater fish and of migrating fish species makes it difficult to relate to impacts occurring at the local scale Long life cycles Large sample sizes requirements Long time series needed for reliable accounts on composition and abundance

Table 3.8 Key features of each hydromorphological quality element for transitional waters

Aspect/feature	Morphological conditions			Tidal regime Hydrological budget
	Depth variation	**Quantity, structure and substrate of the bed**	**Structure of the transitional zone**	
Measured parameters indicative of QE	Shape of the basin	Grain size Organic content	Vegetation cover Vegetation type	Freshwater inputs Exchange with the ocean Water residence time Metereological variables
Pressures to which QE responds	Hydrological modification Suspended solids Dredging	Mechanical and organic pollution Hydrological modification Suspended solids. Dredging	Land use and modification of hydrology	Modifications of land use Modifications of the marine sandy coasts Outlet modification
Level and sources of variability of QE	Slow changes due to impaired decomposition, Solid transport through the ecotone from the terrestrial environment, freshwater transport High variability for some typology due to sand transport and accumulation.	Low natural variability Moderate variability due to human impact	Low natural variability Moderate variability due to human impact	High temporal variability due to hydrological and meteo-conditions Low temporal variability due to groundwater uses and land use
Sampling methodology	Echo soundings Remote sensing	Corers	Remote sensing images and field surveys	In situ measurements of water flows
Typical sampling frequency	Once every 5 years	Once every 3 years	Once every 3 years	A complete annual cycle with quarterly samplings, every 3 years
Time of year of sampling	Indifferent	Indifferent	Spring-summer	Seasonal
Typical "sample" size or survey area	Grid from 1 X 1 m up to 10 m X 10 m	Undisturbed bottom sample from 10 cm X 10 cm up to 200 cm X 200 cm	Entire ecotone	All water inputs and outputs
Ease of sampling /measurements	Rapid electronic measurements	Rapid sampling, time consuming laboratory analysis	Easy Rapid using remote sensing technology, if possible.	Easy and rapid sampling when supported by expensive field equipment
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality	Maps of the National Hydrographical services	No	Corine habitat maps	No
Methodology consistent across EU?	No	FOLC method	No	No
Current use in monitoring programmes or for classification in EU	No	No	No	No
Existing monitoring systems meet requirements of WFD?	No	No	No	No

Aspect/feature	Morphological conditions			Tidal regime Hydrological budget
	Depth variation	**Quantity, structure and substrate of the bed**	**Structure of the transitional zone**	
Existing classification systems meet requirements of WFD?	No	No	N0	No
ISO/CEN standards				
waters	Yes	Yes	Yes	Yes
Main Advantages	Rapidity of sampling and map making	Rapid sampling	Rapid sampling and map making	Rapid sampling and map making
Main disadvantages	None	Time consuming laboratory analysis		Expensive instrumentation

Table 3.9 Key features of each chemical and physico-chemical quality element for transitional waters

Aspect/feature	Transparency	Thermal conditions	Oxygenation	Salinity	Nutrients
Measured parameters indicative of QE	Light penetration & quality	Thermal Profiles along water column	Oxygen profiles	ppt psu	Reactive species and total budgets (N,P,Si)
Relevance of quality element	High	High	High	High	High
Pressure to which the QE responds	Resuspension Solids transport by rivers Aquaculture Eutrophication	Climate variables Thermal pollution Provides information on mixing conditions	Organic matter loading Eutrophication Aquaculture	Freshwater and marine water inflows Water hydrodynamics	Nitrogen and phosphorus loading from river discharge, local point and non-point pollution, aquaculture
Level and sources of variability of QE	High natural variability due to seasonal plankton blooms, freshwater runoff and meteorological factors	Predictable high natural variability due to seasonal and mixing condition Some variability due to human impact	High natural variability due to daily changes in temperature and production/respiration.	Predictable high natural variability due to the thermohaline circulation and freshwater inputs Anthropogenic inputs	High natural variability due to seasonal variation (meteo and biological) Anthropogenic inputs
Monitoring considerations	Dependence from daylight and salinity	Special attention to water column profile Dependence on salinity	Dependence from hydrodynamics, physical characteristics and day time of measurement Due to fast dynamics characterising lagoons and coastal lakes, repeated 24-72 hours continuous samplings are strongly recommended at least twice per year (winter-summer)	Dependence from hydrodynamics (and salinity)	Dependence from hydrodynamics and biological factors Special attention to sediments exchange for total budget consideration
Sampling methodology	Secchi disc, autographic photometers	Portable electronic equipment Automated on site buoy	Portable electronic equipment Automated on site buoy	Portable electronic equipment Automated on site buoy	Water sampling, followed by laboratory analysis
Typical sampling frequency	Monthly	Daily measurements with on site buoy Monthly controls	Daily measurements with on site buoy Monthly controls	Daily measurements with on site buoy Monthly controls	Monthly
Time of year of sampling	Every month	Daily + Every month	Daily + Every month	Daily + Every month	Every month
Typical sample size	none	none	None/100 ml	None/100 ml	1-2 litres
Ease of sampling/measurements	High	High	High	High	High
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality quality/samples/stations					Spatial comparisons and site-based trend assessment
Methodology consistent across EU			OSPAR JAMP Eutrophication Monitoring Guidelines: Oxygen		OSPAR Nutrient Monitoring Guidelines
Current use in monitoring or classification programme in EU					OSPAR Nutrient Monitoring Guidelines

Aspect/feature	**Transparency**	**Thermal conditions**	**Oxygenation**		**Nutrients**
Existing monitoring system meets requirements of WFD					
ISO/CEN standards	No	No	No	No	No
Applicability to transitional waters	High	High	High	High	High
Main advantages	Ease of measurement	Ease of measurement	Ease of measurement if autographical	Ease of measurement.	Rapid sampling
Main disadvantages	Extreme temporal variability.	Account must be taken of diurnal and seasonal variability.	Account must be taken of diurnal and seasonal variability. Time consuming if not autographical	Account must be taken of the tidal state at the time of sampling.	Time consuming High spatial and temporal variation Antagonistic with phytoplankton and seaweeds biomass

3.4 Selection of Quality Elements for Coastal Waters

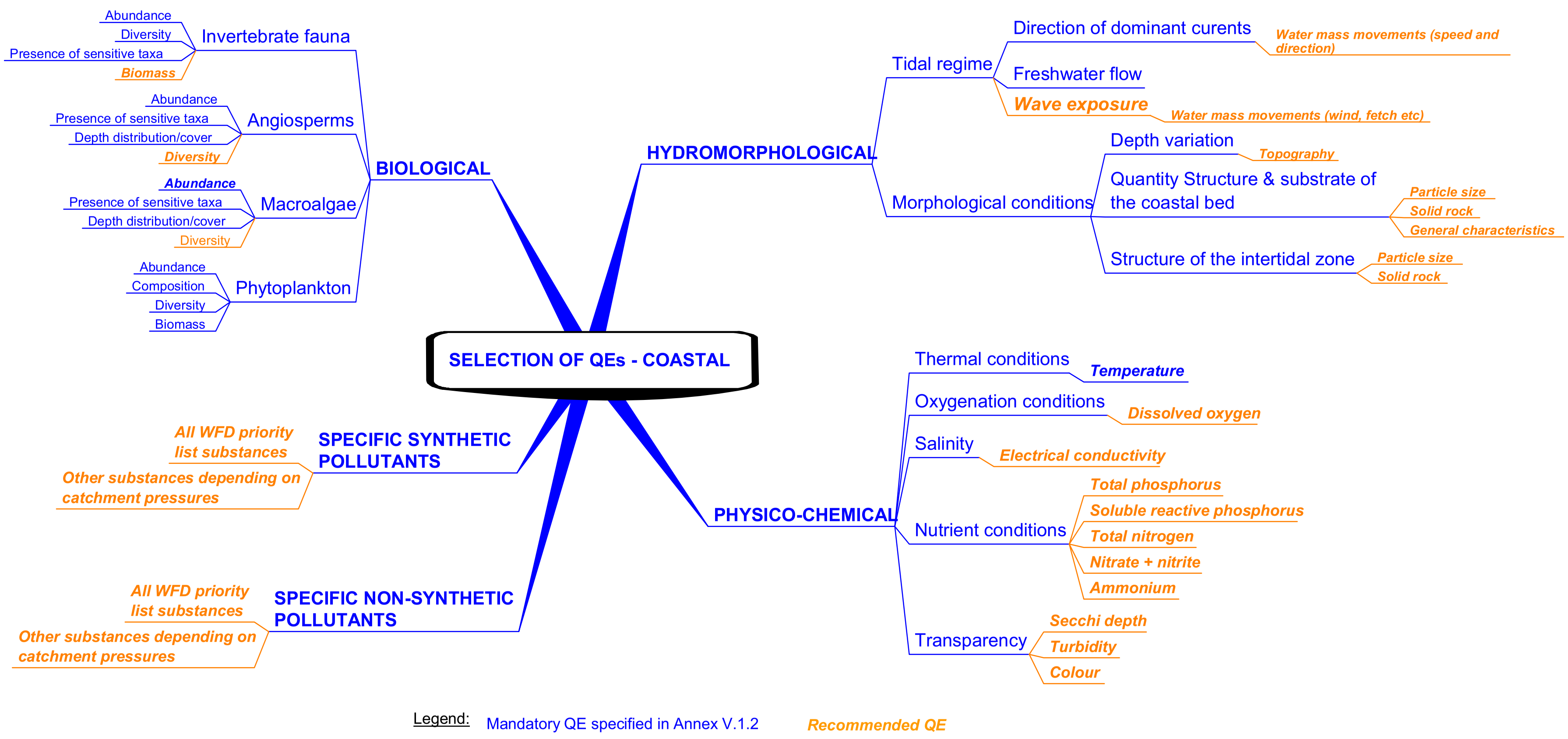


Figure 3.4 Selection of quality elements for coastal waters

Table 3.10 Key features of each biological quality element for coastal waters

Aspect/feature	AQUATIC FLORA		AQUATIC FAUNA
	Phytoplankton	**Macroalgae/Angiosperms (Phytobenthos)**	**Benthic invertebrate fauna**
Measured parameters indicative of QE As reported in Annex V (1.1.4 and 1.2.4)	Composition, abundance, biomass, blooms	Composition, abundance, sensitive taxa, cover	Composition, abundance, diversity, sensitive taxa
Supportive/interpretative parameters measured or sampled at the same time	Physico-chemical parameters: transparency, , temperature, salinity, oxygen, nutrients chlorophyll “a” Hydromorphological parameters: currents Key species	Very important supporting parameter :distribution (Horizontally and vertically) Biomass, density Physico-chemical (transparency , temperature, salinity, nutrients) Hydromorphological parameters: tides, wave exposure, bearing, slope, Sediment and nature of substratum Height above/below tidal datum	Very important supporting parameter: biomass Characteristics of the habitat (morphology, wave exposure, bearing, slope texture, topographic complexity, nature of the substratum etc.) Physico-chemical parameters (temperature, salinity, oxygen, nutrients) Presence and distribution/extent of particular biogenic aggregations (i.e. molluscs beds, polychaete “reefs”)
Pressures to which QE responds	Eutrophication Nutrients discharges, suspended matters, toxic substances	Many types of anthropogenic disturbances (i.e. nutrient loading, fishing, modification of shore and bed structure suspended matter input)	Many types of anthropogenic disturbances (i.e. :eutrophication, organic pollution, mechanical disturbance, physical modification of seabed , sediments dynamics and fishing)
Mobility of QE	High	Low	Low
Level and sources of variability of QE	High inter and intra-seasonal variation in community structure and biomass. Spatial patchiness Influenced by: irradiance, nutrient availability, water column stability and residence time.	Small-scale spatial patchiness and temporal variation, seasonal trends for some taxa Influenced by climatic seasonality (i.e. events, irradiance, nutrient availability)	Small-scale spatial patchiness and temporal variation, seasonal trends for some taxa Influenced by seasonal growth patterns Influenced by substrate variability and physical environmental parameters variations
Presence in coastal waters	Abundant	Abundant to rare: Regional differences: (e.g. seagrass beds are rare in the North Sea)	Abundant
Sampling methodology	Water sampling (plankton net, water samples)	Direct by SCUBA diving or walking in the intertidal: non-destructive (quantitative counts in quadrats or photographic method, semi-quantitative abundance estimation according to defined scale) , destructive (suction or bottom sampler) Indirect: Shipboard sampling using box samplers (grab, corer) Remote sensing surveys (satellite, airborne multispectral or aerial photography) (e.g. density on mudflats) Remote video techniques (ROV, towed sledge) where appropriate	Direct by SCUBA diving or walking in the intertidal: non-destructive (quantitative counts in quadrats or photographic method, semi-quantitative abundance estimation according to defined scale) destructive (suction or bottom sampler) Indirect: Shipboard sampling using box corers, grabs, dredges Remote video techniques (ROV, towed sledge)where appropriate Echo sounding technique (ROXANN) which can be used to measure the extent of biological habitats

Aspect/feature	AQUATIC FLORA		AQUATIC FAUNA
	Phytoplankton	**Macroalgae/Angiosperms (Phytobenthos)**	**Benthic invertebrate fauna**
Habitats sampled	Water column.	Hard and soft bottom	Hard and soft bottom
Typical sampling frequency	Best: 15 days At least: monthly sampling at standard depths Determine best regional/type-specific sampling design (i.e. maximum and minimum levels)	Seasonally preferable (4 times for year) At least twice per year (max/min cover); regionally different (HELCOM: once per year) Frequency may be less for seagrasses and/or other long-lived species	Seasonally preferable at least during peak growth period As recommended in OSPAR/HELCOM/ICES guidelines once per year (same season) At least twice per year for Mediterranean Ecoregion
Time of year of sampling	Should cover all seasons, with emphasis on bloom seasons. And particular events related (exceptional blooms)	Seasonally preferable (4 times for year) At least twice per year (max/min cover) with timing depending on ecoregion As recommended in OSPAR/HELCOM/ICES guidelines(once per year, June-September)	Seasonally preferable at least during peak growth period
Typical sample size	Variable: usually 50-250 ml, /1 litre As recommended in OSPAR/HELCOM/ICES guidelines	Variable dependent on methodology and phytobenthos group types Quadrats of different sizes (from 15x15cm to several m2 depending on the size of the group) As recommended in OSPAR/HELCOM/ICES guidelines or SCUBA Diving transects (ISO std under development)	Variable dependent on methodology Quadrats of different sizes (20÷50 cm) for hard bottom Combination of nets and corers for soft bottom As recommended in OSPAR/HELCOM/ICES guidelines SCUBA Diving transects (ISO std under development)
Ease of sampling	Simple water sampling.	In situ techniques: simple after training of skilled personnel (SCUBA-diving) for species identification and methodology; but variable due to meteo-marine conditions and methodology Shipboard sampling: easy on soft bottom, difficult on hard bottom. Aerial photography is technically demanding	In situ techniques :simple after minimum training but variable due to meteo-marine conditions and methodology Relatively easy shipboard sampling
Laboratory or field measurement	Field collection, laboratory preparation followed by microscopic identification.	Field collection, laboratory preparation, sorting and identification	Field collection, laboratory sorting and identification
Ease and level of Identification	Taxonomy expert work. Difficult at the species level. Usually simple to identify to genus	Simple after adequate training but requires taxonomic experts, particularly for some groups of macroalgae.	Taxonomy expert work. Simple after adequate training.
Nature of reference for comparison of quality/samples/stations	Ref. type material at Universities & research Institutions; quality assurance according to national and international programmes and recommendation (OSPAR/HELCOM/ICES) BEQUALM, under development QUASIMEMME (chlorophyll a)	Ref. type material at Universities & research Institutions; quality assurance according to national and international programmes and recommendation (/HELCOM COMBINE guidelines)	Ref. type material at Universities & research Institutions; quality assurance according to national and international programmes and recommendation (OSPAR/HELCOM/ICES;) BEQUALM (UK and NL)
Methodology consistent across EU?	No but consistent across NE Atlantic and across Baltic Sea (OSPAR and HELCOM Countries)	No but consistent across NE Atlantic and across Baltic Sea (OSPAR and HELCOM Countries)	No but consistent across NE Atlantic and across Baltic Sea (OSPAR and HELCOM Countries)

Aspect/feature	AQUATIC FLORA		AQUATIC FAUNA
	Phytoplankton	**Macroalgae/Angiosperms (Phytobenthos)**	**Benthic invertebrate fauna**
Current use in biological monitoring or classification in EU	Italy, Norway (partly) , Netherlands, Germany, Sweden (monit), Spain	Norway (partly) Germany (tentative),Denmark, Sweden(monit & class), UK, Spain	Norway (partly), Netherlands, Germany, Spain, , Sweden(monit & class)
Current use of biotic indices/scores	Norway	No Spain (Catalonia)	Norway, Sweden UK, Spain
Existing monitoring system meets requirements of WFD?	Generally No Partially in: Italy, Germany, Norway, Sweden	Partially in Germany, Norway, UK, Sweden	Norway, Partially in Germany, Sweden
ISO/CEN standards	No CEN/TC 230 N 0423 in preparation	No Rocky shore ISO standard in preparation (Norway standard 9424):	National Norwegian soft bottom standards (ISO in preparation: TC 230/SC 5: ISO/TC 147/SC5 N350) In preparation ISO16665
Applicability to Coastal waters	High	High	High
Main advantages	Good indicator of changes in trophic status Ease of sampling Indicators of short-term impact due to rapid turn-over times Important monitoring of harmful algae (DSP/PSP)	Good integrating indicator of general state of environment Identify potential disturbance phenomena Evaluation of community evolution: provides information on ecosystem stability Key element in coastal ecosystems Good integrating indicator of broad range of impacts Cost-effective, consistent and amenable to optimisation through statistical procedures	Good integrating indicator of general state of environment Identify potential disturbance phenomena Evaluation of community evolution Cost-effective, consistent and amenable to optimisation through statistical procedures
Main disadvantages	High spatial-temporal variability requires frequent sampling and good spatial coverage Consistent identification requires consistent training and quality assurance procedures as well as intercalibration Taxonomic identification can be difficult and time-consuming	Require certified and skilled divers Not standardised method Lack of taxonomic detail (looping of tiny species into morphological groups) Consistent identification requires consistent training and quality assurance protocols	Lack of taxonomic detail (looping of tiny species into morphological groups) Consistent identification requires consistent training and quality assurance protocols Require certified and skilled divers
Recommendation/ Conclusion	Good indicator of changes in trophic status and of short-term impact, due to rapid turnover times. Identification of nuisance or potential toxic species is a particularly important assessment parameter. Bloom frequency and intensity are indicative parameters for classification of ecological status. WFD minimum frequency (every 6 months) can be inadequate for many regions: pilot studies and local expert knowledge could help in establishing the most appropriate frequencies.	Key elements in coastal ecosystems. Good integrating indicators of the status of the environment, responding to a broad range of impacts. Provide important information on the ecosystem stability, as variations may indicate long-term changes in the physical conditions at the site. For angiosperms, the most important parameter is distribution (extension and variation in time and space).	Good integrating indicators of the status of the environment. Important variables to be considered together with the required parameters (composition and abundance) are diversity of species and presence of sensitive or higher taxa as well as biomass, the latter being indicative of eutrophication. Several indexes exist and their use is quite spread, although not commonly agreed.

Table 3.11 Key features of each hydromorphological quality element in coastal waters

Aspect/feature	Morphological conditions			Tidal regime	
	Depth variation	**Structure and substrate of the coastal bed**	**Structure of the intertidal zone**	**Direction of dominant currents**	**Wave exposure**
Measured parameters indicative of QE	Topography of the type of water body	- Grain size - Solid rock - Other general characteristics: coarse description (mud, sand, gravel, hard soils or rocks sedimentological structures (ripples, sand reefs, under water dunes etc.) - bioturbation, lamination in sediment cover, oxigenation conditions in sediments	- Rock type , form and exposure to waves, - Grain size - Distribution of biological communities - H/L tide levels - erosion/deposition	Water mass movements (speed and direction)	Water mass movements (wave, wind, Fetch-index) frequency of storms directions H/L tide/surge levels
Pressures to which QE responds	Landfill, dredging, dumping, and natural large scale bottom dynamics	Mechanical disturbance and variation in structure and substrate composition due to anthropogenic input	- Mechanical disturbance and variation in structure and substrate composition due to anthropogenic input - Change in macroalgal composition due to chemical inputs. - diking - beach nourish	Natural modification (mechanical and climatic) of coastline Anthropogenic modifications (constructions)	Natural modification (mechanical) of coastline climate constructions
Level and sources of variability of QE	Very low variability due to natural erosion and sedimentation. Moderate variability due to human impact Seasonal variations are important in nearshore areas	Low natural variability Moderate variability due to human impact Seasonal variations are important in nearshore areas	High natural variability (regularly: tidal flooding and drought periods. irregularly: storms, etc.). High variability due to human impact	High natural variability depending on winds, tides and climatic changes low frequency climatic changes (e.g. NAO) (Germany)	Seasonal variability Low frequency climatic changes
Sampling methodology	Echo soundings ROV	Corers Scanning acoustic techniques Diving Video	- Skindiving , photo, corer (intertidal soft bottom) - Remote imaging (satellite airborne systems); - Viewpoint photography; In-situ measurements along transects[39]s	Drifters, in situ measurements, autographic instruments, Doppler Historical flows data , modelled flows (mainly large scale)	In situ measurements, autographic instruments, Fetch calculations Calculations (mainly large scale) from maps and meteorological data modelling gauging

Aspect/feature	Morphological conditions			Tidal regime	
	Depth variation	**Structure and substrate of the coastal bed**	**Structure of the intertidal zone**	**Direction of dominant currents**	**Wave exposure**
Typical sampling frequency	Once every 5/6 years Before and after significant pressure applied	Once every 5/ 6 years Sampling "ad hoc" for specific reasons (i.e. construction, benthic studies support)	Once /twice every 5/ 6 years Sampling for specific reasons (i.e. construction, mapping)	Annual cycle.	Annual cycle.
Time of year of sampling	Indifferent Important if seasonal variations in nearshore areas	Indifferent	Summer (to avoid winter with possible ice cover) and if using biological communities	Annual cycle	Annual cycle
Typical "sample" size or survey area	Hydromorphological grids vary according to desired scales. Suggestion: grid from 100 m X 100 m up to 500 m X 500 m	Undisturbed bottom sample from 10 cm X 10 cm up to 200 cm X 200 cm box grab samples (50cm x 50 cm, where appropriate) (Germany) Larger areas covered by ROV/divers Side Scan Sonar	Whole intertidal zone using imaging techniques Sediment samples collected by 5cm diameter corer, 15cm depth.(UK) Undisturbed bottom sample from 10 cm X 10 cm up to 200 cm X 500 cm (Norway)	Instruments integrate information from large spatial and temporal areas Importance of instrument's location operational modelling	Instruments integrates information from large spatial and temporal areas Importance of instrument's location
Ease of sampling /measurements	Rapid electronic measurements	Rapid sampling, time consuming laboratory analysis	Rapid sampling, time consuming laboratory analysis depending on substrate type or sampling technique	Rapid sampling and map making with autographic instruments	Rapid sampling and map making with autographic instruments
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality	Maps of National Hydrographical /Geological services,	Seabed sediment maps from National Geological Surveys (i.e. British Geological Survey)	Biological maps should use a standard classification such as EUNIS (e.g. UK has the Marine Biotope classification) Maps from National Geological Surveys (e.g. British Geological Survey)	No	No
Methodology consistent across EU?	No	No	No	No	No
Current use in monitoring programmes or for classification in EU	Used in operational monitoring, but not continuously in most of the countries	Italy Sweden (in connection with benthic studies)	UK – SAC monitoring programme		
Existing monitoring systems meet requirements of WFD?			Partially for UK?		
Existing classification systems meet requirements of WFD?					

Aspect/feature	**Morphological conditions**			**Tidal regime**	
	Depth variation	**Structure and substrate of the coastal bed**	**Structure of the intertidal zone**	**Direction of dominant currents**	**Wave exposure**
ISO/CEN standards					
waters	Yes	Yes	Yes	Yes	Yes
Main Advantages	Rapidity of sampling and map making	Rapid sampling Provides information about hydrodynamism and different community distribution	Rapidity of sampling and map making Provides an overview of a whole system to identify extent of localised effects Provides link with biological QE	Continuous measurement, ease of mapping. Information on dispersion of pollution (i.e. oil spill) and loads dilution	Continuous measurement, ease of mapping. Information on dispersion of pollution (i.e. oil spill) and loads dilution
Main disadvantages	None	Time consuming laboratory analysis	Time consuming laboratory analysis for sediment characterisation Mapping can be expensive	Expensive instrumentation.	Expensive instrumentation
Recommendation/ Conclusion	Depth variations could be important elements to be monitored in areas where disturbances are expected: anthropogenic changes will have relevance for the status classification of the water body.	Indicator of hydrodynamism and supporting element for community distribution; Changes in morphological conditions and/or nature of the substratum may exert severe detrimental effects on benthic organisms.	Note relevant for the Mediterranean and the Baltic ecoregions, given their low tidal range. Thus it is suggested to use the "intertidal/ *mediolittoral*" term for meaningful ecological relevance (see Annex VI).	Direction and intensity (speed) of dominant currents are important parameters, especially in ecoregions or part of ecoregions with low tidal range (Baltic, Mediterranea, Skagerrak) where tidal currents play a very minor role, if any. Can be particularly relevant in areas where anthropogenic disturbance occur (see Annex VI). It can be necessary to take into account short term effects.	To be monitored in areas submitted to anthropogenic disturbances. Suggested parameters are frequencies of storm, direction, high/low tide surge levels.

Table 3.12 Key features of each chemical and physico-chemical quality element for coastal waters

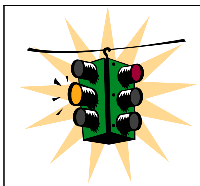
Aspect/feature	Transparency	Thermal Conditions	Oxygenation Conditions	Salinity	Nutrient conditions
Measured parameters indicative of QE	Light penetration & quality	Temperature Water column structure (in stratified waters)	D.O. concentration O2 % saturation	ppt psu	NO3, NO2, NH4, P04, Si concentration, total N, total P
Relevance of quality element	High	High	High	High	High
Pressures to which QE responds	Nutrient surplus (plankton enrichment). Organic matter pollution (sewage, sludge) Particulate load Land runoff Riverine discharges	Thermal point source pollution Thermal alteration due to reduced water exchange and modified dynamics by coastal constructions Climatic changes	Organic pollution, anthropog. enhanced productivity Reduced water exchange by human impacts .	Freshwater runoff. Mixing condition and origin of the water masses Reduced water exchange by human impacts	nutrient surplus, organic pollution (sewage, sludge) Land runoff Local point and diffuse source inputs Atmospheric input (especially N)
Level and sources of variability of QE	High natural variability due to seasonal plankton blooms freshwater runoff, wind and tidal currents action	High natural variability due to seasonal and mixing condition	High natural variability due to daily changes in temperature and production/respiration. and water exchange conditions. Supply of organic matter Wind activity	High natural variability due to the thermohaline circulation (wind, precipitation, riverine inputs…)	High natural variability due to seasonal variation (meteo and biological) Riverine inputs Water mass movements Remineralisation
Monitoring considerations	Dependence from daylight	Special attention to water column profile when necessary	Dependence from hydrodynamism physical characteristics and day time of measurement; Relate sampling time to tidal cycle	Dependence from hydrodynamism	Dependence from hydrodynamism
Sampling methodology	Secchi disc, autographic photometers	Autographic instruments CTD	Autographic instruments, or water sampling deployed automatic systems	Autographic instruments CTD	Water sampling, followed by laboratory analysis. Autographic instruments (experimental)
Typical sampling frequency	Best: every 15-30 days At least seasonal	Best: every 15-30 days At least seasonal	Best: every 15-30 days At least seasonal	Best: every 15-30 days At least seasonal	Best: every 15-30 days At least seasonal
Time of year of sampling	All year round	All year round	All year round	All year round	All year round
Typical "sample" size	Single measurement or water column profile.	Water column profile. deployed automatic systems	Water column profile. deployed automatic systems	Water column profile. deployed automatic systems	Single sample, or water column profile. deployed automatic systems
Ease of sampling /measurements	Simple.	Simple.	Simple using autographic instruments.	Simple.	Simple. Surface water sample or profile using depth sampler.
Basis of any comparison of results/quality/stations e.g. reference conditions/best quality		No	No	Norway UK	Denmark: Quasimemme + national inter comparisons Sweden. Quasimemme Norway (ring tests/ Quasimemme)

Aspect/feature	Transparency	Thermal Conditions	Oxygenation Conditions	Salinity	Nutrient conditions
Methodology consistent across EU?	No	No	No but consistent across NE Atlantic and across Baltic Sea (OSPAR and HELCOM Countries)	No	No but consistent across NE Atlantic and across Baltic Sea (OSPAR and HELCOM Countries)
Current use in monitoring programmes or for classification in EU	Italy, Sweden, UK, Denmark, Spain (Basque Country)	Italy, Sweden, Norway Germany, UK, Denmark, Spain (Basque Country)	Italy, Sweden, Norway Germany, UK, Denmark, Spain (Basque Country)	Italy, Sweden, Norway Germany, UK, Denmark, Spain (Basque Country)	Italy, Sweden, Norway Germany, UK, Denmark, Spain (Basque Country)
Existing monitoring systems meet requirements of WFD?	No Spain (Basque Country)	No Partially for UK and Norway Spain (Basque Country)	No Partially for UK and Norway Spain (Basque Country)	No Partially for UK and Norway Spain (Basque Country)	No Partially for UK and Norway Spain (Basque Country)
Existing classification system meets requirements of WFD?	No	No	No Norway	No	No Norway
ISO/CEN standards	No	No	Norway	No	Norway
Applicability to Coastal waters Information in this row is redundant because parameters are mandatory according to WFD	High	High	High	High	High
Main advantages	Ease of measurement.	Ease of measurement.	Ease of measurement if autographical.	Ease of measurement.	Rapid sampling
Main disadvantages	High temporal variability	None	Time consuming if not autographical	None	Time consuming
Recommendation/ Conclusion	Easy measure. Routinely used in most national monitoring programmes. Measurement is difficult in “troubled waters”, e.g. the NE Atlantic Wadden Sea with high loads of resuspended sediments.	Easy measure. Routinely used in most national monitoring programmes. Temperature profiles along the water column easily obtained by in *situ* autographic instruments. The thermal structure of the water column is a very important information (see Annex VI).	Easy measure. Routinely used in most national monitoring programmes. Important parameter. % of saturation is particularly relevant (see Annex VI).	Easy measure. Routinely used in most national monitoring programmes. Important parameter (see Annex VI).	The concentration of nutrients, together with the concentration of chlorophyll ‘a’, indicator of actual production, provide information on the general trophic conditions. Important parameter (see Annex VI).

4 Design of groundwater monitoring programmes

4.1 Introduction

This Section of the guidance provides specific advice on the design of groundwater monitoring programmes. It also describes the general principles applicable to all of the groundwater monitoring programmes, as well as the specific requirements for each of the groundwater monitoring programmes.



Look Out!

This guidance uses the term conceptual model as shorthand for the understanding, or working description, of the real hydrogeological system that is needed to design effective groundwater monitoring programmes. The term should NOT be taken to imply that a mathematical model is required for all bodies of groundwater. On the contrary, complex mathematical models are only likely to be required to properly design and justify very expensive restoration measures for bodies that are failing to achieve the Directive's objectives.

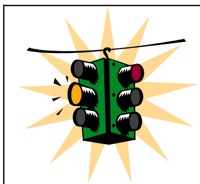
4.2 Principles for the design and operation of groundwater monitoring programmes

4.2.1 Identify the purposes for which monitoring information is required

The design of monitoring programmes involves deciding what to monitor, where and when. The answers to these questions depend first and foremost on the purpose which monitoring will serve. The first step before designing a network is therefore to clearly identify the purpose, or purposes, for which the monitoring information is needed.

The monitoring required by the Directive is intended to provide information to help assess the achievement of the Directive's environmental objectives. Monitoring programmes should therefore be designed to provide the information needed to establish whether the particular environmental conditions specified by these objectives are being achieved. Among other things, this will involve monitoring to test the understanding of the groundwater system on which assessments are based and the effectiveness of any measures applied.

The relevant environmental objectives for groundwater are listed in Section 2.13 of the common understanding.



Look Out!

The requirements of the Directive's 'prevent or limit inputs of pollutants' objective [Article 4.1(b)(i)] are unclear. The Directive does not specify which pollutants[40] should be prevented from entry, and to what extent the entry of others on the list should be limited nor does it describe any relevant monitoring requirements in Annex V. It is therefore not possible to provide guidance on what, if any, monitoring should be implemented to assess the achievement of this objective.

Additional criteria for assessing good groundwater chemical status, including the application of quality standards, may be established by the

[40] *Annex VIII provides an indicative list of the main pollutants*

new groundwater directive envisaged by Article 17. It is assumed that the daughter directive will indicate how compliance with any quality standards it establishes should be assessed. This document only provides monitoring guidance for the good chemical status criteria that are not dependent on the daughter directive.

Annex V of the Directive describes the purposes of the different groundwater monitoring programmes. It also specifies certain criteria for determining what, where and when to monitor in respect of these purposes. Figure 4.1 below summarises these requirements.

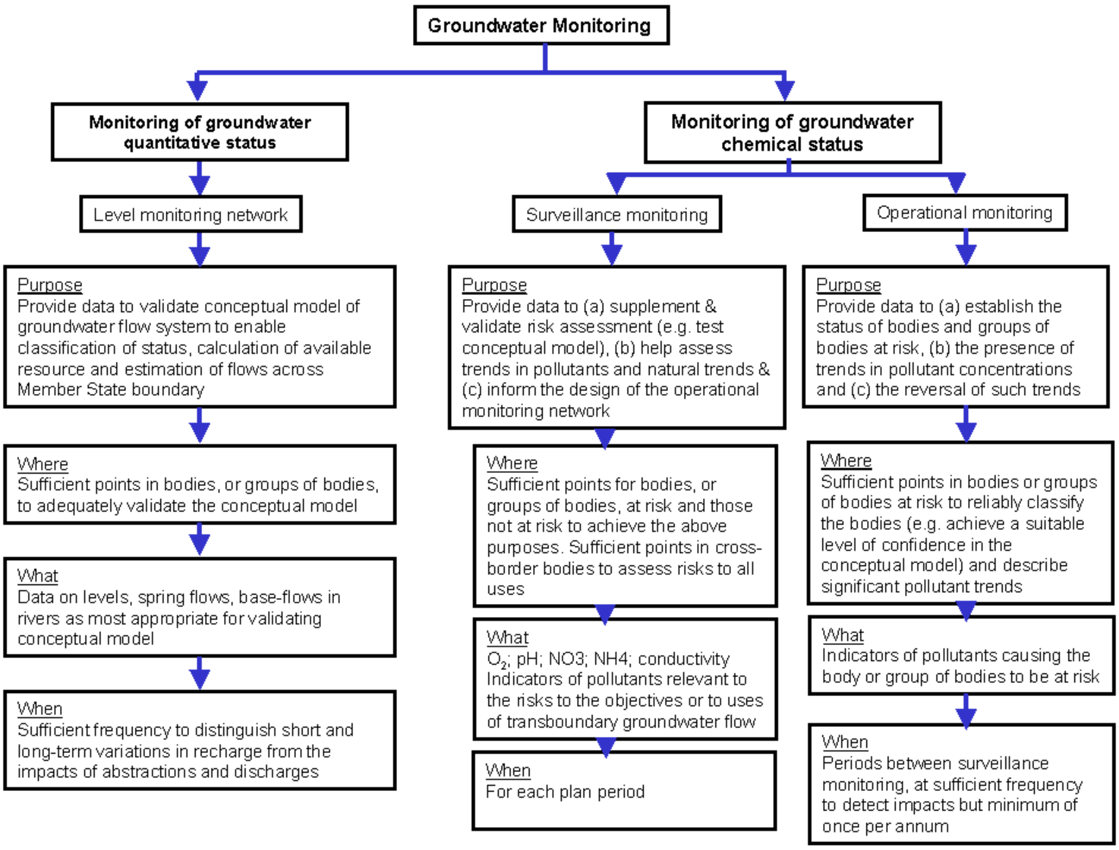
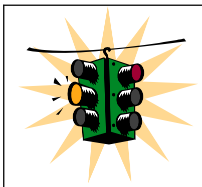


Figure 4.1 Summary of the purposes of, and requirements for, the groundwater monitoring programmes specified in Annex V of the Directive.



Look Out!

Monitoring of spring flows (e.g. flow rate, chemical composition;) and/or river base-flows will often be an important, and sometimes the principal, means of obtaining reliable information for use in assessing quantitative and chemical status.

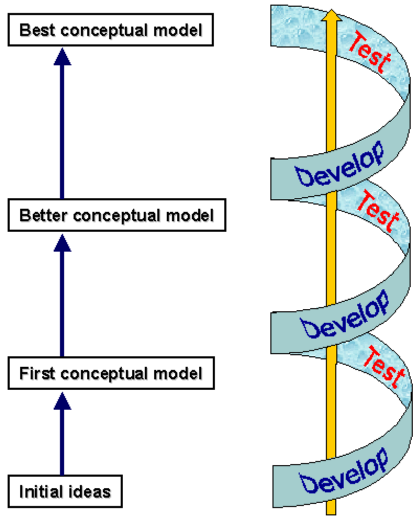
4.2.2 Monitoring should be designed on the basis of an understanding of the groundwater system

The Annex II risk assessment procedure is intended to help target and prioritise monitoring effort to where there are likely to be environmental problems. The monitoring programmes should be designed to provide the information needed to validate the risk assessment procedure and establish the magnitude, and spatial and temporal distribution, of any impacts. Risks assessments for groundwater should be based on a conceptual model/understanding of the groundwater system and how pressures interact with that system. A conceptual model/understanding is not only necessary to design monitoring programmes. It is also needed to interpret the data provided by those programmes, and hence assess the achievement of the Directive's objectives (Figure 4.2).

Definition of conceptual modelling/ understanding

A conceptual model/understanding is a simplified representation, or working description, of how the real hydrogeological system is believed to behave. It describes how hydrogeologists believe a groundwater system behaves.

- It is a set of working hypotheses and assumptions
- It concentrates on features of the system that are relevant in relation to the predictions or assessments required
- It is based on evidence
- It is an approximation of reality
- It should be written down so that it can be tested using existing and/or new data.
- The level of refinement needed in a model is proportionate to (i) the difficulty in making the assessments or predictions required, and (ii) the potential consequences of errors in those assessments.



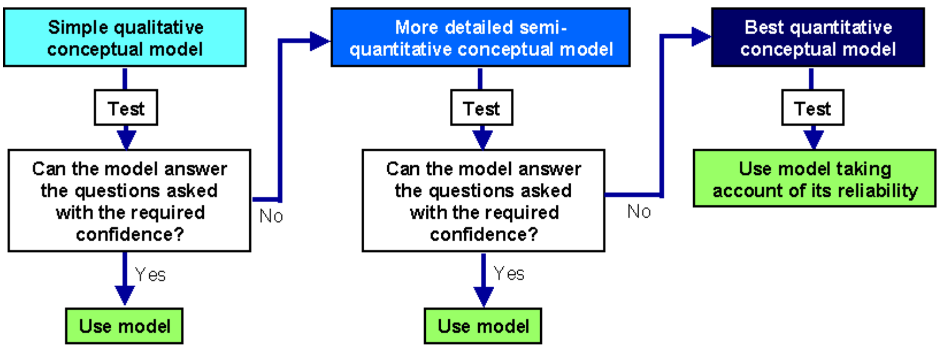
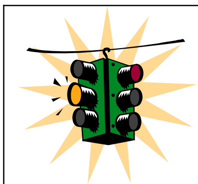


Figure 4.2 Definition of conceptual modelling/understanding



Look Out!

The testing of conceptual models/understandings is important to ensure they provide for acceptable levels of confidence in the assessments they enable. The Directive requires the confidence in the results of monitoring to be reported in the River Basin Management Plans. Guidance on testing conceptual models/understandings using water balances is provided in the toolbox. It is important to note that although the guidance recommends testing models numerically this does not mean that the models themselves have to be mathematical. On the contrary, complex mathematical models are only likely to be required to properly design and justify very expensive restoration measures for bodies that are failing to achieve the Directive's objectives.

The level of detail in any conceptual model/understanding needs to be proportional to the difficulty in judging the effects of pressures on the objectives for groundwater. The first model will be a simple, generalised sketch of the groundwater system. Where necessary, the spatial specificity of this first conceptual model/understanding can be gradually improved (Figure 4.3). Monitoring data is required to test or validate the conceptual model/understanding. Such testing will require some monitoring data for all bodies, or groups of bodies, identified as being at risk as well as a selection of those identified as not being at risk of failing to meet their objectives.

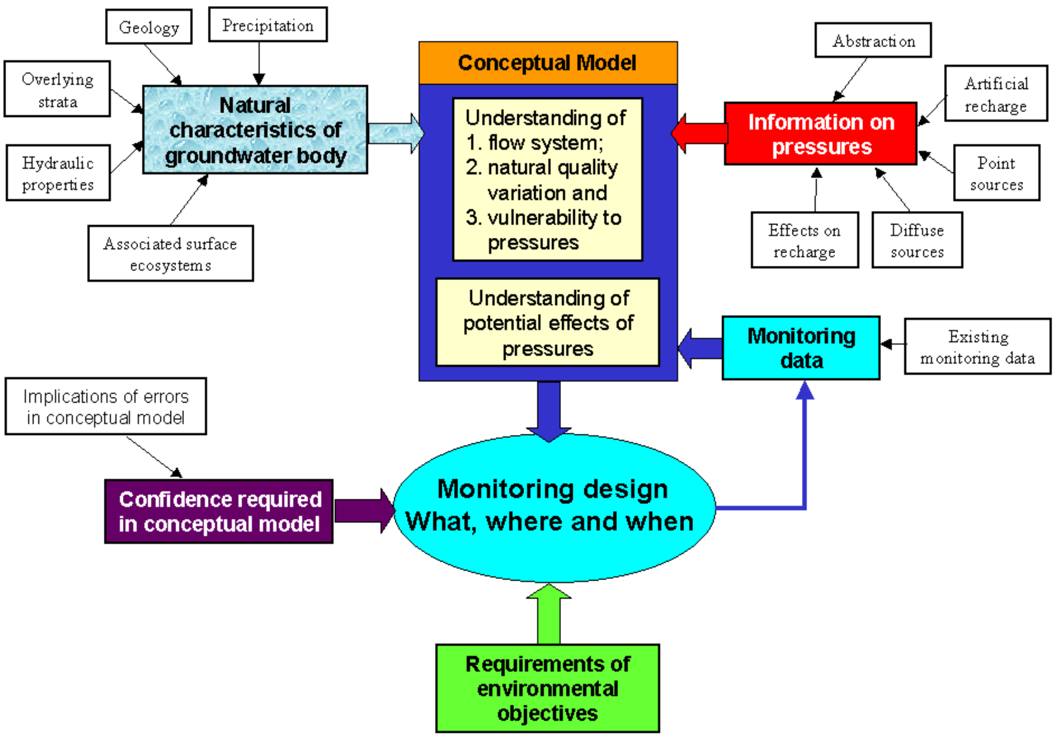


Figure 4.3 **Monitoring programmes should be designed on the basis of a conceptual model/understanding of the groundwater system. The model will represent the current understanding of the groundwater system based on information on its natural characteristics and the pressures on it. Monitoring should provide the information needed to test the model and, where necessary, improve it so that an appropriate level of confidence can be achieved in the prediction and assessment of groundwater problems.**

The amount of monitoring information needed to validate the Annex II risk assessments will depend in part on the level of confidence in, and complexity of, the conceptual model/understanding. The greater the difficulty in judging the risks to the objectives, the more monitoring information is likely to be required. The greatest amount of monitoring will be necessary where the implications of misjudging the risks to the objectives would be very serious (e.g. lead to substantial costs being unnecessarily imposed on water users or fail to identify risks of significant damage that could be averted).

During the course of each planning cycle, and between one planning cycle and the next, new monitoring data will contribute to improved understanding of groundwater systems and their vulnerability to pressures. This will increase confidence in the conceptual model/understanding and the risk assessments it enables.

> **Key principle**
>
> **The amount of monitoring that is required will be proportional to the difficulty in judging (a) the status of a body, or group of bodies, of groundwater and (b) the presence of adverse trends, and (c) to the implications of errors in such judgements.**

Designing the monitoring programmes on the basis of conceptual models/understandings ensures that the programmes will be appropriate to the hydrogeological characteristics of the body, or group of bodies, of groundwater and, where relevant, to the behaviour of pollutants in the groundwater system. For example, monitoring quantitative or chemical status in a low permeability fractured medium will require a different strategy (in terms of what to measure, where and when) than would monitoring quantitative or chemical status in a high permeability inter-granular flow medium.

> **Key principle**
> **The design and operation of monitoring programmes should be informed by:**
>
> **(a) the objectives applying to the body;**
> **(b) the characteristics of the groundwater body, or group of bodies;**
> **(c) the existing level of understanding (i.e. the confidence in the conceptual model/understanding) of the particular groundwater system;**
> **(d) the type, extent and range of the pressures on the body, or group of bodies;**
> **(e) the confidence in the assessment of risk from pressures on the body, or group of bodies; and**
> **(f) the level of confidence required in the assessment of risk.**

Groundwater systems are 3-dimensional. In some circumstances, where a body is at risk of failing to achieve its objectives and potentially costly restoration and improvement measures may be needed, monitoring information from different layers in a body of groundwater may be required to enable appropriate measures to be designed and targeted. The need for this sort of monitoring should be indicated by the risk assessments required under Annex II. However, most pressures are likely to have significant effects in the upper layers of aquifers.

Different types of objectives demand different environmental outcomes. They may therefore require different monitoring strategies to provide the information needed to assess their achievement. However, the design of the monitoring programme should always be based on an appropriate conceptual model/understanding. For example, objectives requiring the protection of associated surface water bodies, directly dependent terrestrial ecosystems, drinking water abstraction points or other legitimate uses from point sources of pollution might require monitoring in the predicted flow path between the source and one of the receptors listed above. However, monitoring data to assess objectives for general groundwater quality could be provided by more dispersed monitoring depending on the conceptual model/understanding of the distribution of pollutants in the groundwater.

4.2.3 Ensuring the cost-effective development of groundwater monitoring networks

Reliable monitoring data are essential for the cost-effective achievement of objectives for groundwater. However, installing groundwater monitoring networks is expensive. Member States may have networks comprising a variety of site types ranging from infrequently used private wells to large yielding public water supply boreholes. The use of conceptual models/understanding as the basis for developing and reviewing monitoring networks should help ensure that each selected monitoring point provides relevant and reliable data for use in assessing the achievement of the Directive's objectives. It will also enable Member States with limited existing networks to iteratively build up their networks to the extent needed to test or develop their conceptual models/understandings. The alternative of installing a very extensive network and reducing this overtime would be far less effective and much more costly.

The Directive permits bodies of groundwater to be grouped for monitoring purposes. This is also important to ensure the most cost-effective design of monitoring networks. For example, in areas of high rainfall and only low levels of groundwater abstraction, existing data and monitoring information from a representative selection of bodies should provide sufficient information to confirm that the bodies achieve good quantitative status. However, such grouping must be undertaken on a scientific basis so that monitoring information obtained for the group provides for a suitably reliable assessment that is valid for each body in the group. This means that either:

- The conceptual models/understandings for the bodies in the group should be similar such that the testing of the models and the predictions made on the basis of those models, for a selection of the bodies in the group will also provide sufficient confidence in the models and predictions for the other bodies in the group; or

- Monitoring information from a selection of the most sensitive bodies in a group demonstrates that those sensitive bodies, and hence the group as a whole, are not failing to achieve 'good' status because of the effects of a pressure, or pressures, to which all the bodies in the group are subject (e.g. diffuse pollution). Monitoring information may be needed initially from a range of bodies in the group to determine which are the most sensitive bodies.

The adequate testing of a conceptual model/understanding may require new, targeted monitoring data. However, particularly where pressures are low, adequate validation of a model may be achieved using existing data or data from a surface water monitoring programme.

Key principle

Groundwater bodies may be grouped for monitoring purposes provided that the monitoring information obtained provides for a reliable assessment of the status of each body in the group and the confirmation of any significant upward trends in pollutant concentrations.

Monitoring data from surface water bodies may be important in assessing the condition of bodies of groundwater. Surface waters with a large base flow can be used to indicate the quality of groundwater. The effects of human alterations to groundwater quality and levels on the status of large base flow surface waters are also likely to be larger than the effects of the same alterations on the status of low base flow surface waters.

Key principle

Designing and operating integrated groundwater and surface water monitoring networks will produce cost-effective monitoring information for assessing the achievement of the objectives for both surface and groundwater bodies.

4.2.4 Quality assurance of monitoring design and data analysis

The confidence in any assessment of groundwater will depend on the confidence in the conceptual model/understanding of how pressures are interacting with the groundwater system. The confidence in any model needs to be evaluated by testing its predictions with monitoring data. However, errors in the monitoring data could lead to errors in the evaluation of the reliability of the conceptual model/understanding. It is important that the probability and magnitude of errors in the monitoring data are estimated so that the confidence in the conceptual model/understanding can be properly understood. For the surveillance and operational monitoring programmes, estimates of the level of confidence and precision in the results of monitoring must be given in the river basin management plans[41].

An appropriate quality assurance procedure should reduce errors in monitoring data. Such a procedure should review the location and design of monitoring points to ensure that the data they provide are relevant to the aspects of the conceptual model/understanding being tested. Errors can also occur in sampling and in the analysis of water samples. Quality assurance procedures may take the form of standardisation of sampling and analytical methods (e.g. ISO standards); replicate analyses; ionic balance checks on samples; and laboratory accreditation schemes.

4.3 Characterisation of groundwater bodies

The Annex II initial and further characterisation should provide the basic information for designing targeted and cost-effective monitoring programmes. To do this, the Annex II procedure must produce a conceptual model/understanding for each body of groundwater, or group of bodies, that is (a) relevant to assessing how the identified pressures could affect the objectives for the body, or group of bodies, and (b) proportionate in terms of its detail and complexity to the likely risks to the objectives for that body, or group of bodies. Monitoring information may be used to iteratively improve the conceptual model/understanding so that it provides for appropriately reliable assessments.

The initial results of the Annex II assessments must be reported at the end of 2004. However, the assessments may need further development to help design the monitoring programmes for implementation at the end of 2006. The monitoring data provided by the monitoring programmes will then be available to validate and refine the assessments and the conceptual models/understandings on which they were based.

4.4 Monitoring of quantitative status

4.4.1 Purpose of monitoring

The Directive's requirements for good groundwater quantitative status are three-fold. Firstly, there is a requirement to ensure that the available groundwater resource[42] for the body as a whole is not exceeded by the long-term annual average rate of abstraction[43]. Secondly, abstractions and other anthropogenic alterations to groundwater levels should not adversely affect associated surface water bodies and terrestrial ecosystems that depend directly for their water needs on the body of groundwater. Thirdly, anthropogenic alterations to flow direction must not have caused, or be likely to cause, saltwater or other intrusion.

In assessing quantitative status, the water needs of associated surface water bodies and directly dependent terrestrial ecosystems must be taken into account. For the latter, good groundwater status requires that human alterations to groundwater flows and levels have not caused, and, taking account of lag times, will not cause, significant damage. However, the Directive does not provide an explanation of what constitutes 'significant damage'. Existing data held by Member States about the ecological, cultural and socio-economic significance of dependent terrestrial systems should be used as the basis of a 'significance test' in this context.

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[41] *Annex V 2.4.1*
[42] *Article 2.27*
[43] *Annex V 2.1.2*

Even if long-term level monitoring data are available, the measurements of groundwater levels may not be sufficient on their own to assess the available groundwater resource (see Table 4.1). For example, there may have been an impact prior to the start of the monitoring or a new abstraction may be proposed. The prediction of adverse impacts on associated surface water bodies or terrestrial ecosystems using level monitoring will normally need to be supported by an estimate of recharge, a conceptual model/understanding of the flow system and a water balance estimate to test the conceptual model/understanding (see Section 1 of the toolbox).

Table 4.1 The role of water level and spring flow data, conceptual modelling and water balance estimation in assessing quantitative status. In scenarios 2, 3 and 4 monitoring data may be required to test the conceptual model/understanding.

Scenario 1	Scenario 2	Scenario 3	Scenario 4
(a) Long-term level monitoring data is available (b) No trends in data indicating falling water levels noted (c) No impacts thought to be present on the water needs of surface ecosystems (d) No increase in the level of abstraction is proposed	(a) Long-term level monitoring data is not available	(a) Long-term level data may or may not be available (b) A new abstraction is proposed	(a) Long-term level data may or may not be available (b) Impacts are thought to be present on the water needs of surface ecosystems
The available level data is sufficient to indicate that the water balance is satisfactory	**Conceptual model/ understanding and water balance calculation will be necessary**	**Conceptual model/ understanding and water balance calculation will be necessary**	**Conceptual model/ understanding and water balance calculation will be necessary**

Key principle

Information on levels (spring flows etc) should be used in conjunction with estimates of recharge and an appropriate conceptual model/understanding of the groundwater flow system when assessing the quantitative status of bodies of groundwater, or groups of bodies.

The estimation of recharge and the development of a suitable conceptual model/understanding should be part of the characterisation of bodies of groundwater, or groups of bodies.

4.4.2 Water Level Monitoring Network Design

The water level monitoring network should be designed so that it supports and aids the development and testing of the conceptual model/understanding. The development of the network will be an iterative process, evolving over time where necessary. The amount of monitoring required also depends on the extent of existing information on water levels and the groundwater flow system. Where this is adequate and reliable, it may not be necessary to extend monitoring programmes.

What to monitor

The most appropriate parameters to monitor quantitative status will depend on the conceptual model/understanding of the groundwater system. For example, spring flows or even base-flows in rivers may be more appropriate than the use of boreholes in low permeability fractured media or where the risks of failing to achieve good quantitative status are low and information from the surface water monitoring network can adequately validate this assessment.

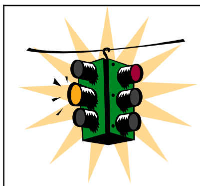
Where to monitor

The choice of where to monitor will depend on what is needed to test the conceptual model/understanding and the predictions it provides. In principle, the more spatially variable the groundwater flow system or the pressures on it, the greater the density of monitoring points that will be required to provide the data needed to make suitably confident assessments of the status of a groundwater body, or group of bodies.

When to monitor

The most appropriate monitoring frequency will depend on the conceptual model/understanding of the groundwater system and the nature of the pressures on the system. The frequency chosen should allow short-term and long-term level variations within the groundwater body to be detected. For example, for formations in which the natural temporal variability of groundwater level is high or in which the response to pressures is rapid, more frequent monitoring will be required than will be the case for bodies of groundwater that are relatively unresponsive to short-term variations in precipitation or pressures. Where monitoring is designed to pick up seasonal or annual variations, the timing of monitoring should be standardised from year to year.

4.5 Monitoring of chemical status and pollutant trends

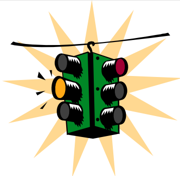
	***Look Out!*** ***Article 17 requires the Commission to come forward with a proposal for a daughter directive on groundwater by the end of 2002. Among other things, this proposal may include further criteria for assessing good groundwater chemical status and for the identification of trends. This may have implications for the design of the monitoring programmes described in this section.***

4.5.1 Purpose of monitoring

Groundwater quality monitoring carried out in accordance with the WFD should be designed to answer specific questions and support the achievement of the environmental objectives. The principal purposes of groundwater quality monitoring are to:

(a) Provide information for use in classifying the chemical status of groundwater bodies or groups of bodies;

(b) Establish the presence of any **significant** upward trend in pollutant concentrations in groundwater bodies and the reversal of such trends.



Look Out!

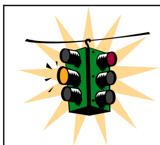
Article 4.1.b.iii requires the reversal of any significant upward trend in pollutant concentrations in groundwater. However, the monitoring requirements set out in Annex V only refer to monitoring in bodies of groundwater. Since all groundwater that could adversely affect surface ecosystems or is capable of providing more than 10 m^3 a day for abstraction will be part of an aquifer (see Horizontal Guidance on Water Bodies), nearly all groundwater will be included within bodies of groundwater. By definition, pollutant trends in groundwater that is not part of a body of groundwater should not be able to significantly affect any surface water bodies, terrestrial ecosystems or uses of groundwater requiring significant abstraction. Therefore, trends in pollutants in any groundwater that is not part of a body of groundwater would not normally be expected to constitute pollution as defined in Article 2.33.

The requirements of good groundwater chemical status are threefold:

1. The concentrations of pollutants should not exhibit the effects of saline or other intrusions as measured by changes in conductivity;
2. The concentration of pollutants should not exceed the quality standards applicable under other relevant Community legislation in accordance with Article 17. The daughter directive will clarify this criterion; and
3. The concentration of pollutants should not be such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.

All three criteria must be satisfied for a body to achieve 'good' groundwater chemical status. If not, the body should be classified as 'poor' groundwater chemical status. The classification of groundwater chemical status is only concerned with the concentrations of substances introduced into groundwater as a result of human activities. The concentration of substances in an undisturbed body of groundwater (e.g. naturally high concentrations of arsenic) will not affect the body's status. However, naturally occurring substances released by human activities, such as mining, will be relevant to the assessment of status.

Additional criteria for starting points for trend reversal may be specified in the daughter directive under Article 17. However, it is already clear that the purpose of trend reversal is to reduce pollution of groundwater, where pollution is defined in terms of risks of harm to the quality of aquatic and terrestrial ecosystems, human health, damage to material property and interference with legitimate uses of the environment[44]. A conceptual model/understanding of the groundwater system and the fate and behaviour of pollutants should therefore be used to predict those trends that have resulted, or would result, in pollution.



Look Out!

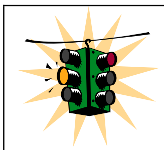
The Directive says surveillance monitoring must be undertaken during each planning cycle, and operational monitoring must be carried out during periods not covered by surveillance monitoring. No minimum duration or frequency is specified for the surveillance programme. Operational monitoring must be carried out at least once a year during periods between surveillance monitoring. Member States should undertake sufficient surveillance monitoring during each plan period to allow adequate validation of the Annex II risk assessments and obtain information for use in trend assessment, and sufficient operational monitoring to establish the status of bodies at risk and the presence of significant and sustained upward trend in pollutant concentrations.

[44] *Article 2.33*

4.5.2 Surveillance monitoring

The confidence in the Annex II risk assessments will be variable depending on the confidence in the conceptual model/understanding of the groundwater system. Surveillance monitoring is intended to provide information to:

- **supplement and validate the assessments** of risks of failing to achieve (1) good groundwater status [Article 4.1(b)(i) and Article 4.1(b)(ii)]; (2) any relevant Protected Area objectives [Article 4.1(c)]; or (3) the trend reversal objective [Article 4.1(b)(iii)]; and
- **contribute to the assessment of significant long-term trends** resulting from changes in natural conditions and anthropogenic activity.



Look Out!

Surveillance monitoring is only specified in the Directive for bodies at risk or which cross a boundary between Member States. However, to adequately supplement and validate the Annex II risk assessment procedure, validation monitoring will also be needed for bodies, or groups of bodies, not identified as being at risk. The amount and frequency of monitoring undertaken for these bodies, or groups of bodies, must be sufficient to enable Member States to be adequately confident that the bodies are at 'good' status and that there are no significant and sustained upward trends. Colour-coded maps of the status of all bodies must be published in the river basin management plans.

Validation will involve testing the conceptual models/understanding to the extent necessary to confidently differentiate bodies at risk from those not at risk and thus classify as 'good' status those bodies considered not to be at risk. Surveillance monitoring may also provide sufficient information to reliably classify, as 'poor' status, some bodies thought to be at risk.

4.5.3 Operational monitoring

Operational monitoring must provide the monitoring data needed to achieve an appropriate level of confidence to classify bodies at risk as either poor or 'good' status or to establish the presence of significant upward trends in pollutants (see Figure 4.4).

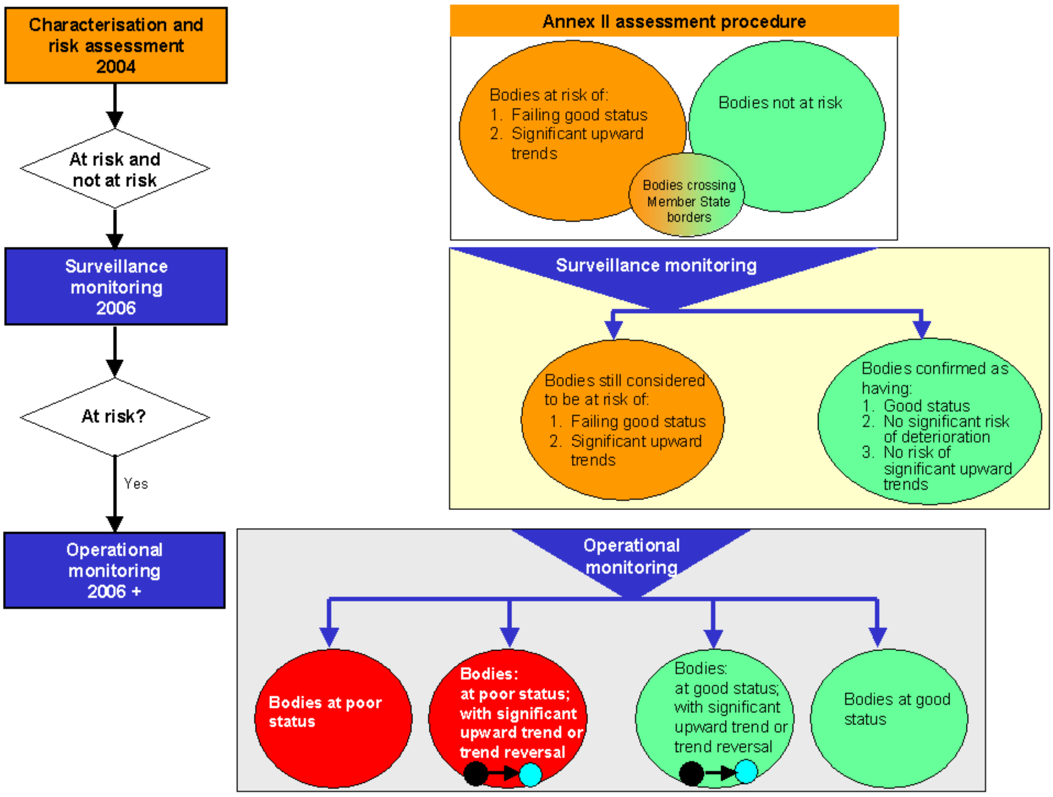


Figure 4.4 The outputs of risk assessment, surveillance and operational monitoring.

The surveillance monitoring programmes must be designed on the basis of the results of Annex II characterisation and risk assessment procedure. Operational monitoring programmes must be designed on the basis of the characterisation and risk assessment as refined by the data from the surveillance monitoring programmes. To supplement and validate the Annex II risk assessments, surveillance monitoring will be necessary in bodies, or groups of bodies, identified as being at risk and a selection of those identified as not being at risk. Operational monitoring is focused exclusively on bodies, or groups of bodies, at risk. Note the information provided by operational monitoring may establish that some bodies, or groups of bodies, considered likely to fail to achieve environmental objectives on the basis of the Annex II risk assessment and the surveillance monitoring programme are at 'good' status.

4.5.4 Where to monitor

Information on pressures, the conceptual model/understanding of the groundwater system, the fate and behaviour of pollutants in it and the consequent risks to the objectives should be used to determine the most appropriate locations for monitoring points. For example, where a surface water body or a directly dependent terrestrial ecosystem is at risk from a significant point source, the monitoring locations to test the prediction provided by the conceptual model/understanding (see Figure 4.5) would be different from those needed to test a conceptual model/understanding suggesting a risk to the objectives from diffuse pollution distributed uniformly across a groundwater body.

Where the conceptual models/understandings of a group of groundwater bodies and the pressures on each of the bodies in the group is similar, the validation of the model may be achieved using monitoring information from a selection of water bodies rather than using monitoring data for each body. In some cases, existing monitoring data or monitoring data collected by the surface water monitoring programmes may be sufficient to adequately test a conceptual model/understanding.

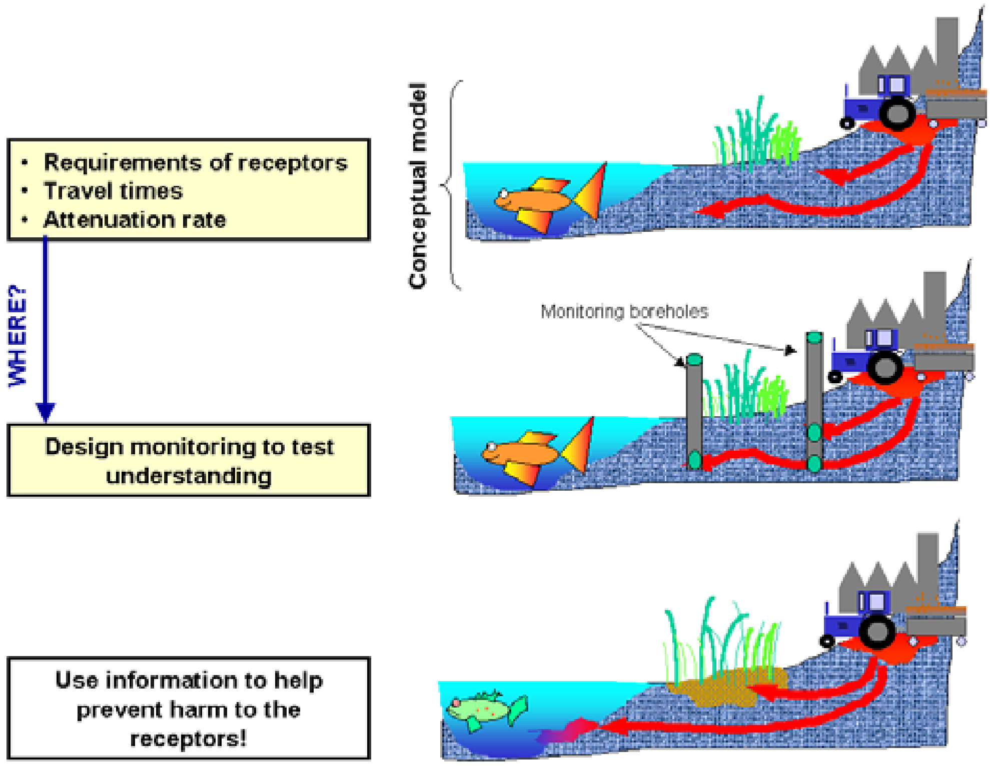


Figure 4.5 The selection of monitoring locations will depend on the development of a conceptual model/understanding of how the objectives for the body of groundwater may be at risk (see Section 1 of the Toolbox). For example, a pollutant plume from a point source discharge that may be adversely affect an associated surface water body may require the use of targeted monitoring compared to that needed to assess risks from pollutants distributed uniformly across a body of groundwater.

4.5.5 What to monitor

Where surveillance monitoring is required, the Directive requires that a core set of parameters be monitored. These parameters are oxygen content, pH value, conductivity, nitrate and ammonium. Other monitored parameters for both surveillance and operational monitoring must be selected on the basis of (a) the purpose of the monitoring programme, (b) the identified pressures and (c) the risk assessments made using a suitable conceptual model/understanding of the groundwater system and the fate and behaviour of pollutants in it. For example, the principal purpose of surveillance monitoring is to supplement and validate the Annex II risk assessments. To do this, the predictions of risk made during the Annex II assessments must be tested. Such testing should involve consideration of:

(a) the predicted effects of pressures identified during the Annex II risk assessment procedure; and

(b) whether there are any significant effects due to pressures not identified during the Annex II assessment procedure.

In the case of point (b) above, the guidance recommends that Member States select monitoring parameters that, if present, would indicate effects associated with different types of human activity. Some examples of indicators relevant to different activities that may be present in the recharge area of bodies, or groups of bodies, of groundwater are suggested in Table 5.2 (Chapter 5).

Table 5.3 (Chapter 5) provides examples of pollutants typically associated with different human activities, and which may therefore be appropriate to consider in monitoring programmes depending on the conceptual model/understanding and the likely risks to the objectives. For example, suites of parameters commonly associated with certain types of pressures have been identified (e.g. gas works: PAH, Phenol, hydrocarbons, etc). Parameters indicative of the pollutants that are liable to be present can be used to ensure cost-effective monitoring. The toolbox outlines some of the indicators used by Member States.

Other chemical parameters may need to be sampled for quality assurance purposes. For example, measuring the concentrations of major ions in a water sample so that an ion balance can be used as a check that the water analysis results are representative of the sampled groundwater should be considered as a routine quality assurance procedure.

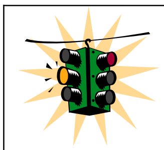
4.5.6 When to monitor

The conceptual model/understanding of the groundwater system and the understanding of the fate and behaviour of pollutants within it, and the aspect of the model being tested should also determine the appropriate frequency of monitoring. The toolbox provides examples of frequencies that Member States have found appropriate in a number of hydrogeological circumstances and in relation to different pollutant behaviours.

4.6 Monitoring of Protected Areas

The Water Framework Directive establishes a planning framework to, among other things, support the achievement of the standards and objectives for Protected Areas established under Community legislation. In the context of groundwater, these areas may include Natura 2000 sites established under the Habitats Directive (92/43/EEC) or the Birds Directive (79/409/EEC), Nitrate Vulnerable Zones established under the Nitrates Directive (91/676/EEC) and Drinking Water Protected Areas established under Article 7 of the Water Framework Directive.

To ensure monitoring programmes are as efficient and as effective as possible, it would be appropriate to ensure that the quantitative status and the chemical status monitoring programmes described above complement, and are integrated with, the programmes established for Protected Areas so that the groundwater monitoring networks are as far as possible multi-purpose



Look Out!

For Drinking Water Protected Areas, Article 7.1 requires Member States to make sure they monitor, in accordance with Annex V, bodies of groundwater providing more than 100 m^3 a day as an average. Annex V does not define any specific additional monitoring requirements for such bodies. In contrast, Annex V does define specific monitoring requirements for surface water bodies used to provide more than 100 m^3 a day as an average.

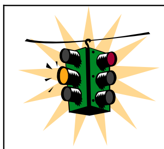
No specific monitoring requirements are described in relation to the Drinking Water Protected Area objective of preventing deterioration in quality in order to reduce the level of purification treatment required in the production of drinking water [Article 4.1(c), Article 7.3]

The achievement of the Drinking Water Protected Area objective requires that the quality of the abstracted groundwater prior to treatment does not change as a result of human activities in a way that would require an increased level of purification treatment to meet the standards required at the point of consumption under Directive 80/778/EEC, as amended by Directive 98/83/EC. Assessing compliance with, and providing the necessary information to achieve, this objective requires:

- Establishing the chemical composition of the abstracted water prior to any purification treatment. This analysis should take account of any parameters that could affect the level of treatment required to produce drinking water. Member States are required under Annex II 2.3(c) to collect and maintain information on the chemical composition of water abstracted from (i) any points providing an average of 10 m^3 or more per day, whether or not that water is intended for human consumption, and (ii) points serving 50 or more persons;

- During each planning period, collecting information, where relevant, on the composition of water abstracted in a way that is proportionate to the risks to the quality of that water identified in the Annex II risk assessment procedure. This should enable the detection of any deterioration in the abstracted water's quality that could affect the level of purification treatment required to produce drinking water – and hence indicate a failure to achieve the Protected Area objective;

- Establishing a conceptual model/understanding of the groundwater system from which the abstracted water is drawn. The model should be proportionate to the likely risks to the objective and should enable measures to be designed, where necessary, to protect the recharge area from any inputs of pollutants that would result in a failure to achieve the Protected Area objective (see Section 6 of the groundwater toolbox).



Look Out!

Revisions are currently being proposed to the draft guidelines for the monitoring required under the Nitrates Directive (91/676/EEC).

4.7 Reporting Requirements

A summary report of the network must be submitted to the Commission by 22 March 2007[45], and a map showing the network must be included in the river basin management plan.

4.7.1 Chemical and quantitative status assessment

The results of monitoring should be used to assess whether any of the criteria defining 'good' status have been failed. If so the body should be classed as 'poor' status. The Directive specifies that in assessing chemical status for a groundwater body, the results of individual monitoring points within a groundwater body should be aggregated for the body as a whole. Figure 4.5 describes the tests involved in assessing the status of a body of groundwater.

[45] *Article 15*

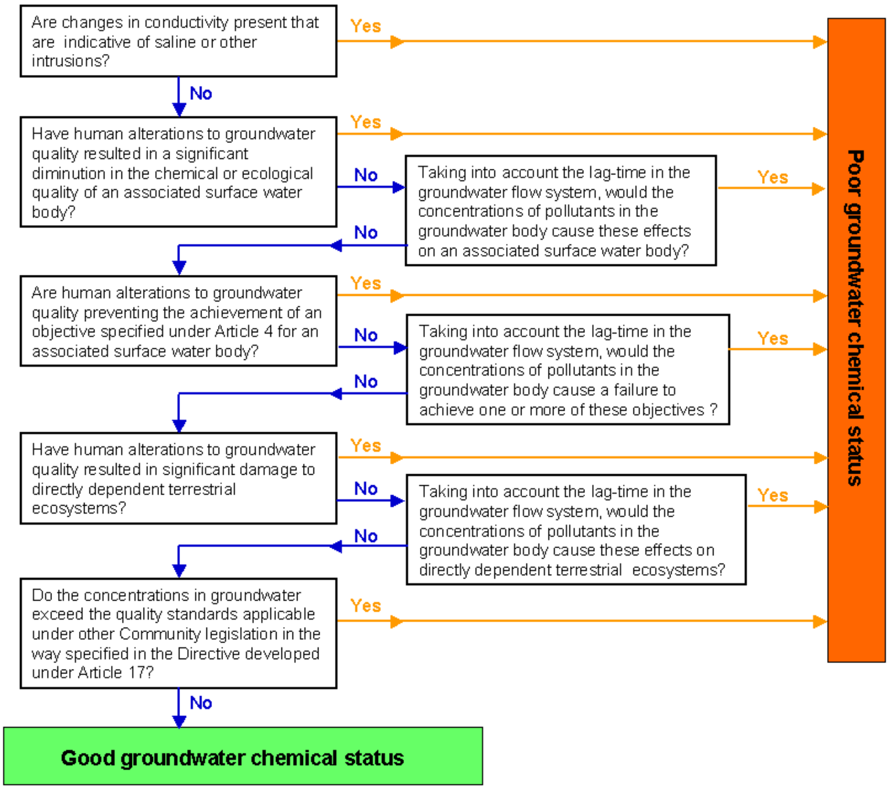


Figure 4.6 **Tests involved in determining the chemical status of a body of groundwater. In conjunction with a suitable conceptual model/understanding of the groundwater system, information from monitoring points in the body of groundwater, or group of bodies should be used to make an assessment of the chemical status of the body, or bodies. Such an assessment requires consideration of each of the tests shown in the Figure.**

4.8 Schedule of Monitoring

Table 4.2 Critical Path Analysis for Work Needed on Monitoring for WFD

FORMAL WFD REQUIREMENT	Monitoring Work needed to aid decisions	Related work from other CIS WGs, EAF	Time needed	When start to hit critical path	To be completed
Initial delineation of water bodies		Water body paper is being prepared by the Commission	1 yr	2002	Beginning 2003
Characterisation of water bodies according to Annex II		Guidance is being developed by CIS 2.1: IMPRESS	2 yrs	2002/3	End 2004
Defining information needs	Translate information from characterisation into monitoring strategy		0.5 yrs	2004	2005
Design and installation of monitoring network	Implement strategy for quantitative monitoring and chemical monitoring		1 yr	2005	2006
	Compare existing monitoring stations/networks with the strategy		0.5 yrs	2005	End 2005
	Installation of new monitoring stations, modification of existing ones, if required		1 yr	2005	2006
	Make monitoring network operational				End 2006
Performing monitoring, data collection	Monitoring of groundwater quantitative status		1 yr	2006	2007
	Monitoring of groundwater chemical status surveillance monitoring operational monitoring	Scope of monitoring is defined by Annex V and may be supplemented by a new Groundwater Directive under Article 17	1 yr	2006	2007
Assessing monitoring results, interpretation and presentation of groundwater status	Quality assurance and quality control	Additional criteria for defining good groundwater status and defining significant trends may be introduced by a daughter directive under Article 17	0.5 yrs	2008	2008
Detail work programme for RBMPs		Guidance will be developed by BESTPRACT	0.5 yrs		2003-5
Identify significant water management issues	Could not be based on monitoring results because they are not available in time	Guidance will be developed by BESTPRACT	0.5 yrs	2005	2007
Publish and consult on draft RBMPs	Could be based on preliminary monitoring results, if available on time	Guidance will be developed by BESTPRACT	1yr	2007	2008
Publish RBMPs and establish programme of measures in each basin for each RBMP	Based on status assessment according to monitoring results	Guidance will be developed by BESTPRACT	0.5 yrs	2008	2009 end
Implement measures			3 yrs (?)		2012
Continuation of first monitoring cycle			7 yrs	2008	2015
Second cycle of monitoring	Aim: inter alia validation of effects of measures		6 yrs	2016	2021

5 Best Practices and Tool Box

5.1 General Guidance for Optimisation of Monitoring Programmes

5.1.1 Issues for Consideration

The key processes involved in designing an environmental monitoring programme are to determine what to monitor, where, when and how often. The answers to these questions depend on:

- The objective(s) of the monitoring (e.g. to determine the chemical status of a water body, or to test for a trend);
- The desired precision and confidence with which the required statistic (e.g. a percentile, or the slope of a linear trend) is to be estimated; and
- The types and magnitudes of variability exhibited by the water body or bodies to be monitored.

It is therefore imperative to clearly identify the key objectives that the monitoring needs to address. This will govern the approach to programme design and enable identification of:

- The hypotheses to be tested;
- Realistic and measurable goals/targets; and
- The acceptable level of risk, precision and confidence.

The information obtained can then be used to formulate an understanding of the system to be studied and develop the appropriate questions to be asked, based on the identified hypotheses. This can be formalised using a conceptual process model, which links the driving forces, pressures and current state of the system. The assumptions underlying the model can be reviewed and validated throughout the study, as more information becomes available.

Temporal and spatial heterogeneity, both natural and anthropogenic, should be considered, as this will influence the location and number of water bodies monitored, the location and number of monitoring stations within each water body, and the frequency of sample collection.

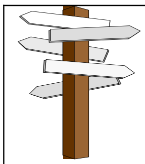
Selecting acceptable levels of risk, precision and confidence would set limits on how much uncertainty (arising from natural and anthropogenic variability) can be tolerated in the conclusions obtained from monitoring programmes.

Once the acceptable levels of risk, precision and confidence associated with the identified objectives have been defined, an optimal monitoring programme can be developed using a range of statistical tools. These tools will ensure that the programme:

- Meets the required objectives of the programme;
- Monitors a sufficient number of sites and at a frequency that provides the required precision and confidence in the results; and
- Is implemented in a cost effective and scientifically robust manner.

Statistical planning tools covering a comprehensive range of common monitoring objectives are provided by the ‘Manual of Best Practice for the Design of Water Quality Monitoring Programmes’. This manual presents the results of a collaborative study between the UK and Italy to assist organisations charged with monitoring activities. The manual provides step-by-step guidance on the choice of an appropriate monitoring strategy, the quality elements to be monitored, the sample numbers needed to achieve the desired precision and confidence, and appropriate data analysis methods. The manual emphasises the importance of ensuring that the method of data analysis is specified at the programme planning stage, as this forms an integral part of the calculation of required sample numbers. For example, if the required number of samples to achieve a specified precision and confidence were calculated on the assumption that linear regression would be the method of trend analysis, that precision would not subsequently be achieved if it were later decided to switch to the use of Sen's test for trend.

The guidance covers the use of both chemical and biological monitoring methods, for rivers, estuaries and coastal waters.



Information to assist with the Statistical Design of Monitoring Programmes can be found in:

- *Manual of Best Practice in the Design of Water Quality Monitoring Programmes*
- *Vos, P., E. Meelis and W.J. ter Keurs, 2000, A framework for the design of ecological monitoring programs as a tool for environmental and nature management. In: Environmental Monitoring and Assessment 61: 317-344.*
- *Nagelkerke, L.A.J. and W.L.T. van Densen, The utility of multivariate techniques for the analysis of fish community structures and the design of monitoring programmes, 2000. In: Proceedings Monitoring Tailor-Made III (eds J.G. Timmerman, W.P. Cofino, R.E. Enderlein, W. Jülich, P. Literathy, J.M. Martin, P. Ross, N. Thyssen, R. Kerry Turner, R.C. Ward), p. 323-332.*

5.1.2 Development of a Conceptual Understanding

Conceptual models[46] play a key role in the guidance and should be used as a basis for the development and review of monitoring programmes in accordance with the Directive.

The level of detail required in the model is proportional to the difficulty in judging the effects of pressures on the objectives. Monitoring data is required to test or validate the conceptual model/understanding. Such testing will require some monitoring data for all bodies, or groups of bodies, identified as being at risk as well as a selection of those identified as not being at risk of failing their objectives.

The amount of monitoring information needed to validate the Annex II risk assessments will depend in part on the level of assurance in the conceptual model/understanding. The greater the difficulty in judging the risks to the objectives, the more monitoring information is likely to be required. The greatest amount of monitoring will be necessary where the implications of misjudging the risks to the objectives would be very serious - where, for example, it could lead to substantial costs being unnecessarily imposed on water users (the Type I error), or fail to identify risks of significant damage that could be averted (the Type II error).

The amount of monitoring that is required will be related to:

- **the difficulty in judging (a) the status of a water body, or group of water bodies and (b) the presence of adverse trends, and the implications of errors in such judgements.**

[46] A conceptual model in this context does not refer to a quantitative mathematical model, rather a 'qualitative conceptual understanding' of the interrelationships occurring within the system.

During the course of each planning cycle, and between one planning cycle and the next, new monitoring data will contribute to improved understanding of the water bodies concerned and their vulnerability to pressures. This will increase confidence in the conceptual model/understanding and the risk assessments it enables.

Key Principle

The conceptual model/understanding represents the current understanding of the system based on information on its natural characteristics and the pressures on it. Monitoring should provide the information needed to test the model and, where necessary, improve it so that it produces an appropriate level of assurance in the assessment pressures and impacts.

5.1.3 Quality assurance/Quality control

ISO 5667-14 describes a variety of quality control techniques for monitoring all types of water samples.

Where available, methods standardised by ISO, CEN or national standardisation bodies should be used. In any case, the laboratory using a method should be responsible for ensuring that the method is adequately validated. If the method has been validated by a standards approving organisation, the user will normally need only to establish performance data for their own use of the method.

In the case of methods that have not been validated by a standardisation body, the documentation describing the method should be clear and unambiguous in order to allow easy implementation. ISO 78-2 advises on methods documentation for general chemical methods.

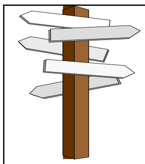
In order to assure comparability across Europe, laboratories must document a programme of quality assurance/quality control (EN ISO 17025) and participate regularly in proficiency testing programmes.

A requirement of the WFD is that all monitoring shall conform to the relevant standards on the national, European or international scale to ensure the provision of data of an equivalent scientific quality and comparability. Therefore, all biological and physico-chemical assessment systems must comply with the relevant international and national standards where they exist.

At present there are a number of standards covering the sampling of macroinvertebrates. Equivalent standards are currently lacking for phytoplankton, macrophyte, benthic algae, and fish sampling, but they all are under development in CEN, and will probably be ready before 2006. Though there are appropriate standard methods for many of the physico-chemical quality elements, for many of the priority substances there are no standard analytical techniques. The expert working group on the analysis and monitoring of priority substances will deal with standard analytical methods for priority substances.

Key Issue

It is recommended that appropriate standards are developed as a matter of priority and urgency for those aspects of monitoring for which there are no internationally agreed standards or techniques/methods.



You can obtain ISO/CEN Standards

For details of the available ISO/CEN standards, refer to the following sites:

- *CEN www.cenorm.be/catweb*
- *ISO www.iso.ch*

For rivers, lakes and ground water there are monitoring guidelines prepared by UN/ECE Working Group on Monitoring and Assessment.

For coastal and transitional waters, there are also monitoring guidelines of OSPAR (Joint Monitoring and Assessment Programme) and HELCOM (COMBINE-Programme). Ongoing work of the ICES/OSPAR and ICES/HELCOM Steering Groups on Quality Assurance in the North East Atlantic (SGQAE) and in the Baltic (SGQAB), and the work of quality assurance groups like QUASIMEME and BEQUALM should also help to ensure that comparable and quality monitoring data are produced for the Water Framework Directive.

Implementation of QA programmes

Errors inevitably occur both in the process of sampling and in the analysis of water samples. The aim of an appropriate quality assurance procedure is to quantify and control these errors. Quality assurance procedures may take the form of standardisation of sampling and analytical methods, replicate analyses, ionic balance checks on samples and laboratory accreditation schemes.

Notwithstanding the benefits of the one-off intercalibration exercise for the purpose of classification and comparison with the results from other appropriate Member States, a continuous quality assurance system should be developed to ensure that all monitoring results meet assured target levels of precision and bias. Therefore, QA measures should be implemented for each monitoring institution as well as in data collection centres, and encompass all operational facets of a monitoring programme, including:

- Field sampling and sample receipt;
- Sample storage and preservation; and
- Laboratory analysis;

These measures are based on:

- Developing comprehensive and understandable Standard Operating Procedures (SOPs);
- Using validated monitoring methods (sampling, chemical or biological analysis, reporting), that means experimental proof and related documentation confirms that each method is fit for its intended purpose;
- Establishing routine internal quality control measures (control charts, reference materials, internal QA audits); and
- Participation in external QA schemes (laboratory proficiency testing schemes, taxonomical workshops, external QA audits, QA accreditation).

It is generally accepted that approximately 25% of a laboratory's effort is required to establish and maintain an effective quality assurance system.

Experimental evidence must be supplied and documented in SOPs such that:

- All methods possess sufficient sensitivity, selectivity and specificity;
- Method accuracy and precision meet the requirements (still to be established) for each programme of measures developed for implementation of the Water Framework Directive; and
- Analytical detection limits (i.e. the smallest concentrations that are quantitatively detectable with a defined uncertainty) do not jeopardise the assessment of compliance with quality limits/targets or decisions made between good and moderate status.

In routine monitoring, quality assurance should ensure at any time that the methods used are strictly controlled and monitored. For that purpose, all monitoring institutions should have implemented an internal QA system according to ISO 17 025 (2000). To obtain long-term control of the performance of monitoring methods, results of internal QA measures (e.g. analysis of certified reference materials) must be recorded in control charts.

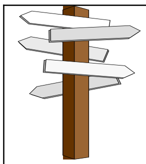
To evaluate the comparability of monitoring data throughout the Member States, participation in external quality audits and in external quality assessment schemes like international laboratory proficiency testing or taxonomical workshops is highly recommended.

An acceptable level of quality must be achieved for all monitoring data generated within the WFD Monitoring. It is possible to evaluate if monitoring data is fit for the intended purpose using the following QA criteria:

- Monitoring data are reported with an uncertainty estimate calculated from method validation or from inter-comparison exercises;
- Limits of detection are well below the principal levels of interest and allow the control of quality objectives;
- Satisfactory results can be obtained in analysing independent reference materials/samples, and this is demonstrated by appropriate control charts (or electronic equivalent) for the determinands of interest; and,
- Participation in relevant proficiency testing schemes at least once per year (with the proportion of results identified as outside limits of error being below 20% for all parameters) Quality Assurance

Expression of results

The results of measurements must indicate any rounding of numbers, final units, ± combined uncertainty, confidence interval. The detection limit (limit of quantification) of the method should be reported. The procedure of calculation of the detection limit (limit of quantification) should also be clearly reported.



Key sources of information on sampling protocols and quality assurance

- *The UN/ECE Task Force on Monitoring and Assessment provides practical guidance on methods and quality assurance for monitoring transboundary waters (www.iwac-riza.org).*
- *The European Environment Agency provides technical guidance on design and operation of monitoring networks through its EUROWATERNET initiative (www.eea.eu.int).*

5.2 Best Practice and Tool Box for Monitoring Surface Waters

5.2.1 Objectives of monitoring

While the overall objectives of monitoring for the Directive are clearly defined, the specific monitoring objectives cannot be specified in any detail, as they will change depending on the purpose i.e. surveillance, operational or investigative monitoring, or monitoring for protected areas. In this respect, monitoring programme objectives will be different when assessing ecological status, as opposed to monitoring seasonal or long-term trends. Similarly, investigative monitoring may involve different determinands, sites and frequencies than general operational or surveillance monitoring, as the programme will be designed to assess a specific stress or impact.

Key Principle

The monitoring programmes must provide the information necessary to assess whether the Directive's environmental objectives will be achieved. This means that, to design monitoring programmes in accordance with the requirements of the Directive, a clear understanding of the environmental conditions required for the achievement of the objectives, and how these could be affected by human activities, is essential.

5.2.2 Holistic Assessment of Ecological Quality

Most ecological assessment systems used to date have been restricted to the assessment of a single impact element, such as organic pollution or acidification, and are not applicable to a broad range of waterbody types or geographical regions. As identified by Nixon *et al* (1996), the WFD (then the Ecological Directive) requires that a classification system be capable of incorporating the full range of impacts. However, the system should also be capable of detecting specific impacts, such as organic pollution, where this has been identified as a key stressor during the surveillance monitoring period.

Numerous predictive systems have been developed, which compare the observed communities to those expected under reference conditions. The outputs of such systems give rise to unitless ratios of observed to expected values that are ideally suited to the WFD.

It has been agreed that the results of the systems operated by each Member State will be expressed as EQRs for the purposes of classification of ecological status. These ratios will represent the relationship between observed values and the values expected under the reference conditions applicable to that particular site. Member States will be required to express the ratio as a numerical value between zero and one, with 'good' ecological status represented by values close to one and 'bad' ecological status by values close to zero.

5.2.3 Incorporation of Natural and Artificial Habitat Variation

While a number of different assessment systems for rivers have attempted to incorporate natural habitat variation, the majority of biological classification systems do not account for variations in physical habitat. As a result, the observed diversity at many sites (e.g. lowland rivers, naturally silted) will not meet the expected diversity of the prescribed reference conditions, even if the site has pristine water quality.

Examples of systems which have attempted to include artificial habitat variation are the UK's RIVPACS (macroinvertebrates) and HABSCORE (salmonid fish abundance) systems. In these cases the reference condition is defined in terms of pristine water quality and existing physical habitat. Therefore, if the community is as would be expected for the existing physical habitat, and the water quality is pristine, it will receive that same EQI score as a pristine site that is not physically impacted.

5.2.4 Locations of water bodies to be monitored

It is not economically feasible to monitor all water bodies for all conditions. Therefore, it is necessary to group 'similar' water bodies (as discussed below) and to select appropriate representative sites for the determination of ecological status for that particular group of sites. As discussed in Chapter 2, while the Directive requires that monitoring is undertaken for all surface and groundwater bodies, grouping is permitted as long as sufficient water bodies are monitored within a group to provide an accurate assessment of status for that group.

Member States should firstly determine which water bodies are required to be monitored in accordance with the Directive. The water bodies selected will vary depending on the objectives of the programme. For example, Annex V of the Directive provides different criteria for the selection of water bodies, depending on whether the objectives of the programme are established to satisfy the requirements for surveillance, operational or investigative monitoring, or for protected areas. Therefore each Member State must first discriminate according to the specific requirements of the Directive (e.g. size/population boundaries) and eliminate those water bodies in which monitoring is not required.

Once the relevant water bodies have been identified, further grouping may be required due to economic constraints. Water bodies may be grouped based on similar hydrological, geomorphological, geographical or trophic conditions. Alternatively water bodies could be grouped based on similar catchment impacts or land-uses. However, the latter may only be possible in catchments that are dominated by a single land-use. Another possibility is to use multivariate classification procedures for identifying groups of sites that form relatively homogenous areas (although this 'black box' approach should be used with caution as there is no guarantee that the composition of the resulting groups will have a recognisable or obvious rationale). Whatever the method by which the water bodies are grouped, it is essential that sufficient water bodies are selected from each group to enable the specific objectives of the monitoring programme to be met with the required levels of precision and confidence.

The characterisation required by Annex II makes possible a characterisation of water bodies based on environmental variables. Water body characterisation as a function of pressures would be made possible through an assessment of pressures and impacts, in which optimisation of the monitoring programme could be achieved by a grouping of pressures.

A relationship may exist between the defined typologies and human pressures due to the fact that the human race tends to adapt to environmental conditions. This theory is supported by the results of a regionalisation study based on the geomorphology, physiography, climate and macroinvertebrate communities undertaken in the Ebro River Basin. The study found that almost 50% of the control stations investigated were considered as non-or less perturbed by human activity. However, substantial regional variation was reported. For instance, in mountain and high mountain regions, the percentage rose to between 70 and 90%, whereas in the southern mountain area the percentage decreased to 60%. In the central zone and in the hollow area, where there is the greatest concentration of human activity, the area assessed as "natural state" decreased to 20%.

5.2.5 Risk, Precision and confidence in the assessment of surface water and groundwater status

The concepts of risk, precision and confidence and how they relate to the Directive are discussed in Chapter 2. For convenience the definitions are repeated here:

Risk At the simplest level, a risk can be thought of as the chance of an undesirable event happening. It has two aspects: the chance, and the event that might happen. These are conventionally called the probability and the consequence.

Confidence The long-run probability (expressed as a percentage) that the true value of a statistical parameter (e.g. the population mean) does in fact lie within calculated and quoted limits placed around the answer actually obtained from the monitoring programme (e.g. the sample mean).

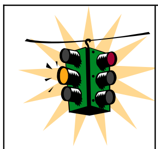
Precision Most simply, precision is a measure of statistical uncertainty equal to the half-width of the C% confidence interval. For any one monitoring exercise, the estimation error is the discrepancy between the answer obtained from the samples and the true value. The precision is then the level of estimation error that is achieved or bettered on a specified (high) proportion C% of occasions.

Where the monitoring objective relates to quality characterisation (e.g. to determine the status of a water body) the statistical objective is specified by stating:

- the parameter to be estimated (e.g. the mean or the 90-percentile);
- the desired precision (e.g. 0.5 mg/l; 20%); and
- the desired confidence (e.g. 90%, 99%).

Then, given an estimate of the variability of the determinand of interest in the water body, the required number of samples can be calculated. As a simple example, if s is the standard deviation, d is the desired precision, and u is the standard Normal deviate corresponding to the desired confidence level (e.g. u = 1.65 for 90% confidence), then the required number of samples is given approximately by:

$$n = (us/d)^2$$



Look Out!
Further information on methodology for the calculation of sample numbers to achieve desired levels of precision and confidence, or desired Type I and II errors, can be found in:

- ***Manual of Best Practice in the Design of Water Quality Monitoring.***
- ***Ellis 1989. Handbook on the Design and implementation of monitoring programmes;***
- ***Strien, A.J. van, R. van de Pavert, D. Moss, T.J. Yates, C.A.M. van Swaay and P. Vos, 1997, The statistical power of two butterfly monitoring schemes to detect trends. In: Journal of Applied Ecology, 34: 817-828.***
- ***Strien,. A.J. van, W. Hagemeijer and T.J. Verstrael, 1994, Estimating the probability of detecting trends in breeding birds: often overlooked but necessary. In: Bird Numbers 1992. Distribution, Monitoring and Ecological***
- ***Aspects (eds E.J. M. Hagemeijer and T.J. Verstrael), pp 525-531. Proceedings of the 12th International Conference of IBCC and EOAC. Statistics Netherlands/ SOVON, Voorburg/ Beek-Ubbergen***
- ***Matheron G., Traite de geostatistique appliquee. Tome 1(1962). Tome 2(1963), Editions Technip, Paris.***
- ***Matheron G., la theorie des variables regionalisees, et ses applications. Les cahiers du centre de morphologie mathematique, fascicule 5. Ecole des Mines de Paris, 1970.***

Other monitoring objectives will relate to the detection of trends or differences. The statistical objective is then expressed slightly differently, because there are two types of error to consider. It is now necessary to specify:

- the parameter to be estimated (e.g. the before-after mean difference, or the slope of a trend line);
- the desired confidence (C%) associated with any assertion that a change has been detected (e.g. 90%, 99%). The 'Type I error' - the risk of a false positive - is then given by (100 - C)%.
- the Type II error - the risk that a difference which is truly present fails to be detected by the monitoring programme.

As before, the required number of samples can be calculated given chosen values for the above items together with an estimate of the variability of the determinand of interest in the water body. As a simple example, if s is the standard deviation, D is the before-after mean difference that it is desired to detect, and u_1 and u_2 are the standard Normal deviates corresponding to the desired Type I and II errors, then the required total number of samples (split equally between the two periods of comparison) is given approximately by:

$$n = 2(\{u_1+u_2\}s/D)^2$$

Although a confidence level of 95% is commonly used, scope is available to trade off precision against confidence to produce a more congenial statistical specification for a given amount of sampling effort. However, Ellis (1989) points out that reducing the confidence level much below 90% represents a spurious saving. There is nothing to be gained by having a high degree of precision if there is only a poor level of confidence that it will actually be achieved. As a possible starting point Member States may wish to set the required confidence level at 90% and compare the achievable precision obtained for the different water body types, quality elements and summary statistics. Similarly the Type II error (the risk of failing to detect a change that has truly occurred) could be set at 10% when determining the amount of change or differences that can practically be detected by existing monitoring programmes.

Look Out!

Guidance on the level of precision required for classification should arise from WG 2.3 Reference conditions inland surface water and WG 2.4 Typology, classification of transitional, coastal waters, particularly for the different monitoring types – Surveillance, operational and investigative. This will influence advice on sampling frequencies and spatial distribution of sites.

The appropriate level of confidence and precision will, in part, relate to the implications of getting the assessments wrong (e.g. misclassifying a water body and thus imposing costs on water users). In a sub-catchment with no pressures upon it, relatively little monitoring information would be required to enable reliable classification. In a sub-catchment in which severe and obvious environmental damage is extensive, high confidence in status classification could also be achieved with limited monitoring. In contrast, considerable monitoring effort may need to be directed at sub-catchments subjected to a range of different pressures and with a range of sensitivities to those pressures.

Note that the number of water bodies in these sub-catchments has only a slight bearing on the required monitoring effort. Monitoring effort is dictated by the difficulty of determining the effects of significant pressures upon the water environment.

Figure 5.1 provides a practical example of how the number of stations required changes with different levels of precision for the same level of confidence. It concerns the estimation of mean phosphate concentration for different types of rivers (grouped as river types not as individual water bodies) in England and Wales. To achieve 50% precision with 90% confidence, the number of samples varies from 13 in small upland rivers to 39 in small lowland rivers. This indicates that the variability of phosphate is greater in the latter compared to the former and hence more stations are required to achieve the same precision. The numbers of stations to achieve 10% precision are much higher, namely 214 for small upland rivers and 675 in small lowland rivers. However, it should be pointed out that the Directive would only require such monitoring information if it were relevant to the assessment of significant effects upon the status of water bodies in the basin district.

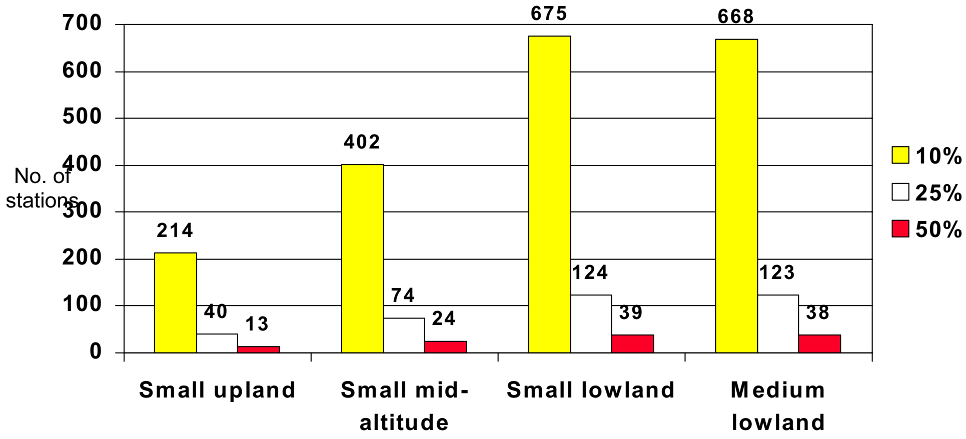


Figure 5.1 **Number of river stations required to estimate phosphate mean concentrations to 10%, 25% and 50% precision with 90% confidence***

**Note there were 103 stations on small upland rivers, 653 on small mid-altitude rivers, 3769 stations on small lowland rivers and 425 stations on medium lowland rivers*

Risk of failing environmental quality objectives

The Directive refers to the identification of water bodies at risk of failing environmental quality objectives as defined in Article 4. This identification will be partially based on existing monitoring data (initially) and then on data arising from surveillance monitoring for subsequent periods of RBMPs. Those water bodies identified as being at risk will then be subject to operational monitoring which will confirm or reject their status in terms of failure to meet the relevant objectives. By implication this means that operational monitoring may need to provide a more precise assessment of the status of those water bodies identified at-risk than that originally obtained from surveillance monitoring.

Not all the Environmental Objectives given in Article 4 will be applicable to all water bodies: they can be summarised as follows:

- To achieve good groundwater status, good ecological status, good ecological potential or good chemical status;
- To comply with any standards and objectives associated with Protected Areas;
- To prevent deterioration in the status of a body of surface water or groundwater;
- To progressively reduce pollution from priority substances, and cease or phase out emissions, discharges and losses of priority hazardous substances; and,
- To reverse any significant and sustained upward trend in the concentration of any pollutant in groundwater.

Objectives 1 and 2 imply that assessments will have to be made as to whether status is better or worse than that which defines the threshold value between good and moderate status (or potential), or is in compliance with defined standards. Objectives 3 to 5 relate to assessing whether status is deteriorating with time or pollution is decreasing with time. In the latter cases, threshold levels or concentrations of substances against which risk of failure is judged will be specific to the water body of interest and will relate to levels or concentrations specified at a particular time.

As indicated above, the assessment of the risk of failure of a water body will make use (when possible) of data from monitoring stations within the body. The discrimination between good and moderate and hence the risk of failure could be determined based on comparison of the calculated 'confidence of compliance' with the appropriate standard or threshold value.

As noted earlier, the assessment of failure would have to consider what would be acceptable Type I and Type II errors. A Type I error would occur when a water body that was truly satisfactory was failed on the evidence of the monitoring programme. Conversely, a Type II error would occur when a water body that was truly unsatisfactory was passed by the monitoring programme.

In the figure below (Figure 5.2), where the parameter of interest might for example be the 90%ile, the judgement will be easy to make when the sample 90%ile and the entire confidence interval better than the threshold or standard (case A, or when they are worse than the threshold or standard (case D. However, there will be many cases where there is an overlap between the confidence limits and the thresholds (cases B and C). There are three possible approaches to assess failure in these cases. In a benefit-of-the-doubt approach, a monitoring station/water body is deemed to have passed, even when the estimate P has marginally failed, as long as part of the confidence interval falls into the 'good' status range. In a fail-safe approach, conversely, the monitoring station/water body fails, even when the estimate P has marginally passed, as long as part of the confidence interval falls into the less than 'good' status. Finally, in a face-value judgement sampling error is ignored and the pass/fail rule depends solely on the observed value of the summary statistic P.

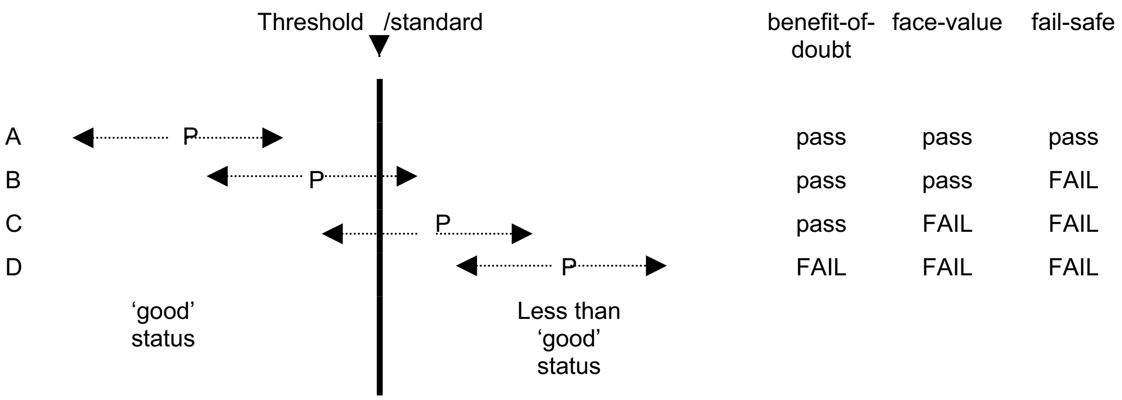


Figure 5.2 Methods of classification for groundwater bodies

NB: P denotes the parameter of interest (e.g. 90%ile) calculated from the sample data
represents the confidence interval for the unknown true value of P

The agreed or desired level of precision required in the estimate of the parameter P of interest and the desired level of confidence will determine how easy the above judgement of success or failure is going to be. For a given level of confidence, an increasingly precise estimate of P (obtained by increasing the number of samples) will reduce the width of the confidence interval, thus making the judgement of success or failure easier.

Risk of misclassification of status

The design of surveillance and operational monitoring should aim to control to acceptable levels the risk of a water body's status being wrongly assessed and hence misclassified.

Many water bodies and stations will lie close to class/status boundaries, and this, coupled with the uncertainty produced by infrequent/discrete monitoring, means that there is a substantial risk that such water bodies will be misclassified. This issue was examined by the Environment Agency of England and Wales. For their chemical general quality assessment ('GQA') scheme, it was demonstrated that, for any particular stretch of river, there was an average misclassification risk of 19%. The equivalent risk of misclassification based on sampling river invertebrates was calculated to be 22%.

The issue of misclassification was discussed at the REFCOND workshop held in Uppsala in May 2001. Two presentation slides from the workshop are reproduced below (Figure 5.3). They illustrate how the statistical uncertainty in the estimate of a water quality parameter (in this case 90%ile BOD) may cross a number of class boundaries. In this instance, the 'statistical confidence' curve spans three different classes. With 70% of the area of the curve lying within the moderate class, on a face value assessment the station would be classified as moderate.

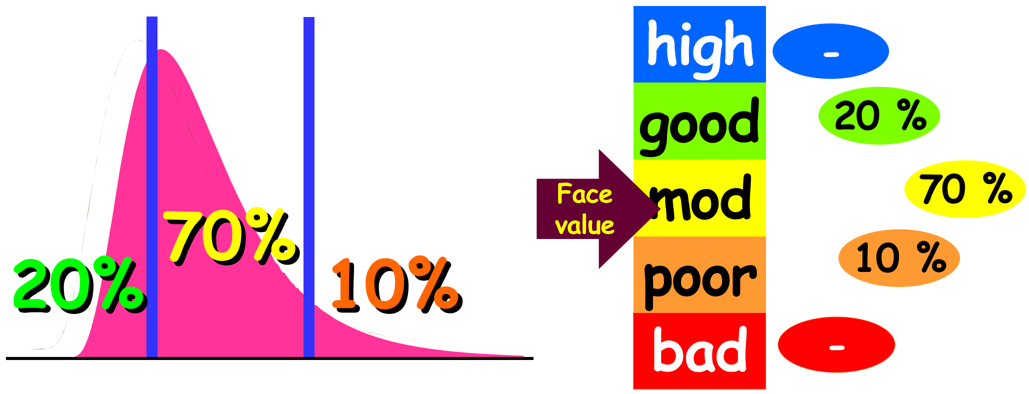


Figure 5.3 **Classification of a monitoring station based on 'face value' assessment of quality (from presentation by Tony Warn the EA (England and Wales) at the REFCOND workshop, May 2001).**

5.2.6 Surveillance monitoring of surface waters

Number and location of monitoring stations

Surveillance monitoring is required in a sufficient number of surface water bodies to provide an assessment of the overall surface water status within each catchment or sub-catchment within the river basin district. The location of monitoring stations within a water body should provide information that is representative of the general conditions of the water body, and which specifically addresses the objectives of the surveillance monitoring programme (as defined in Section 2.7.1). Therefore, it must enable the assessment of long term changes resulting from natural or anthropogenic activity and provide sufficient information to both supplement the Annex II risk assessments and assist with design of future monitoring programmes.

It is often assumed that a waterbody is well mixed and that a mid-water or mid-stream sample will be sufficiently representative. However, this is often not the case. For example, in thermally stratified waters the depth of sampling is critical because the concentrations of many measured parameters can vary greatly between the thermal layers. Ideally, therefore, monitoring should be undertaken at sufficient stations to provide an adequate description of the key spatial effects. However, it is worth noting the considerable resource implications of such investigations, any one of which would need at least 20 or 30 samples. This is in marked contrast with the minimum frequencies specified in Annex V of the WFD - typically four per year.

It was noted earlier that although the Directive requires assessments of status to be made for each individual water bodies, it does nevertheless permit water bodies to be grouped, provided they are sufficiently similar in all critical characteristics, and a group assessment made using just a representative sample of water bodies selected from the group. This is an instance of the well-established statistical principle of stratified random sampling[47]. Here, however, the aim is not to produce the most precise overall estimate of average status across all groups. Each group of water bodies is individually of interest, and the aim is to produce acceptably precise estimates of the relevant water quality measures for each of those groups. Thus the optimal allocation of samples across groups is not a relevant issue here. What is critical, however, is the requirement for the groups to be relatively homogeneous.

The grouping of water bodies has been discussed in some detail earlier in the document. How this would be done in practice depends very much on the statistical definitions of the boundaries determining whether the quality status is ’high’, ’good’ or ’moderate’. For chemical quality, for example, it would be possible for the assessment to be based on (a) mean concentrations, (b) extreme percentiles (such as the 10%ile for dissolved oxygen or the 90%ile for ammoniacal nitrogen), or (c) the proportion of samples falling below a given concentration limit. Thus it is not possible to go into detail here. Some general points can nevertheless be made.

The validity of the approach depends critically on the within-group variation shown by the water bodies in a selected group being **small in relation to the difference between the ‘High’/’Good’ and the ‘Good’/’Moderate’ limits**. For example, suppose these two status boundaries were defined by mean BOD values of 1.0 mg/l and 2.0 mg/l. On the one hand, if it were the case that the mean BODs for the various water bodies in the group all fell within 0.2 mg/l of each other, then given a sampled group mean of, say, 1.3 mg/l, this would provide sound evidence that all the water bodies in the group could be classified as ’good’. But if, on the other hand, the group had been formed less tightly and within-group mean BODs spanned a range of 1.2 mg/l, it would no longer be valid to assume that, because a sample of water bodies had a mean of 1.3 mg/l, all water bodies fell into the ’good’ category. (In that example, we might expect about 10% of water bodies to have mean BODs below 1.0 mg/l - and hence be misclassified by the group sampling approach.)

Any consideration of the water body grouping option should therefore include a thorough assessment of (a) the degree of homogeneity of the group, and (b) the likely size of misclassification risks introduced by applying the estimated average group class to all individual water bodies in the group.

Frequency of monitoring

Minimum monitoring frequencies for surveillance monitoring are outlined in Annex V of the WFD. The Directive states that the frequencies identified should be applied unless "greater intervals would be justified on the basis of technical knowledge or expert judgement". Furthermore, it is the requirement of the directive that "frequencies shall be chosen so as to achieve an acceptable level of confidence and precision" and that "monitoring frequencies shall be selected which take account of variability in parameters resulting from both natural and anthropogenic pressures. The times at which monitoring is undertaken shall be selected so as to minimise the impact of seasonal variation on the results".

A number of important questions are prompted by these extracts from the Directive - especially in relation to the proposed ‘minimum frequencies’, which are typically 4 per year. Assuming that the confidence level is set at 90%, it is worth noting what can be achieved with just 4 samples in a year. If the aim were to estimate annual mean concentration, the

[47] *With stratified sampling, the population is divided into a number of strata (in this case, groups of water bodies) in such a way that the within-stratum variations are small in relation to differences between strata. Then, for any given total number of samples, statistical theory shows how samples can best be allocated across strata so as to produce the most precise overall estimate of the mean.*

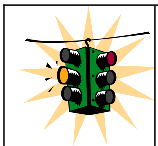
90% confidence interval for this would be "sample mean ±1.18s" (where s is the standard deviation). For many common determinands, the relative standard deviation (i.e. s/mean) is at least 50%. Thus the annual means would be estimated to no better than ±60%, which for many purposes might be thought unacceptably wide. Confidence intervals for percentiles would generally be a lot wider - and furthermore dependent on the assumed statistical distribution (which there would be no way of testing with so little data). This means that in practice it would be unrealistic to address any percentile-based objective:

The position is substantially worse when considering the magnitude of change that could be detected between any two years - the procedure envisaged under surveillance monitoring. The 90% confidence interval for the true mean difference would be sample mean difference ±1.37s. Thus, assuming the same relative standard deviation as before, the two sample means would need to differ by at least 70% before it could be claimed with 90% confidence that there was a genuine difference between the two years. This, again, will be unhelpfully wide for many purposes.

Given this background, the suggestion that greater sampling intervals (i.e. lower frequencies than 4 per year) could be justified on the basis of expert judgement needs to be treated with some caution.

The recommendation made in the Directive to target sampling times so as to minimise the impact of seasonal variation is sound in principle. This will reduce the standard deviation, and so, for a given level of confidence, improve the precision (i.e. narrow the width of the confidence interval). However, it is important that the basis on which the targeting is justified is made clear, as the very act of targeting causes the samples to be drawn from a sub-population whose characteristics will usually be different from those of the overall population. For example, sampling a river only in summer will commonly generate much lower dissolved oxygen values (and hence a lower mean and 10%ile) than if sampling spans the full year. It is critical, therefore, to check that the process of targeting does not introduce bias in relation to the original purpose of the monitoring. For example, if High status is defined in terms of an annual 10%ile dissolved oxygen value, summer-only sampling could produce a very biased assessment of the water body.

In view of the above comments about sampling frequency, and as discussed in Section 2.7.2, monitoring may initially need to be more extensive to account for the expected lack of background data and information and the more comprehensive requirements of the Directive as compared to previous Directives. It is especially important to ensure that an adequate amount of data has been collected to characterise the 'before' or baseline conditions, as any shortcomings at this stage clearly cannot be corrected retrospectively. Nor can they be compensated for simply by increasing the 'after' frequency. For example, a comparison based on 12 samples in each of two time periods has a greater power to detect a change in mean than does a comparison with 6 samples before and 100 afterwards. It should be noted that the greater the analytical error in relation to environmental variability, the poorer the precision will be for a given number of samples and confidence level.



Look Out!

Specific guidance on statistical design for individual monitoring programmes cannot be provided at this stage. Monitoring program design will be influenced by:

- *The levels of confidence and precision identified in individual River Basin Management Plans;*
- *Outcomes of working group 2.3 REFCOND (guidance document No. 10);*
- *How the physico-chemical status boundaries will be classified; and,*
- *The outcomes of the pilot testing exercises*

Further guidance on statistical analysis for the design of surveillance and operational monitoring programs will be required following the pilot testing exercises and subsequent development of River Basin Management Plans.

5.2.7 Operational monitoring of surface waters

The number and locations of monitoring stations required for operational monitoring are, in part, governed by the outcomes of the Annex II risk assessments and surveillance monitoring. Therefore, specific guidance on the number and location of water bodies and sites cannot be provided until those bodies at risk of failing the environmental objectives of the Directive are determined. However, random or stratified random sampling will be needed for bodies at risk from diffuse sources or hydromorphological pressures.

In any case, the same principals mentioned in the preceding discussions on sampling frequency in the context of surveillance monitoring should equally be applied to the design of an operational monitoring programme.

5.3 Best Practice and Tool Box for Groundwater

5.3.1 Introduction

5.3.2 Description of conceptual model/understanding approach

Conceptual models/understandings are simplified representations, or working descriptions, of how real hydrogeological systems are believed to behave. Their development under the Annex II characterisation procedure will be necessary to allow assessments of the risks of failing to meet the Directive's environmental objectives to be made. Conceptual models/understandings will also be required for designing effective monitoring programmes, classifying the status of water bodies and designing suitable programmes of measures. Because of their importance in the planning process, conceptual models/understandings should be tested numerically to ensure that they are adequately reliable and sufficiently precise for the purposes for which they will be used. The testing of the models should be based on water balance calculations. If a model accurately reflects the real hydrological system, over the long-term groundwater recharge would be expected to equal groundwater discharges to surface ecosystems and to adjacent bodies of groundwater. As well as validating conceptual models/understandings, water balance calculations will also be involved in assessing quantitative status (see Section 7 of the toolbox).

The level of complexity involved in any model will depend on the difficulty in judging the status of the body of groundwater and the implications of that status assessment. For example, where a body of groundwater is subject to no or only minor pressures, a very basic conceptual model/understanding will be adequate. However, to justify, and properly target, very costly restoration or enhancement measures for bodies failing to achieve 'good' status, relatively complex models are likely to be required. Different sorts of data, and different levels of confidence and precision in data, will be relevant to the development and subsequent testing of conceptual models/understandings in these different circumstances (Figure 5.4). This Section describes the development and testing of basic conceptual models/ understandings, and provides examples of under what circumstances and in what ways such models may need to be improved (Figure 5.6 to Figure 5.10).

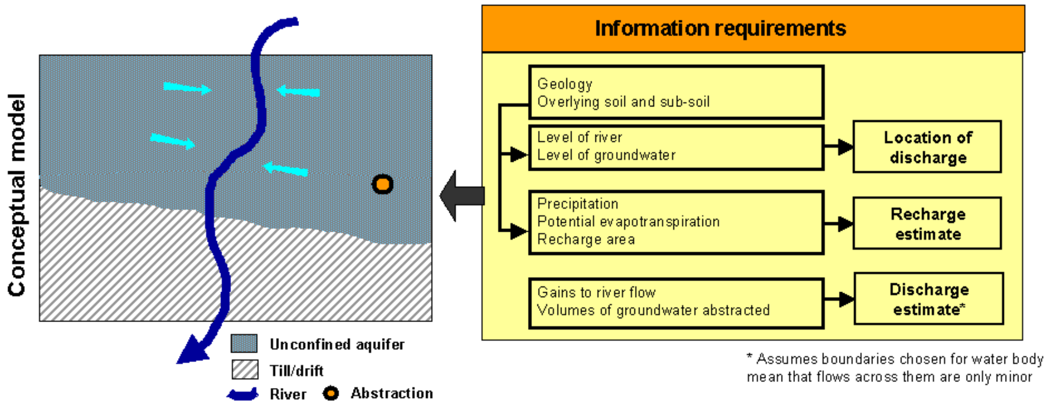


Figure 5.4 **Schematic illustration of a simple conceptual model/understanding of a body of groundwater in which the only significant groundwater discharge is to a river [i.e. the groundwater body has been delineated in such a way that any flows across its boundaries are negligible - See WFD CIS Guidance Document No. 2 on Water Bodies].**

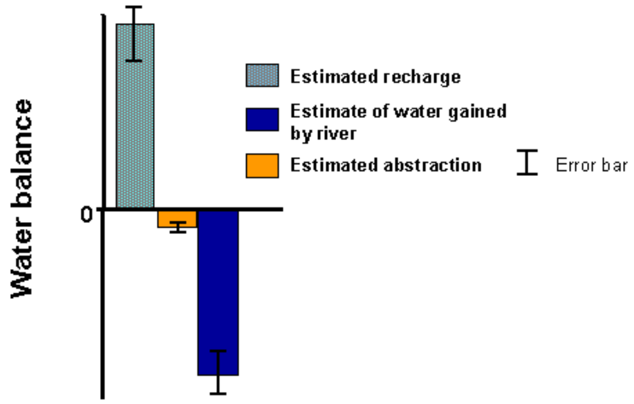


Figure 5.5 **Water balance used to test the conceptual model/understanding illustrated in Figure 5.4.**

The simple conceptual model/understanding illustrated in Figure 5.4 can be tested by lumped estimates of recharge, discharge and abstraction to see if it explains the bulk flows of water in the hydrogeological system (see Figure 5.5). If the water balance calculation balanced, and the model was adequate for use in assessing the status of the body of groundwater, no further development of the model would be necessary (see Figure 5.6). Where there is an apparent long-term water balance deficit, this could indicate over-abstraction but it could also result from errors in the conceptual model/understanding or the estimation of one or more of the components of the water balance (e.g. error in the recharge estimate). An improved, more detailed conceptual model/understanding would be required to enable a reliable assessment of status.

The level of precision required in the water balance will vary with the complexity, and likely significance, of the pressures to which a water body is subject (see Figure 5.7). For example, if a water body were subject to only minor pressures, provided there were no orders of magnitude imbalances in the water balance calculation, the model would be adequate. Where pressures were greater, in terms of numbers, distribution and/or significance, improvements to the conceptual model/understanding would be necessary in order to adequately assess status and design appropriate measures. Improving on a basic conceptual model/understanding involves reducing the errors in the estimates of recharge, groundwater discharge and abstraction, and appropriately refining its spatial and temporal resolution.

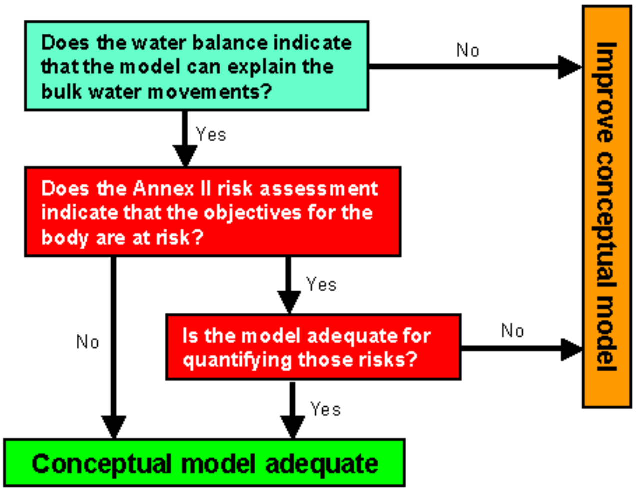


Figure 5.6 Considerations involved in determining the adequacy of a conceptual model/understanding.

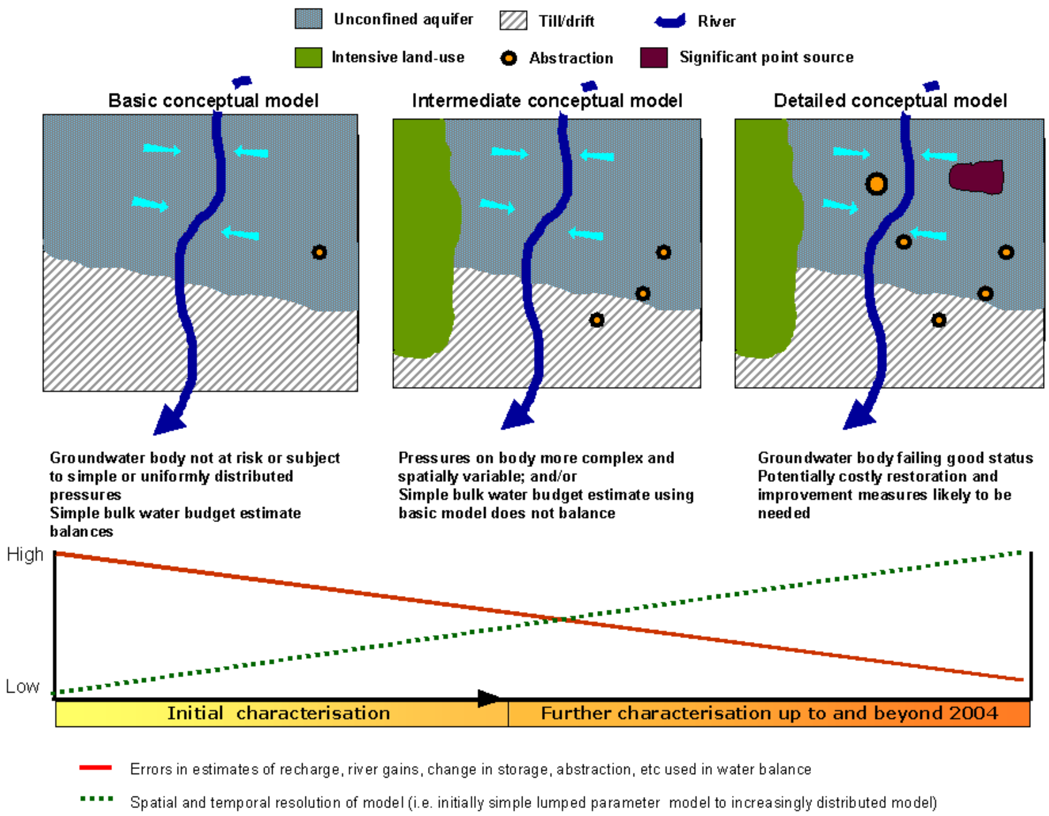


Figure 5.7 Development of a conceptual model/understanding in relation to the increasing complexity of pressures on the body and the cost of restoration and improvement measures.

For example, a complex quantitative model would tend to be based on (and tested), using estimates of the properties of different parts of the body of groundwater rather than relying on lumped estimates for the groundwater body's catchment. This produces a better understanding of spatial and temporal variability in the hydrogeological system and reduces the errors in the estimates of recharge and discharge used to test the model.

Table 5.1 Illustration of potential differences in data requirements for simple and best quantitative conceptual model/understandings.

	Basic conceptual model/understanding	Best quantitative model
Recharge	➢ Precipitation	➢ Precipitation
	-	➢ Estimate of artificial sources of recharge (e.g. leaking drinking water supply pipes etc)
	➢ Lumped estimate of potential evapotranspiration	➢ Estimate of actual evapotranspiration based on properties of land cover (e.g. types of crops).
	➢ Recharge area based on simple assumption of unconfined/confined	➢ Detailed properties of overlying soils and sub-soils; land-sealing (sub-balances to test properties)
River Gain	➢ Use of river flow data if available ➢ Standard length/gain coefficients for different geological settings ➢ Expert judgement	➢ Naturalisation estimates of river flows (e.g. estimated hydrograph with all river abstractions and discharges (other than groundwater) removed. Hydrograph separation to determine groundwater contribution. ➢ Estimate of change in storage.

Monitoring programmes should be designed to provide the data needed to appropriately test conceptual models/understandings (Table 5.1). The monitoring data needed to test any particular model will depend on the extent and quality of existing data and on the difficulty in assessing the status of the body, or group of bodies, and the implications of that assessment for the programmes of measures. Different types of monitoring data may be used in validating a conceptual model/understanding. For example, information on the physico-chemical properties of the groundwater and the surface water body at low river flows may improve confidence in the estimates of the extent of groundwater – surface water connectivity.

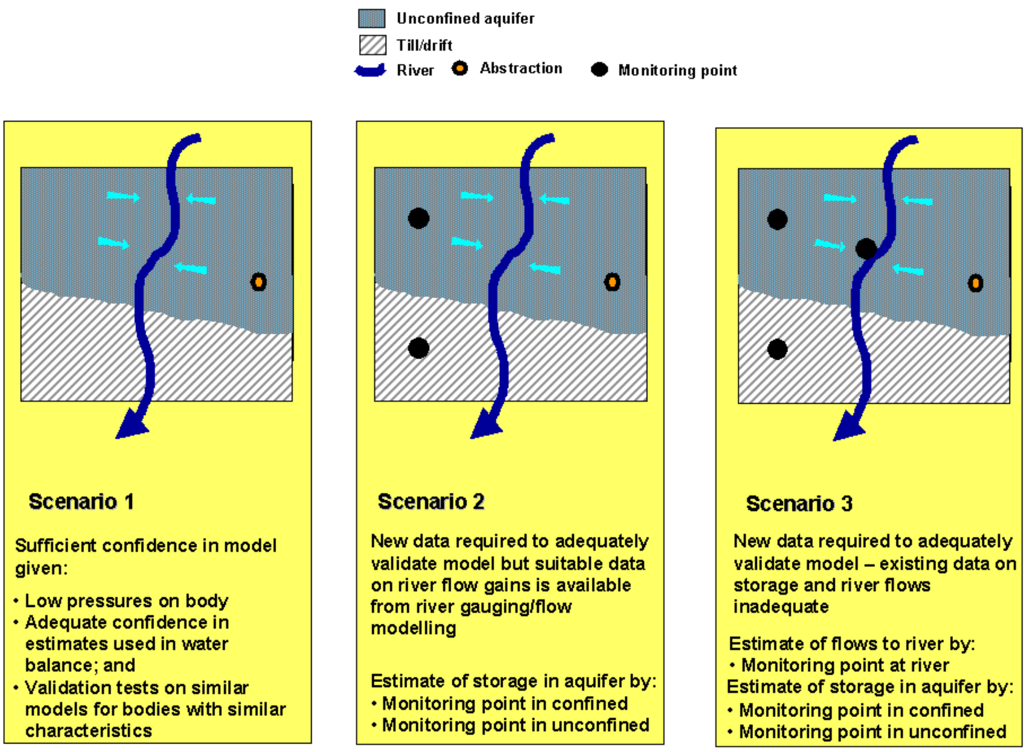


Figure 5.8 **Monitoring design in relation to conceptual model/understanding validation. Groundwater monitoring requirements will depend on the confidence required in the model and the extent and quality of existing data.**

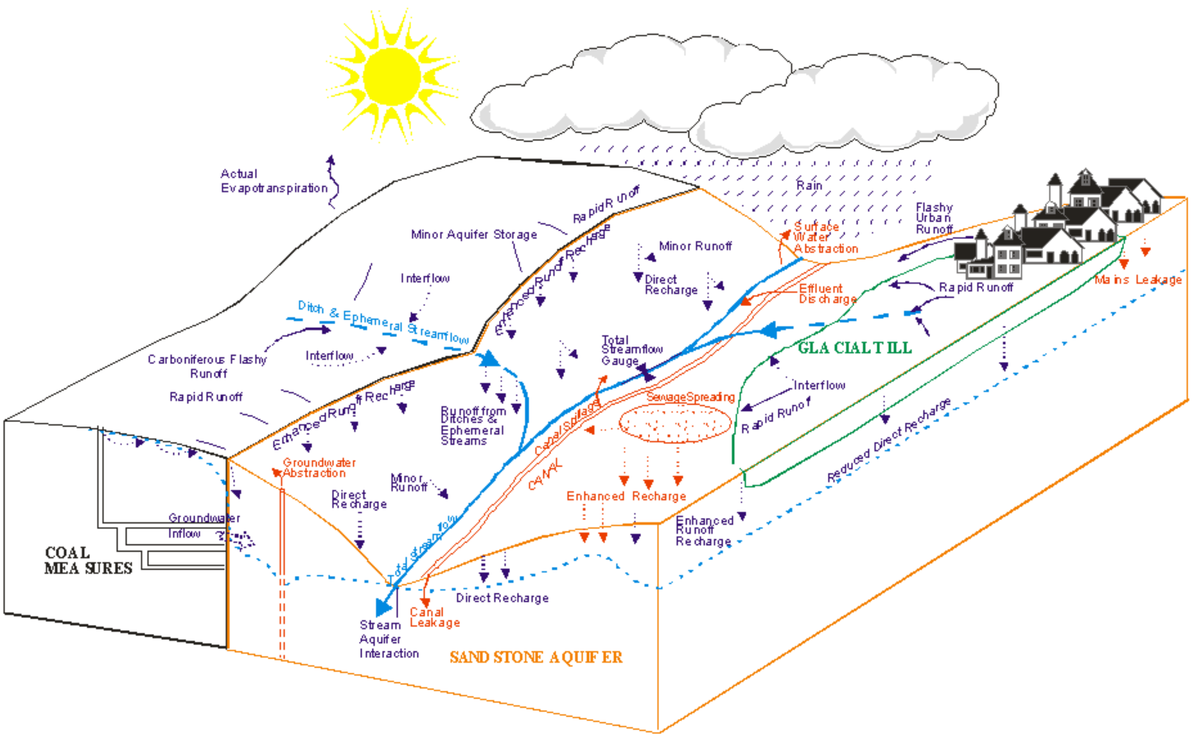
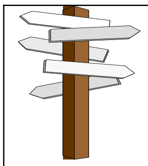


Figure 5.9 **Illustration of an intermediate conceptual model/understanding**



Further information on water balances is available from:

- ***Rushton, K. R. and Redshaw, S. C. (1979). Seepage and groundwater flow. John Wiley & Son Chichester pp 133***
- ***Freeze, R. A. & Cherry, J. A. (1979). Groundwater. Prentice Hall New Jersey***

5.3.3 Chemical Status Monitoring

Approaches to selecting pollutant suites in relation to particular human activities

Table 5.2 Examples of analytical suites that have been used in monitoring programmes in the UK to provide data on the risks to groundwater objectives from particular types of land use.

	Land use					
	Arable	Managed grassland	Managed woodlands	Urban	Sheep	Amenity
Field parameters						
Major ions	✓	✓	✓	✓	✓	✓
Trace metals				✓		
Special inorganics				✓		
Organonitrogen pesticides	✓		✓		✓	
Organochlorine pesticides	✓					✓
Acid herbicides	✓	✓		✓		✓
Uron/urocarb pesticides	✓			✓		✓
Phenols				✓		
VOCs				✓		
PAHs				✓		
Special Organics	✓				✓	

Useful indicators for monitoring in relation to different types of human activity

Table 5.3 Examples of parameters that may be used in monitoring programmes to indicate that a particular human activity may be affecting groundwater quality.

Parameter(s)	Source
Nitrate	Agriculture
Ammonia	Urban areas, agriculture, land-fill
Phosphorous	Agriculture
Pesticides	Agriculture, traffic areas (rail tracks)
Sulphate	Agriculture, atmospheric depositions (acid rain), urban areas
pH-value	Atmospheric deposition (acid rain)
Chloride	Traffic (de-icing salt, road salt), agriculture, urban areas
Tetrachloroethene and Trichloroethene	Housing area, small trade (e.g. dry cleaner), industry
Micro-biological parameters	Animal or human waste disposal

The UN-ECE's guidelines also identify indicator parameters related to different problems, functions and uses. These are summarised in Table 5.4.

Table 5.4 Parameter suites for groundwater quality assessment related to some problems and functions/uses. (After Chilton *et al*, 1994)

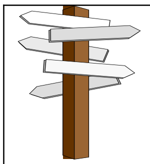
Problems	Functions and Uses	Suite/groups	Parameters
Acidification, salinization	Ecosystems, agriculture	1. Field parameters	Temperature, pH, Dissolved Oxygen (DO), Electrical Conductivity (EC)
Salinization, excess nutrients	Drinking water, agriculture, ecosystems	2. Major ions	Ca, Mg, Na, K, HCO_3, Cl, SO_4, PO_4, NH_4, NO_3, NO_2, TOC, EC, ionic balance.
Pollution with hazardous substances	Drinking water, ecosystems	3. Minor ions and trace elements	Choice depends partly on local pollution sources as indicated by land-use approach.
Pollution with hazardous	Drinking water, ecosystems substances	4. Organic compounds	Aromatic hydrocarbons, halogenated hydrocarbons, phenols, chlorophenols. Choice depends partly on local pollution sources as indicated by land-use approach.
Pollution with hazardous substances	Drinking water, ecosystems	5. Pesticides	Choice depends in part on local usage, land-use approach and existing observed occurrences in groundwater.
Pollution with hazardous substances	Drinking water, agriculture	6. Bacteria	Total coliforms, faecal coliforms.

List II substances are Fe, Mn, Sr, Cu, Pb, Cr, Zn, Ni, As, Hg, Cd, B, F, Br and Cyanide.
(Drinking Water and Nitrate Directive)

Assessing background chemistry

An understanding of the natural chemical composition of a body of groundwater is important where:

- it is not clear whether concentrations of non-synthetic substances detected in the groundwater (e.g. As, Cd) are: (i) part of the natural chemical composition of the body of groundwater; (ii) occur as a result of human activities and should therefore be regarded as pollutants; or (iii) are a combination of (i) and (ii); or
- estimates of the background (i.e. reference condition) values for the physico-chemical quality elements are required for an associated surface water body. Where groundwater contributions to river base flows are high, the base flow chemistry of the river will be significantly influenced by groundwater chemistry.



Further information on assessing background chemistry is available from:

- **The EU Framework V funded Baseline project (EVK1 – CT1999-0006) (E-mail: hydro@bgs.ac.uk; Website: www.bgs.ac.uk/hydro/baseline)**

Designing chemical status monitoring networks; General principles

Definition of the objectives of groundwater monitoring is an essential prerequisite before identifying monitoring strategies and methods. Monitoring design includes: selection and design of monitoring sites, frequency and duration of monitoring, monitoring procedures, treatment of samples and analytical requirements. ISO 5667-1 and EN 25667-1 give the principles on the design of sampling programmes in aquatic environments.

Selecting monitoring sites and density in relation to risk

The assessment of chemical status and the identification of pollutant trends require a flexible, risk-based approach to selecting sites for monitoring. The conceptual model/understanding and the risk assessment it enables should be used to identify locations for, and the density of, monitoring points in relation to different land use pressures. The actual density of monitoring sites and location of individual sites will depend on the difficulty of reliably assessing the effects of pressures on the status of the body and the likelihood of costly measures being required. Such decisions must be made locally and be iteratively based on an appropriately detailed conceptual model/understanding of the groundwater system coupled with the assessment of risks to the Directive's objectives.

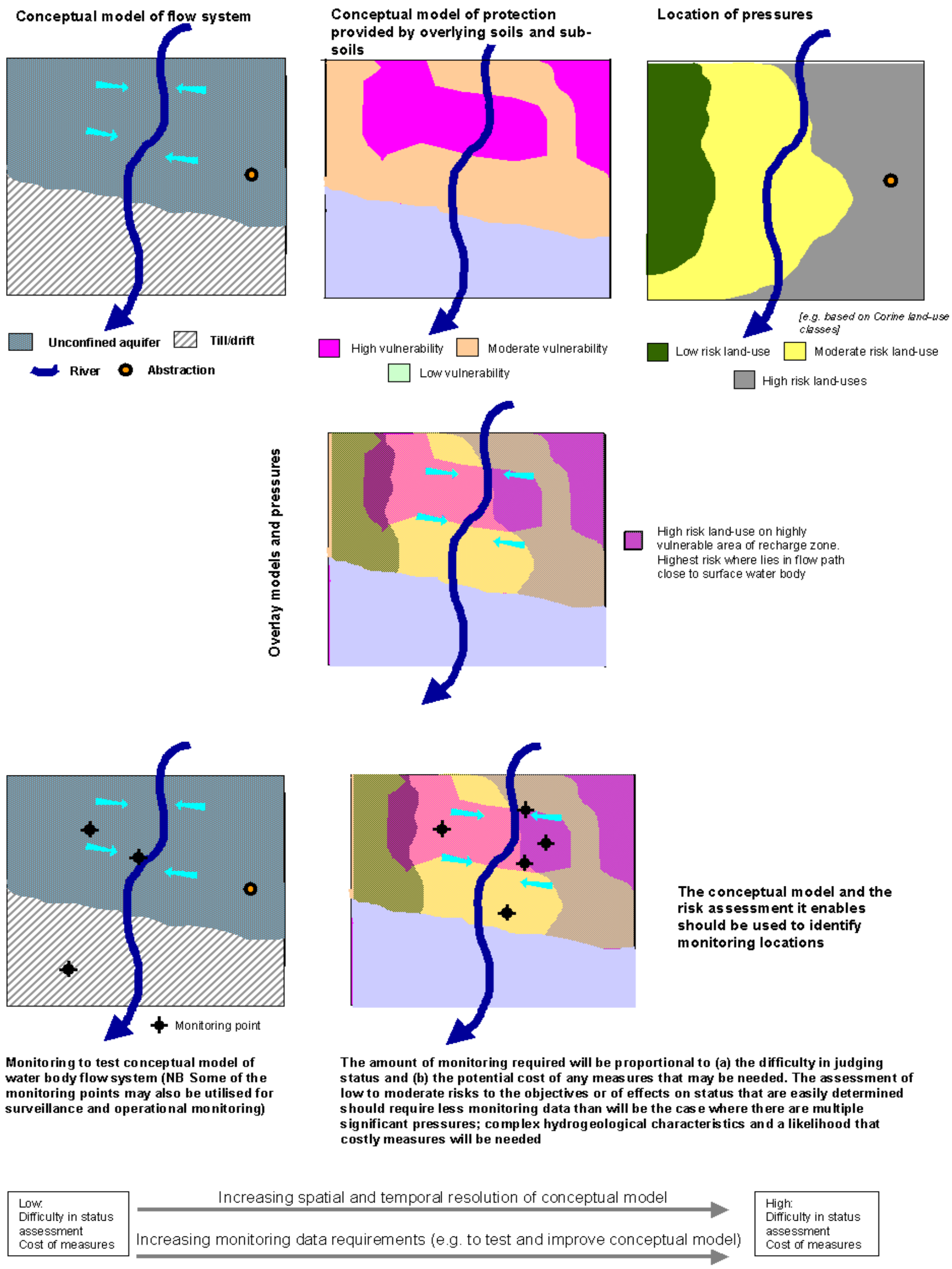


Figure 5.10 **Monitoring locations for assessing chemical status should be selected on the basis of the Annex II risk assessments.**

Where a body is at risk (illustrated in **Figure 5.10**) its status is difficult to determine because of its complex hydrogeological characteristics and/or the complex range of pressures to which it is subject; and costly measures may be required, improved conceptual models/ understandings and greater monitoring density will be necessary.

Approaches to determining monitoring frequencies in relation to groundwater body characteristics and the behaviour of pollutants

The sampling frequency for pollutants should be based on:

- the conceptual model/understanding of the groundwater system and the fate and behaviour of pollutants in it; and
- the aspect of the conceptual model/understanding being tested.

In the UK, a sampling frequency for groundwater quality is used that combines the requirements of the Directive with the main hydrogeological factors that influence groundwater flow. The framework ensures more frequent sampling in aquifers in which groundwater flow is rapid and less frequent in aquifers with slower movement (Table 5.5). It also builds in a less frequent requirement for sampling in confined aquifers than in unconfined aquifers, reflecting the greater degree of protection from pollution provided by the confining layers. The schedule is consistent with the Directive's requirements for operational monitoring to be undertaken at least annually between surveillance monitoring periods and for surveillance monitoring to be undertaken during each planning cycle. These frequencies may not be relevant for trend assessment. Guidance on monitoring frequencies for trend assessment are provided in CIS 2.8.

Table 5.5 Sampling frequency for groundwater hydrogeology

			SURVEILLANCE	*OPERATIONAL*
Hydrogeology	SLOW	Unconfined	3 years	6 monthly
		Confined	6 years	Annual
	FAST	Unconfined	Annual	Quarterly
		Confined	3 years	6 monthly

In Germany, the following table (Table 5.6) provides guidance on monitoring frequencies in relation to aquifer properties. The table does not address monitoring frequencies in relation to point sources, especially infiltrating dense liquid phases.

Table 5.6 German guidance on monitoring frequencies in relation to aquifer properties

Scenarios	Frequencies					
	Monthly	Quarterly	Half yearly	Yearly	Every two Years	Every five Years
shallow ground-water (depth to table ≤ 3 m), unconfined porous aquifer	x	X	X	x		
deep ground-water (depth to table ≥ 10 m), unconfined porous aquifer				x	X	X
shallow ground-water (depth to table ≤ 3 m), unconfined fractured aquifer	x	X	X	x		
deep groundwater (depth to table ≥ 10 m), unconfined fractured aquifer		x	X	X		
karst aquifer (without more or less impermeable cover)	X	X	X			
karst aquifer (with more or less impermeable cover)	x	X	X	x		
confined groundwater (with more or less impermeable cover with thickness < 2 m)				X	X	x
confined groundwater (with more or less impermeable cover with thickness > 2 m)				x	X	X
high rate of recharge		x	X	X		
Trend assessment			X	X		
season-dependent human activities		x	X	x		

Notes on Table: Large X indicates the most likely frequency. Small x indicates the range of frequencies depending on the particular circumstances. The frequencies suggested may not be relevant for trend assessment. Guidance on monitoring frequencies for trend assessment are provided in CIS 2.8.

Intrusions

One of the criteria required to achieve both good groundwater quantitative status and good groundwater chemical status is that a body of groundwater is not subject to saline or other intrusions resulting from human induced changes in flow direction. Some alterations to flow direction, however localised, would be expected to accompany any abstraction. Sometimes these will induce movements of water into a body of groundwater from an adjacent groundwater body or an associated surface water body. This water may well have a different chemical composition to that of the body of groundwater, either because of the pollutant concentrations it contains or because of its natural chemistry. The Directive does not regard temporary or continuous changes in flow direction and their associated effects on chemical composition as intrusions so long as they are limited spatially and do not compromise the achievement of any of the Directive's other environmental objectives for the body of groundwater (see Figure 5.11).

An assessment of whether an intrusion is present requires:

- the development of a conceptual model/understanding of the groundwater system;

- the use of that model to predict whether the pressures on the water body may have caused an intrusion; and
- the testing of that prediction to the extent necessary to develop the required confidence in the model and in the classification decisions it enables.

The testing of the conceptual models/understandings and the validation of their predictions will require the use of monitoring data.

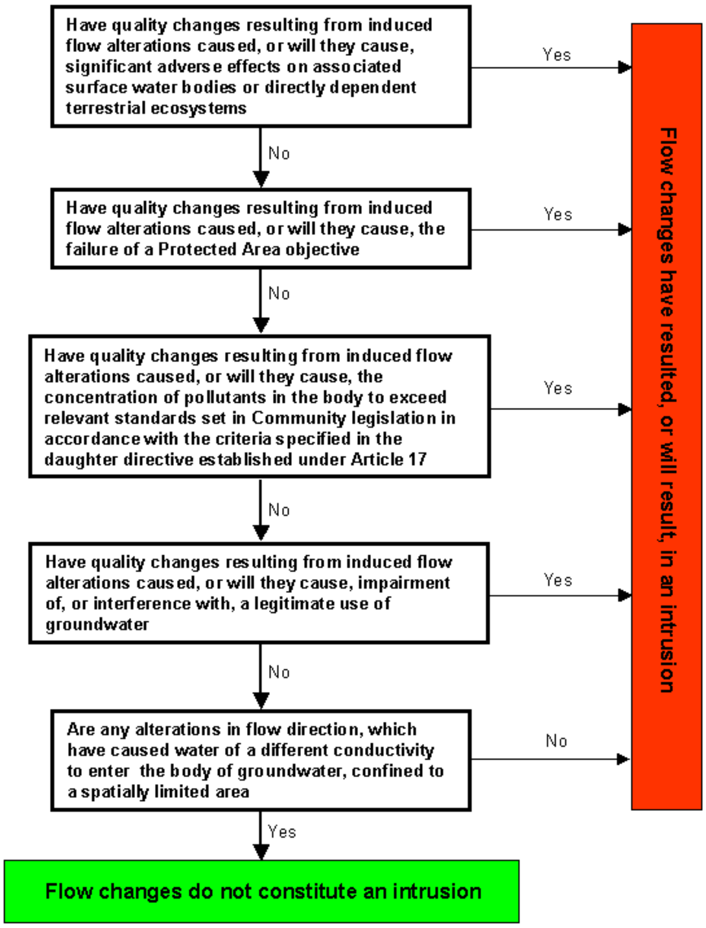


Figure 5.11 **Criteria for defining a saline or other intrusions into groundwater bodies. Where one of the intrusions defined in the figure occurs, a body of groundwater will fail to achieve good quantitative status and good chemical status.**

5.3.4 Sampling protocols

General principles

Care should be taken in the construction and operation of sampling points and in the analysis of samples collected so that they do not inadvertently affect the data provided.

Sampling design

A definition of the purpose of groundwater sampling is an essential prerequisite before identifying the sampling strategies and methods. Sampling design includes: selection and design of sampling sites, frequency and duration of sampling, sampling procedures, treatment of samples and analytical requirements. ISO 5667-1 and EN 25667-1 give the principles on the design of sampling programmes in aquatic environments.

Sampling methods

ISO 5667-11 (1993) gives the principles for groundwater sampling methods focused to survey the quality of groundwater supplies, to detect and assess groundwater pollution and to assist in groundwater resource management. ISO 5667-18 (2001) gives the principles of groundwater sampling methods at contaminated sites.

ISO 5667-2 gives the general information on the choice of material for sampling equipment. Generally polyethylene, polypropylene, polycarbonate and glass containers are recommended for most sampling situations. Opaque sample containers should be used if the sampled parameter degrades in light (e.g. some pesticides). Contamination or modification to the chemistry of groundwater samples should be minimised by selecting suitable materials for sampling equipment and borehole construction.

Sample storage, conditioning and transportation

Groundwater samples storage, conditioning and transportation from the sampling sites to the laboratory are extremely important, because the results of the analysis should be representative of the conditions at the time of sampling. General guidance on these aspects is given in ISO 5667-2 and ISO 5667-3. Specific indications for groundwater samples are given in ISO 5667-11.

Sample identification and records

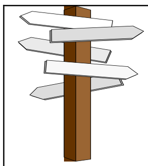
An identification system that provides an unambiguous method for sample tracking should be adopted. It is crucial that a clear and unambiguous labelling system be used for samples to enable effective management of samples, accurate presentation of results and interpretation. ISO 5667-11 gives guidance on sample identification and record procedures. In addition, other relevant environmental data should be reported and recorded in order that any repeat sampling can be carried out and any variability in results examined.

Monitoring points

The influence of the construction of a monitoring point and its condition and maintenance on the data obtained should be evaluated. For example, could the condition of the casing of the borehole be affecting the results? Are the intended geological strata exposed in the borehole? Is water entering the borehole from the surface?

Key sources of information on sampling protocols and quality assurance

- **The UN/ECE Task Force on Monitoring and Assessment provides practical Guidance on methods and quality assurance for monitoring transboundary groundwaters (www.iwac-riza.org).**
- **The European Environment Agency provides technical Guidance on design and operation of groundwater monitoring networks through its EUROWATERNET initiative (www.eea.eu.int).**
- **The AMPS working group under the EAF Priority Substances aims to ensure "the availability of good quality data..." and could deliver useful input on quality assurance requirements. http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/experts_advisory/advisory_substances/monitoring_substances&vm=detailed&sb=Title**



List of standards for Groundwater Monitoring and Sampling used in Germany

- **DVGW-Arbeitsblatt W 108 (2002): Messnetze zur Überwachung der Grundwasserbeschaffenheit in Einzugsgebieten von Trinkwassergewinnungsanlagen (will be published in November 2002 as draft), *(Networks to monitor the status of groundwater in areas used for drinking water abstraction).***
- **DVGW-Merkblatt W 112 (2001-07): Entnahme von Wasserproben bei der Erschließung, Gewinnung und Überwachung von Grundwasser *(Water sampling in recovery, capture and observation of groundwater)*.**
- **DVGW-Merkblatt W 121 (2002-07): Bau und Ausbau von Grundwassermessstellen *(Construction and design of groundwater monitoring wells).***
- **DVGW-Hinweis W 254 (1988-04): Grundsätze für Rohwasseruntersuchungen *(Principles of raw water analysis)*.**
- **DVWK-Regel 128 (1992): Entnahme und Untersuchungsumfang von Grundwasserproben *(Withdrawal and analysis of groundwater samples).***
- **DVWK-Merkblatt 245 (1997): Tiefenorientierte Probennahme aus Grundwassermessstellen *(Depth oriented sampling of groundwater).***
- **E EN ISO 5667-1:1995-03, Wasserbeschaffenheit Probenahme - Teil 1: Anleitung zur Aufstellung von Probenahmeprogrammen *(Water quality, sampling – Part 1: Guidance for setting up sampling programmes)*.**
- **E EN ISO 5667-2:1995-03, Wasserbeschaffenheit - Probenahme - Teil 2: Anleitung zur Probenahmetechnik *(Water quality, sampling – Part 2: Guidance on sampling techniques)*.**
- **E EN ISO 5667-11:1995-03, Wasserbeschaffenheit - Probenahme - Teil 11: Anleitung zur Probenahme von Grundwasser *(Water quality, sampling – Part 11: Guidance for sampling of groundwater)*.**
- **DIN EN ISO 5667-3, Wasserbeschaffenheit – Probenahme - Teil 3: Anleitung zur Konservierung und Handhabung von Proben *(Water quality, sampling – Part 3: Guidance for conservation and handling of samples)*.**
- **DIN 38402-13, Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung - Teil 13: Allgemeine Angaben (Gruppe A), Probenahme**
- **aus Grundwasserleitern (A 13) *(German standards for analysis of water, wastewater and sludge – part 13: General Remarks (Group A), Sampling of groundwater (A 13).***
- **LAWA AQS-Merkblatt P8/2, Probennahme von *Grundwasser (LAWA Guidance on quality assurance P8/2, Sampling of groundwater).***
- **LAWA (1987): Grundwasser - Richtlinien für Beobachtung und Auswertung - Teil 2: Grundwassertemperatur *(Groundwater – Guidance for monitoring and assessment – part 2: groundwater temperature).***
- **LAWA (1993): Grundwasser - Richtlinien für Beobachtung und Auswertung, Teil 3: Grundwasserbeschaffenheit *(Groundwater – Guidance for monitoring and assessment – part 3: groundwater quality).***
- **LAWA (2000): Grundwasser – Empfehlungen zur Konfiguration von Meßnetzen sowie zu Bau und Betrieb von Grundwassermeßstellen (qualitativ) *(Groundwater – recommendations on the design of monitoring networks and on the construction and operation of monitoring stations (qualitative))*.**
- **LAWA (2000: Empfehlungen zur Optimierung des Grundwasserdienstes (quantitative) (*Recommendations on the optimisation of quantitative groundwater monitoring)*.**

5.3.5 Quantitative status monitoring

Guidance on how to estimate the interaction of groundwater with surface waters and terrestrial ecosystems

An understanding of groundwater connections to surface waters and terrestrial ecosystems is necessary for:

- the development of a conceptual model/understanding of the hydrogeological system;
- the determination of the available groundwater resource;
- the assessment of quantitative status; and
- the assessment of groundwater chemical status.

The degree of precision and confidence needed in this understanding will depend on the risks of failing to meet the objectives for the body of groundwater and the implications of errors in an assessment of groundwater status.

Figure 5.12 outlines a series of steps that may be used to develop an initial understanding of where and how groundwater may interact with surface waters, and in particular river water bodies. This initial understanding should be tested and improved to the extent needed to provide an appropriate level of confidence in the assessments that depend on it. For example, where abstraction and pollution pressures are low, a generalised estimate of the extent of interaction is likely to be sufficient to enable a conceptual model/understanding of the interaction of groundwater and surface water to be developed and then tested using a water balance (see Section 1).

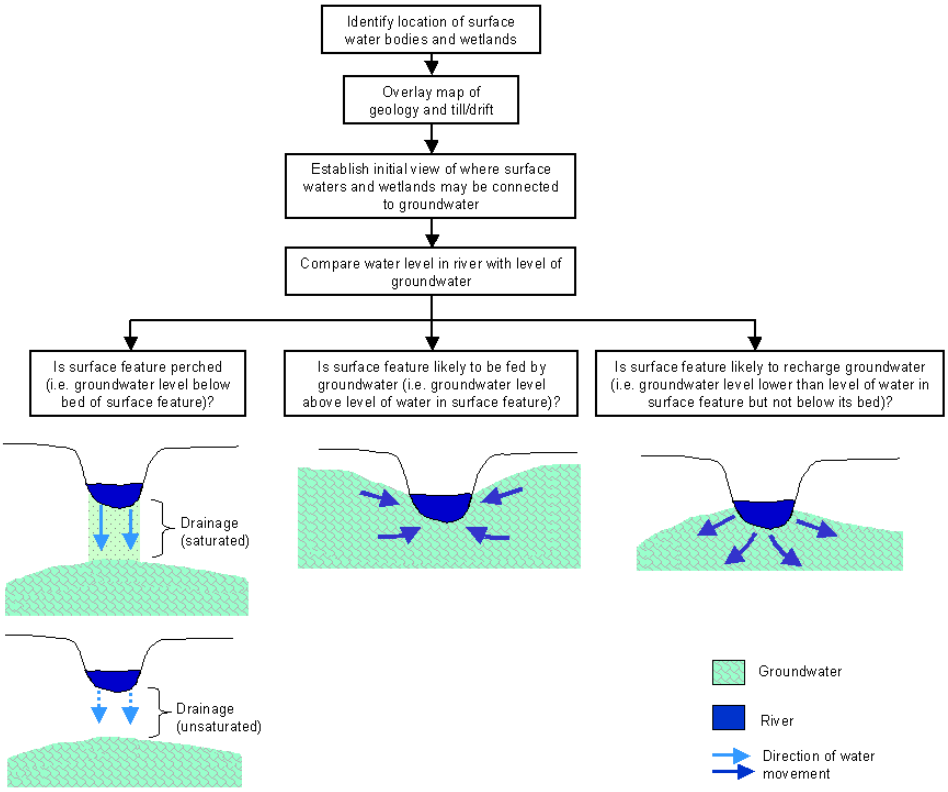


Figure 5.12 Suggested steps in the development of an understanding of the locations and types of interaction between groundwater and surface ecosystems.

Different approaches to testing the understanding of groundwater interactions with surface waters will be appropriate in different geological settings and for bodies subject to different pressures and associated risks of failing to achieve their objectives. Figure 5.13 lists some general approaches and the circumstances in which they may be appropriate.

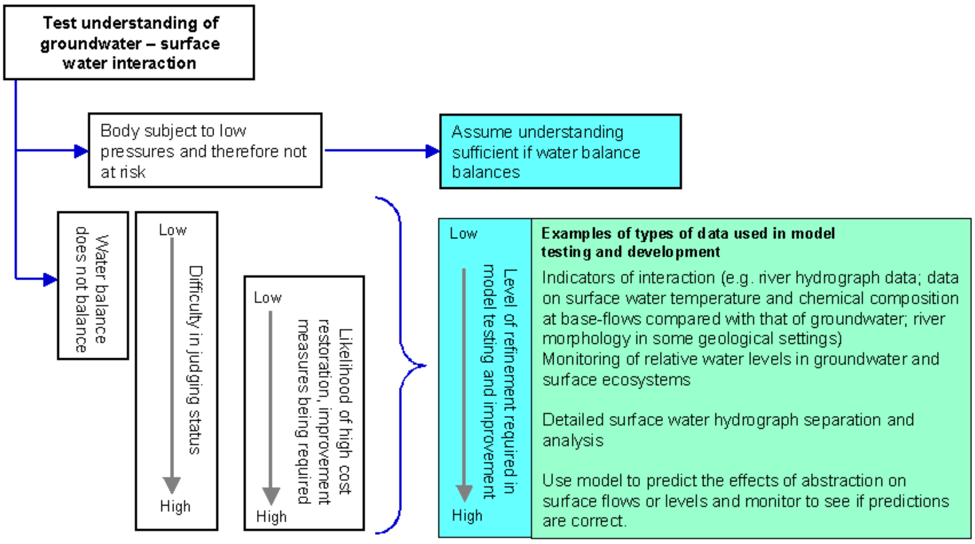


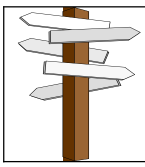
Figure 5.13 Approaches to testing and developing initial assessment of groundwater interactions with surface waters

5.3.6 Where to get further information

Interactions with rivers

To achieve 'good' status, the Directive requires the control of abstractions that could cause a significant diminution in the ecological or chemical quality of a surface water or significant damage to a directly dependent terrestrial ecosystem. An important means of testing a conceptual model/understanding of how groundwater interacts with surface water and terrestrial ecosystems is to use it to predict the effects of an abstraction on water flows and levels in the surface ecosystems, and then use monitoring (e.g. in conjunction with a pump test) to see if the predictions made by the model were correct.

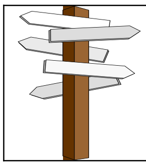
A system has been developed in the UK called 'Interaction of Groundwater Abstraction and River Flows' for providing a consistent means of using a conceptual model/understanding to predict the effects of an abstraction on river flows (e.g. design of pump tests etc). Monitoring to see if the predicted effects have occurred provides information for assessing the accuracy and precision of the conceptual model/understanding and for helping to improve the model if required.



Interaction of Groundwater Abstraction and River Flows (IGARF)] Environment Agency, Bristol England. [Will be available from web site: www.environment-agency.gov.uk in early 2003].

Interactions with terrestrial ecosystems

An assessment of groundwater body status also requires an understanding of how groundwater interacts with terrestrial ecosystems. As with surface water interactions, this requires the development and testing of a suitable conceptual model/understanding. It also requires information on the dependence of those ecosystems on the quality and the levels and flows of groundwater. The level of detail required in an estimate of the water needs of terrestrial ecosystems will depend on the likelihood of (a) those water needs being significantly affected, given the pressures on the body of groundwater, and (b) potentially costly improvement and restoration measures being required. Generic, orders of magnitude estimates of water needs may be adequate where risks are low. Where risks are high, specific research to establish the water needs of the terrestrial ecosystems may be required.

	A guide to monitoring water levels and flows at wetland sites (2000). Environment Agency, Bristol, England (Website: www.environment-agency.gov.uk)

How to measure available groundwater resource

Good quantitative status requires that the available groundwater resource is not exceeded by the long term annual average rate of abstraction and that any alterations to groundwater levels resulting from human activities have not resulted, and will not result, in (i) a failure to achieve any of the environmental objectives for associated surface water bodies; (ii) any significant diminution in the status of those bodies; nor significant damage to terrestrial ecosystems directly depending on groundwater.

The estimation of the available groundwater resource requires:

- an appropriate conceptual model/understanding of the groundwater body tested using a water balance; and;
- an estimate of the groundwater flow/levels needed by associated surface water bodies and directly dependent terrestrial ecosystems to achieve the criteria described above.

The steps involved in the estimation are illustrated in Figure 5.14. The accuracy and precision needed in the conceptual model/understanding and in particular the estimates of groundwater recharge and surface water - groundwater interaction it provides, will depend on the difficulty in judging whether the recharge to the body of groundwater, less the water needs of surface ecosystems, exceeds the rate of abstraction (see Figure 5.15). For example, for groundwater bodies, or groups of bodies, subject to only small groundwater abstractions (e.g. the recharge and river base-flow greatly exceed the rate of abstraction), orders of magnitude estimates of recharge and river flow needs are likely to be sufficient for testing the water balance, determining the available groundwater resource and assessing quantitative status.

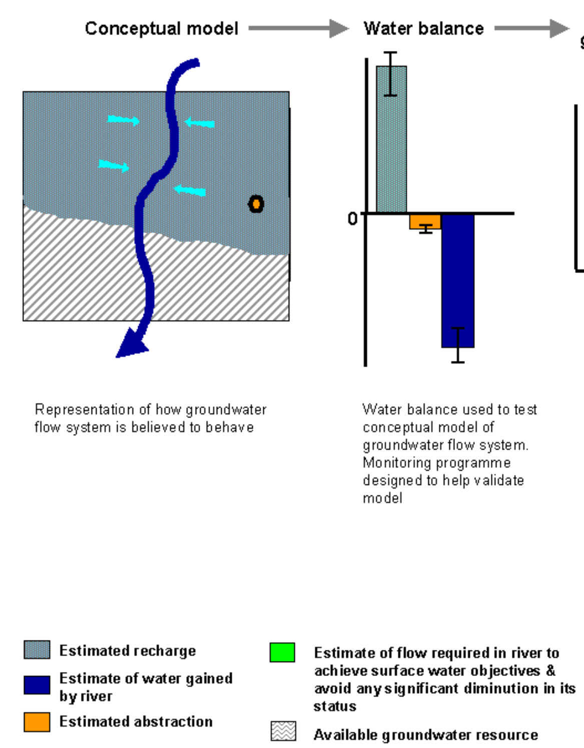


Figure 5.14 Illustration of the steps involved in estimating the available groundwater resource for a body of groundwater

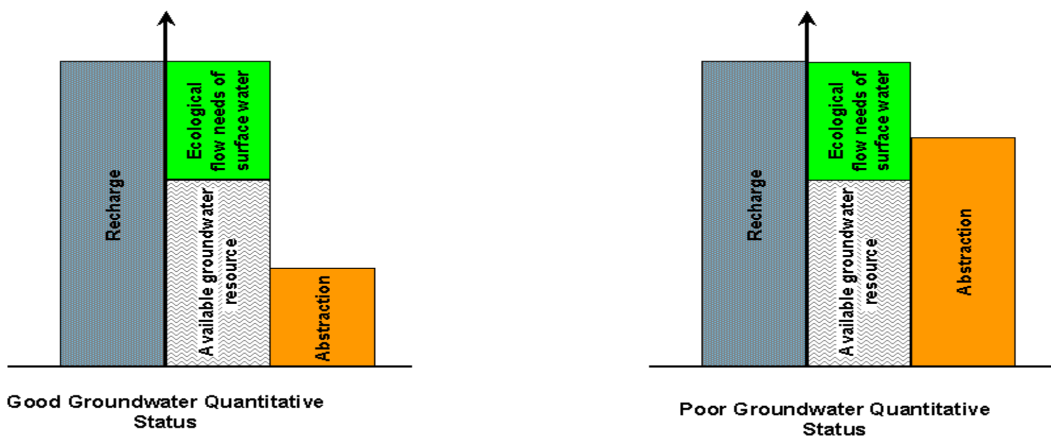
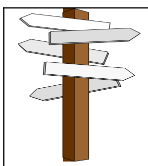


Figure 5.15 Illustration of bodies at poor and 'good' status in terms of the requirement to have a positive available groundwater resource once abstractions have been taken into account.



Where to get further information

- *Theis, C.V., (1941). The effect of a well on the flow of a nearby stream. American Geophysical Union Transactions 22 pp 734 – 738*
- *Hantush, M. S., (1965). Wells near streams with semi-pervious beds.*

	Journal of Geophysical Research 70 pp 2829 2838. ➢ *Stang, O., (1980). Stream depletion by wells near a superficial, rectilinear stream. Seminar No. 5, Nordiske Hydrologiske konference, Vemladen, presented in Bullock, A., A. Gustard, K. Irving, A. Sekuli and A. Young, (1994). Low flow estimation in artificially influenced catchments, Institute of Hydrology, Environment Agency R & D Note 274, WRc, Swindon, UK.*

Approaches to estimating flow across Member State boundaries

The Directive requires Member States to estimate groundwater flows across their boundaries. This is a separate requirement from the assessment of the status of bodies of groundwater. It will provide management information to Member States on how groundwater and its associated surface ecosystems may be affected by pressures in neighbouring States, and therefore how the measures needed to achieve the Directive's objectives should be apportioned between those States.

To provide estimates of flows across a national border, conceptual models/understandings tested using water balances will be needed for the groundwater systems on both sides of the border. The degree of accuracy and precision needed in such models will be proportionate to the difficulty in reliably judging the status of water bodies on either side of the border and in assessing the achievement of other relevant objectives, and should be such as to enable effective measures to be designed.

5.3.7 Application of CIS 2.8 Guidance in trend analysis

Summary of Technical Report No. 1 (CIS Working Group 2.8)

One of the focuses of Technical Report No. 1 prepared by CIS Working Group 2.8 was the development of particular statistical methods for the identification of upward trends in pollutants and the reversal of trends in accordance with Annex V 2.4.4 of the Directive. The Guidance also outlines the monitoring design considerations needed to provide suitable for time series data trend analysis.

The main results of CIS Working Group 2.8 (www.wfdgw.net) consist of the:

- Development of an appropriate data aggregation method for the assessment of groundwater quality at the groundwater body level respectively for groups of groundwater bodies including the determination of minimum requirements for calculation; and,
- Development of an appropriate statistical method for trend assessment and trend reversal including the determination of the minimum requirements for calculation.

The following general requirements are met by the proposed statistical procedures:

- Statistical correctness;
- Development of a pragmatic way;
- One data aggregation method suitable for small, large and groups of GW-bodies as well as for small GW-bodies with few sampling sites; and
- Applicability for all types of parameters.

The Guidance also outlines the monitoring design considerations for providing suitable data for chemical status assessment and time series data for trend analysis. All results are expressed at a certain level of confidence.

Application of Technical Report No. 1

Figure 5.16 below illustrates the role of Tecnical Report No. 1 in the assessment of trends in pollutant concentrations in groundwater.

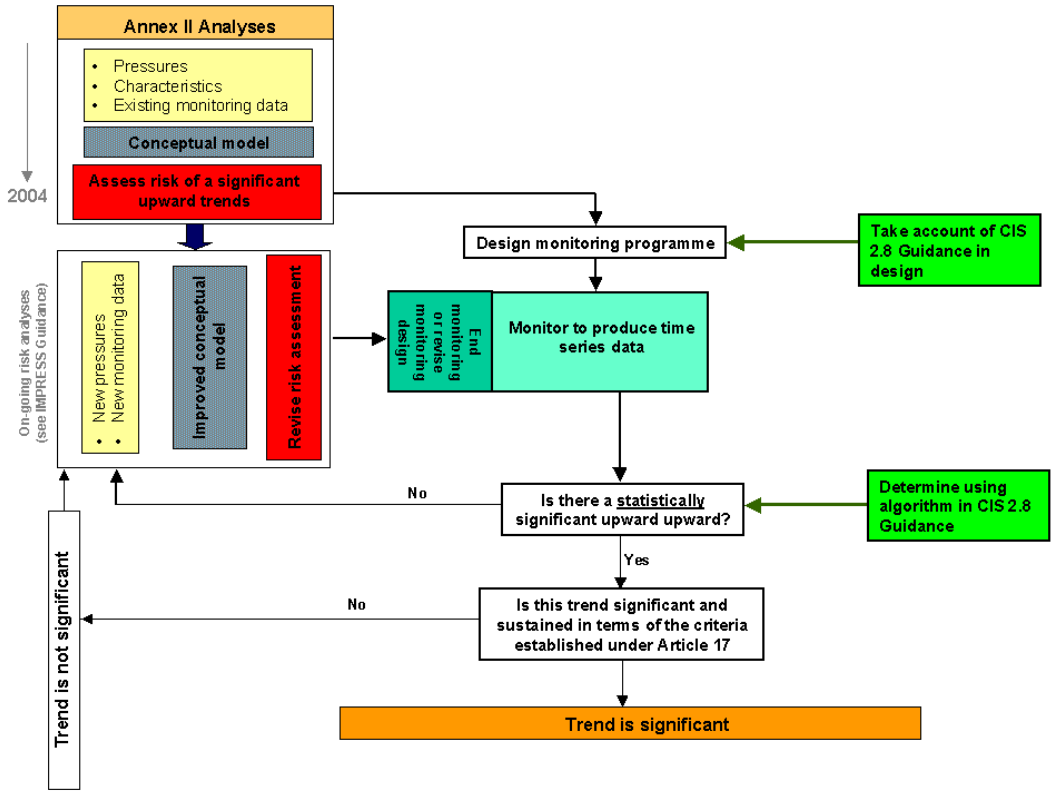


Figure 5.16 Use of CIS 2.8 Guidance in trend analysis

The Article 17 Daughter Directive is expected to establish criteria for the identification of significant and sustained upward trends. Until these criteria have been established, Member States must decide whether a trend is significant and sustained according to their own criteria. In developing such criteria, Member States should take into account the purpose of the trend reversal objective, which is to progressively reduce pollution of groundwater [Article 4.1(b)(iii)].

5.3.8 Drinking Water Protected Area Monitoring

One of the objectives for drinking water Protected Areas is to avoid deterioration in groundwater quality in order to reduce the level of purification treatment. Compliance with this objective can be simply monitored by assessing changes in the quality of abstracted water prior to any purification treatment. However, the design of the protection measures needed to ensure that the objective is achieved will require a means of predicting which pressures could cause a deterioration in the quality of the abstracted water. An appropriate conceptual model/understanding for the Protected Area will be necessary to enable such predictions. The complexity of any such model should be proportionate to the likely risks to the achievement of the objective. Where risks are minor (e.g. because pressures are low or the soil and sub-soils are impermeable) a simple conceptual model/understanding will be sufficient (Figure 5.17). Where the risks of quality deterioration are high, a more accurate and precise conceptual model/understanding, which includes more detailed consideration to groundwater flow characteristics, will be required, and monitoring data will be needed for its validation.

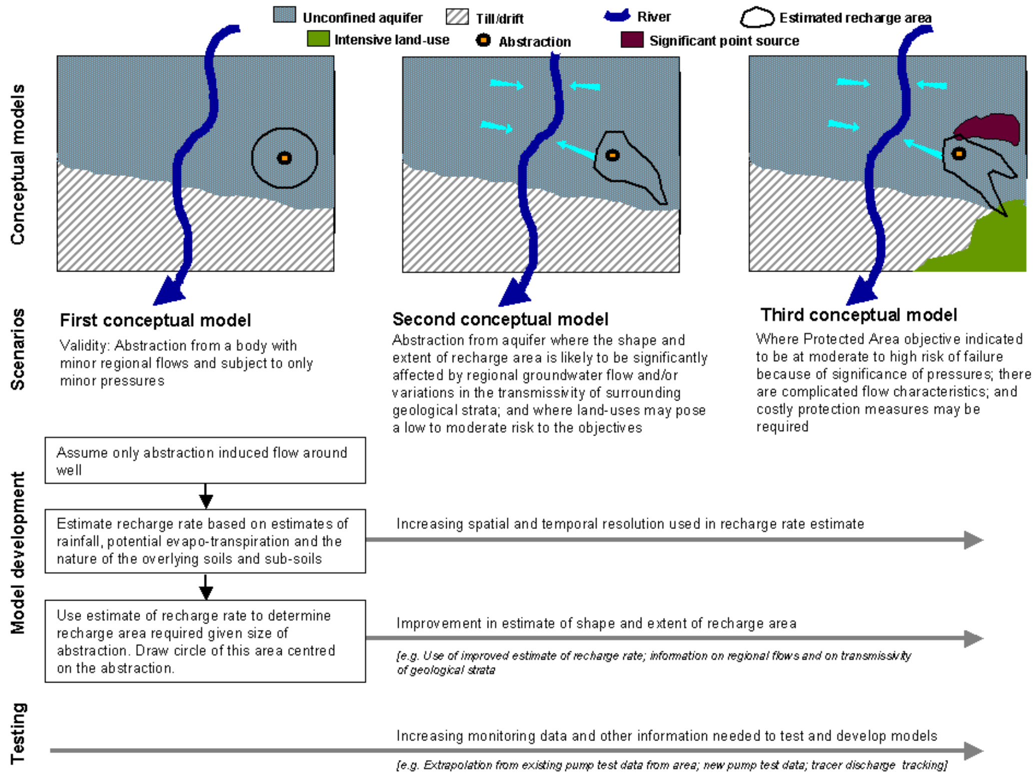


Figure 5.17 Development of conceptual models/understandings for drinking water protected areas.

6 Best Practice Examples for Using the Guidance

6.1 Contributions from Member States on Monitoring Methods -Fact Sheets

As a result of the third workshop in Brussels, Member States were requested to provide fact sheets on current monitoring methods undertaken in their country, which could be used or developed for the implementation of monitoring programmes in accordance with Annex V of the Directive.

Due to the overwhelming response from a number of countries, it was decided that, rather than include only a selection of fact sheets in the Guidance Document, all fact sheets would be uploaded directly to Circa. These fact sheets are available for Member States to review and use at their discretion.

Each fact sheet provides the following information:

- Details of the water category and quality element;
- Name and brief description of the method;
- Which country proposes the method, and where the method is currently being used;
- If the method provides a comparison to reference conditions/communities, and whether or not this is compliant with the requirements of the Directive;
- If there are existing national or international standards for the method;
- If the method is currently published in scientific literature;
- Applicability of the proposed method for use in implementation of the Directive;
- Relevant references; and
- Contact details to obtain additional information about the method.

Annex IV provides a list of fact sheet contributions, including the fact sheet title, country that has proposed the method and weblinks to the fact sheet.

7 Summary and Conclusions

A common strategy for the implementation WFD was developed in May 2001. The strategy aims provide support to Member States to ensure a coherent and harmonious implementation of this Directive.

An informal working group Working Group 2.7 was established within the CIS to facilitate the production of a practical and non-legally binding Guidance Document to assist Member States with developing surface and groundwater monitoring programmes in accordance with Article 8 and Annex V of the Directive.

The Guidance document provides a common understanding on the monitoring requirements of the Water Framework Directive. Guidance and principles generic to all water categories are provided as well as more specific Guidance on groundwater, rivers, lakes, transitional waters and coastal waters. This is largely based on current best practice in Member States and Norway. In addition, details of current monitoring practices in Member States and Norway are also given with details of national experts that could provide additional assistance.

The Guidance Document proposes an overall pragmatic approach. Because of the diversity of circumstances within the European Union, Member States may apply this Guidance in a flexible way in answer to problems that will vary from one river basin to the next. This proposed Guidance will therefore need to be tailored to specific circumstances. However, these adaptations should be justified and should be reported in a transparent way.

It is recommended that the Commission considers establishing a drafting group to further develop horizontal Guidance on the classification of ecological status of surface waters particularly in relation to Annex V.1.4.2 and Annex V.1.2. This is to do with the interpretation of the normative definition of good ecological status in terms of the physico-chemical quality elements, and the role of physico-chemical and hydromorphological quality elements as supporting the biological quality elements. This issue is also of relevance to Working Groups 2.3 on reference conditions for inland surface waters and 2.4 on typology and classification of transitional and coastal waters.

The Article 17 Groundwater Directive may establish additional criteria for the assessment of groundwater status. This Guidance may need to be updated once such criteria have been established.

Additional monitoring is required for drinking water abstraction points and habitat and species protection areas. However the register or registers of protected areas also includes areas designated as bathing waters under Directive 76/160/EEC, as vulnerable zones under Directive 91/676/EEC and areas as sensitive under Directive 91/271/EEC. These latter Directives also have monitoring and reporting requirements. The EAF on Reporting is considering not only the reporting required under the WFD but also existing reporting requirements with the aim of 'streamlining' the reporting process. The Working Group on Monitoring also recommends that ways of integrating, rationalising and streamlining the monitoring requirements under the other Directives should also be considered in future work that might revise this draft Guidance Document.

It is recommended that appropriate standards are developed as a matter of priority and urgency for those aspects of monitoring for which there are no internationally agreed standards or techniques/methods.

It is anticipated that the Guidance can be further developed by work undertaken in the next phase of the Common Implementation Strategy, for example, by the development of further horizontal Guidance on some aspects, and in the light of experience gained during the pilot basin testing phase.

ANNEX I GLOSSARY

Glossary of terms (excluding terms already defined in Article II of the Directive).

Term	Definition
Common Implementation Strategy	The Common Implementation Strategy for the Water Framework Directive (known as the CIS) was agreed by the European Commission, Member States and Norway in May 2001. The main aim of the CIS is to provide support in the implementation of the WFD, by developing a common understanding and Guidance on key elements of this Directive. Experts from the above countries and candidate countries as well as stakeholders from the water community are all involved in the CIS to: • Raise awareness an exchange information; • Develop Guidance Documents on various technical issues; • Carry out integrated testing in pilot river basins; and A series of working groups and joint activities has been developed to help carry out the activities listed above. A Strategic Co-ordination Group (or SCG) oversees these working groups and reports directly to the Water Directors of the European Union, Norway, Switzerland, the Candidate Countries and Commission, the engine of the CIS. For more information refer to the following website: http://europa.eu.int/comm/environment/water/water-framework/index_en.html.
Conceptual Model	A conceptual understanding of the interrelationships occurring within a system. The conceptual model graphically describes how experts believe the system behaves. Once developed the model is continuously refined as scientists obtain an improved understanding of the water bodies concerned and their vulnerability to pressures.
Confidence	The long-run probability (expressed as a percentage) that the true value of a statistical parameter (e.g. the population mean) does in fact lie within calculated and quoted limits placed around the answer actually obtained from the monitoring programme (e.g. the sample mean).
Ecological Quality Ratio	Ratio representing the relationship between the values of the biological parameters observed for a given body of surface water and values for these parameters in the reference conditions applicable to that body. The ratio shall be represented as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero (Annex V 1.4(ii)).
Impact	The environmental effect of a pressure (e.g. fish killed, ecosystem modified).
Intercalibration	An exercise facilitated by the Commission to ensure that the high/good and good/moderate class boundaries are consistent with the normative definitions in Annex V Section 1.2 of the Directive and are comparable between Member States (see Guidance produced by WG 2.5) (Annex V 1.4. (iv)).

Term	Definition
Monitoring Standards	International or national standards developed to ensure provision of data or an equivalent scientific quality and comparability (e.g. those developed by CEN and ISO).
Parameter	Parameters indicative of the quality elements listed in Annex V, Table 1.1 in the Directive that will be used in monitoring and classification of ecological status. Examples on parameters relevant for the biological quality element composition and abundance of benthic invertebrate fauna are.: number of species or groups of species, presence of sensitive species or groups of species and proportion of tolerant/intolerant species.
Precision	A measure of the statistical uncertainty equal to the half width of the C% confidence interval. For any one monitoring exercise, the estimation error is the discrepancy between the answer obtained from the samples and the true value. The precision is then the level of estimation error that is achieved or bettered on a specified (high) proportion C% of occasions.
Pressure	The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry of surface and groundwater.
Quality Assurance	Procedures implemented to ensure results of monitoring programmes meet the required target levels of precision and confidence. Can take the form of standardised sampling and analytical methods, replicate analyses, ionic balance checks and laboratory accreditation schemes.
Quality Element	Annex V, Table 1.1 in the Directive, explicitly defines the quality elements that must be used for the assessment of ecological status (eg. composition and abundance of benthic invertebrate fauna). Quality elements include biological elements and elements supporting the biological elements. These supporting elements are in two categories: ‘hydromorphological’ and ‘chemical and physicochemical’.
Risk	2.7 Monitoring: Chance of an undesirable event happening. It has to aspects: the chance and the event that it might happen. These are conventionally called the probability and the confidence.
WFD, The Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy.

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Links to Other Work

Table III.1 Completed and current research relevant to the WFD.

Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
4	Reverse any significant upward trend in pollutants	**DG Environment Ad hoc – (Austria) statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results**. After initial characterisation, bodies at risk require detailed characterisation of human impacts. Surveillance to verify if those identified at risk actually are is then required using indicative parameters. Plus operation monitoring of those confirmed at risk. This research clarifies statistical aspects. Status: current. Now part of the water group 2.8 under the Commissions Common Strategy	?
4	Environmental objectives	**Finnish Environment Institute.** Ecological basis for the discrimination, classification and monitoring of Finnish water bodies (krister.karttunen@vyh.fi , anas.pilke@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Environment Institute.** Ecological basis for the discrimination and classification of regulated lakes in Finland (Mika.marttunen@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Environment Institute.** Analysis of existing monitoring data for ecological classification of coastal waters (saara.back@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Regional Environment Centre.** Use of macrozoobenthos in assessing the ecological state in the coastal waters of the Quark region (hans-goran.lax@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Regional Environment Centre (Finland).** Ecological status of streams in Vuoksi River basin (kari-matti.vuori@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Regional Environment Centre.** Applicability of periphyton methods for biomonitoring and classifying ecological status in the Vuoksi watercourse in littoral and pelagical zone (pekka.sojakka@vyh.fi, pertti.manninen@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Regional Environment Centre.** Development of aquatic macrophyte monitoring for the national implementation of the WFD (olavi.sandman@vyh.fi). Status: current.	?
4	Environmental objectives	**Finnish Game and Fisheries Research Unit.** The analysis of fish community structure as a basis for the development of ecological classification and monitoring of surface waters (martti.rask@rktl.fi). Status: current.	?
4	Environmental objectives	**Helsinki University (Finland).** The control mechanisms required by the WFD and its Finnish implementation (jukka.matinvesi@vyh.fi, kai.kaatra@mmm.fi**).** Status: current.	?
4	Environmental objectives	**LIFE (Ian Codling, WRc, UK) Efficiency of Applied Policies regarding the Prevention and Control of Diffuse Pollution in Surface Waters: Inventory and comparison of approaches in seven countries, Germany, Denmark, France, The Netherlands, Sweden and the UK.** Project highlights those practices relevant to the aims of the proposed WFD, which seek to achieve good water quality status within river catchments through control of both point and diffuse sources of pollution. Status: current.	Nov 1999-April 2000
4	Environmental objectives	**Finnish Regional Environment Centre. Typology and restoration of the lakes of lowered water level (**heikki.tanskanen@vyh.fi **).** Status: current.	?
5	Characterise water body types	**FP5. TARGET. Functional assessments of surface water body ecological status.** Status: current.	?

Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
5	Analysis of characteristics	**Finnish Environment Institute. The application of the WFD in heavily modified water bodies in Europe –** The Lake Kemijarvi case study (mika.marttunen@vyh.fi). Status: current.	?
5	Analysis of characteristics	**FP5 An operational system of Groundwater Recharge at European scale.** Contact persons: Professor M.A.Mimikou, Dr. E.A.Baltas. To develop a simple consistent and reliable system to estimate groundwater recharge at the catchment and regional scale. Status: recommended.	?
5	Analysis of characteristics	**FP5 River basin modelling for holistic catchment management.** Contact persons: M. A. Mimikou, Dr E. A. Baltas. The aim of this project is to establish current state of the art in river basin scale modelling and catchment management to identify issues for research to underpin the implementation of the WFD.	?
5	Analysis of characteristics	**FP5 Decision Support System for Integrated Water Resources Management.** Contact persons: Professor M.A.Mimikou, E.L.Varanou. Managing water resources on the river basin scale as the proper physical unit to account for the interaction between surface water and ground water as well as water quantity and quality. Status: recommended.	?
5	Analysis of characteristics	**FP5 Hydrological and Hydrometeorological Systems for Europe – HYDROMET (FP 4)** Contact persons: Professor M.A.Mimikou, Dr. E.A.Baltas. This project aimed to develop weather radar system for hydrological applications. Status: completed.	?
5	Analysis of characteristics	**FP5 Impact of Climate Change on Hydrological and Water Resource Systems in the European Community (FP 4).** Contact persons: Professor M.A.Mimikou, Dr. E.L.Varanou. This project aims to assess the impacts of climate change on water resources in Northern Greece on a regional basis (catchment scale). Status: completed.	?
5	Analysis of characteristics	**FP5 European River Flood Occurrence & Total Risk Assessment System – EUROTAS (FP 4).** Contact persons: Professor M.A.Mimikou, E.L.Varanou. To develop and demonstrate an integrated catchment model for the assessment and mitigation of flood risk. Status: current.	?
5	Analysis of characteristics	**FP5 Climate Hydrochemistry and Economics of Surface – Water Systems – CHESS (FP 4).** Contact persons: Professor M. A. Mimikou, E. C. Gkouvatsou. This project aims to investigate how expected changes in climate and land cover will affect the quality of freshwater resources in Europe. Status: current.	?
5	Integrated Catchment Management	**FP5 (EVK1) Data assimilation within a unifying modelling framework for improved river basin water resources management (contact Cees Veerman).** The aim of this project is to develop, implement and test a model that incorporates stream channel, land surface and soil components.	2000 - 2001
5	Integrated Catchment Management	**FP5 (EVK1) Integrated evaluation for sustainable river basin governance (contact Leopoldo Guimaraes).** This project aims to develop a set of guidelines for river basin authorities describing an integrated evaluation process, establishing criteria for assessing the sustainability of an evaluation process and providing practical tools to make the guidelines operational.	2001 - 2004
5	Integrated Catchment Management	**FP5 (EVK1) Freshwater integrated resource management (contact Peter Brooks, University of Surrey).** The aim of this project is to improve water resource planning through the use of multi-agent models that integrate hydrological, social and economic aspects of water resource management through the representation of stakeholder decision making.	
8	Determine ecological status .	**EA (E1-S01). Use of macrophytes for environmental monitoring of rivers.** This project aimed to develop a macrophyte-based methodology for monitoring the ecological health of river environments, and assessing their rehabilitation requirements. Status: completed.	?
8	Determine ecological status	**EA (E1D(01)15. Assessment of LIFE scores to link freshwater invertebrate communities to flow conditions.** Status: current.	?
8	Determine ecological status	**EA (E1A (01)02. Implementation of the PYSM system for the ecological assessment of ponds.** The aim is develop a co-ordinated monitoring programme for ponds and small water bodies in England and Wales. Status: current.	?
8	Determine ecological status	**EA (PR W1/017/1). PLANTPACS – A Study into the Feasibility of Producing a Predictive System to Assess River Quality and Ecological Status using Macrophytes.** This project was designed to develop a predictive system for macrophytes in rivers to determine overall environmental quality. Status: completed.	Published January 2000
8	Determine ecological status	**EA (E1-091). Still water ecological classification systems.** This project aims to review ecologically based classification systems that would be applicable to temperate standing freshwaters over 0.5km^2 surface area. Status: current.	04/05/99-31/03/01
8	Determine ecological status	**FP5 TARGET - Integrated assessment tools to gauge local functional status within freshwater ecosystems.** Develop a suite of generic tools for assessing functional status of running water ecosystems, based on modified versions of existing limnological and ecotoxicological tests. Has created	2000-2002

Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
		Ecological Quality Manual containing procedures for the selection of tools and interpretation of results within ecoregion studied. Status: current.	
8	Determine ecological status	**FP5. EMERGE European Mountain Lake Ecosystem Regionalisation Diagnostic and Socio-economic Evaluation (contact: Simon Patrick Environmental Change Research Centre UCL).** Assessing the status of remote mountain lake ecosystems following the requirements of the WFD. Provides an evaluation of findings in ecological, environmental and socio-economic terms. Status: current.	2000-2002
8	Determine ecological status	**FP5 (contact: Dr Daniel Hering Institute of Ecology, Department of Hydrobiology University of Essen DE). AQEM, assessment method for defining ecological quality of surface water using benthic macroinvertebrates.** To develop an assessment procedure for rivers that meets the demands of the WFD using benthic macroinvertebrates. System based on fauna of near natural reference streams, new data sets to be comparable. Status: current.	2000-2002
8	Determine ecological status	**FP5 (contact: Prof. Brian Moss, school of Biological Sciences, University of Liverpool). ECOFRAME - Ecological quality and functioning of shallow lake ecosystems with respect to the needs of the WFD.** Shallow lakes are complex systems due to importance of higher plants, and thus pose particular problems for the implementation of WFD. Aims to test robustness of proposed sampling frequencies, to decide best criteria for determination of ecological status (high, good, moderate and worse). Status: current.	2000-2002
8	Determine ecological status	**FP5 (contact: Prof. Edwin Taylor; School of Biological Sciences, University of Birmingham, UK). CITYFISH.** This is a project that is modelling ecological quality of urban rivers: ecotoxicological factors limiting restoration of fish populations. Status: current.	2000 - 2002
8	Determine ecological status	**EPA (contact: Larry Stapleton, Environmental Monitoring and Laboratory Services Division, Ireland). Remote sensing of lakes: improved chlorophyll calibration and data processing.** Project developed aerial remote sensing facility to produce routine chlorophyll estimations for Irish lakes, as well as information on lake macrophytes and catchment land-use. Led to creation of a GIS suitable for lake management purposes. Status: completed.	1995-98
8	Determine ecological status	**EPA (contact: Larry Stapleton, Environmental Monitoring and Laboratory Services Division, Ireland). Ecological assessment of Irish lakes.** Developed field based assessment technique similar to that developed for rivers, to allow lakes to be graded using a range of ecological characteristics – flora, fauna, catchment type, and trophic status. Provided a data set of biological and chemical characteristics and catchment data (land use, rainfall) to investigate associations between patterns of land use and lake nutrient concentrations. Status: completed.	1995-99
8	Determine ecological status	**FP5 Predicting aquatic ecosystem quality using artificial neural networks: impact of environmental characteristics on the structure of aquatic communities (contact Raymond Bastide Universite Paul Sabatier de Toulouse III).** This project aims to develop the methodology for linking environmental characteristics and community structure and at a functional level the sensitivity of organisms and their response to disturbance.	2003
8	Determine ecological status	**FP5 Integrated assessment tools to gauge local functional status within freshwater ecosystems (contact Amadeu Mortagua, Universidade de Coimbra).** The aims of this study, which is based in Portugal, The Netherlands and the UK, are to develop an integrated set of tools for assessing ecological processes that maintain ecosystem services. The bioassays include energy supply, energy consumption and transfer.	2000 - 2003
8	Determine ecological status	**FP5 (EKV1) Towards harmonised procedures for quantification of catchment scale nutrient losses from European Catchments.** The aim of this project is to evaluate 10 tools that are currently used to support policy reporting at national and international level for estimating diffuse losses of N and P across a range of catchment types.	?

NOTE: FEI = Finnish Environmental Institute; FREC = Finnish Regional Centre; FF&G = Finnish Fish and Game, NERC = National Environment Research Council

ANNEX III SUMMARY OF FACTSHEETS ON CURRENT MONITORING UNDERTAKEN BY MEMBER STATES

Fact Sheet Title	Quality Element	Proposed by
Rivers		
Biological http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/rivers&vm=detailed&sb=Title		
Determination of the acute lethal toxicity of substances to a freshwater fish (*Brachydanio rerio* Hamilton-Buchanan (*Teleostei, Cyprinidae*))	Fish	Finland
IBGN Expert System	Benthic invertebrate fauna	France
Acidification index	Benthic invertebrate fauna	UK
Fresh water algal growth inhibition test with *Scenedesmus subspicatus* and *Selenastrum capricornutum*	Setting EQS -chronic toxicity data	Finland
HBMWP (Hellenic BMWP) +HASPT+Hindex	Benthic invertebrate fauna	Greece
IBE Extended Biotic Index modified for Italian rivers	Benthic invertebrate fauna	Italy
Environmental Quality Criteria – Benthic fauna - rivers	Benthic invertebrate fauna	Sweden
Determination of the inhibition of the mobility of *Daphnia magna* Straus (*Cladocera, Crustacea*)- Acute toxicity test	Setting EQS -chronic toxicity data	Finland
Protocol for monitoring epilithic diatoms at ECN river sites	Aquatic flora	UK
Protocol for monitoring aquatic macrophytes at ECN rivers sites	Aquatic flora	UK
Electric Fishing	Fish	UK
Swedish fish index	Fish	Sweden
IP (Indice poissons)	Fish	France
Quantitative sampling of fish with electricity	Fish	Sweden
Determination of toxicity to embryos and larvae of freshwater fish – semi-static method	Setting EQS -chronic toxicity data	Finland
IBD (Indice biologique diatomées)	Aquatic flora	France
Biological GQA (General Quality Assessment) classification	Benthic invertebrate fauna	UK
Acidification index based on invertebrates	Benthic invertebrate fauna	Norway
Lotic-invertebrate Index for Flow Evaluation (LIFE) Index	Benthic invertebrate fauna	UK
River Ecosystem Survey	General biological QEs	France
FBI monitoring method – Fish based index, indice poissons	Fish fauna	France
Determination of the inhibitory effect of water samples on the light emission of *Vibrio fischeri* (Luminescent bacteria test)	Setting EQS -chronic toxicity data	Finland
Mean Trophic Ranking (MTR)	Aquatic flora	UK
IBMR (Indice biologique macrophytes en rivière)	Aquatic flora	France
Occurrence of river macrophytes	Aquatic flora	Sweden
Periphyton method in running waters	Aquatic flora	Finland
Guidance standard for routine sampling of benthic algae in swift running water	Aquatic flora	Norway
Diatoms in running waters	Aquatic flora	Sweden

Fact Sheet Title	Quality Element	Proposed by
Rivers ***Biological continued..***		
The Trophic Diatom Index (TDI) and Diatom Quality Index (DQI)	Aquatic flora	UK
Composition, abundance and age structure of fish fauna	Fish	UK
Hydromorphological http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/rivers&vm=detailed&sb=Title		
River Habitat Survey (RHS) classification	Aquatic habitat/River structure	UK
REH (habitat assessment network)	Fish habitat/River structure	France
River Habitat Survey	Aquatic habitat	Greece
Physical SEQ (Quality Evaluation System)	Aquatic habitat	France
IFF – Indice di Funzionalità Fluviale (River Functionality Index)	Hydromorphology	Italy
QBR Index	Structure of riparian zone	Spain
Physico-chemical http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/rivers&vm=detailed&sb=Title		
Determination of alkalinity	Acidification	Sweden
Determination of ammonia nitrogen of water	Nutrients	Finland
ANC (Acid neutralizing Capacity)	Acidification	Norway
Determination of dissolved oxygen content in water	Oxygenation conditions	Finland
Determination of total-P after digestion with peroxidisulphate	Nutrients	Sweden
Determination of the sum of nitrite and nitrate nitrogen, nitrate nitrogen and total nitrogen in water by automated analytical equipment	Nutrients	Finland
Determination of phosphate in water	Nutrients	Finland
Determination of pH-value of water	Acidity	Finland
Determination of total phosphorus in water. Digestion with peroxidesulphate	Nutrients	Finland
Water -SEQ	General phys-chem	France
Guidance on Input Trend Assessment and the Adjustment of Loads	Identify and quantify pollution sources	The Netherlands
Lakes		
Biological http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/lakes&vm=detailed&sb=Title		
Chironomid Pupal Exuviae Technique (CPET) for assessing canal water quality	Benthic invertebrate fauna	UK
Predictive System for Multimetrics (PSYM)	Benthic invertebrate fauna	UK
Determination of the acute lethal toxicity of substances to a freshwater fish (*Brachydanio rerio* Hamilton-Buchanan (*Teleostei, Cyprinidae*))	EQS for acute toxicity data	Finland
Fresh water algal growth inhibition test with Scenedesmus subspicatus and Selenastrum capricornutum	Setting EQS for chronic toxicity data	Finland

Fact Sheet Title	Quality Element	Proposed by
Lakes ***Biological continued..***		
Environmental Quality Criteria – Benthic fauna - lakes	Benthic Invertebrate fauna	Sweden
Chironomid Pupal Exuviae Technique (CPET) for assessing lake status	Benthic invertebrate fauna	UK
Determination of chlorophyll-a, spectrophotometric determination in methanol extract	Aquatic flora	Norway
Determination of the inhibition of the mobility of *Daphnia magna* Straus (*Cladocera, Crustacea*)- Acute toxicity test	EQS for acute toxicity data	Finland
Protocol for monitoring aquatic macrophytes at ECN lake sites	Aquatic flora	UK
Electric Fishing	Fish	UK
Sampling of fish with gillnets	Fish	Sweden
Swedish fish index	Fish	Sweden
Determination of toxicity to embryos and larvae of freshwater fish – semi-static method	Setting EQS for chronic toxicity data	Finland
Composition, abundance and age structure of fish fauna	Fish	UK
Acidification index based on invertebrates	Benthic invertebrate fauna	Norway
Predictive System for Multimetrics (PSYM)	Aquatic flora	UK
Determination of the inhibitory effect of water samples on the light emission of *Vibrio fischeri* (Luminescent bacteria test)	EQS for acute toxicity data	Finland
Aquatic plant monitoring method	Aquatic flora	Finland
Submerged macrophytes in lakes	Aquatic flora	Sweden
Phytoplankton sampling in lakes for ECN sites	Aquatic flora	UK
Inverted microscope analysis	Aquatic flora	Sweden
Methods for quantitative assessment of phytoplankton in freshwaters	Aquatic flora	Finland
Physiochemical		
Determination of alkalinity	Acidification	Sweden
Determination of ammonia nitrogen of water	Nutrients	Finland
ANC (Acid neutralising Capacity)	Acidification	Norway
Determination of dissolved oxygen content in water	Oxygenation conditions	Finland
Determination of the sum of nitrite and nitrate nitrogen, nitrate nitrogen and total nitrogen in water by automated analytical equipment	Nutrients	Finland
Determination of phosphate in water	Nutrients	Finland
Determination of pH-value of water	Acidity	Finland
Determination of total phosphorus in water. Digestion with peroxidesulphate.	Nutrients	Finland
Toxicity and ecotoxicity		
Determination of toxicity to embryos and larvae of freshwater fish – semi-static method	Setting EQS for chronic toxicity data	Finland
Determination of the inhibition of the mobility of *Daphnia magna* Straus (*Cladocera, Crustacea*)- Acute toxicity test	Setting EQS for chronic toxicity data	Finland
Determination of the acute lethal toxicity of substances to a freshwater fish (*Brachydanio rerio* Hamilton-Buchanan (*Teleostei, Cyprinidae*	Setting EQS for acute toxicity data	Finland
Fresh water algal growth inhibition test with *Scenedesmus subspicatus* and *Selenastrum capricornutum*	Setting EQS for chronic toxicity data	Finland

Fact Sheet Title	Quality Element	Proposed by
Coastal –transitional		
Biological http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/transitional_coastal&vm=detailed&sb=Title		
Guidelines for marine biological investigations of littoral and sublittoral hard bottom	Aquatic flora Benthic invertebrate fauna	Norway
Guidelines for quantitative investigation of marine softbottom macrofauna	Benthic invertebrate fauna	Norway
Effect-directed identification procedures	Contaminants	The Netherlands
Seine Netting	Fish fauna	UK
Benthic invertebrate fauna	Benthic invertebrate fauna	UK
Soft bottom macrozoobenthos	Benthic invertebrate fauna	HELCOM
Soft bottom macrozoobenthos	Benthic invertebrate fauna	Sweden
Composition and cover of macroalgae	Aquatic flora	Denmark
Cartography of littoral benthic communities	Aquatic flora Benthic invertebrate fauna	Spain
Phytobenthic plant and animal communities	Aquatic flora	HELCOM
Sampling of Littoral benthic communities	Aquatic flora Benthic invertebrate fauna	Spain
Phytobenthic plant and animal communities	Aquatic flora	Sweden
Power Station Intake Screens - fish abundance/competition	Fish	UK
Beam Trawling - fish abundance/competition	Fish	UK
Kick Sampling - fish abundance/competition	Fish	UK
Otter Trawling – fish abundance/competition	Fish	UK
Fish fauna abundance/competition	Fish	UK
REPHY – Composition, abundance and biomass of phytoplankton	Phytoplankton	France
REBENT –Composition and abundance of phytobenthos and benthic invertebrate fauna	Aquatic flora, benthic invertebrate fauna	France
RSP – Distribution, abundance and vitality of angiosperms (P*osidonia oceanica*) - Mediterranean	Aquatic flora	France
RSG –Distribution, abundance and vitality of gorgons (*Paramuricea clavata*) - Mediterranean	Benthic invertebrate fauna	France
RINBIO – Biological integrators: inorganic and organic contaminants in mussels - Mediterranean	Contaminants	France
Catography of littoral benthic communities in Mediterranean	Aquatic flora, benthic invertebrate fauna	France
Physiochemical http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/wg_2_monitoring/factsheets_monitoring/transitional_coastal&vm=detailed&sb=Title		
Determination of alkalinity	Acidification	Sweden
Determination of ammonia nitrogen of water	Nutrients	Finland
Co-ordinated environmental monitoring programme	Physiochemical	Belgium Netherlands
Determination of dissolved oxygen content in water	Oxygenation conditions	Finland
Determination of the sum of nitrite and nitrate nitrogen, nitrate nitrogen and total nitrogen in water by automated analytical equipment.	Nutrients	Finland
Organotin determination in sediments	Contaminants	Netherlands
Determination of phosphate in water	Nutrients	Finland

Fact Sheet Title	Quality Element	Proposed by
Determination of pH-value of water	Acidity	Finland
Determination of total phosphorus in water. Digestion with peroxidesulphate.	Nutrients	Finland
Guidance on Input Trend Assessment and the Adjustment of Loads	Physico-chemical	Netherlands
Phytoplankton chlorophyll a	Aquatic flora	HELCOM Sweden
Method for monitoring littoral waters	Nutrients	Spain
Nutrient determination	Nutrients	HELCOM Sweden
Determination of oxygen concentrations in coastal waters and the Baltic Sea	Oxygenation conditions	HELCOM Sweden
Determination of salinity in coastal waters and the Baltic Sea	Salinity	HELCOM
Light attenuation	Transparency	HELCOM Sweden
Determination of temperature in coastal waters and the Baltic Sea	Thermal conditions	HELCOM
Groundwater		
Monitoring of groundwater: criteria to set the monitoring network of groundwater according to socio-economic and hydrogeological conditions of the regional district	Hydrogeological	Italy

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ANNEX V KEY CONSIDERATIONS FOR MONITORING QUALITY ELEMENTS

V1.1 Rivers

V1.1.1 Key considerations for rivers

River systems across Europe are extremely variable in size and structure and, although they have a long and very intense history of study in relation to their responses to an equally varied range of pressures, monitoring the effects of the impacts on biological communities is complex. The choice of the quality elements to be used in the monitoring programmes will improve over time but, in the first instance, choosing the quality elements most relevant to specific pressures will depend on the size of the river system, availability of existing monitoring methods and data-sets, and local knowledge of the significant pressures.

V1.1.2 Key Biological Quality elements

The use of macroinvertebrates to assess the effects of organic pollution of rivers has a long history throughout Europe and, although the details in methodologies might vary from country to country, their use for this purpose is well understood. Currently, this is the most commonly used element for biological classification of rivers in Europe.

More recently methods for using macroinvertebrates as indicators of other pressures including toxic chemicals and alterations in river flows and channel morphology, have or are being developed. The sensitivity of macroinvertebrates to a wide range of impacts makes them a very useful tool for assessing river quality. They are less useful in deep rivers where they may be difficult to sample.

Monitoring macrophyte community structure and biomass is most relevant for assessing the impacts of eutrophication in small to medium-sized rivers. They can be used for assessing the impacts of high flows and flow variation associated with hydropower effects and of stream maintenance. As with macroinvertebrates, they are not widely used in large, deep river systems or in more shallow rivers subject to wide flow variations, such as those subject to the impact of melting snow. Further macrophytes can absent in streams in dense forested areas.

Methods are available and several countries use macrophytes for river quality assessment. A CEN sampling method is currently nearing completion but further work will be needed on the use of macrophytes for the Directive.

Benthic algae currently have limited use in European countries but are valuable under some circumstances, particularly for describing the impacts of eutrophication. Diatoms and filamentous algae have been used most effectively for this purpose.

River phytoplankton species and abundance are important indicators of eutrophication but are limited in their use to large, slow flowing rivers.

The use of fish as indicators of impacts on river systems is relatively uncommon across Europe. Although it is clearly recognised that fish are important indicators of river condition, they are difficult to sample without specialist equipment and the results are difficult to interpret because of their mobility within the river systems, barriers in the river systems, effects of fishery and stocking etc. Care must be taken in choosing the most appropriate indicators of local conditions and impacts, particularly in the case of migratory Salmonids.

The use of fish as indicators of accidental pollution is an important consideration in setting up monitoring schemes.

V1.1.3 Key hydromorphological elements

The physical structure and flow dynamics of river systems are very important elements for determining ecological quality. All the biological quality elements vary in accordance with their habitat requirements and the processes associated with the hydromorphological quality elements and flow dynamics are highly influential in determining the basic floral and faunal community composition. Of particular importance are the influences of these elements on substrate, the decomposition of organic matter and the extent of interaction with the riparian zone.

Further work is needed to provide better methods to describe the relationships between the biological quality elements and the morphology, river continuity and hydrological regime.

The influence of groundwater inputs to river systems (or loss to groundwater systems and/or irrigation) is also an important issue to be considered under the Directive, both in terms of maintaining the river system and the potential to cause pollution.

V1.1.4 Key physico-chemical elements

Many of the basic physico-chemical quality elements in Annex V of the Directive are basic measures of river condition and like the physico-chemical elements are important influences on natural river systems. These includes temperature, nutrients, salinity and the pH balance. It is important therefore to include measurements of these elements in relation to their natural as well as potential polluting influences. For example, nutrient concentrations outside the expected range of concentrations are likely to cause eutrophication.

The other main quality elements, which need to be taken account of, are the specific pollutants identified as being likely to cause a failure of the biological quality status. These will vary locally and will need to be determined during the analysis of pressures.

V1.2 Lakes

V1.2.1 Influence of eutrophication on ecosystem structure and function

The key element influencing ecosystem structure and function in lakes and reservoirs is anthropogenic eutrophication. Eutrophication, which in principle is a natural, but very slow phenomenon of lakes, contributes to a number of water quality problems such as phytoplankton blooms, reduced recreational aesthetics, hypolimnetic oxygen depletion, reduced transparency and fish kills. It is important to note that the fundamental processes, such as stratification and internal nutrient loading, occurring in natural lakes and artificial reservoirs are similar. However, differences in morphology, hydrology and water residence times need to be recognised before comparisons can be made.

The figure below Figure 7.1 illustrates the major physico-chemical and biological processed occurring in lakes during stratified and mixed conditions.

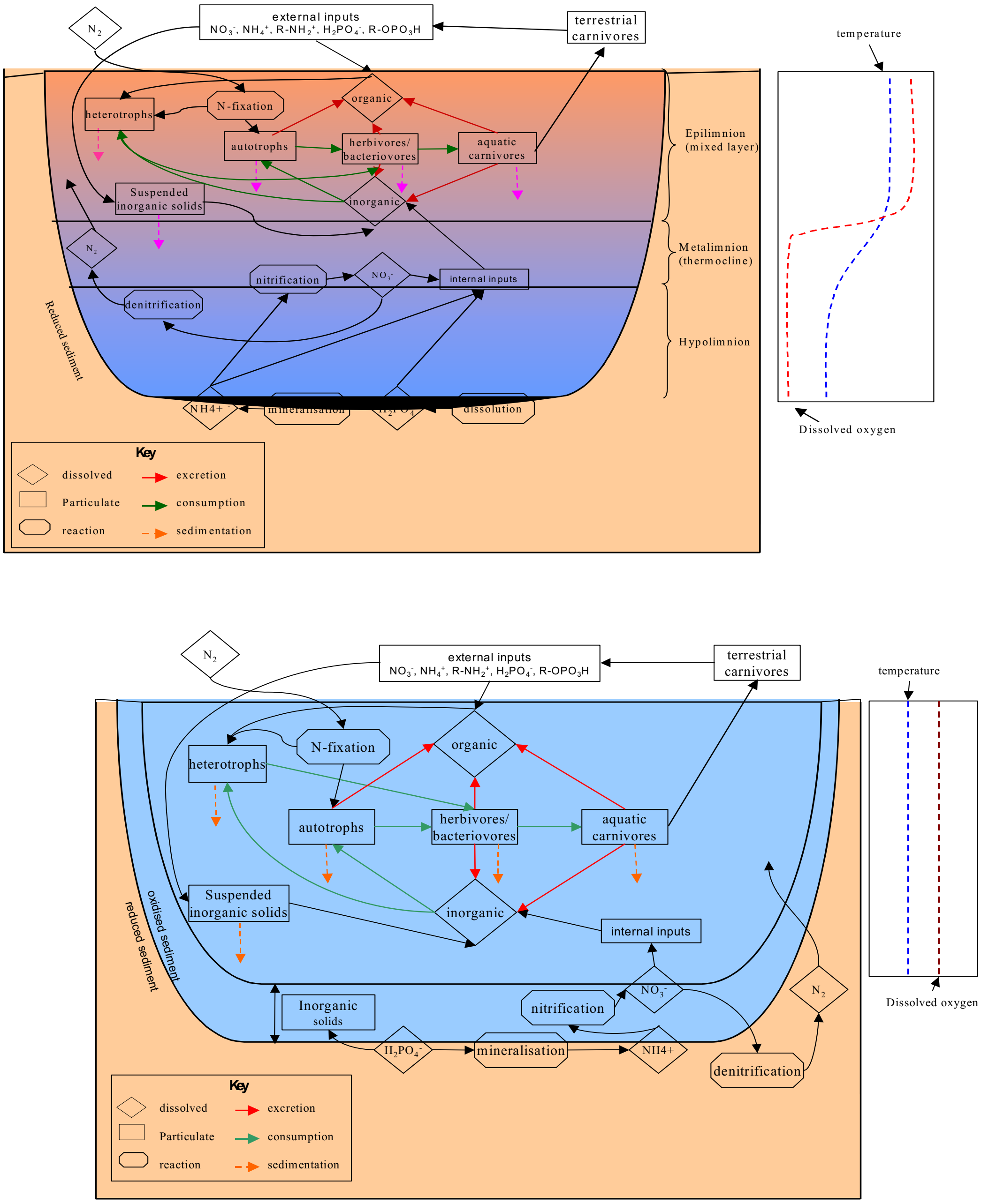

Figure 7.1 **Conceptual model/understanding illustrating the key physico-chemical and biological processes occurring in lakes under stratified and mixed conditions (from Littlejohn 2002).**

V1.2.2 Key biological quality elements

The assessment of phytoplankton diversity, abundance and biomass is of fundamental importance in lakes and reservoirs (Willén, 2000). Phytoplankton growth and distribution is influenced rapidly by physico-chemical changes and excessive blooms of phytoplankton are considered evidence of eutrophication. Chlorophyll-a concentrations can provide a good indicator of phytoplankton biomass and is often a major component of trophic state indices. Attention should, however, be paid to the methods used in analyses. However, due to the number of different methods which can produce variable results as indicated by the findings of the SALMON Project (cf. Premazzi et al., 1999), an important consideration is the standardisation of methodology

Littoral vegetation plays an important role in the regulation of metabolism in lakes and reservoirs. Although the response of macrophytes to pollution have not been previously well documented determination of their composition and abundance are important in defining flow and habitat structure for other biotic elements. Macrophyte communities and associated epiphytic microflora can function as sieves for inorganic nutrients and dissolved organic matter. Large water level fluctuations water level can restrict the development of productive and stabilising littoral flora (Kimmel *et al.* 1990). Therefore, reservoirs (which are the most abundant of lacustrine environments in non-alpine countries like Spain) do not support abundant macrophyte life due to water level fluctuations. This results in a reduction in the nutrient sieving capacity, enabling pelagic processes to assume a greater importance.

Fish have not been frequently used in classification systems due to their behavioral characteristics (e.g. mobility, seasonal upstream or downstream migration and avoidance to pollution). Furthermore, a clear relationship between community structure and ecological quality is not always obvious. For example, stocking programmes can greatly obscure the effects of environmental degradation in that high observed species diversity might be due to the introduction of new fish species. Nevertheless, the composition, abundance and structure of fish communities are useful indicators of long-term ecological impacts as they have long life cycles, are composed of several trophic levels and are relatively simple to identify. Some fish species (as well as mussels) can also be used in monitoring harmful organic substances and heavy metals because they have a high bioaccumulation capacity.

V1.2.3 Key hydromorphological quality elements

Each water body has a unique hydrology that depends on the pluviometric regime and on the morphometry of the river basin. The quantity and temporal patterns of water flow, and hence the residence time, influence the ecology of a water body through nutrient loading, growth of aquatic flora, the maintenance of marginal fish spawning habitat etc. However, natural variability also results from natural and anthropogenic climatic changes.

The quantity and dynamics of flow is greatly influenced by water abstraction and diversion. Furthermore, the addition of water to a lake or river in water supply transfer schemes may be ecologically damaging due to the introduction of water with different chemical and biological characteristics.

Lake morphology, particularly the surface area to depth ratio, is important in the development of littoral zones, to ensure there is adequate sediment substrata available for the establishment of littoral flora. Most European lakes and reservoirs are relatively shallow (mean depth <10m), resulting in a large proportion of the lake or reservoir basin potentially suitable for colonisation by littoral flora. This along with higher sediment deposition rates means that shallow lakes can theoretically support greater numbers of aquatic macrophytes. Wetzel (1990) suggests that based on the evidence of the shallow nature of most of the world's lakes, the global conclusion is that the littoral zone dominates over the pelagic zone.

Increased water residence time leads to greater stability and increased sedimentation of nitrogen and phosphorus and influences the accumulation of sediments and organic matter (Petrere, 1996). Additionally, water residence time governs the time available for biological interactions to occur and influences such factors as sedimentation, resuspension, dilution, diffusion, turbidity and nutrient supply (Soballe and Kimmell, 1987). Small impoundments, such as weirs, generally have low water residence times and the phytoplankton growth and species composition may be influenced by the flushing rate of the system.

Reservoir construction interferes with ecosystems, by creating a physical barrier for fish migration, increasing mean water depth, altering residence times and flushing rates and ultimately impacting on community structure and function (Petrere 1996). Therefore few autochthonous river fishes are found in reservoirs and generally most of the fish fauna has been recently introduced. The introduction of exotic fish species significantly contributes to the destabilisation of fish populations in reservoirs.

V1.2.4 Key physico-chemical quality elements

Different trophic levels create different conditions for lake metabolism, therefore influencing internal nitrogen and phosphorus cycling through altering the redox state of the sediment-water interface. Low primary production in oligotrophic lakes means that oxygen demand is not sufficient to cause complete deoxygenation of the hypolimnion during the stratification period. Alternatively, the flux of organic matter to the sediments may be significant in eutrophic waters increasing the sediment oxygen demand, leading to complete hypolimnetic anoxia.

Anaerobic conditions limit the diversity of hypolimnetic organisms, and can have a detrimental affect on the quality of fisheries. Low levels of dissolved oxygen at critical times of the year hinder the movements of migratory fish, which in turn may affect breeding success. Therefore monitoring temperature and oxygen are key elements for the determination of stratification/mixing regimes, and the level of biological productivity and respiration rates. Oxygen conditions have been used to characterise lake trophy and can be related to nutrient loading (OECD,1982).

Phosphorus, and to a lesser extent nitrogen, are the nutrients limiting algal growth in lakes and hence monitoring is essential to support the assessment of ecological status. Nutrient monitoring should provide an indication of general trophic conditions and enable discrimination of pollution sources (e.g. point and diffuse). Therefore, in order to provide adequate discrimination, monitoring should include the major forms of nitrogen and phosphorus, including dissolved and particulate and organic and inorganic forms. Additionally, the measurement of silicate ($Si\text{-}SiO_3$, $\mu g/L^{-1}$) may be a useful indicator of potential growth of diatoms.

V1.3 Transitional Waters

Aspects and features of the different quality elements to be monitored are summarised in the Tables 3.7-9.

V1.3.1 Biological Quality Elements

NOTE: see section V1.4.1 (coastal waters) of Annex V

Phytoplankton

Particularly relevant is the identification of nuisance or potentially toxic species, if they are typical for the transitional water studied. The main difficulties in using phytoplankton as a quality element for transitional waters with pronounced tides are represented by the extremely high natural spatial and temporal variability of the planktonic communities which may make phytoplankton monitoring a useless exercise in some transitional waters. The use of size fraction and size spectra may overcome the problems of taxonomic identification and intercalibration, but still require a standardisation of methods In shallow environments, the structure of phytoplankton community can be influenced by the resuspension of benthic microalgae, mostly due to wave and wind.

Seasonal monitoring is suited representing the phytoplankton community variability when seasonal patterns are predictable. However, the seasonal frequency applies only for taxonomic analyses. At least monthly samplings for phytoplankton chlorophyll-a should be considered during the vegetation period, weekly sampling would be optimal, fortnightly sampling recommended. Chlorophyll-a analyses give a coarse assessment of the phytoplankton biomass (expressed as $\mu g\ L^-$), therefore parallel sampling for cell identification and counting should be collected and stored. In case of significant month-by-month changes of chlorophyll-a the stored samples might be used for taxonomical analyses. In addition to the chlorophyll-a analysis, the direct water colour can also give important information, namely the coloured waters are symptoms of typical blooms (e.g., red waters for dinoflagellates, etc.).

Macroalgae (seaweeds)

The main difficulties in using macroalgae as a quality element are represented by the ephemeral behaviour of these quality elements undergoing some spatial and temporal variability which bias monitoring, however, to a much lesser extent than in case of phytoplankton. Therefore in some transitional waters, macroalgae and other macrophytes such as angiosperms may be better suited for monitoring the ecological quality than phytoplankton.

The sampling frequency should be suited for representing changes in seaweed communities thus be selected on a region- and type-specific level. During the vegetation period, sampling should be carried out fortnightly to monthly.

Changes in community structure and specific biomasses may be rapid and unpredictable due to the ephemeral characteristics of some of the macroalgae, therefore seasonal samplings are not well suited.

The coverage (as a % of the total system area), changes of this area, the frequency of macroalgal blooms, their size together with the community variability are a good indicator of the state the macroalgae and their environment, and can be used as an early warning systems. Qualitative analyses of new species (new forms) can be also performed by site-trained personnel as an additional warning detection.

Angiosperms (seagrasses)

Optional parameters that countries may wish to use in addition are species abundance (as number of individuals per m^2) and biomass (as g dry weight m^{-2}) as well as depth distribution (lower limit of occurrence). Changes in coverage and composition as well as the occurrence of rare or sensitive species may be used as indicators of human, but also natural impact (e.g. storms, ice winters).

The sampling frequency suited for representing changes in seagrass communities in shallow transitional waters is monthly during the vegetation period. Depending on region and assemblage, it may be sufficient to sample twice during the vegetation period (extensive mapping at a time when species identification is most easy, e.g. during the bloom period, followed by a second survey at the end of the vegetation period).

Benthic invertebrate fauna

Optional parameters that countries may use in addition are biomass (usually expressed as g ashfree dry weight m^{-2}) as well as fractionated biomass (size fractions or body size spectra). However, the reliable determination of macrozoobenthic biomass at a representative station requires a very large number of samples (e.g. 200 replicates per station). Apart from natural small-scale variability, the methodological bias is fairly high due to several steps involved (fresh/wet weight, dry weight, ash-free dry weight). A solution could be to use conversion factors derived from reliable time-series taken in the region/type concerned.

A standardisation of methods is still required and there is a lack of quality assurance protocols. On a temporal scale, the sampling frequency suited for representing changes in benthic invertebrate communities in shallow transitional waters should be selected on a regional/type-specific basis. Sampling should take place at least twice per year (spring and autumn) A recommendable approach for transitional waters in temperate areas (e.g. river Elbe) is fortnightly sampling during spring/early summer (April–June) followed by 2-3 samplings in August/September. In other areas (e.g. Mediterranean), seasonal sampling might be preferable. Recent attempts to apply statistical analyses to the higher taxonomic levels or on species pooled into ecological or trophic guilds have been successful.

Fish fauna

For classifying the ecological status, the limnological classification scheme based on indicator fish species could be used. Sound abundance estimates require long time series due to high variability. In general, the species composition (do typical and specially sensitive species including migrating species and spawning schools[48] occur as to be expected) of transitional waters seems to be most appropriate for WFD purposes; abundance or biomass are not good in these waters because of high variability.

It should be noted that sampling for fish faunal composition and abundance should preferably be carried out at least 2 times per year (spring/autumn) and that for reliable estimates of fish abundance, long time series of at least 10 years are inevitable because of natural variability.

V1.3.2 Hydromorphological Quality Elements

Expertise's suggestion is to consider the hydrological budget a quality element more general than the freshwater flow, which is actually a component of the hydrological budget. Hydrological budget responds to variation of the freshwater flow but also to variation in the sand accumulation vs. sand erosion processes.

Morphological conditions

Refer to same paragraph of Section 1.4.2 (coastal waters).

Depth variations

Refer to same paragraph of Section 1.4.2 (coastal waters).

Structure and substrate of the transitional water bed

Refer to same paragraph of Section 1.4.2 (coastal waters).

Structure of the transitional zone

The structure of the transitional zone can be monitored in terms of structure of the vegetation occurring at the land-water interfaces, as affected by features of the substrate (mud, sand, rock, etc.), of the climatic and hydrologic regimes and of the anthropogenic pressures.

Vegetation coverage, vegetation type and floristic composition are the parameters that can be monitored.

A major problem is that the structure of vegetation is only an indirect indicator of the activity of the transitional zone as a buffering zone for the pressures of the anthropogenic activities in the watershed.

The structure of vegetation can be monitored every three years.

Hydrological budget

The hydrological budget characterizes the different transitional waters, i.e. estuaries, deltas, lagoons, coastal lakes, ports or gulfs, determines the sediment distribution and affects the sensitivity and resilience of transitional water ecosystems. Consequently, the hydrological budget has a major influence on all the quality elements in transitional waters.

Hydrological relevant parameters for an estuary are the volumes entering the estuary during high and low tide (tidal volume). The waterflow (volume and velocity) varies very locally. Subsequently erosion and sedimentation processes are sensitive to anthropogenic measures (LT-process) and extreme events like storm (ST-process). Special attention has to be given to the fish breeding areas between 0 to 5 m water depth and currents below 0.5 m. Monitoring these area's should be included in the program.

Changes in the components of the hydrological budget, due to human activities, are expected to be relatively slow. Therefore, monitoring is recommended every three years.

[48] e.g. of the stickleback (*Gasterosteus aculeatus*)

Monitoring should be performed with data collection on all the freshwater inputs and outputs arranged on a seasonal scale.

V1.3.3 Chemical and Physico-chemical Quality Elements

For all the chemical and physico-chemical quality elements refer to the same paragraphs of section 1.4.3 (coastal waters).

<u>A specific consideration for transitional waters is:</u>

Salinity

It is fundamental to measure the salinity gradient horizontally as well as vertically, especially for the physical delimitation of the transitional zone.

V1.4 Coastal Waters

V1.4.1 Biological Quality Elements

A very important issue when using biological elements as QE is the need of expertise required for taxonomic identification at the species level and the *in-situ* taxonomic resolution limitation.

Appropriately scientifically qualified personnel should carry out the surveys. They should be able to document competence within their specialist field, and participate in ring-testing, when the appropriate routines are available. For investigations spanning several years, priority should be given to continuity in personnel carrying out the recordings.

Phytoplankton

Particularly relevant is the identification of nuisance or potentially toxic species as important assessment parameters. Bloom frequency and intensity is considered an indicative parameter for classification of ecological status.

High natural spatial and temporal variability of the planktonic communities requires frequent sampling to ensure meaningful data for classification or detection of events (blooms). Sampling frequency is determined by the variability, and it is recommended a minimum of monthly sampling with optional increased sampling frequency in seasons with main bloom events. Sampling should be performed together with measurements of chemical and physico-chemical parameters. Seasonal sampling is a minimum frequency.

The minimum sampling frequency required by the Directive is every 6 months; however, available expert knowledge and pilot studies on sampling frequencies could be helpful to set up the most appropriate sampling frequency, number and location of stations on a regional or type-specific level. A selection of region/area-specific phytoplankton indicator species could be useful.

New monitoring programmes for the WFD could build on the existing phytoplankton monitoring programmes for other purposes, as, for example the Shellfish Hygiene Directive (Council Directive 91/492/EEC of 15 July 1991), to ensure best ‘value for money’ in monitoring.

Macroalgae / Angiosperms (Phytobenthos)

It is important to monitor not only their composition and abundance (as requested in the Directive) but also their distributions, extension and variation in time and space (mapping at different needed scales), as it provides important information not only on the health status of the plants’ habitats, but also on the ecosystem stability, as variations may indicate long-term changes in the physical conditions at the site.

Macroalgae are an important region-specific parameter. Macroalgal communities often include a wide range of species/functional groups that may change upon eutrophication e.g. highly diverse algal species can be replaced by opportunistic and stress-resistant seaweeds.

For angiosperms, distribution is the most important parameter because changes are not occurring from month to month. It may therefore be sufficient to monitor angiosperms every 6 months (spring/autumn), once a year or even only once every 3 years, depending on the species.

Supplementary variables essential for interpretation of macrophytobenthos results include: substrate type, depth in relation to sea level or standard datum, slope and bearing, presence of loose sediment, degree of wave exposure, tidal range, Secchi disk depth, and salinity.

Benthic invertebrate fauna

The required parameters to be measured are composition and abundance. Important variables to be considered are also diversity of species and presence of sensitive or higher taxa as well as biomass, the latter being indicative of eutrophication phenomena.

Recent studies in taxonomic classification have shown that looping species into higher taxa (including morphological categories) does not necessarily limit the sensitivity of animal assemblages to detect impacts.

It should be noted that sometimes it is difficult to show a clear correlation between possible changes found in the benthos (e.g. long-term changes in zoobenthos species composition) and eutrophication. Biomass may be a better parameter though not mandatory for WFD monitoring. Therefore it is recommended to include biomass as optional monitoring parameter. Furthermore it should be noted that other factors, e. g. fisheries, may have an overriding effect compared with eutrophication effects. A distinction should be made between acute, direct effects on the benthos (e. g. directly related to dredging or oxygen deficiency and/or toxic blooms) and long-term changes. Both may need different sampling frequencies and spatial coverage.

V1.4.2 Hydromorphological Quality Elements

Morphological conditions

The morphological characteristics of coastal areas are generally subjected to low variability due to natural large-scale bottom dynamics processes or changes in tidal regime and weather patterns.

Relevant for ecological status is the time scale of the changes resulting from human impact in the past. A time scale of 10 to 25 years means that relevant changes in hydro morphological conditions have an impact on ecology. In addition sea level rise makes it necessary to adapt the monitoring frequency and spatial scale to analyse the processes and to find the sand budgets in coastal zone, sheltered seas and estuaries.

Monitoring the trends in depth gradients has to take into account water management measures like dredging and dumping activities and naturally induced variability, under particular weather conditions such as storm events and ice winters/ice coverage, as well as natural coastal erosion and elevation of the land e.g. Baltic.

Depth variations

The topography of the area (shape, bathymetry, slope) influences the biological communities living in it. Depth variations could be important elements to be monitored in areas where disturbances are expected, anthropogenic changes will have relevance for the status classification of the water body.

Structure and substrate of the coastal bed

Changes in morphological conditions and/or nature of the substratum may exert severe detrimental effects on benthic organisms. Differences between communities in coastal zones and estuaries are linked to a coastal typology (see link with CIS WG 2.4):

Possible causes of anthropogenic alterations in structure, substrate and shape of the coastal bed are:

- coastal constructions (dredging, dumping, dams, artificial reefs, etc.); and
- variations in riverine sediment inputs (solid transport regime) due to human impact.

For depth variation and structure and substrate of the coastal bed it may be sufficient to collect the required information once (e.g. a map of the coastal bed) and to record:

- at each sampling carried out after first thorough survey: typical parameters (e.g. nature of substratum) and obvious changes (e.g. visible changes after big storm events); and
- changes due to anthropogenic impact (e.g. dam construction).

A thorough survey should be repeated in regular, but longer intervals (e.g. once per management period or longer, depending on parameter).

Structure of the intertidal zone

As for the structure of the intertidal zone, it cannot be used as a quality element in the Mediterranean and the Baltic ecoregions, given the low amplitude of tides in the Mediterranean basin and in the Baltic Sea.

Thus it has been proposed to introduce the intertidal***/mediolittoral*** term as its ecological relevance is due to the fact that it comprises living assemblages that require or tolerate immersion but cannot survive permanent or semi-permanent immersion (same definition for the intertidal). Thus mediolittoral zone supports diverse and very productive assemblages of algae and invertebrates that can be considered analogues to those of intertidal habitats.

Possible causes of anthropogenic alterations in structure, substrate and shape of the intertidal are:

- coastal constructions (dredging, dumping, dams, artificial reefs, etc.);
- chemical inputs (nutrients) leading to a change in the composition of macroalgal communities; and
- variations in coastal or riverine sediment movements (sediment transport regime) due to human impact.

Mediterranean experts' judgements suggest to focus particular attention on the structure and condition of the mediolittoral and upper infralittoral zones in tideless seas, at least in the Mediterranean, since several species and communities thriving in this area are very good biological indicators, as exposed to a wide range of anthropogenic impact due to their critical position at the interface between the sea and the land.

Tidal regime

Tidal regime in terms of direction of dominant currents and level of wave exposure can be seasonally predictable and are available from most of the National Hydrographic Services. Deviations from the natural pattern in tidal regime derive from direct anthropogenic intervention on the profile of the coastline and may have severe bearings on the stability of the biological assemblages, thus they need to be taken into consideration. Asymmetry in the tidal waves results in positive or negative yearly budgets of sediments.

Due to the low tidal range in the Mediterranean and Baltic Seas, tidal currents play a very minor role, if any. It is the case also in part of North Sea e.g. Skagerrak.

Direction of dominant currents

The direction and intensity (speed) of currents represent the main hydromorphological quality elements influencing the biological elements. They could be important elements to be monitored in areas where anthropogenic disturbance could be relevant for the status classification of the water body.

These parameters assume quite a relevant importance in those ecoregions and specific areas where the tidal range being very low poorly influences the coastal processes.

Mainly changes in hydrodynamics induced by morphological changes will result in relevant ecological effects. Temporal changes (storms, anthropogenic activities) could be balanced in the time scale of 5-6 years. On local scales this could not be the case. Monitoring should take into account these short term-effects.

Wave exposure

Wave exposure (wave height, wind, Fetch-index) varies considerably according to coastal typology (from highly exposed to very sheltered) and meteorological conditions, in the different ecoregions. Parameters to be monitored in case of anthropogenic disturbances are e.g. frequencies of storms, directions, high/low tide surge levels.

V1.4.3 Chemical and physico-chemical Quality Elements

In most of the EC countries, all these parameters (with the exception of specific pollutants) are routinely measured as part of their national monitoring programmes, with a variable frequency (weekly to monthly), using national guidelines or OSPAR/HELCOM standards.

Transparency

Transparency is mainly affected by mineral turbidity, organic pollution (e.g. urban discharges) and eutrophication; it can naturally vary due to local hydrodynamics, river discharge and seasonal plankton blooms.

The transparency parameter is necessary for the determination of the depth of the euphotic layer, where primary production exceeds respiration. Measurement is difficult in “troubled waters”, e.g. the NE Atlantic Wadden Sea with high loads of resuspended sediments.

Thermal conditions

Temperature profiles along the water column can be easily obtained by means of *in situ* autographic instruments. The thermal structure of the water column is a relevant information for assessing mixing/stratification conditions, which strongly influence primary production as well as possibly the development of oxygen deficiency.

Oxygenation conditions

Dissolved oxygen concentration is subjected to high natural variability since its solubility depends on temperature and salinity. Deviation, in absolute value, of % saturation from 100% is indicative of intense primary production and/or organic pollution.

Salinity

Salinity in coastal waters can be subjected to high natural variability due to freshwater inputs and mixing of water masses, and due to tidal currents.

Salinity measures in coastal waters can be used to detect freshwater ingressions from the continent; the dilution rate of nearshore waters varies considerably in different areas and can be used, together with other quality elements to indicate potential pollution.

Nutrient conditions

The concentration of nutrients, together with the concentration of chlorophyll ‘a’, indicator of actual production, provide information on the general trophic conditions.

Natural variability of nutrient concentrations can be relevant on a seasonal basis; in coastal waters, high nutrients concentration, mainly related to riverine inputs, are indicative of eutrophication and/or organic pollution.

In order to enable discrimination of pollution sources, the following parameters should be analysed:

- Total Phosphorous (TP, $\mu g\ L^{-1}$)
- Soluble Reactive Orthophosphate (P-PO4, $\mu g\ L^{-1}$)
- Total Nitrogen (TN, $\mu g\ L^{-1}$)
- Nitrate+Nitrite (N-NO3 + N-NO2, $\mu g\ L^{-1}$)
- Ammonia (N-NH4, $\mu g\ L^{-1}$)
- An additional parameter is silicate (Si-SiO3, $\mu g\ L^{-1}$), which is a growth requirement for Diatoms.
- For a better understanding of nutrient cycling in coastal waters, the following supplementary parameters are recommended:
  - Particulate Organic Carbon (POC-C, $\mu g\ L^{-1}$)
  - Particulate Organic Nitrogen (PON-N, $\mu g\ L^{-1}$)
  - Particulate Organic Phosphorous (POP-P, $\mu g\ L^{-1}$)

Nutrient ratios (N/P/Si) are useful for the interpretation of results and eutrophication status.

Existing guidelines and international standards

Quality Element	Object	Guideline / International standard
BIOLOGICAL Q.E.		
Phytoplankton	Sampling procedure; Abundance	OSPAR and HELCOM Conventions: HELCOM COMBINE Manual, Part C., Annex C-6, OSPAR JAMP Eutrophication Monitoring Guidelines: Phytoplankton).
	Abundance ; Composition	Standard in preparation: CEN/TC 230 NO423 "Water quality - Guidance standard for the routine analysis of phytoplankton abundance and composition using inverted microscopy (Utermöhl technique)" - The first working document shall be available in December 2003.
	Chlorophyll a	HELCOM COMBINE Manual (Part C, Annex C-4), OSPAR JAMP Eutrophication Guidelines: Chlorophyll-a. ISO guideline (ISO 10260), only for the spectrophotometric determination of chlorophyll- a.
Macroalgae / Angiosperms	Phytobenthos	HELCOM COMBINE Manual (Part C, Annex C-9) OSPAR JAMP Eutrophication Guidelines: Benthos. ISO standards are being developed (see Annex IV) See also Marine Monitoring Handbook, JNCC (downloadable from http://www.jnvv.gov.uk/marine)
Benthic Invertebrate Fauna		HELCOM COMBINE Manual (Part C, Annexes C-8 and C-9): Guidelines for Macrozoobenthos Monitoring OSPAR JAMP Eutrophication Monitoring Guidelines: Benthos. In preparation: ISO TC 147/SC5 N350: ISO/CD 16665 - 'Water quality - Guidelines for quantitative investigations of marine soft-bottom benthic fauna in the marine environment'. See also Marine Monitoring Handbook, JNCC (downloadable from http://www.jnvv.gov.uk/marine)
MORPHOLOGICAL Q.E.		
		No reference
CHEMICAL AND PHYSICO-CHEMICAL Q.E.		
	Most parameters, incl. nutrients, oxygen	OSPAR JAMP Eutrophication Monitoring Guidelines: Nutrients, Oxygen, HELCOM COMBINE Manual Part B, Annex B-11 and B-14 and Part C, Annex C-2.

For **OSPAR** see: http://www.ospar.org web site, under the sub-heading Measures and sub-heading Agreements

For **HELCOM** see: http://www.helcom.fi/Monas/CombineManual2/CombineHome.ht

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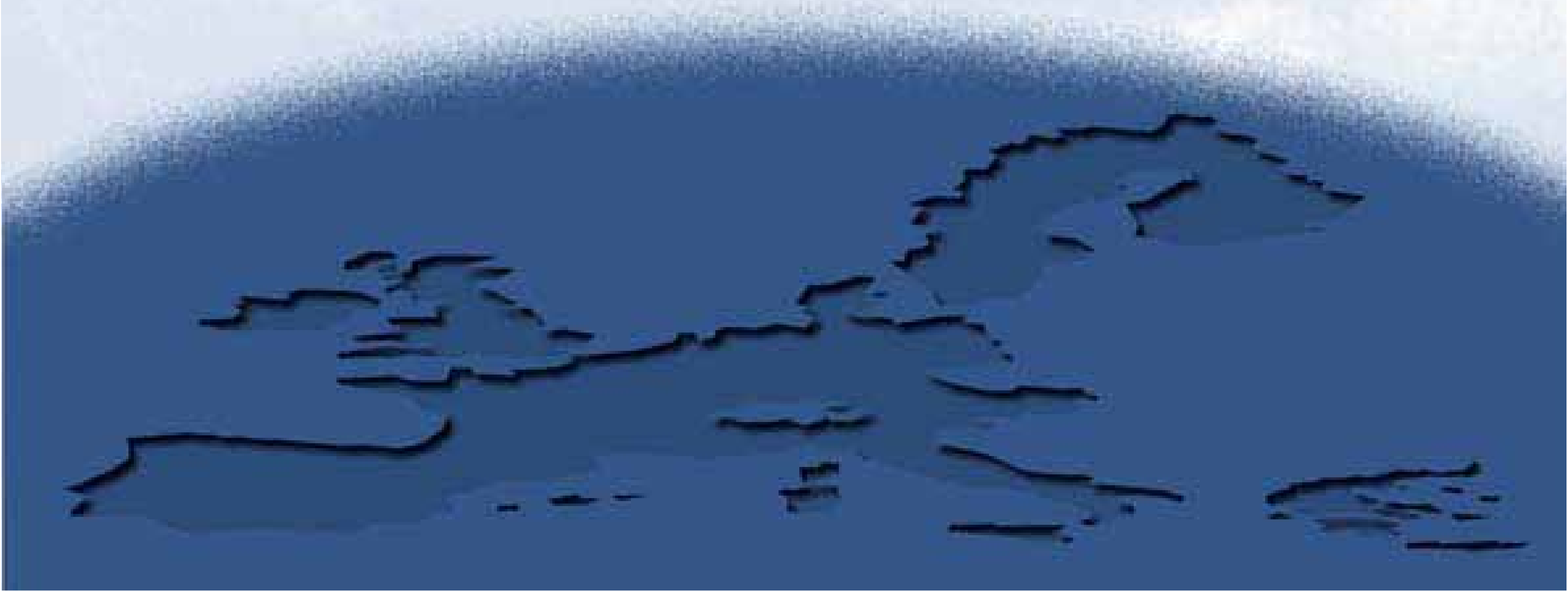
Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 8

Public Participation in relation to the Water Framework Directive



COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 8

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, an informal working group dedicated to the issues of public participation of the Water Framework Directive has been set up in October 2001, under working group 2.9 (on the Best practices in river basin management planning). The Netherlands, Spain and the Commission are responsible for the secretariat and animation of the working group that is composed of experts from governmental and non-governmental organisations.

The present Guidance Document is the outcome of the informal working group on Public Participation. It contains the synthesis of the output of the group activities and discussions that have taken place since October 2001. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the process of guidance development through meetings, workshops or electronic communication media, without binding them in any way to its content.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Danish Presidency in Copenhagen (21/22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leaders, the Netherlands and Spain, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

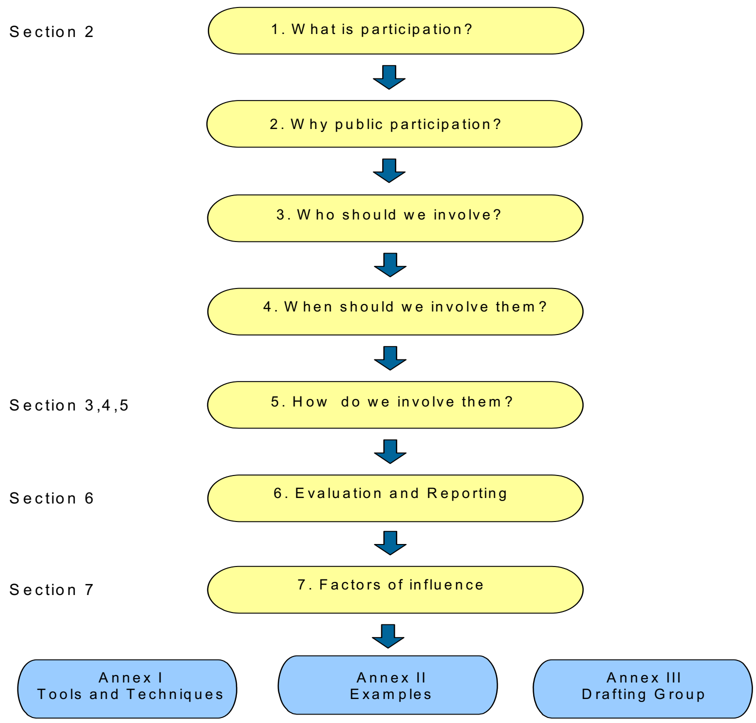
Executive summary

Purpose of this Guidance Document

This Guidance Document aims at assisting competent authorities in the Member States and Accession Countries with the implementation of Article 14 of the Water Framework Directive about Public Participation. This document can also benefit stakeholders and general public by informing them about the public participation process, encouraging them to engage in river basin management planning explaining what can be expected and outlining opportunities. This Guidance is horizontal Guidance since it is of concern to most activities under the Common Implementation Strategy for the Water Framework Directive.

This advisory and non-binding document has been developed by an informal European drafting group of experts and stakeholders under working group 2.9: Best Practices in River Basin Planning in the context of the Common Implementation Strategy for the Water Framework Directive. A list of members of the drafting group and contributing authors can be found in Annex III of this Guidance.

What can you find in this document?



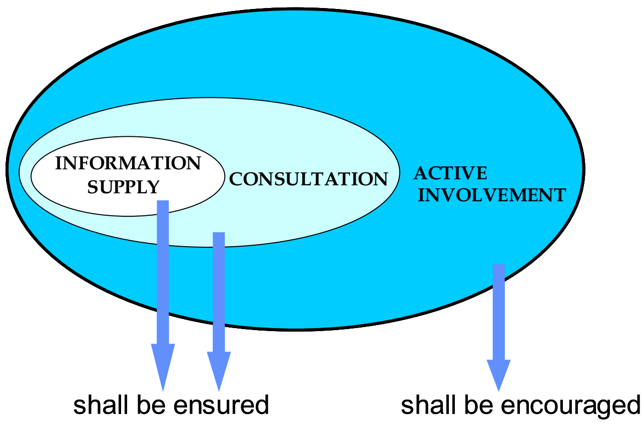
This Guidance starts with creating a *common understanding* regarding the meaning of public participation in the context of the Water Framework Directive (**Section 2**). Public participation can generally be defined as allowing people to influence the outcome of plans and working processes. It is a means of improving decision-making, to create awareness of environmental issues and to help increase acceptance and commitment towards intended plans. Public participation for the implementation of the Directive is recommended at any stage in the planning process, from the Article 5 requirements to the Programme of Measures and the design of the River Basin Management Plan.

After setting out a common understanding of public participation in the context of the Directive, the Guidance gives specific help on how to implement public participation in the different steps of the management process. The general planning steps to be undertaken are indicated in **Section 2.8** and elaborated for public participation in **Sections 3, 4 and 5.**

Although the phrase "public participation" does not appear in the Directive, three forms of public participation with an increasing level of involvement are mentioned:

- Information supply;
- Consultation; and
- Active involvement.

According to the Directive, the first two are to be ensured, the latter should be encouraged. Although the Directive does not require active involvement, this Guidance shows how active involvement can be very useful for reaching the objectives of the Directive. These three forms can be interpreted as being "public participation", although public participation usually covers a wider range of activities than prescribed by the Directive.



Who should we involve? The Directive is prescriptive in the sense that at least stakeholders (i.e. interested parties) should be involved when dealing with active involvement and also the public when dealing with consultation. Background information should be available at any time for anyone. A stakeholder analysis as described in **Annex I** will help to identify the stakeholders "who have something at stake" in the process and could be involved. A stakeholder will generally have an interest in an issue because he/she or it is either affected or may have some influence.

To avoid disappointing the parties involved it is very important to make clear which form of public participation is dealt with and what the role of those involved is. Also it should be borne in mind that Member States are responsible for the public participation process since they are responsible for achieving the objectives of the Directive. A clear signal should be given that *no blue-print exists for public participation* and that the public participation process should be organised and adapted to national, regional and local circumstances. **Annex I** gives examples of *tools and techniques*, which support the process in a practical way. Ingredients for organising a public participation process are given in the main text of this Guidance. **Annex II** gives several *examples* of public participation that are related to different scales and different forms of public participation. Collectively, this information should make it possible to design a tailor-made public participation process at any level in the River Basin District.

With regard to *timing* (**Section 2.6 and 2.8)** public participation should be started early in the river basin planning, today rather than tomorrow in order to establish a good public participation process and allow integration of ideas, comments and input from stakeholders along the way. Moreover, early involvement will most likely prevent the competent authority from ending up with a river basin management plan on which no consensus can be achieved by 2009. The Directive mentions the following deadlines concerning consultation (with a repetitive cycle of 6 years for future river basin management plans):

December 2006 at the latest July 2007	Time table and work programme for the production of the plan, including a statement of the consultation measures to be taken; Comments in writing.
December 2007 at the latest July 2008	Interim overview of the significant water management issues identified in the river basin; Comments in writing.
December 2008 at the latest July 2009	Draft copies of the river basin management plan available; Comments in writing.
December 2009 at the latest	Start implementation of the plan.

The *scale* (**Section 2.7)** at which public participation should take place is not pre-determined. At a local scale the effects of management will be felt more directly and more responses from public and (local) stakeholders can be expected. This input can be aggregated to a higher level to take advantage of local knowledge at river basin or river basin district level. Sometimes the focus should be on a wider area than the one where public participation is undertaken, for example when dealing with measures.

In **Section 3** the significance and practical approach of *active involvement* is elaborated in relation to steps in the planning of the implementation of the Directive. Early active involvement for the identification of the River Basin will raise awareness while involvement in characterisation of the River Basin District will also help to collect data, information and experiences from stakeholders and to identify conflicts or establish common understanding. For the Programme of Measures active involvement is particularly important since it will most likely improve the effectiveness of the implementation and contribute to delivery in the long term.

Section 4 addresses the *3-step consultation* that is foreseen in the Directive (see also table above), trying to indicate practical issues that need to be dealt with when organising a consultation process, either a written or oral consultation process. One of the messages here is the need for clarity about who is being consulted and about what issues and the need for concise information or documents, which will be subject to consultation. Examples of tools for supporting the consultation process can be found in Annex I. Processing comments received and using this input for improvement of the River Basin Management Plan requires a good management plan. Finally it is very important to give feedback to participants.

Access to information and background documents should be secured by the competent authorities. **Section 5** addresses questions like what kind of information should be available, in what way and who will be the one maintaining and disseminating this information. As a minimum the background documents should include all the documents that are summarised in the River Basin Management Plan. Usually on-line information like Internet or e-mail and off-line information like meetings are combined to inform stakeholders and public. One suggestion is to create one central information or knowledge centre in a river basin responsible for information management and dissemination.

During the whole process of public participation *iterative reporting and evaluation* are important tools to make the process transparent for participants. Therefore evaluation should be integrated with the public participation process. In **Section 6** indicators are mentioned that will help reporting and evaluation.

Finally the competent authority (who will often be the manager of the process) should be aware of the fact that any form of public participation requires *capacity building and investment* in order to build relations and understanding between different stakeholders. These and other factors which will help enable a learning approach to public participation are explored in **Section 7**.

A well-managed public participation process is not free of costs and demands time and energy, but it will pay off in the end. Public participation is not an end in itself but a tool to achieve the environmental objectives of the Water Framework Directive. Trust, transparency of process and good management of expectations will help to achieve good participation.

Now just do it!

Table of Contents

Introduction - A Guidance Document: What For?

Look out! What you will <u>not</u> find in this Guidance Document!

The Guidance Document will not provide you with a manual how to exactly perform public participation in your country. Political, organisational and cultural contexts vary a lot from one Member State or Accession country to another and will influence methodologies for public participation. Therefore one blueprint for all States is not possible.

This document focuses on the implementation of public participation in the broader context of the development of integrated river basin management plans as required by the Water Framework Directive.

Public participation is a subject that concerns different steps and phases in the implementation of the Directive and applies to most activities under the Common Implementation Strategy. This Guidance is therefore a *horizontal* Guidance.

To whom is this Guidance Document addressed?

Member States and Accession countries

To create a common understanding and provide guidelines and examples of how to make public participation operational in order to improve the decision making process when implementing the Directive in general, and when developing river basin management plans.

Competent authorities of river basin districts

To support and provide guidance in practice on how, when and at which level to involve the public, water users and stakeholders in order to increase transparency and participation in developing river basin management plans.

Look out! Target group of the document.
This document aims at guiding **the competent authorities in the Member States and Accession countries** in the implementation of Article 14 of the Water Framework Directive.

Stakeholders

To provide a resource in order to support successful participation in water management and successful input into river basin management plans.

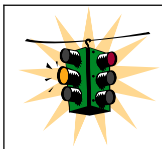
Look out! It also benefits stakeholders and the public! The document:

- explains why stakeholders should engage in river basin management planning and what can be expected by them and the general public: to voice opinions and concerns about future decisions, to ensure that relevant locally-held knowledge finds its way to the right decision platform;
- outlines practical opportunities and approaches for engaging at different levels and at different stages of planning; and
- clarifies, that this is a new process and a new form of partnership, which requires patience and mutual trust.

What can you find in this document?

The document:

- Aims at creating a common understanding with regard to public participation in the Directive and its benefits in order to increase transparency and participation in developing river basin management plans;
- Provides guidelines by explaining the requirements of the Directive with regard to the implementation steps and stages of river basin management planning and by analysing the possibilities the Directive offers; and
- Provides tools, examples and experiences of how to make public participation operational.



Look out! The methodology from this EU Guidance Document must be adapted to national, regional and/or local circumstances.
This is an EU Guidance Document on public participation. It aims to provide general principles and will need to be tailored according to political, organisational, cultural and physical contexts in each Member State and Accession country.

Some Member States have already decided to "translate" this Guidance Document into a national Guidance paper on public participation in the context of the Water Framework Directive.

… And Where?

The role of public participation in the Water Framework Directive

Section 2 *– What is public participation? Which role for public participation in the Directive? Why bother doing public participation? Annex I: Public participation techniques.*

Public participation in the planning steps

Section 2 *– Public participation in the planning steps. Ensuring coherency with the overall implementation process.*

How do we involve them? Tools and techniques for public participation

Section 3 - active involvement of all interested parties. Section 4 – consultation. Section 5 - access to information and background documents. What do you need to do? And what do you need to do by 2004? ***Annex II*** *– Examples of public participation in water management projects.* ***Annex III*** *– Lists and contacts of the Public Participation group*

Reporting the results of public participation

Section 6 *– How to report on and evaluate the processes of public participation in River Basin Management? Section 7 – Developing a learning approach to public participation.*

Section 1 – Implementing the Directive: Setting the Scene

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

December 2000: A Milestone for Water Policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the Water Framework Directive.

The Water Framework Directive: new challenges in EU water policy

What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

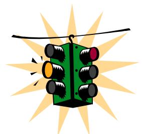
- Prevents further deterioration of, protect and enhance the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

... and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (Article 2 (22), *Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*); and
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).



Look out!
Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

Changing the management process – information, consultation and participation
Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Wetlands
Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and

restore the status of water. Relevant definitions are developed in CIS horizontal Guidance Documents water bodies (WFD CIS Guidance Document No. 2) and further considered in Guidance on wetlands (currently under preparation).

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal Guidance paper on wetlands.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fish water Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;

- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters; and
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

WHAT IS BEING DONE TO SUPPORT IMPLEMENTATION?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

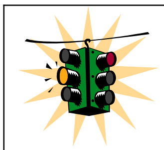
The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance (see *Annex I*). A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision body for the Common Implementation Strategy.

The 2.9 Working Group and drafting group on public participation

A drafting group has been created under working group 2.9 Best Practices in River Basin Planning for dealing specifically with public participation. The main short-term objective of this drafting group was the development of a non-legally binding and practical guidance for supporting the integration of public participation in the implementation of the Water Framework Directive. The members of the drafting group are policy makers, technical experts and stakeholders from European Union Member States and international NGO's (unfortunately no candidate countries to the European Union were involved).

To ensure an adequate input and feedback during the Guidance development phase from a wider audience, and to evaluate earlier versions of the Guidance Document, national consultation rounds have been organised by several Member States. The drafting group has organised an international workshop.



Look out! You can contact the experts involved in the public participation activities
The list of the members of the drafting group with full contact details can be found in Annex III If you need input into your own activities, contact a member from the group in your country. If you want more information on specific examples of public participation in water management projects, you can also contact directly the persons in charge of carrying out these studies.

Developing the Guidance Document: an interactive process

Within a very short time period, a number of experts and stakeholders have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- Three workshops of the experts and stakeholder members of the drafting group;
- Some Member States organised national consultation rounds to collect comments on the draft Guidance version 1.1 (270802);
- Organisation of an international workshop to present and discuss the activities and output of the drafting group with not previously involved experts and stakeholders. To discuss the comments of the national consultation rounds (October 2002 – Amsterdam, the Netherlands);
- Interactions with experts from other working groups of the Common Implementation Strategy, via the members of the drafting group on a national basis.

Annex III provides the names of the members of this drafting group and of other contributors, and a list of activities of the Drafting Group.

Follow up activities

The activities of the working group dedicated to public participation will not stop with the endorsement of this Guidance by the Water Directors in Copenhagen (November 2002). The coming about of this Guidance allowed setting up a whole network of experts from several Member States. This network will still continue to follow the implementation of the Guidance and contribute to integrating public participation in the decision making process. Thus, several future activities are been already identified as follows, but other developments could appear in later stages.

From the beginning of 2003 to 2005, the Guidance Documents produced by the different working groups under the Common Implementation Strategy will be tested in a range of pilot river basins through the European Community, to assess the practicability of all the Guidance Documents and the coherence between them. The issues related to 2004 steps will be tested first (2003-2004), the issues related to later steps being tested afterwards. The so-called « horizontal Guidances », will be tested in all the pilot river basins in the first phase. This Guidance on public participation is likely to be tested as such. To help the pilot river basins to test the Guidance on public participation, a specific and more practical format will be elaborated. This format-document will provide a pragmatic approach to the issues that the pilot river basins have to take care of with respect to public participation; it will be prepared for the end of 2002 in co-operation with the working group on Pilot River Basin Testing.

It has to be underlined that the testing exercise will involve a range of stakeholders (and also the general public in certain cases) in the pilot river basins. It will provide the basis for a concrete testing of tools proposed in Annex I and for readjustment of these if necessary.

Section 2 – Introduction to Public Participation in River Basin Management

2.1 The Public Participation provisions of the Directive

Public participation plays a key role in the Water Framework Directive. This Section discusses the different provisions of the Directive. The box below gives the relevant text from the Directive Of these texts Article 14 plays a leading role.

Preamble 14

(14) *The success of this Directive relies on close cooperation and coherent action at Community, Member State and local level as well as on information, consultation and involvement of the public, including users.*

Preamble 46

(46) *To ensure the participation of the general public including users of water in the establishment and updating of river basin management plans, it is necessary to provide proper information of planned measures and to report on progress with their implementation with a view to the involvement of the general public before final decisions on the necessary measures are adopted.*

Article 14

Public information and consultation

1. *Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users:*

(a) *a timetable and work programme for the production of the plan, including a statement of the consultation measures to be taken, at least three years before the beginning of the period to which the plan refers;*

(b) *an interim overview of the significant water management issues identified in the river basin, at least two years before the beginning of the period to which the plan refers;*

(c) *draft copies of the river basin management plan, at least one year before the beginning of the period to which the plan refers.*

On request, access shall be given to background documents and information used for the development of the draft river basin management plan.

2. *Member States shall allow at least six months to comment in writing on those documents in order to allow active involvement and consultation.*

3. *Paragraphs 1 and 2 shall apply equally to updated river basin management plans.*

(this box continues to the next page)

Annex VII
RIVER BASIN MANAGEMENT PLANS

A. *River basin management plans shall cover the following elements:*

…

9. *a summary of the public information and consultation measures taken, their results and the changes to the plan made as a consequence;*

11. *the contact points and procedures for obtaining the background documentation and information referred to in Article 14(1), and in particular details of the control measures adopted in accordance with Article 11(3)(g) and 11(3)(i) and of the actual monitoring data gathered in accordance with Article 8 and Annex V.*

Look out! Public Participation in relation to the Directive

As indicated by the title, this Guidance elaborates public participation in relation to the Directive and with the corresponding prescriptions. Public participation in general is however a process of which no blueprint exists and which needs to be designed according to the needs with the available means and tools. For the benefit of the results it can be wise to look further than minimum requirements.

Preamble 14 highlights the fact that public participation will contribute to the overall success of the Directive. Preamble 46 emphasises the importance of informing the general public well in order to ensure or rather facilitate their participation in the planning process. According to Annex VII, the river basin management plan should tell where and how background information can be obtained. This plan should moreover summarise the public participation measures taken and should evaluate their results and the impact on the plan.

The key public participation provision of the Directive is article 14. This article prescribes three main forms of public participation:

- Active Involvement in all aspects of the implementation of the Directive, especially – but not limited to – the planning process;
- Consultation in three steps of the planning process;
- Access to background information.

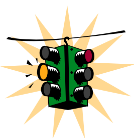
The Member States have to *encourage* active involvement and *ensure* consultation and access to background information.

It may be clear from for instance preamble 14 that active involvement is not the same as consultation. Consultation means that the public can react to plans and proposals developed by the authorities. Active involvement, however, means that stakeholders actively participate in the planning process by discussing issues and contributing to their solution. Essential to active involvement is the potential for participants to influence the process. It does not necessarily imply that they also become responsible for water management.

Look out! The Directive requires more than consultation

In addition active involvement in all aspects of the implementation of the Directive has to be encouraged. Moreover, access has to be given to background information.

Beside the Directive there are other requirements on public participation in other EU legislation, especially in the Directive on Strategic Environmental Impact Assessment (Directive 2001/42/EC). The relationship of the Directive to the SEIA Directive is quite complex and has to be clarified with regard to the programme of measures and the River Basin Management Plan.



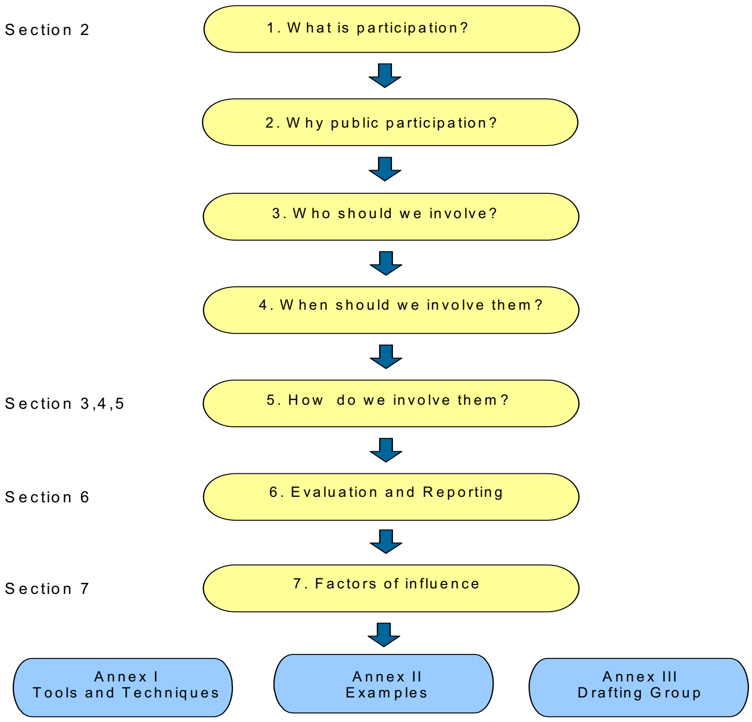
Look out! Public Participation is not only required for the river basin management plan

The programme of measures and individual measures are probably even more important.

The Box below gives an overview (glossary) of the main terms used in the Water Framework Directive and in this Guidance. The different forms of public participation will be discussed in more detail in Section 2.2, and the different types of public in Section 2.4.

Public participation
Allowing the public to influence the outcome of plans and working processes. Used in this Guidance as a container concept covering all forms of participation in decision-making. The Water Framework Directive does not use the term.
Public (or "**general public**")
"One or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organisations or groups" (SEIA Directive (2001/42/EC), Aarhus convention art. 2(4))
Interested party (or "**stakeholder**")
Any person, group or organisation with an interest or "stake" in an issue, either because they will be directly affected or because they may have some influence on its outcome. "Interested party" also includes members of the public who are not yet aware that they will be affected (in practice most individual citizens and many small NGOs and companies).
NGO
Non-governmental organisation
Broad public
Members of the public with only a limited interest in the issue concerned and limited influence on its outcome. Collectively, their interest and influence may be significant.
Consultation
Lowest level of public participation if we consider information supply as being the foundation. The government makes documents available for written comments, organises a public hearing or actively seeks the comments and opinions of the public through for instance surveys and interviews. "Consultation" in art. 14 of the Directive refers to written consultations only. Preamble 14 and 46 and Annex VII refer to consultation in general.
Active involvement
A higher level of participation than consultation. Active involvement implies that stakeholders are invited to contribute actively to the planning process by discussing issues and contributing to their solution.
RBMP
River basin management plan, required by Article 13 of the Directive.

Before discussing active involvement, consultation and information supply in the planning process, guidance will be given on some key participation questions, which all those involved in organising participation, need to consider:

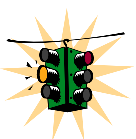


What, Why, Who, When, How questions, addressed in Sections 2-5

2.2 What is public participation?

Public participation can generally be defined as allowing people to influence the outcome of plans and working processes. However, there are different levels of influence.

The foundation for any form of public participation is **information supply** to the public. Strictly speaking, the Directive only requires access to background information and no active dissemination of information. The latter is, however, essential to make the prescribed consultation and active involvement work, as is also mentioned in preamble 46.



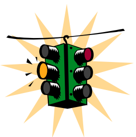
Look out! Public Participation covers a wider range of activities than prescribed by the Directive.

The Directive requires active involvement, consultation and access to information. More may be useful to reach the objective of the Directive (preamble 14).

The first level of real participation is **consultation**. Administrative bodies consult people and interested parties (stakeholders) to learn from their knowledge, perceptions, experiences and ideas. Consultation is used to gather information or opinions from those involved to develop solutions based on this knowledge. Reports, scenarios or plans are presented and people are asked to comment. The process does not concede any share in decision-making, and professionals are under no formal obligation to take on board people's views.

In this Guidance two types of consultation are distinguished: written consultation and oral consultation. Written consultation is the minimum requirement as stated in Article 14(1) i.e. "to publish and make available for comments to the public, including users". Oral consultation is more active and stakeholders have possibilities to have a dialogue or discussion with the competent authorities.

A higher level of participation is **participation in the development and implementation of plans**. Interested parties participate actively in the planning process by discussing issues and contributing to their solution. Still higher levels of participation are **shared decision-making** and **self-determination.** Shared decision-making implies that interested parties not only participate actively in the planning process, but also become partly responsible for the outcome. E.g. water use sectors could be represented in river basin organisations. Self-determination implies that (parts of) water management are handed over to the interested parties, e.g. by establishing water users' associations. Encouraging the first should be considered the core requirement for **active involvement**, the latter two forms are not specifically required by the Directive but may often be considered as best practice.



Look out! Management of Expectations

In order to avoid disappointment, it is very important to make clear towards the public which form of public participation they are dealing with and which role they play. During and after the process feedback should be given to the stakeholders and public.

The different levels of participation are not mutually exclusive. They build on each other: consultation implies information supply and active involvement implies consultation. Moreover, different levels can be useful at different stages. The choice of level depends on aspects like: the timing of public participation and the stage of the planning process, the (political and historical) context for public participation, available resources, objectives or benefits of public participation and the stakeholders identified to be involved.

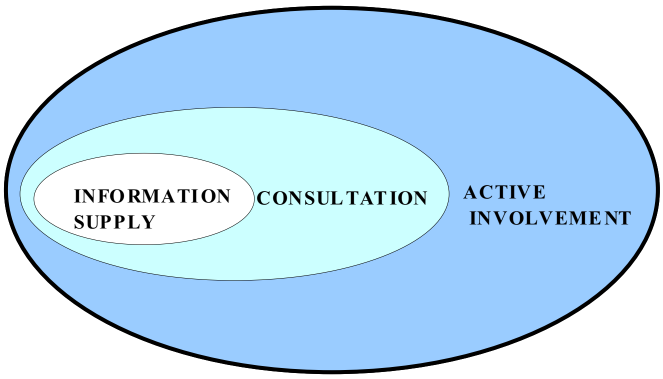


Illustration
Public participation can start with a stakeholder analysis using interviews with selected persons, be followed by public debate where the population is consulted on the identification of significant water management issues, be followed by a consultation of water users representatives (professionals, associations). More examples will be provided in Section 3 and 4.

Look out! Public participation is not necessarily about:
Everybody joining: be selective with actors, do a stakeholder analysis;
Everybody deciding: make clear what everybody's responsibilities are;
Losing control: participation cannot work if the outcome is completely predetermined, yet organise it well;
Achieving consensus at all expense: make clear that it will be impossible to satisfy all wishes hundred percent. Participation will help to explain decisions as they occur and promote ownership of the outcome arrived at.

2.3 Why public participation?

Initially of course to comply with the Directive and to achieve environmental goals and other benefits. Besides these requirements of the Directive it is good to emphasise the fundamental rationale for undertaking public participation, which is to ensure the effective implementation and achievement of the environmental objectives of water management (good status in 2015).

Look out! Public participation is a means to improve decision-making

Public participation is not an objective in itself. Public participation helps to define the rationale, framework, outcomes and validity of decision-making processes.

The main purpose of public participation is to improve decision-making, by ensuring that decisions are soundly based on shared knowledges, experiences and scientific evidence, that decisions are influenced by the views and experience of those affected by them, that innovative and creative options are considered and that new arrangements are workable, and acceptable to the public.

Key potential benefits that can result from public participation are (which are not mutually exclusive):

- Increasing public awareness of environmental issues as well as the environmental situation in the related river basin district and local catchment;
- Making use of knowledge, experience and initiatives of the different stakeholders and thus improving the quality of plans, measures and river basin management;
- Public acceptance, commitment and support with regard to decision taking processes;
- More transparent and more creative decision making;
- Less litigation, misunderstandings, fewer delays and more effective implementation;
- Social learning and experience–if participation results in constructive dialogue with all relevant parties involved then the various publics, government and experts can learn from each other's "water awareness".

Through participation, long term, widely acceptable solutions for river basin planning can be arrived at. This can avoid potential conflicts, problems of management and costs in the long term.

Wise Use of Floodplains project, EU Life Environment (see Annex II)
The WUF Project took place in Somerset, South West England, where it facilitated a creative and positive dialogue on the future management of flood events in the catchment of River Parrett. The aim was to encourage the wise use of water resources in river catchments to benefit people, their livelihoods and their environment. All stakeholders with an interest in the management of water resources in the Parret Catchment were welcomed.
In this project participation has resulted in the following benefits [1]:

- Helped identify long-term sustainable solutions for people, their livelihoods and environment;
- Built up ownership and trust;
- Was an investment as it involved early identification of issues and consensus-building;
- Raised awareness of catchment management issues; and
- Provided a means of accessing local knowledge and expertise.

2.4 Who should we involve?

The Directive uses different terms to refer to the public. With respect to consultation and access to background information simply the term **public** is used. This term is not defined in the Directive, but art. 2(d) of the SEIA Directive (2001/42/EC) gives a definition, which is also applicable to the Directive: "*One or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organisations or groups*". Article 2(4) of the Aarhus convention contains the same definition. In preamble 14 and 46 the Directive also uses the phrases "public, including users" and "general public" respectively without any difference in meaning.

Concerning active involvement the term **interested party** is used. Interested party can be interpreted as meaning any person, group or organisation with an interest or "stake" in an issue either because they will be affected or may have some influence on its outcome. This also includes members of the public who are not yet aware that they will be affected (in practice most individual citizens and many small NGOs and companies). This Guidance will use the term **stakeholder** as synonymous with "interested party".

For practical reasons it is impossible to actively involve all potential stakeholders on all issues. A selection will have to be made. This selection can be based on the following factors:

- The relation of the stakeholder to the water management issues concerned;
- The scale and context at which they usually act, who they represent;
- Their involvement, being governor; user/victim/stakeholder; expert and executer of measures;
- Their capacity for engagement; and
- The political, social, "environmental" context.

Different stakeholders can make different contributions. Some stakeholders can contribute primarily by means of their ideas and the information they possess. Others may have more direct interests such as land or property that may be directly affected. In many cases organisations can represent the individual stakeholders. For every phase of the project the role of the different stakeholders should be reviewed. Some will be more affected by others, represent a larger party, be more active, or have more (financial) resources or knowledge.

Some stakeholders may be more difficult to handle than others, but that shall not influence their identification as stakeholders.

Annex I presents a technique for selecting the relevant stakeholders with a so-called **stakeholder analysis**. This will enable you to prioritise which stakeholders are vital to an issue in a specific phase of the project. Note that in order to ensure transparency and trust, it is important to be able to justify why the final set of stakeholders has been prioritised.

The box below illustrates a typology of possible stakeholders involved in water management. It makes no assumptions about their relative importance.

A typology of possible stakeholders:
Professionals – public and private sector organisations, professional voluntary groups and professional NGOs (social, economic and environmental). This also includes statutory agencies, conservation groups, business, industry, insurance groups and academia.
Authorities, elected people - government departments, statutory agencies, municipalities, local authorities
Local Groups- non-professional organised entities operating at a local level. It usefully breaks down into:
Communities centred on place – attachment centred on place, which includes groups like residents associations and local councils.
Communities centred on interest – e.g. farmers' groups, fishermen, birdwatchers.
Individual citizens, farmers and companies representing themselves. Key individual landowners for example or local individual residents.

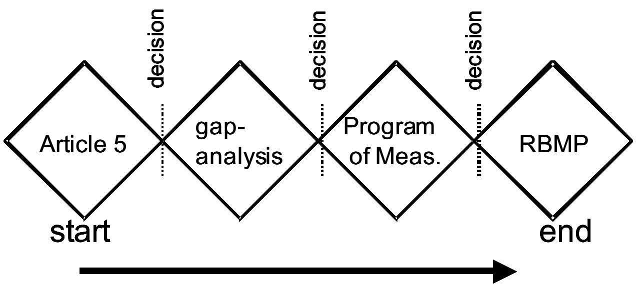
An illustration of governing bodies in Spanish River Basin districts

According the Spanish Water Act and the Regulation on Water Public Administration and Planning (Royal Decree 927/1988), different decision bodies are "governing and managing the river basin districts".
The *Government Board* proposes the plan of activities of the institution, its annual budget and, in general, it is in charge of every matter regarding the direction of the river basin district. At least one third of its members must be representatives of the water users. Representatives of the regional and central administrations form the other two thirds.
The Law also establishes the so called "decision bodies on participation regime" as the *Management Boards.*
The *Management Boards* have to coordinate the management of the different water structures in the sub basins usually defined as "management systems". Actually, they coordinate the water sharing in the basin solving conflicts between users. Members of the Management Boards are users with water rights described in the so called "Waters Register" and include representatives for every town, municipality or company in charge of water supply utilities, representatives of irrigation communities, industrial users and hydropower companies. The totality of the Management Boards according the law is grouped in the so-called "Users assembly". (this example is not presented in Annex II)

2.5 When should we involve them?

This question is divisible into two issues, firstly the matter of timing with regard to the process, secondly the actual necessity to embark on public participation, i.e. is the effort to organise the participation proportionate to the results?

Firstly **timing**. It is important to clearly define the stages of the process and every stage requires a review of the "why" and "who" question. The role and involvement of the stakeholder can differ from stage to stage. When to involve the stakeholders in the process depends on a number of factors. The objective of the project, the history and political setting, but also scale and the kind of stakeholders influence the timing of public participation. Also the stakeholder-analysis (see Annex I) will help to make this more transparent.



Model of a planning process

One may say that the stakeholders should be involved as early as possible, before decisions are taken. Only then the authorities are able to benefit optimally from their insight, experience and knowledge and allow maximum involvement, influence and ultimate acceptance of eventual decisions. It is never *too* early. When involving stakeholders at a very early stage in the process it should be made perfectly clear to the stakeholder what his role is and how his contribution will be handled. Otherwise do not involve them. For example when organising public participation during a reconnaissance study (to identify the sense of urgency of problems and to decide to invest in it or not), you must communicate in advance that the result of this study can be that the foreseen project will not be carried out. The fact is that people will spend energy and time on discussing issues, while the politicians may still decide not to invest in it.

Thus, the degree of participation of stakeholders in the early phases may be different from those in the later phases. Ultimately, timing of public participation has to be assessed on a case-by-case basis. It should be explained to participants how their involvement will be used to avoid false expectations (management of expectations!).

Secondly the **concept of proportionality** with regard to participation. When is the energy (human resources, money) that is put into the process proportionate to the outcome? There is a need to balance costs in terms of time and money and potential benefits. This is relevant for both the organiser of the process and the participants. This will have to be evaluated on a case-by-case basis depending on the form of participation you intend to use and circumstantial factors. Expert judgement and common sense will be your tools to perform a kind of risk analysis for proportionality.

Some questions that might help to consider the proportionality of your specific process are given below:

- In which stage of the process do you want to apply public participation?

- What is the specific problem in this stage and what are the expected activities (refinement of problem definition)?
- Is the outcome of this stage still flexible and open-minded or determined and fixed?
- At what scale do you plan to work?
- What form of participation are you planning to use?
- Which stakeholders are to be involved?
- What are your boundary conditions regarding:
  a) human resources;
  b) finances; and
  c) time.
- What is the political context like with regard to your process (pro/contra/neutral)?
- What is the actual acceptance level towards public participation processes?
- Who will decide in the end?
- Who will be involved from your own organisation in what way?
- Are there ongoing process/research of the same nature?
- How are you going to communicate? (See also Annex I on communication tools)
- What results are to be expected? Is it likely that involvement of stakeholders can positively influence the results?
- What do you want to achieve with public participation?
  - ownership of problem by third parties;
  - commitment of other parties;
  - innovative solutions;
  - acceptance of measures to be taken;
  - raising awareness.

Public and stakeholders should be aware that participation in the planning process will cost both time and money, like administrative cost for the NGO´s, stakeholders and the use of consultants etc.

Illustration from running spatial planning in Sweden
Consultation with the public on overall plans and detailed plans is compulsory in Sweden. Consultation and information are important procedures to realise the plans and to prevent appeal against the plans. Example from one of the municipalities in Sweden shows that up to 25% of the costs and time to produce such a plan, mentioned above, fall on consultation and information just to prevent appeal against the plan and to “get everybody on the train”. This may seem expensive, but appeal against the plans may delay the realisation of the plans to high costs of those involved both authorities and the publics.
In Sweden, no formal costs of the participation process fall on the users – except the time they use for the process.

2.6 The scope and timing of public participation

Note that the Directive tells us that Member States *shall encourage* active involvement and *shall ensure* consultation. In the first case Member States have to make a clear effort to promote and facilitate active involvement, in the second case consultation is an obligation, which has to be performed.

Furthermore the Directive gives no clear boundaries when it comes to the extent of these forms of public participation. This Guidance elaborates the range of possibilities between **minimum requirements** and **best practices** for each topic. It is up to the competent authority, which will – as a representative of the Member State – commission the public participation process, to decide which possibilities will be used in the public participation process. This choice is dependent of several factors such as the available financial means, the scale of the project, the cultural context, the effect on the environment and not in the least the political context. At the same time it should be emphasised that a competent authority should not fear a 'wider' form of public participation: the benefits with regard to improved decision making and the acceptance by the public of (unpopular) measures to be taken can be considerable. Moreover for compliance with the Directive the competent authority is dependent on the willingness of the public to participate in the (consultation) process.

Look out! The Member State is responsible

It should be borne in mind that the member state– and in practice most likely the appointed competent authority – is the final responsible body for achieving the objectives of the Directive. For the public participation process it means that only the member state (competent authority) can decide if it will stay in charge of final decisions or share its responsibility with stakeholders. Of course all without prejudice to the obligations of the Directive.

Article 14(1) 1st sentence deals with the encouragement of *active involvement of all interested parties* in the whole implementation process of the Directive. The success of this involvement will certainly not be met solely via the 3-phased information and consultation procedure pursuant to Article 14(1) 2nd sentence of the Directive ((a) timetable and work programme, (b) interim overview, (c) draft copies). The river basin management plan is to a large extent a summary and justification of all the choices and involvement of the public that has taken place earlier. Starting public participation only in 2006 will not work if the public has not been involved in making these choices. To ensure transparency and acceptance public participation has to start as soon as possible. Besides, the 3-phased procedure of 14(1)(a, b, c) will be successful only if the previous steps of information supply, awareness raising and consultation have been performed before.

Look out! Timing

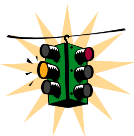
Start public participation as soon as possible and do not wait until 2006.

The timetable for public participation and the steps of the planning process receive attention in Section 2.8. How the three forms of public participation can be applied with regard to the steps of the **planning process** will be further explained in the coming Sections 3, 4 and 5. Firstly the scale issue in relation to public participation will be addressed in this Section.

2.7 The scale issue

The implementation of the Directive will require activities at many different scales: river basin district, river basin, sub basin, water body, national level, national part of an international river basin district, regional and local government level, etc. An important issue is at which scale public participation should be organised.

It follows from article 14 of the Directive that active involvement should be encouraged at all scales where activities take place to implement the Directive. Not only the area where the activities will be implemented should be considered, but the whole area where their impact may be felt. Consultation is required in the planning process for the river basin management plan and therefore at the scale of the river basin district or the national parts of an international river basin district.



Look out! Do not forget the impacted area and people!

When organising public participation on a specific issue, do not focus exclusively on the area where measures may be taken. Consider the whole area that may be impacted.

A public participation requirement at a specific scale does not mean that public participation should actually be organised at that scale. There are good reasons for organising public participation at lower scales. At the local scale the effects of management will be felt most directly and more responses from especially local stakeholders can be expected if public participation is organised at this scale. If for instance in a river basin district just one meeting is held, issues can only be discusses at a general level only and participants would have to travel large distances. Instead, several regional or local public participation meetings could be held, organised either by the competent authority for the whole district or by regional water managers. Of course, the staff requirements and costs would need to be considered.

A possible approach for the scale issue in public participation consists of five steps:

1. Determine which issues should be addressed at which level.

   The competent authorities in each river basin district should, together with the main stakeholders, define and analyse the main issues and their geographical scale. In large international river basin districts international co-ordination will be needed. If it is agreed that an issue should be addressed at for instance the regional level, a similar exercise could be held at the regional level to determine which aspects of the pertinent issue can be addressed at the local level. On top of the geographical scale of the issue, the existing institutional structure needs to be taken into account too, in particular the allocation of tasks and competences;

2. Determine what types of publics can make what types of contribution and what type of public participation is most appropriate for the publics and possible contributions concerned.

   As discussed, different publics may make different contributions in different phases;

3. Organise public participation as close to the public concerned as possible, given budgetary and staffing constraints;

4. Communicate the (first) results as soon as possible across different scales and between relevant units at the same scale.

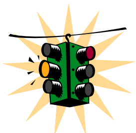
   Much local information and many local concerns and solutions will need to be incorporated, in an aggregated form, in the river basin management plan for the river basin district ("scaling up"). Issues that play at a higher scale should be communicated to and discussed with the local level ("scaling down"). Local information, concerns and solutions may also need to be communicated to upstream and downstream areas and to neighbouring areas outside of the basin (horizontal communication); and

5. Report on follow-up not only in the river basin management plan, but also at the level where public participation was organised.

   In the river basin management plan many details that are of concern for the regional or local level may be lost. The input of the participants needs to be recognised.

In this approach the initiative comes from the competent authority at the district scale. In addition, public participation initiatives can be taken at lower scales and then be "scaled up." River basin management can benefit if there remains room for experimentation.

In principle any level of public participation can be organised at any scale, even at the international river basin district scale. Nowadays many stakeholders are represented by larger international organisations, which is an advantage for the public participation process at large scales. The main issue is to find for each Directive issue the right combination of scale, stakeholders, public participation levels and methods. Stakeholder analysis (Annex I) can be very helpful for this.



Look out! Stakeholder Analysis (see Annex I)

Stakeholder analysis will help you to prepare for public participation at any scale.

The four boxes below give examples of public participation at the local scale and at the national and international river basin district scale. The first example shows, first, that public participation can be organised at the local level while still keeping the process manageable, and secondly, that it is possible to involve the broad public actively. The second, third and fourth example show that also at the national and the international river basin district level active involvement is possible. Annex II gives many more examples of all types of public participation at all scales (see especially the matrix).

Active Involvement of the broad public at the local scale

The Fens Floodplain Project – East of England (Wise Use of Floodplains Project) (see Annex II)

In the Fenlands in Eastern England the Wise Use of Floodplains project, as well as talking to stakeholders and organisations at a strategic level across the floodplain, wanted to talk to local people. In view of budget constraints, the views of communities in two representative villages within the 4,000-km^2 river basin were sampled. A range of local people was involved from school students to adults and retired people. They were invited to make any proposal they wished about making the floodplain more sustainable. A method called "planning for floodplains" was developed. This involved local people putting symbols onto a map based model to indicate the floodplain restoration projects they wanted. 200 different proposals were made in each village (2% of the population). Results of local community involvement were then compared with the views of other stakeholders obtained through other participation techniques (e.g. river basin level workshops, seminars) to assess how well the public proposals matched those of key organisations. The results supported proposals for floodplain restoration from an existing catchment wide project called "Wet Fens for the Future".
The local involvement showed that even just sampling participation in 2 villages in the sub-region can produce useful data to confirm existing proposals or to assess whether it is worth investing in a larger scale participation process.

Active involvement and consultation of stakeholders at the national river basin districts scale

The SDAGE projects, France (see Annex II)

For each of the 10 French large river basins, a management plan has been produced according to the 1992 French Water Act, called SDAGE. In a modified form they will become the river basin management plan according to the Directive. The so-called Basin Committee is responsible for their initial elaboration. This Committee is composed of the representatives of all stakeholders and users in the River Basin District (about 100 members):

- 1/3 local elected officials (i.e. mayors, local communities);
- 1/3 users, consumers, NGOs;
- 1/3 representatives of the State.

The Basin Committee defines the management plan (SDAGE) and co-ordinates the coherence between SAGE Projects (management plans at the sub-basin/local scale). It arbitrates water conflicts, decides on the taxes to be paid by the users and defines action programmes. The SDAGE document was made available to the general public only after its approval, but this will have to change.

Each Basin Committee created a Planning Commission and several Geographic Commissions (implanted at a more local level) in which a number of debates and meetings took place. Hundreds of interested parties were able to voice their opinions in the meetings of these geographic commissions. For example in the Rhone-Mediterranean-Corsica (RMC) Basin, the stakeholders were consulted through 10 geographic commissions, 6 technical committees and 7 socio-professional committees. Besides, the SDAGE Project was submitted to the associations by way of a specific dialogue. 1500 written comments from stakeholders and the general public were received.

National Water Council, Spain

According the Spanish Water Act and the Regulation on Water Public Administration and Planning (Royal Decree 927/1988), the National Water Council (“Consejo Nacional del Agua”), is the highest advisory body on water issues at national level. Three types of members compose the Council: Regular, designated and elected. The first group is formed by “positions” instead specific persons (i.e. the Water Director), the second is formed by appointed representatives that are members of the Council for a non limited period of time and the last one includes members that has to be elected every four years.

Regular members are:

- Chairpersons of the different river basin districts (12).;
- Directors of different Ministries with responsibilities regarding water as Environment, Agriculture, Economy and so on (For instance, the Water Director) (8)..

Designated members are:

- Designated representatives of different Ministries with responsibilities regarding water as Environment, Agriculture, Economy and so on (11);
- Representatives of each one of the Regional administrations (17) ;
- One representative of the Federation of Municipalities;
- One representative of the irrigation users communities;
- One representative of the hydro power companies;
- One representative of the water supply companies;
- One representative of the Commerce Chambers;
- Three representatives of the farmers;
- Two representatives from the limnology field;
- Three representatives of ecological NGOs;
- Three representatives from the University and the research field;
- One expert in irrigation techniques (appointed by the Agricultural Ministry).

Elected members are:
- Elected representatives of the regional administrations that belong to the water river basin district councils (12).;
- Elected representatives of the water users that belong to the water river basin district councils (12)..

According the Law, the National Water Council shall discuss and approve or refuse among others, the following[1]issues:
- The National Hydrological Plan, prior to their consideration by the Government and the Parliament;
- The River Basin Districts Water plans prior to their consideration by the government;
- Projects of regulation to be implemented in the entire Spanish territory affecting the hydraulic public domain;
- Projects and sectorial plans on agriculture, territory, energy or industry if they are considered as being of "general interest" and affect the water planning or the water uses;
- All the issues affecting more than two River basin districts.

It should be taken into account that this situation needs to be assessed and, consequently modified, following the objectives and legal consequences of the Directive.
(this example cannot be found in Annex II)

Active involvement of stakeholders, consultation and access to information at the international river basin district level

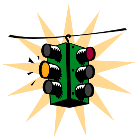
Danube River Commission / Danube Environment Forum (see Annex II)

Planning of the Danube River basin 'occurs' at a range of levels from sub-catchment/communities to international commissions. Participation of stakeholders happens in different ways at different levels in the overall process. The cascade of approaches to public participation from working with communities directly at one level to ensuring that representative organisations are involved at an international level is a good illustration of how public participation can mean different things at different levels, but should have a common set of principles of transparency of process and inclusion.
The co-ordinating body for the international aspects of the Directive in the Danube basin is the International Commission for the Protection of the Danube River (ICPDR). ICPDR is promoting public participation in the planning process through financial support to the ICPDR Information System, including the Danube Watch, as well as operating networks such as the Danube Environmental Forum (DEF), MLIM and AEWS.
Several large international NGOs have observer status in the ICPDR. They can participate in the meetings of the ICPDR, but they have no voting rights in its working groups. They provide significant input to the work of the Commission (for example in the establishment of an Ecological Expert Group). Through their networks, they provide small (national and local) NGOs with direct or indirect access to the international arena.

Key to managing the scale issue in river basin management is communication and co-ordination across scales and between units at the same scale (e.g. upstream and downstream countries or regions). This is very much facilitated by building up formal and especially informal networks across scales and between units at the same scale. Staff members of one competent authority could attend meetings organised by the other relevant competent authorities and vice versa. Moreover, the establishment of a central clearinghouse in each river basin district for public participation could be considered for exchanging the results of and experiences with public participation. Note that public participation at the international

[1] The National Water Council is an advisory body, so, its decisions are not legally binding. However, in practice, there is no record of one decision of the Council that has not been endorsed by the Government

river basin district level encourages the participation process at lower scales within the district. In basins where different languages are spoken sufficient funds for translating the most important documents need to be made available.



Look out! Keep each other informed across scales

Keep each other informed about all public participation processes going on in one river basin district, by formal means but especially informally. Sufficient funds for translating the most important documents need to be made available.

2.8 How do we involve them?

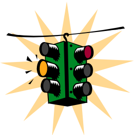
The timetable, which is linked to the program cycle of the Directive, as described in Section 3 is another determining factor in timing public participation. The different planning steps provide different possibilities for public participation. The Directive defines a number of phases and deadlines for its implementation, shown below (enumeration is not exhaustive).

STEP 1 By end of 2003	**Framework** Identification of River Basin Districts Assignment of the Competent Authorities Transposition of the Directive into national legislation
STEP 2 By end of 2004	**Characterisation and Analysis (Art.4)** Characterisation of the river basin district, review of the environmental impact of human activity and economic analysis of water use. Assessment of the likelihood that surface water bodies within the river basin district will fail to meet the environmental quality objectives set for the bodies under Article 4 ('gap analysis' Annex II (1.5)).
STEP 3 By end of 2006	**Planning for establishing programs of measures and outline of river basin management plans** Further characterisation for those bodies identified by the gap analysis as being at risk, in order to optimise the monitoring programme and the programme of measures. Monitoring programmes start
	For Public information and consultation about the RBMP, MS make available for comments a timetable and work programme for the production of the RBMP (MS shall allow at least six months to comment on those documents).
STEP 4 2007	For Public information and consultation about the RBMP, MS make available for comments an overview of the most important water management issues within the RBD (MS shall allow at least six months to comment on those documents).
STEP 5 2008	For Public information and consultation about the RBMP, MS make available for comments a draft copy of River Basin Management Plan (MS shall allow at least six months to comment on those documents).
STEP 6 2009	Final River Basin Management Plan published Programmes of measures shall be established.
STEP 7 2012	**Implementation** Programmes of measures implemented
STEP 8 2015	**Evaluation and updating, derogations** Good water status achieved? Objectives for Protected Areas achieved? Establishing and publishing the next plans and programs Derogations
STEP 9 2027	Final deadline for achieving objectives, following 2 6-year prolongations

In the next Sections the Guidance will describe how the three different degrees of participation can be organised in the different planning steps:

- active involvement (Section 3);
- 3-step consultation (Section 4);
- information supply (Section 5) .

As stated many times before, every process of consultation or active involvement is unique and depending on context and circumstances. Section 7 will help you to reflect on the public participation in your situation.



Look out! Remember communication

The backbone of public participation is two-way communication between the competent authorities, the participants and all other interested parties. Transfer of information between different planning steps is essential. Tools which support communication and interaction such as public meetings, interviews, workshops, websites, etc. are described in Annex I.

Section 3 – Active involvement of all interested parties in the Planning process of the Directive

"Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans." (Article 14.1, 1st sentence).

3.1 Introduction to active involvement

The purpose of the participatory requirements of Article 14, including active involvement, is to support the effective implementation of the Directive. While this has particular focus on the production, review and updating of the River Basin Management Plans, the encouragement of active involvement of stakeholders in the wider implementation of the Directive also needs to be considered. The potential benefits of greater stakeholder can be summarised as follows:

- RBMPs are likely to be more successful through achievement of "buy-in" to their objectives and delivery by promoting "ownership", acceptability and the co-operation of relevant stakeholders;
- Decision-making is likely to be more efficient through earlier identification and, where possible, resolution of conflicts;
- Solutions are likely to be more sustainable and equitable through the input of a wider range of knowledge and perspectives; and
- In the longer term, relationships between competent authorities and stakeholders are likely to be strengthened.

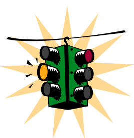
Although "active involvement" has not been defined in the Directive, it implies that stakeholders are invited to contribute actively to the process and thus play a role in advising the competent authorities as described in the spectrum of participation presented in Section 2.2.

It is important to note that there is no single correct approach to the organisation of active involvement. It will require a tailor made process which is context specific. This makes it difficult to be prescriptive in terms of defining an active involvement process. One possible solution would be for the competent authorities to develop a strategy to adapt the common understanding, outlined in Section 2, to the national, River Basin District and local context. In order to secure greater acceptance of the consultation and involvement process amongst stakeholders, the strategy should be published early in the process of implementation.

The ideal for active involvement is inclusiveness but, in practice, the notion of involvement of being open to everyone who has a stake, usually needs to be qualified by "as appropriate" to the particular context due to imposed constraints such as the Directive timetable, technical complexity, and limits on influence etc. Understanding, establishing and communicating clear boundaries for active involvement in the strategy will help keep stakeholder expectations realistic.

Given the above points, this Section presents the broad principles of active involvement: why, what, who and how stakeholders should be involved in the different steps of Directive cycle outlined in Section 2.8.

It is important that this Section is read in conjunction with the Guidance Documents produced by the other Working Groups in the Common Implementation Strategy.



Look out! Active Involvement is not a voluntary exercise
In the first place since Article 14 '*shall encourage*' implies that Member States have to make a clear effort to promote and facilitate active involvement. In the second place since the River Basin Management Plan (Annex VII, element 9) shall give account of the measures taken to inform and consult the public and the changes of the plan that followed from this involvement. In the third place since Preamble 46 tells us "*provide information.... with a view to the involvement of the general public before final decisions on the necessary measures are adopted*".

3.2 Active involvement in the program cycle of the Directive

STEP 1 By end of 2003	**Framework** Identification of River Basin Districts Assignment of the Competent Authorities Transposition of the Directive into national legislation

Why, what and who?

Active involvement in this step will help raise awareness of the introduction of the Directive and the early decisions that will establish the competent authority and spatial outline of the River Basin Districts.
Active involvement in this step is unlikely to be significant, and public participation will be characterised by information supply and consultation via existing national procedures.
Input should be sought from as wide a range of stakeholders as can be reached.

How?

By communication planning (see Annex I) and using the existing national procedures.

Consultation on the Directive Annexes 2 and 5, UK environment agencies (see Annex II)
The technical annexes of the Directive are complex and not easily understood or interpreted. They do, however, provide the basis and instruction as to how the water environment will be assessed, monitored and classified. These tasks inform Objective setting, the development of Programmes of Measures and regulatory regimes. As such it is important that, as far as possible, the principles being adopted, or being considered for adoption, are understood and supported by the range of stakeholders, authorities and organisations potentially affected by these assessment or related activities.

In the summer of 2002 the UK environment agencies issued public consultation documents on "The Guiding Principles on the Technical Requirements of the Water Framework Directive".

The objectives of this exercise were to:

- *Allow stakeholders to input their priorities and concerns as to how technical annex*

interpretation might affect them;
- *Allow stakeholders to comment on proposed WFD technical interpretations and principles;*
- *Provide a framework by which a range of public bodies across the UK could input to the development of a common interpretation and understanding of Directive requirements.*

A number of key lessons are summarised below:
- *It is possible to develop and provide participative opportunities associated with WFD technical processes and issues;*
- *Attempt to involve stakeholders in such issues and processes are appreciated by them and deliver benefits to prospective competent authorities in terms of both transparency and trust and through the valuable and insightful contributions made by stakeholders;*
- *The collaborative working of agencies and public bodies in both Scotland and England and Wales is beneficial in increasing national understanding and co-working relationships;*
- *Similarly the reciprocal involvement of SEPA, EA and EHS in each others drafting processes increased UK wide shared understanding while providing reassurance to stakeholders that common interpretations were being applied and proposed.*

STEP 2 By end of 2004	**Characterisation and Analysis (Art.4)** Characterisation of the river basin district, review of the environmental impact of human activity and economic analysis of water use. Assessment of the likelihood that surface water bodies within the river basin district will fail to meet the environmental quality objectives set for the bodies under Article 4 ('gap analysis' Annex II (1.5)).

Why, what and who?

Active involvement in the characterisation and analysis step will be useful to:
- Raise awareness of the process of characterisation and analysis;
- Collect data, information and views of a range of stakeholders;
- Identify issues and where possible resolve conflicts and manage expectations.

The characterisation and analysis step can be broken down into a number of distinct processes. The delivery of these processes, and ultimately the RBMP which they lead to, will stand a greater chance of success with the involvement of key stakeholders. Some specific detail is offered below for each process.

Review of pressures and impacts: This review forms one of the foundations of RBMP and helps determine which water bodies are likely to be at risk of not reaching ecological status by 2015 (or later) because of the pressures on them. The purpose of stakeholder involvement would be to help determine the pressures and impacts on water bodies and provide input to the identification of waters most at risk.

Economic Analysis: This process will help a) set up a trend scenario which predicts the socio-economic trends for the future, which is essential for the "gap analysis", and b) evaluate current levels of cost recovery and c) analyse the cost-effectiveness of measures between 2004 and 2009. Stakeholder involvement will help to determine a), b) and c). Secondly, involvement is also important since good ownership could mean also better financial support (either directly by the public or by political pressure).

Classification and objective setting: In this process a start has to be made with the definition of the **status of the water bodies** on the basis of the characterisation of water bodies within the River Basin Districts required by Annex II and V. Also **environmental quality objectives** have to be set. When setting the environmental objectives, it is most important to have good ownership of local people, but it has to be guided carefully as capacity building is indispensable (interpretation of Guidance Documents). There is risk of failure of objectives of the Directive by "overriding" economic issues (e.g. clean hydropower and navigation), but there is also a big chance to create awareness and to win the pro-environmental sections of society. This involvement should be organised from bottom (small basin or even water body) to basin districts and whole basin.

Gap analysis: When the current water status and envisaged environmental quality objectives are set, the **gap analysis** can be performed. The first gap analysis is to be performed before the end of 2004, for the purpose of the first RBD characterisation, in order to define the water bodies being at risk of failing to meet the objectives of the Directive for 2015. This first gap analysis will be based mostly on expert judgements and currently available data and information. After 2004, this first gap analysis will be refined on the basis of new data, among them the results from monitoring programmes (operational after end 2006). This new information will be used to update the RBD characterisation to be included in the river basin management plan (Annex 7), involve key-stakeholders in the identification of gaps and set up of trend scenarios. In the case of gaps, this makes them aware of a need for change, and it will help to get their input in the identification of appropriate measures (next step).

Designation of Heavily Modified Water Bodies: Like gap analysis, the designation of heavily modified water bodies is a two step process, with a provisional designation by 2004 and a final designation by 2008 The purpose of stakeholder involvement would be to support the identification of heavily modified water bodies (HMWB), resolve conflicts and contribute to the acceptance of HMWB designation.

The most important stakeholders to be considered at this strategic level of dialogue will be those who can really contribute to delivering solutions (e.g. other government bodies, water companies, wastewater treatment companies), those who have technical expertise and are 'representative' of a particular constituency (e.g. NGOs, research community) and those who pay for action (consumers).

How?

When considering the different processes, active involvement may be undertaken at national, River Basin District and local levels. Involvement at the national level would predominantly be with national government, industry bodies, consumer bodies, national NGOs and technical and academic experts. At the River Basin District and local level, involvement would tend to be with representatives of regional and local government and stakeholders with an interest in a specific River Basin District, river basin or water body.

At each of these levels it may be useful organise involvement using the following methods:

- Bilateral meetings;
- Steering groups;
- Advisory groups.

Possible activities for active involvement are:

1 "Process Start Up" meeting/workshop(s) with key-stakeholders to discuss:
  - The objectives;
  - The working process (how to reach the objectives) and decide on their role;

- The preconditions (Terms Of Reference) for their involvement;
- Availability and relevance of existing data;
- Communication plan.

2 Inventory of knowledge and perceptions on:
- The description of the surface waters and groundwater bodies; what are the major issues (problems)? This can be done through workshops, interviews, panels and fieldtrips with stakeholders.

3 Analysis and structuring, decision making on characterisation;
4 Information supply to all relevant stakeholders.

River Basin Management Plan Maas/sub-basin Niers, (see Annex II)

Pilot project with regard to Article 14 (North Rhine-Westphalia, one of the 16 German Lander)
In the three Niers fora: Municipalities, districts, water companies, water associations, chambers of agriculture, forest authorities, nature conservation NGO's, biological planning units, the Netherlands authorities and stakeholders (all of the relevant region), have been consulted. In round tables with 30 – 40 persons per forum the following activities took place: Information supply, discussion, distribution of relevant materials, exchange of experience, involvement with regard to data collection.

Integrated reconnaissance study on the River Basins of the Rhine and Waal (see Annex II)

Objective:
To give advice to the national government on possible scenario's for future water management
The open interactive process has the following elements:
- a close cooperation with other governmental organisations. In steering committees, the 2 provinces, municipalities, the regional office of PW, VROM and LNV as well as the water boards are represented. They are responsible for the decision making and the advice to the government on further policies. (Before only the regional office of the Ministry developed such studies and gave advice) ;
- an expert group (of government staff (and representatives of NGO's);
- (in a later phase) "working groups" of experts per theme:
    - ◊ water flow, use and land use;
    - ◊ juridical and governmental issues;
    - ◊ communication.
- open communication; from the start the project team showed a positive attitude towards interviews, questions by stakeholders and took care to produce clear reports, and leaflets to inform about the progress and results;
- symposia (IVB). The IVB project has organised two symposia. One for the governors and the other one for NGOs and interested citizens. The aim was to explain about results of the screening study so far, to create understanding and support and to seek reactions and advise on the proposed measures;
- information evenings for the general public with a (DVD) film putting water management in a historical perspective, bringing interests together under the flag of security and illustrating all proposed measures and its consequences;
- The objective is to inform people, provide them the knowledge they need, generate understanding for the necessity and gain insight on the different perceptions and ideas people have. What are the consequences of these measures for the user, inhabitants and local governors?
- "Kitchen table" conferences with the ministry and farmers in the area to discuss possible measures;
- Consultation rounds (interviews) among the parties involved on how to proceed.

STEP 3 By end of 2006	**Planning for establishing programmes of measures and outline of river basin management plans** Further gap characterisation for those bodies identified by the gap analysis as being at risk, in order to optimise the monitoring programme and the programme of measures. Monitoring programmes start. For Public information and consultation about the RBMP, MS make available for comments a timetable and work programme for the production of the RBMP (MS shall allow at least six months to comment on those documents).

NB: The Directive requires consultation and active information supply for the phases from 2006-2009. These subjects are discussed in more detail in Section 4 respectively 5.

Why, what and who?

This step is mainly focussed on planning the potential measures which may be used to achieve the objectives set for different water bodies, and to determine which options would be feasible and effective. Active involvement will help determine stakeholders' views on the potential options, and to elicit other possibilities to be screened which in turn would help determine the final measures selected. The programme of measures should be co-ordinated with other water and land- use planning processes and funding mechanisms. This may have significant financial benefits, in addition to improving effectiveness of the implementation. Also the SEIA directive refers to plans and programmes of measures (see Section 2.1 and 2.4).

The examples on the SDAGE project in France (see Section 2.7 and Annex II) do also illustrate this step.

The most important stakeholders to be considered at this step will be those who can really contribute to delivering the Programme of Measures (e.g. other government bodies, water companies, wastewater treatment companies etc), those who have technical expertise and are 'representative' of a particular constituency (e.g. NGOs, research community) and those who pay for action (consumers).

How?

When considering the different measures, active involvement may be undertaken at national, River Basin District and local levels. Involvement at the national level would predominantly be with national government, industry bodies, consumer bodies, national NGOs and technical and academic experts. At the River Basin District and local level, involvement would tend to be with representatives of regional and local government and stakeholders with an interest in a specific River Basin District, river basin or water body.

At each of these levels it may be useful organise involvement using the following methods:
- Bilateral meetings;
- Steering groups;
- Advisory groups.

The IIVR project, The Netherlands (see Annex II)

The project has chosen for a cooperative style in which the different authorities and nongovernmental organisations (NGO) (and interest groups) work together and have an equal say in the final outcome.

The interaction is organised through:
- a steering committee formed by governors of the different government authorities. They gave

direction to the process and take decisions. The steering committee is supported by the initiative-group;

- an initiative group. This group of experts, government employees and members of NGO's, discussed the content of the planning process;
- consultations of citizens and interest groups. In addition, several sessions were organised during a period of two years to consult citizens and interest groups and give them a chance to share their problem perceptions and generate ideas.

STEP 4 2007	For Public information and consultation about the RBMP, MS make available for comments an overview of the most important water management issues within the RBD (MS shall allow at least six months to comment on those documents)..

See Section 4 and 5.

STEP 5 2008	For Public information and consultation about the RBMP, MS make available for comments a draft copy of River Basin Management Plan (MS shall allow at least six months to comment on those documents)..

See Section 4 and 5.

STEP 6 2009	Final River Basin Management Plan published. Programmes of measures shall be established.

See Section 4 and 5 with respect to the publication of the RBMP.

Why, what and who?

This step is mainly focussed on establishing the Programme of Measures, which will be used to achieve the objectives, set for different water bodies. As stakeholders will implement or be affected by some of the measures, active involvement in this step will help gain commitment to the delivery of the Programme of Measures.

The most important stakeholders to consider at this step will be those who can really contribute to delivering the Programme of Measures (e.g. other government bodies, water companies, wastewater treatment companies, farmers etc) and those who pay for action (consumers).

How?

When establishing the different measures, active involvement may be undertaken at national, River Basin District and local levels. Involvement at the national level would predominantly be with national government, industry bodies and consumer bodies. At the River Basin District and local level, involvement would tend to be with representatives of regional and local government and stakeholders with a role in delivery of the Programme of Measures.

At each of these levels it may be useful organise involvement using the following methods:

- Bilateral meetings;
- Steering groups;
- Advisory groups;
- Workshops and meetings to generate solutions and define measures.

Erne Sustainable Wetlands Project (see Annex II)

In the Erne catchment (cross border Northern Ireland and Ireland) covering over 4,000square km's) the aim was to produce a model for agreeing a vision for management of the river basin (catchment). Active involvement with a range of stakeholders and a range of methods was tried at different geographic levels. It was found that people generally related better to the more local scale.
Methods included questionnaires, community mapping and workshops. Everyone living within the river basin was considered as a potential stakeholder and active involvement was encouraged by a participatory approach of holding workshops open to the public and any interested organisation and going out into public places like town centres.

STEP 7 2012	**Implementation** Programmes of measures implemented.

Why, what and who?

This step is concerned with the implementation of the Programme of Measures. Active involvement in this step will help to maintain the awareness of the measures and contribute to their sustained delivery.

The most important stakeholders to consider at this step will be those who are contributing to the delivery of the Programme of Measures (e.g. other government bodies and industry sectors etc).

How?

When implementing the Programme of Measures, active involvement may be undertaken at national, River Basin District and local levels. Involvement at the national level would predominantly be with national government and industry bodies. At the River Basin District and local level, involvement would tend to be with representatives of regional and local government and stakeholders with a role in delivery of the Programme of Measures.

At each of these levels it may be useful organise involvement using the following methods:

- Bilateral meetings;
- Steering groups;
- Consultation methodologies.

River Tyreså project, Sweden (see Annex II)

Public participation to restore and develop a River basin.
A steering group was set up consisting of politicians from the municipalities. Working groups were formed of representatives of municipalities, county board and from the water users (total 11 persons). The working group has close contact with the sport fishing associations, house-owners associations and many other associations within the catchment area. After the first introductory meeting some interest/issue groups were established: recreation/outdoor life, local history and eutrophication. The working groups have regular meetings once a month with these groups. The public participated also through panel debates. The outcome was a list of measures being implemented resulting in a.o. The establishing of walking paths, improved of the quality of the surface water, protection of an ecological park.

STEP 8 2015	**Evaluation and updating, derogations** Good water status achieved? Objectives for Protected Areas achieved? Establishing and publishing the next plans and programs. Derogations.

Why, what and who?

This step is concerned with the achievement of the objectives. Active involvement in this step will be useful to raise awareness of the achievement of the objectives and facilitate the understanding of the effectiveness of the Programme of Measures.

The most important stakeholders to consider will be those who can really contribute to delivering the Programme of Measures (e.g. other government bodies, water companies, wastewater treatment companies, farmers etc), those who have technical expertise and are "representative" of a particular constituency (e.g. NGOs, academics etc) and those that pay for action (consumers).

How?

When considering the achievement of the objectives, active involvement may be undertaken at national, River Basin District and local levels. Involvement at the national level would predominantly be with national government, industry and consumer bodies, national NGOs and technical experts. At the River Basin District and local level, involvement would tend to be with representatives of regional and local government and stakeholders with an interest in a specific River Basin District, river basin or water body.

At each of these levels it may be useful organise involvement using the following methods:

- Bilateral meetings;
- Steering groups;
- Consultation methodologies.

The Emå River, Sweden (see Annex II)

Catchment area of 4 500 km^2.
Objectives public participation:

- To contribute to sustainable development by encouraging commitment and support from local people as regards restoration of the area and other environmental measures;
- To use knowledge and experience from NGO's and other stakeholders;
- To avoid new and, if possible, solve old conflicts.

Municipalities, county administrative boards, NGO's, etc., cooperated in different working groups from 1994 onwards (from 1997 there were 8 groups). Different associations took part in these working groups such as the Emå River Council, farmers associations, owners of fishing waters, angling associations, local history associations, nature conservation associations, municipalities and tourism enterprises.
Public participation is achieved by holding seminars, information meetings and hearings, circulating documents (e.g. objective documents) for comments, forming working groups (those in the group bring information back to their organisation and vice versa) and distributing newsletters, etc. Minutes from the various meetings were taken and distributed.

West country River Trust (WRT), UK (see Annex II)

The objective of the project is:

- To raise awareness;
- To use the knowledge and experience of stakeholders for the sustainable development of river catchment areas;
- To improve water quality through comprehensive involvement of farmers;
- Participation has largely focused on farmers and key regional stakeholders (e.g. statutory environment agencies, the local water company, other NGOs). The WRT works both as a leader and facilitator in the region to effect change through the development and delivery of action. For instance, WRT has recently used WWF-UK funding to bring together key regional stakeholders in a workshop to begin the process of agreeing a long-term vision for the landscape of the southwest. The workshop has been followed by a questionnaire exercise, which asks stakeholders to identify their priorities for rural land-use. Hence knowledge on local issues, resources in terms of active participation and commitment and willingness to imply changes in their production practices to ensure environmental quality is gained.

The Tubaek stream, Denmark (see Annex II)

The key to the constructive dialogue was:
Public meetings were organised through the farmers union and that meetings took place at the farm – the "kitchen-table model";
Negotiation and signing of voluntary agreements on water management has taken place.

STEP 9 2027	Final deadline for achieving objectives, following 2 6-year prolongations

The six-year programme cycle will remain, including public participation as described before.

Section 4 – Consultation

4.1 Introduction to consultation

Consultation aims at learning from comments, perceptions, experiences and ideas of stakeholders. Unlike active involvement, consultation is only possible after completion of draft plans and other documents, and during the preparation of these documents. Moreover, it is a less intensive form of public participation. Yet, whereas active involvement often is necessarily somewhat selective, consultation allows everybody who is interested to become involved in decision-making. It is a useful complement to active involvement and can function as a kind of check on active involvement, to see if all interests, points of views were represented.

According to Article 14 consultation concerns the following requirements and timetable for consultation (with a repetitive cycle of 6 years for future river basin management plans):

December 2006 (at the latest)	Time table and work programme for the production of the plan, including a statement of the consultation measures to be taken;
July 2007	Comments in writing.
December 2007 (at the latest)	Interim overview of the significant water management issues identified in the river basin;
July 2008	Comments in writing.
December 2008 (at the latest)	Draft copies of the river basin management plan available;
July 2009	Comments in writing.
December 2009 (at the latest)	Start implementation of the plan.

Thus consultation refers to:
- Publishing;
- Making available for comments;
- *For the public*, which is a wider range than stakeholders only.

Further on in this Section the three required consultation phases are discussed separately and something will be said about the timing of consultation.

The Directive specifies that public comments must be provided in writing, e.g. either in paper form, by mail, or via e-mail. Additionally however, other ways of consultation can be considered (oral consultation). So basically, there are two different forms of consultation:

1. *Written consultation*, where people are asked to comment in writing on the proposed analysis or measures (this can include the use of internet);
2. *Oral or active consultation*, where the consult is sought in interviews, workshops or conferences. During these meetings major issues are presented and the invited stakeholders are asked (in small groups) to give their perception, knowledge and ideas on the specific issues (Annex I gives an example of such a workshop). They can also be consulted on the development of measures through questions like: "how to solve these issues?" or "how to proceed with our working process".

Written consultation is regarded as a minimum requirement for implementation of the Directive, oral consultation as best practice. However combinations of these two are often applied.

Code of practice on written consultation for the Directive:

1 Timing for the organisation of consultation, apart from the dates mentioned by Article 14, should be built into the planning process for a policy or service from the start;
2 It should be clear who is being consulted, about what questions, in what timescale and for what purpose, the consultation process is open to anyone;
3 the documents which are subject to consultation (timetable, work programme, significant water management issues, draft copy of river basin management plan) should be as simple and concise as possible (including a summary of 2 pages of the main questions it seeks views on), some summaries for a broader audience should be prepared;
4 the documents should be made widely available, with the fullest use of electronic means and effectively drawn to the attention of all interested groups and individuals;
5 Anyone with an interest has six months respond to the documents;
6 Responses should be carefully and open-mindedly analysed, and the results made widely available, with an account of the views expressed, and reasons for decisions finally taken;
7 Departments should monitor and evaluate consultations, designating a consultation coordinator who will ensure the lessons are disseminated.

4.2 Management of comments

Management of information and comments is important with consultation. There are several available tools for informing the public and at the same time asking them to comment on the plans: fact sheets, newsletters, Internet, brochures, advertisements, articles in magazines, columns in newspapers, exhibitions, open house, info evenings and TV/radio (see description of communication tools in Annex I). The whole area that is potentially affected by the river basin management plan should be covered for example by display in city halls, libraries, local newspapers and actively sent to stakeholders or anybody that is likely to have an interest. Once the information is published you should be prepared to get responses and to act.

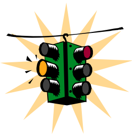
4.2.1 Where to collect responses?

Point 7 in the box above also refers to the question of where comments should be received. For the management plan as a whole, they could be collected centrally, by an (inter)national co-ordination agency, or non-centrally, by the authorities displaying the plan. The Directive contains no provisions regarding collection and processing of comments received from the public.

Comments regarding international management plans can be collected on a national basis, at defined locations. Once collected, comments must be sent immediately to the authorities concerned, in the interest of speedy assessment. Where comments are well founded, the relevant results (such as adaptation of measures plans, etc.) should be collected on a national basis, for the river basin district, and then forwarded to the international agency (if existing) that co-ordinates or facilitates the preparation of an international management plan. In administrative areas that cross boundaries – such as those along the upper Rhine or the Moselle/Saar area – and thus will require sub-plans, co-ordinated processing of comments regarding the relevant areas/sub-plans, by authorities co-operating within the relevant areas, would be a useful way of reducing co-ordination overhead at the international co-ordination agency.

4.2.2 How to analyse the comments?

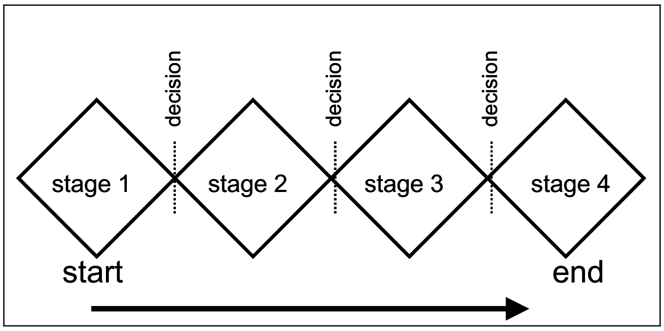
Responses should be carefully and open-mindedly analysed, and the results made widely available, with an account of the views expressed, and reasons for decisions finally taken. It is important that the authority of the area in question is able to respond to the comments and be responsive to the public/stakeholders. They need to be informed on the arguments for decisions taken and the final outcome of the planning process. Also, it should be ensured, that the authority that displays the plan, or the authority that collects comments, is able to forward, to the co-ordination unit and/or the relevant regionally competent authority, comments that refer to parts of the river basin district for which the authority does not have regional competence. When many comments are received it is advisable to categorise the comments. Subsequently the answers, motivations and decisions can be prepared per category in one surveyable document and returned to the public/stakeholder.



Look out! Feed-back
It is important to give feedback to the participants of the consultation. The feedback should contain a motivation and be returned in a reasonable time frame. Remember that in future these consultations need to be organised every 6 years. 'Cherish' the participants: you will need them again!

4.3 How to organise consultation

Dealing with organisation there is the need for a well-organised tailor-made design, using the earlier mentioned planning process diagram:



Stage 1	Starting stage: TOR for your project, indicate clearly the boundary conditions;
Stage 2	Exploring stage: diverge and explore all possibilities/ideas;
Stage 3	Ranking stage: converge and cluster/prioritise the possibilities, make a decision and agreements on further activities;
Stage 4	Implementation and information.

4.3.1 More practically:

- Stage 1 "Process Start Up" meeting/workshop(s) with these groups or groups of key-stakeholders to discuss:
  - The objectives for consultation;
  - The working process (how to reach the objectives of art. 14) and decide on their role;
  - The preconditions (Terms Of Reference) for their involvement;
  - Availability and relevance of existing data;
  - Communication plan;
- Stage 2 Inventory of knowledge and perceptions on:
  - The description of the information to be consulted upon; what are the major issues?
  - Timing of this supply of information; is the time schedule of the Directive practical? Refine the time schedule
  - Who are we going to consult?
  - How are we dealing with the responses; management of information?
  - What tools do we have at our disposal for communication?
  - How do we give feedback;
- Stage 3 Analysis and structuring, decision making on consultation;
- Stage 4 Information supply to all relevant stakeholders.

4.4 Consultation on the timetable and work program (art 14 (1) a)

4.4.1 What tasks to be done?

By the end of 2006 at the latest, the public must be informed and consulted about the timetable and the work programme for production of the management plan and about the planned consultation measures.

4.4.2 How to organise the consultation?

The way consultation is organised depends to a large extent on the geographic scale of management plans.

At *river basin level and Sub-basin level*, both written and oral consultations can be organised. The relevant stakeholders and public in the river basin district should be given an overview of the planned plan-production steps (data collection, assessment, definition of objectives, decision regarding measures) and of the participating authorities and agencies (who is responsible for doing what, and by when). If necessary, information about other options should be provided; for example, regional informational events regarding the Directive could be held. With such overview information, the interested stakeholders and public become aware when they can raise their concerns and proposals.

The public that is consulted does not necessarily have to live in the river basin district concerned, a measure within the district may have effects on areas that are not assigned to the river basin district in question (e.g. adjacent coastal areas, groundwater aquifers). Persons, groups and organisations in these areas also fall under the definition of "public" and consequently they too have to be consulted. Practically this means that at a very early stage the area that may be affected has to be determined and that in the whole area (also if outside of the river basin district) the documents mentioned in Article 14 should be published and made available for comments.

At the *international river basin district level* a useful approach for the written consultation would be to publish internationally prepared papers, all with very similar wording, throughout the river basin district. A form of international co-ordination is needed on making the timetable and work programme including the proposed public participation measures. On the other hand, it is not clear whether such papers will be available on the international level at the time in question. But since only a first general overview is being provided, extensive co-ordination will probably not be required. The data regarding the competent authorities, and a timetable, must be available for all river basin districts by 2006.

Alternatively, the Member States would have to take action independently from each other. In any case, certain content of this information level (such as who does the international co-ordination, who works internationally in support of whom) should be provided in standardised form. Consequently, the relevant discussion on the EU level and in the international river district commissions must be awaited.

Article 14 (1) 2nd sentence, "*Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users:*"
The information and documents mentioned in Article 14(1) a) through 14(1) c) must be published and made available. The Directive does not specify what type of publication is required, but we can refer to the Code of practice on written consultation (see Section 4.1).

In discussions in Brussels, the Commission has repeatedly called attention to the Internet, which some Member States have already been using successfully even for larger planning projects. The Internet offers a good opportunity to describe and present transposition of the Directive, which is a complex process, in an understandable way. Using the Internet some questions have to be answered, e.g. the rate of the target audience with a connection to the Internet, whether additional paper versions have to be made available to the part of the public without access to the Internet, if personnel would have to be assigned to guide through a management plan, if internet access of appropriate authorities could be used by the public.

4.5 Consultation on "significant water management issues"

4.5.1 What tasks need to be done?

In the second consultation step, a preliminary overview of the important water management issues for the relevant river basin district and for its river basin(s) (the Directive's use of these terms in Article 14 is not standardised) is to be published by the end of 2007 at the latest. The important issues for the river basin district can be derived from:

- The analysis of the water-quality inventory that is to be completed by the end of 2004;
- The subsequent discussion regarding definition of objectives (taking into account the exceptions provided by the Directive);
- The necessary measures;
- The perceptions, knowledge and experience of the relevant stakeholders.

By the end of 2007, a relatively homogeneous assessment of the key requirements for action should be available throughout the entire river basin district. By this point, assessments should no longer differ, since otherwise any co-ordinated approach would be endangered.

4.5.2 How to organise the consultation?

The examples in the boxes hereafter show different forms of consultation at different geographic scales:

(Inter)national and district level

The International Commission for the Protection of the Danube River (ICPDR) is the co-ordinating body for international aspects of the Directive's implementation. ICPDR is promoting public participation in the planning process, through financial support to the ICPDR Information System, including the Danube Watch, as well as operating networks such as the Danube Environmental Forum (DEF), MLIM and AEWS. NGO observers attend the ICPDR meetings, and provide significant input to the work of the Commission (for example in the establishment of an Ecological Expert Group). Stakeholders are observers to the Commission, which implies full participation, no voting rights.

River Basin level

Water management Plan of the municipality of Örebro, Sweden (see Annex II)

The objective of the consultation is to fulfil the demands about public participation of the Swedish planning and building act concerning consultation in the development of comprehensive plans. A working group and a steering group consisting of a civil servants implement the work. A total of about 70 different authorities and organisations upstream the catchment areas and within the boarders of the municipality have been consulted on a draft plan during a seminar and information meetings. The working and steering group acknowledged their opinions and comments. The adjusted document was sent for a new round of consultations. Farmer- and water protection associations and the university were also involved

4.6 Consultation on River Basin Management Plans

4.6.1 What tasks need to be done?

The centrally important third phase of public information and consultation will begin at the latest at the end of 2008: publication of draft versions of the management plans. The content requirements for plans are described in Annex VII. Such plans, especially those for the larger river basin districts, are likely to consist of extensive documents with maps. At this point, these documents must already be nationally and internationally harmonised, to the maximum possible extent, so that they will clearly show what co-ordinated water management is planned.

4.6.2 How to consult?

National scale
A useful approach could be for the national or international co-ordination unit responsible for the river basin district overall to compile these papers and then provide them to the affected states.

River Basin scale

Consultation on the River Basin Water Plans, Spain

In Spain the development of Water Plans in the river basin districts is made by "Water Councils".

According the Spanish Water Act and the Regulation on Water Public Administration and Planning (Royal Decree 927/1988), the Water Council in each river basin districts has the duty of discussing and proposing the river basin plan to be approved by the Government. At least, one third of the total number of the Water Council members has to be of the representatives of the users.

A river basin Plan in Spain includes, among others, the following contents:
- Water resources assessment;
- Water demands evaluation;
- Criteria for water uses priorities;
- Water resources allocation for current and future uses;
- Basic water quality requirements;
- Measurements for groundwater protection;
- Water infrastructures needs.

4.7 Timing of consultation and international co-ordination

Article 14 (2) "*Member States shall allow at least six months to comment in writing on those documents in order to allow active involvement and consultation*"

For each of the above-described consultation steps, the public must be allowed a period of at least 6 months to comment in writing about the relevant documents. This period is probably reasonable but the over-all time schedule is tight, since results of consultations have to be incorporated within relevant papers, in harmonised form, for the entire river basin district. Especially with regard to consultation regarding draft versions of the management plans, the question arises of how the workload is to be managed. Therefore some consultation steps might be initiated earlier than the final deadlines specified by the Directive. This could save time that would then be available for later work. Therefore, an internationally co-ordinated approach is required, if co-ordinated results are to be presented.

Article 14 (1) requires that the public be consulted regarding the management plan for the entire river basin. This brings up the question of how such consultation should be internationally co-ordinated.

Harmonisation of the timetable plays a central role in this context. In light of the tight deadlines for transposition of the Directive, and the close succession in which the various consultation phases take place, international co-ordination regarding a parallel approach – if at all possible – would seem necessary. Suitable procedures for this should be approved by the relevant international bodies.

Furthermore, the question of what documents must be submitted, a question already mentioned above must also be considered. The key issue in this connection is what an international management plan should look like. Some international river basin district commissions are currently discussing the structure of a management plan for a river basin district. There is concern that too little time will be available to produce such a complex work, especially if it is to be logical and coherent.

Section 5 – Access to information and background documents

Access to information and to background documents covers two aspects:

- Sufficient "Information supply" in the different implementation steps; and
- Access to background documents and information according to Article 14 (1).

5.1 Sufficient "Information supply" in the different implementation steps

In the whole implementation process sufficient information is necessary to enable active involvement of stakeholders and the public in general. The following Section will describe how this can be organised.

Sufficient refers to:

- The different stakeholders and the public;
- The kind of information (progress in the planning process, results and outcome of analysis, proposed measures and plans, arguments in decision making);
- The way information is being provided (in a understandable and easy way, with e.g. announcements where to find information if required). For the public in general, the Internet, brochures and television spots are useful means. The organised stakeholders will most probably get all the relevant information in the steering groups or commit-tees established.

The following examples illustrate how the information supply can be organised. You often see a combination of "on-line" information supply through Internet and mail and off-line meetings and conferences to inform the public of the output of the planning process. Objectives like awareness rising, promoting changes or just to inform people influence the final selection of tools. The availability of budget resources often determines the final choice.

Alcobendas-city, Spain (see Annex II)

The objective of the project is to raise awareness of the population, local authorities and SME's in Alcobendas, a Madrid suburb, on water consumption. A comprehensive package of activities has been implemented, including:

- Exchanging technical and scientific information to encourage the introduction of effective water-saving technologies and programs and water demand management;
- Promoting new regulations;
- Stimulating the water-saving technology market;
- Promoting changes in the productive sectors;
- Increasing public awareness of the need to participate actively in saving water;
- Offering an example of the introduction of effective water saving measures in new homes;
- Publicising the results and methodology so that they can be adapted to other towns.

Activities included press conference, calls and visits by media-rep's, TV reports on water-saving systems, interviews radio stations, and publishing of articles.

Information letters for the implementation of the Directive in Thuringia, Germany (see Annex II)

The objective is to make the persons or organisations interested in water management issues acquainted with the objectives and necessary steps of the Directive and to express their ideas and proposals. At the moment the information letters (six pages) are published twice or three times a year (available in printed form or via internet. At the end of the letters a contact person is named (phone and email) The until now huge demand for the information letters encouraged the Thuringian Environment Ministry to expand this approach in the future. The information letters and the contact to the ministry should be used also as platform with regard to other Thuringian ministries and to other of the 16 German Lander. The information should become intensified and specified, e.g. by information on special issues.

The National Commission for Public Debate, France

A wide range of methods and tools is applied to inform the public

- **"supporting dossier":** provided by the project leader, gives to the public the necessary information to participate - general description of the objectives and the main characteristics of the project, estimation of the economic and social stakes, identifications of the main environmental impacts and evaluation of the economic and social costs of the project - (for example, for the TGV Rhin-Rhône project, 6000 were distributed);
- **"information letters of the debate"** or "lettres du débat: to inform the public on the debate, mobilise it regularly to participate and communicate information on the evolution of the debate " (for the TGV Rhin-Rhône project: 2 700 000 were distributed);
- **public meetings** (TGV Rhin-Rhône project: 10 in different cities);
- **Internet web site:** to have information on the project and the organisation of the public debate (for the TGV Rhin-Rhône project: 6500 visits, 70 per day);
- **Visits** to the headquarters of the specific commission to consult more detailed documents on the project;
- **Question-answer system** (TGV Rhin-Rhône project: 2000 questions received);
- **Prepaid cards**: distributed with the information letters, to ask for further information;
- **mail:** for sending remarks, opinions or thoughts;
- **toll-free number**: to ask for information and questions;
- **E-mail:** from the Internet web site, to ask questions and consult all the answers already given;
- **"contributions"**: mails received at the commission which showed one particular and developed position (TGV Rhin-Rhône project: 85);
- **"stakeholders book"**: selection of some of the observations from the public were published in so-called "stakeholders books" ("cahiers d'acteurs") and distributed (TGV Rhin-Rhône project: 10 books in total);
- **press** (example, for the TGV Rhin-Rhône project: 163 articles published in the regional press, 26 in the national press and 10 press meetings in the 10 cities where the public meetings took place).

For more information, see Annex II.

5.2 Access to background documents and information according to Article 14 (1)

Article 14 (1) "*c) request, access shall be given to background documents and information used for the development of the draft river basin management plan.*"

As a minimum the background documents should include all the documents that are summarised in the river basin management plan (Annex VII). The Article 14 sentence above is referring to an additional right to information, a right that must be exercised via special application. The Directive does not specify to whom such application must be made. There may be one central information- and knowledge centre in a river basin and a national and/or regional centres can be considered (in case of an international river basin). At least these centres should have access to background documents or information. The set-up of these centres and the procedures for providing access to information has to be decided on (see Annex VII A. 11) in the river basins. Background documents can be provided in the form of inventories of pressures and impacts on water bodies or details with regard to the programs of measures or more detailed information on implementation levels under the river basin district level (the public will ask "What consequences will the river basin management plan have for myself or my water uses?"). The Directive does not specify how quickly a request for information should be answered, but taking the Aarhus convention as a reference, one month could be advised.

The possibility of also placing background documents on Internet, and of making relevant reference, should also be considered. This will be a rather small effort, as relevant files have to be prepared anyway for inventories under the Directive.

The Municipality of Örebro's water management plan, Sweden (see Annex II)

Objectives Public participation
To fulfil the requirements for public participation under the Swedish Planning and Building Act of 1987 concerning consultation in the development of overall plans. A working group and steering group consisting of civil servants have been implementing the project.
A total of about 70 different authorities and organisations upstream of the catchment area and within the municipality's borders have been consulted on a draft plan. Their opinions and comments were acknowledged by the working and steering groups. The adjusted document was circulated again for consultation.
Those involved included farming and water conservation associations along with Örebro University.
Consultation was effected by organising seminars, information meetings and hearings and by circulating proposed land use plans for consideration by the parties involved.

The access that must be provided to background materials and information could be seen in connection with the Environmental Information Directive, its transposition into national law and the Aarhus Convention. The Aarhus Convention caused an amendment of the Environmental Information Directive (Directive 90/313/EC) and national laws will have to be harmonised with this amendment by the end of 2006. The materials and information referred to in the framework of Article 14 (1) 3rd sentence are all environmental information within the meaning of the information Directive (both definitions are extensive in scope and also include, for example, measures that could have an impact on environmental media). For this reason, transposition of Article 14 (1) 3rd sentence could employ a cross-reference to national environmental information law and its procedures.

Section 6 – Evaluation, Reporting results of active involvement, public information and consultation measures

Annex VII of the Directive requires that the river basin management plans cover *"a summary of the public information and consultation measures taken, their results and the changes to the plan made as a consequence"* (Annex VII.9) and *"the contact points and procedures for obtaining background documentation and information referred to in Article 14(1) (…)"* (Annex VII.11)

This requirement serves the information of the Commission in its role as "Guardian of the Directive", but can also be used as a tool to improve public participation in the next planning cycle. In that case, reporting is used in an evaluative manner, introducing a learning process. In this Section, both reporting and evaluation are treated.

6.1 Reporting

6.1.1 Why, what, who?

The Directive, as pointed out above, requires reporting on the public participation process. Reporting brings transparency into the public participation process, and gives feedback to the participants on what has happened with their comments. With respect to that, more than an *ex post* tool for supervision of the Commission over the Competent Authority, reporting is a tool for involving the public. Reporting therefore, should not only be directed at the Commission, but emphatically also to the participants involved before. It deserves consideration to report not only at the end of a participative process, but also during the process after participative activities (direct feedback). As stated in the requirements of the Directive, the whole process of participation should be described; from the way information is made accessible for stakeholders and the public, to the effect of the participation process on the River Basin Management Plan.

6.1.2 How?

The requirement from Annex VII, element 9 can be fulfilled by drafting a table with the measures taken and techniques used, the responses received from what sectors, and the implications of the responses for the River Basin Management Plan. It is recommended to take into account the reporting aspects on forehand, when designing a public participation process (this also has to do with 'management of expectations'; what do people expect to happen with their comments?).

It also is recommended to add quality indicators to the report, like:

- 'Facts and figures', description of the public participation plan (objectives and methods, who did you contact and why, how many reached, how many reactions etc.);
- Measuring of 'customer satisfaction' (how do participants judge the information supplied, the possibility to react, the actions following from their participation?);
- Comments per sector (did every sector react; implies stakeholder analysis);
- Proportion between resources for public participation and resources for the rest of the planning process.

The SDAGE projects, Reporting in the Adour Garonne Basin, France (see Annex II)

For each of the 10 French large river basins, a management plan has been produced according to the 1992 French Water Act, called SDAGE. In a modified form they will become the river basin management plan according to the Directive. The so-called Basin Committee is responsible for their initial elaboration. This Committee is composed of the representatives of all stakeholders and users in the River Basin District (about 100 members):

- 1/3 local elected officials (i.e. mayors, local communities)
- 1/3 users, consumers, NGOs
- 1/3 representatives of the State

The Basin Committee defines the management plan (SDAGE) and co-ordinates the coherence between SAGE Projects (management plans at the sub-basin/local scale). After three consultation rounds with 600 stakeholders and 1000 civil servants, a proposal for a river basin management plan for Adour Garonne Basin was finalised. The proposal was put out to a wider public for comments during 50 public meetings and finalised afterwards into a SDAGE, a river basin management plan, for the Adour Garonne Basin.

Reporting

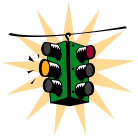
- The comments of the first three consultation rounds are reported in a "registry of comments" which is publicly available;
- Three documents will be published: the final river basin management plan (110 pages), an executive summary (25 pages) and a 4 pages leaflet. The information will be available on a website and can be downloaded from there. Background information is available on demand;
- Every year the Operation Board (under the Basin Committee) publishes an annual report including an executive summary and an informative leaflet, describing the progress of implementation of the plan;
- The SDAGE was made available to the *general* public only after its approval.

6.2 Evaluation

6.2.1 Why, what, who?

Evaluation can improve the quality of the public participation process. Evaluation has been defined as "a process of assessment which identifies and analyses the nature and impact of processes and programmes" (Interact 2001). The essential purpose of evaluation in the context of participatory processes is therefore to assess what they have achieved. Achievement can be assessed against both qualitative and quantitative criteria. And evaluation can examine how particular participation methodologies worked and if they worked well or not. In this way, those involved can assess the "worth" of the exercise, and how things may or may not be done differently in the future. It is vital from many viewpoints that an evaluation is carried out. Not only from the viewpoint of participants who have invested time and effort but also from the viewpoint of the organisers and (if different people) those that have funded a process.

In an ideal situation both competent authority (the organiser of the participation) and participants are involved in the evaluation. Not only to hear from the opinions of participants and stakeholders, but also to include them into the learning process. Further, it is recommended to draft evaluation from the start into the design of the public participation process. On the one hand, objectives should be drawn up in clear terms that actually can be evaluated, and on the other hand, evaluative steps can be build into the participative process in order to 'keep track of the process' and introduce improvements on the way.

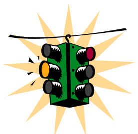


Look out! Evaluation should not be an afterthought
The needs of evaluation should be built into the design of the participation process from the beginning

6.2.2 How?

First: take into account the evaluation aspect when designing a public participation process. This already starts with explicit objectives (preferably quantified), together with timetables for their achievement, included to provide benchmarks against which progress may be assessed. The use of a common framework for evaluation can help ease of comparison where participation has occurred in several places within a river basin.

Outcomes are one of the hardest areas to assess and often outcomes can develop over time and it was too early to evaluate them fully. Outcomes can also be tangible in terms of hard outputs or intangible in terms of process and both are valid reasons for doing participation.



Look out! Evaluate on the basis of the objectives
It will be essential to evaluate public participation against set objectives and review it as the process progresses and plans and programmes are written

A quick evaluation sheet for specific events can be useful and an evaluation form could include questions like:

- Your role/how did you become involved;
- What do you think were the aims of the activity?
- What effect has your contribution made?
- What effect has the activity had on (physical environment, local economy, local organisations)?
- Was the activity worthwhile?
- Ideas for improvements;
- Advice to others holding similar events.

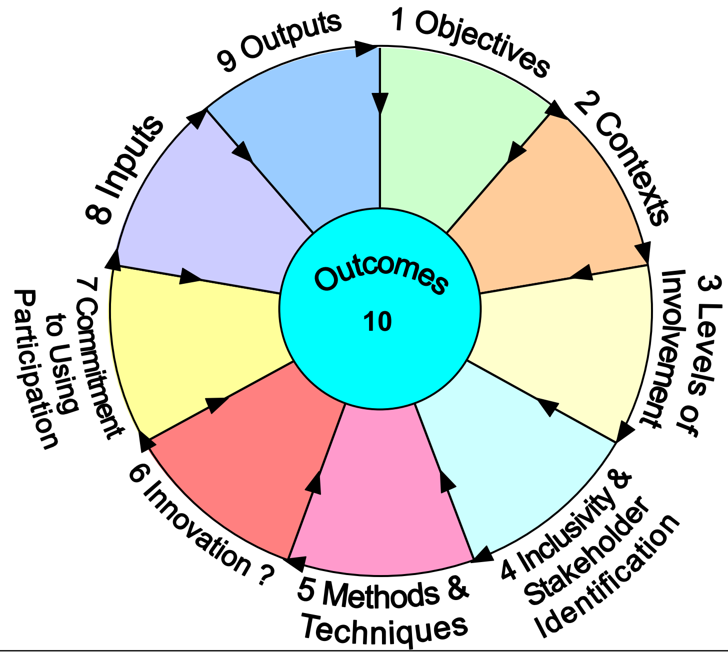
As with most of the issues surrounding participation, there is no right or wrong way to conduct evaluation and the key is to be as inclusive and flexible as possible.

A Framework for evaluation of participation

The following is one suggested basic summary sequential 10-point framework within which to approach the evaluation of the use of various participatory processes within a project or planning process.

Essentially this framework aims to evaluate both the participation 'process itself and the impacts of that process'. It is an adaptation for the EU Wise Use project of work done by Interact – (see references to this Guidance). The user would consider the headings for evaluation starting at 1 – the objectives of the participation and work round through headings 2- 10 culminating in consideration of number 10: the outcome of the participation – that is what was really achieved. Based on evaluation public participation processes and methods may then need to be reviewed.

Summary Framework for Evaluation of Participatory Processes



6.2.3 Evaluation principles:

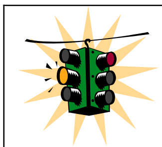
Principle: Try and incorporate time and resources for evaluation of participatory processes into the decision making process itself.
Principle: Carry out evaluation where possible throughout a process, not just once it is completed so processes can be revised and reviewed.
Principle: Make evaluation as inclusive as possible by involving a range of stakeholders (e.g. funders, project staff, participants)
Principle: Use evaluation frameworks where appropriate but also be flexible and allow for other, perhaps less formal evaluation methods.
Principle: Be aware that evaluation will reveal tangible results (e.g. product orientated) as well as intangible ones (process orientated).

Section 7 – Developing a Learning Approach to Public Participation; A key to success

The previous Sections have shown the importance of public participation in the implementation of the Directive. This Section aims to stimulate the reader to contemplate an intended public participation processes. Several factors are highlighted which should be considered for the benefit of the public participation process, but are not prescribed by the Directive. The factors mentioned here could sometimes make the difference between success and failure. Although the text of the Directive does not explicitly require an active participatory approach, the implementation of the Water Framework Directive should be done **together**. The future will also require a more inter-sectoral approach and a broader view on water management, crossing established boundaries and watersheds.

A willingness to improve, trust, transparency and a positive attitude to the process of implementing the Directive in conjunction with other stakeholders and members of the publicis essential for success. Each can learn much from the others. Such a learning approach has increasingly gained attention in, for example, larger commercial companies, which, on the one hand, have to constantly adjust to new expectations and demands of the market, while on the other hand, have to re-organise themselves and adjust their capacities accordingly. Active involvement of the public is indeed comparable to such a situation and subsequently calls for a more dynamic approach to participation and self-understanding among water management authorities.

While many examples have been used to illustrate practical ways in which participation can be undertaken, this Guidance cannot hope to encompass the variety of situations, which will be encountered over the next decade or more, as the Directive is implemented. Yet it will be necessary for competent authorities and other stakeholders to be able to respond to these challenges in a way, which is consistent with the spirit of the Guidance.

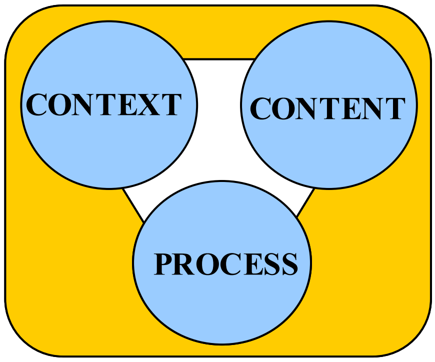


Look out! A dynamic and learning approach will pay off in the future
All, public, stakeholders and competent authorities, at any level, will benefit from increased communication, accumulation of knowledge and sharing of each other's experiences. Lessons learnt in the past will be valuable input for the future.

This Section draws attention to the factors, which underpin a learning approach to participation with three aims in mind. First, to *raise awareness* amongst competent authorities and other stakeholders that there is a need to develop approaches to public participation, which are tailored to local conditions (here 'local' even means the customs and traditions of an international River Basin District). Second, to enable the competent authorities to review and assess their own and others' *current approaches* to public participation. Finally, to enable the competent authorities and other stakeholders to begin to develop a *learning approach* to public participation.

A learning approach means that competent authorities and other stakeholders collectively take responsibility for creating the necessary conditions so that public participation becomes a way of learning about each others perspectives, views and knowledges, thereby providing the basis for negotiation between stakeholders about how best to implement the Directive.

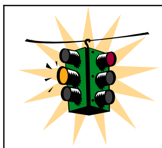
The following Sections illustrate some of the factors, which competent authorities will need to be aware of to assess and inform their own current practices and provide a basis for developing new approaches to public participation in the future. These factors can be grouped under the headings '**context**', '**process**' and '**content**'. Each is explained in turn.



Factors influencing the public participation process grouped in three main groups.

7.1 Context factors

Context refers to the **existing conditions or circumstances** in which the approach to public participation is being developed, since there will always be a 'history' of environmental management before the implementation of the Directive. It is impossible to describe the context of public participation in advance since there will be considerable variations between member states, over time, at different locations and scales and so on. However, the context can significantly influence public participation in terms of process design, content of discussions and outputs. In some instances the context may mean that it is inappropriate to initiate public participation without some change in existing relations between stakeholders. It is therefore necessary to be aware of the starting conditions if processes of public participation are to be successful.



Look out! Existing conditions 'set the scene' for public participation
These conditions evolve from a historical and local context regarding:
- Political culture of decision-making;
- Culture of stakeholder involvement;
- Organisational or institutional practices;
- Budget and resources;
- History of previous attempts to engage stakeholders;
- Environmental conditions;
- The scale of the project.

The strength of a good process is **to recognise the context** in which public participation is being developed and to realise that it may require competent authorities and other stakeholders to accept the need for some or all of the following **changes**:
- Changes in attitude of public authorities to the environment and other stakeholders;
- Organisational changes;
- Political commitment and resource allocation;

- Capacity building and representation of stakeholders;
- Reaching beyond stakeholders to individual citizens and enterprises;
- Demonstration projects to build trust and to learn from experiences.

These factors are explained in more detail.

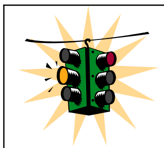
7.1.1 Change in attitude: stakeholders as partners in water management

Many government authorities have realised that the "command-control" resource management systems prevalent in the 1960s and 1970s have had some significant environmental consequences. Sharing the management of natural resources with the people that depend upon them for their livelihood, can help to make their management more sustainable, more efficient, less expensive, and more socially acceptable.

This shift means that the competent authorities may have to change their own organisational perspectives on the value of involving stakeholders in the process of decision-making and implementation. Dominating behaviour by authorities may inhibit participation, while an attitude where authorities realise they need to listen to knowledge, insight and solutions of their partners (stakeholders) in order to be able to provide high quality RBM plans encourages it. For those in powerful positions to adopt a non-dominating, learning attitude may even entail personal change amongst staff. This implies that water managers need to be technical experts *and* process managers. Adopting an attitude, which begins by defining water problems as human problems rather than technical issues, is a good way to begin to appreciate perspectives of other stakeholders.

As a simple way of revealing current attitudes to public participation, we invite reflections on the following questions:

- Why does your organisation (want to) engage in public participation?
- How is this achieved?
- With what results?
- To what extent have either the process or outcomes changed you or your organisation in any way?



Look out! Listen and be open minded
Public participation will not be successful if competent authorities and stakeholders do not respect, listen and learn from the views and perspectives of each other so that over time they become partners in the implementation of the Directive.

7.1.2 Organisational changes

Since public participation often requires a different working approach by competent authorities, it follows that a number of organisational changes may also be necessary. At the most basic, it may be necessary for the competent authority to :

- **Review its current organisational structure** to determine the level and focus of public participation at present and the extent to which its current organisational structure encourages or constrains public participation in decision-making;
- **Review the skills, experience and competencies of staff** to assess whether the competent authority either currently has the competency to engage in processes of public participation or whether it may need additional training;
- **Review the current budget and resources allocated to public participation.**

The need for an organisational review of competent authorities and the findings of the review will vary across the different member states. A review should really be considered since it is often too easy and too simplistic for one organisation to assume that it is *other* stakeholders that need to change when there is conflict. Equally, a review will encourage the competent authorities to determine training needs for staff that may have limited experience of public participation.

The process of public participation may also affect the organisation's practices. These may require the competent authority to ensure some or all of the following become part of the organisations 'way of doing things':

- **Making the results of the planning process more open-ended** (depending on new insights, knowledge, ideas for solutions). Active involvement is characterised by more open-ended processes. Active involvement is by its nature more uncertain and unpredictable in terms of content, scale, financial cost and time;
- **A flexible approach to the contributions of stakeholders**. The timing and tempo of stakeholder involvement may change throughout the process. The competent authority may have to make allowances for this;
- **A flexible approach to financial planning**. As decisions are made in partnership with other stakeholders, there will need to be some provision for open budgets (i.e. not earmarked to certain measures before hand);
- **Retaining a local rather than organisational perspective**. Public authorities working within a certain sector and or institution inevitably orientate towards their own obligations ands objectives and the delivery of these become the key concern. It is important to ensure that the local, broader context is not forgotten. 'Local' in this sense are also the habits and traditions within an international River Basin District.

The challenge of all types of organisations will be to handle these changes. Changes in procedures and structures take their time. However, in the meantime the change in attitude and skills of the motivated employees, actively supported and resourced by senior level management, will help in finding "room for change" within the existing organisational and institutional context.

7.1.3 Political commitment

The starting point for embarking on a participatory approach is a commitment at political level. This commitment has to be based on an understanding and awareness of the new obligations and why active involvement is not only beneficial but also necessary in order to deliver the anticipated water quality objectives as a significant part of promoting sustainable development.

In this regard, political representatives need to be aware of the following:

- The aims of public participation in relation to the development and implementation of the directive;
- The nature of participation, its implications and whether it compliments or replaces previous practices;
- The potential of stakeholders' contribution to water management;
- The need for political commitment to the process *and* the outcome;
- The role and timing of formal decision-making in the process and hence the particular contribution of political representatives;
- Means to reach beyond organisations and institutions to individual citizens;

- Possible consequences of the process. For example will changes in water pricing be more or less acceptable as a result of public participation in the decision-making process?
- Water management is no longer the sole responsibility of government authorities. Network organisations are needed in which government organisations work together with NGO's, business enterprises, interest groups, and experts (universities);
- The commitment from the politicians needs to be transformed into concrete resource allocation ensuring sufficient staff, budget, mandate, ambitious public participation objectives and internal training.

The **Danube River Basin** takes up approx 1/3 of the surface of Europe. Within this scale, linking local and international levels constitute a major challenge. The international cooperation takes place within the framework of the Danube River Commission ICPDR). **(see Annex II)**

Stakeholders e.g. NGOs can apply for observer status to the Commission, which implies full participation, no voting rights. A large number of smaller (national and local) NGOs are connected with this through co-operation platforms, notably the Danube Environment Forum (Assembly of NGOs), and other networks such as the Global Water Partnership CEE. The GEF-financed Danube Regional Project supports the Danube Environment Forum (DEF) by financial means, hereby enabling the NGO-participation in practise.

DEF is an NGO platform with combined local and regional structure, established in 1999 to promote NGO participation in government fora, programmes and initiatives. Within this context, the NGOs have been able to contribute e.g. as follows: facilitating dialogue on trans-boundary River Basin Planning, participating in the establishment of ICPDR Expert Group on River Basin Management and WFD Implementation, development of Issue Paper on WFD and Public Participation, ensuring NGO and public participation in the Danube River management and co-ordination through DEF, providing concrete, local cases for the ICDPR discussions.

7.1.4 Capacity building and representation of stakeholders

To take the steps from some degree of "consultation" towards "active involvement", whatever shape it may take, will be a challenge for the competent authorities and other stakeholders. As noted above, an organisational review will help identify whether those involved (whether the competent authority or any other stakeholder) in the process have sufficient capacity to engage in public participation. The capacity to engage could be dependent on resources, availability of experienced and qualified staff, their knowledge of the situation (e.g. what happens down-stream) and the extent to which those involved are willing to acknowledge the potential for change in the management of the water issues under consideration. This will mean that participants will have to be willing to take co-responsibility for decisions, which emerge from the participation process.

Providing stakeholders with improved access to information and decision-making, will also oblige them to take shared responsibility for utilising their networks and communication channels. Their members and associates should be made aware of some of the implications of the Directive and possible consequences of its implementation, for example about the Programme of Measures.

For example, business sectors that are further involved in the decision-making, and are eventually presented with demonstration projects aiming to identify appropriate water management solutions, will have an obligation to inform their members and encourage them to adopt a new approach to water use. For companies, an analysis of their situation and interests with regard to water management could include questions on the following issues:

- Current water use;
- Current pollution levels/recent pollution permits;
- Current measures to reduce/prevent pollution or other pressures;
- Relative cost levels on water use and wastewater services;
- Current incentives / legislative framework for water use;
- Degree of subsidises in the production process;
- Experiences with EMA / code of conduct / good agricultural practices;
- Awareness level and knowledge of the river basin, particularly down stream.

Equally, NGOs usually have intermittent problems financing their work programmes. Often they depend on various funding schemes offered by national or international donors. These schemes will become particularly relevant in situations where the competent authorities request participation in water management bodies. This problem is particularly relevant for local NGOs and regional branches of national NGOs, being less experienced and having less resource than the central offices, with often only voluntary members.

It will be up to the competent authority to determine how its own organisational approach to public participation can help other stakeholders overcome some of these and similar problems to build the capacity among a wide range of stakeholders to progress the issues. In some cases it may be appropriate for the competent authorities to provide, for example, secretariat support to stakeholder networks, to make information widely available and perhaps to offer training events on specific aspects of the Directive. Equally, the possibility of stakeholders informing and providing 'training' to the competent authority should not be discounted. Capacity building will be a two-way process.

7.1.5 Reaching beyond organisations to the individual citizens and companies

A significant part of a participation strategy should be prioritised to consider reaching beyond organisations and institutions to individual citizens. A large part of the water use as well as water pollution is generated at the level of single households, dispersed settlements, individual companies and agricultural units.

Reaching beyond organisations to individual citizens and companies is crucial for water management, due to the large share of water use and water pollution held by individual households, dispersed settlements, small and medium enterprises and small agricultural units.

7.1.6 Demonstration projects to build trust and to learn from experiences

Demonstration projects will help evaluate and demonstrate the success of public participation in the water management sector and offer the potential for all stakeholders to learn from practical experience. Competent authorities should be encouraged to initiate such projects. These projects could have a wide range of aims:

- Through a "don't talk about it - show it"-approach, to convince target groups to embark on new, different practices with regard to active involvement;
- To create win-win situations: active involvement gives stakeholders the possibility to influence the implementation process with regard to their interests, while the competent authorities will achieve a more widely accepted implementation.

Reducing water consumption in the Graphic Sector, Denmark (see Annex II)
The objectives are:
- To involve stakeholders in the set-up and implementation of demonstration activities;
- To make them "ambassadors" of the new water consumption practices, by showing results and its impact on sustainable water consumption.

The Danish Environmental Protection Agency unit for cleaner production consultancy company, selected companies from the Graphics Sector. The Graphics Business Sector Association were involved comprehensively throughout the entire process shaping the improvements within the daily activities of the companies and testing new equipment, supported economically by the project. With rather limited funding schemes, demonstration activities can successfully be conducted, with the results being extracted for later inclusion in revision of environmental regulation of the sector's environmental impact. Demonstration of concrete opportunities and providing of win-win examples allows for a new business paradigm to spread. Further, through this co-operation the Competent Authorities also get input on how to establish a feasible planning and incentive framework.

7.2 Process Factors

'Process' refers to **the ways in which stakeholders participate** in the implementation of the directive. This is not limited just to the 'delivery' of the directive, but includes the process in which stakeholders engage with each other to negotiate on issues of concern, possible actions and to determine how implementation can be best achieved. Experience has often shown that the quality of the process determines whether wider support for actions and measures is forthcoming.

The quality of the process is dependent on the principles which inform its design. It cannot be overstated that **trust and transparency** are fundamental to mobilising stakeholders to engage with each other and to take on shared responsibility beyond their own immediate interests. The difference between being partners in water management and opponents often rests on a lack of a trust, suspicion of hidden agendas and lack of a co-operative climate for creative solutions. The participation process should encourage:

- Trust;
- Openness;
- Transparency;
- Honesty;
- Respect;
- Inclusion;
- Positiveness.

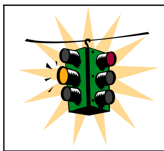
Translating these principles and using them for the design of a participation process is not always easy, since there are many stakeholders, new situations emerging and many aspects of process which need to be considered. However, practical experience suggests that a number of common factors, relating to process design and performance, are key issues for consideration by competent authorities and other stakeholders.

In summary, **processes for public participation should be characterised by some or all of the following:**

- Early involvement of people in setting the terms of reference;
- Developing co-ownership of the process design;
- Opportunities for learning between stakeholders;
- Mutual respect;

- Flexible and 'open' process;
- Iterative and continuous evaluation;
- Independent facilitation;
- Ongoing.

The above list does not include specific recommendations as to *how* to enable opportunities for learning, for example. This is because there is no one method which will work for all in all situations.



Look out! Challenges in the process
The challenge for the competent authority is to take these factors into account while developing and organising the process of public participation in conjunction with other stakeholders.

7.2.1 Early involvement in setting the terms of reference

This is an important consideration and should not be overlooked by competent authorities since one of the most common causes of problems in participation occurs when stakeholders feel excluded from the aims and design of the process. Involving stakeholders in setting the terms of reference can help to build trust and establish dialogue between different interest groups from the outset. The terms of references for the process might include agreement about the following:

- Objectives of the process;
- The general scope of the process;
- The range of stakeholders who are likely to be interested;
- Expectations of those involved;
- Communication protocols;
- Financial resources and allocation;
- Organisational support and contributions as required;
- Timescale and timetabling; and
- The contribution of the process and its outputs to formal decision making.

It is important to remember that the terms of reference can be modified as conditions change, the process gets underway or as new stakeholders are involved for example. This is particularly true of the process objectives, scope and participants.

7.2.2 Developing co-ownership of process design

As with setting the terms of reference, it is important that competent authorities explore with other stakeholders how best to proceed with public participation since there is no single design for participation which will suit every situation. A process based on co-development and co-ownership is likely to build trust, attract greater support from stakeholders and create a mutual willingness to make the process a success. Co-ownership also tends to ensure that the process is more suited to its purpose and maximises the skills and capacities of those involved. It will therefore be necessary for competent authorities to guard against presenting a pre-determined approach without an equal opportunity for participants to contribute to the process design.

7.2.3 Opportunities for learning between stakeholders

The design of the process should help to create opportunities for learning between stakeholders. This goes beyond simply presenting information (such as a lecture or presentation), which tends to be one-way rather than two-way communication. Instead, the design of the process should seek to encourage active dialogue between participants. In some instances, simply the act of bringing people together for the first time results in new insights about the different perspectives, aims, successes and problems of each other's work. This can develop into regular meetings of stakeholders to help establish new partnerships and help alleviate problems before they arise. While dialogue to develop understanding and enable learning between stakeholders is important, the process has to be more than a 'talking shop'. Experience and research suggests that stakeholders are highly motivated by achieving results 'on the ground'.

7.2.4 Mutual Respect

In many instances, stakeholders are not always in agreement with each other and differences of interest and opinions can often be entrenched. The process should encourage stakeholders to respect each other's views. Independent facilitation is often useful in these instances. For some, including competent authorities, this will not be easy to accept particularly if previous encounters have been marked with hostility and strong disagreement. Nonetheless, a learning approach to public participation will only succeed if there is an explicit acknowledgement of difference *and* a commitment to exploring the nature of that difference to identify possible common ground and agreement on how to proceed. The differences are often expressed in a variety of ways such as: disagreement about what the problem is (the identification of the problem); the kinds of information which are considered acceptable (scientific and non-scientific); and ways to proceed and the likely consequences of particular causes of action. The competent authority is likely to be in a central position here and should work to ensure that the invitation to participate and the process of participating builds a sense of mutual respect among all stakeholders by valuing the diversity of interests, views and opinions.

7.2.5 Flexible and 'open' process

This design factor is an important reminder that all stages of the process cannot be pre-determined. A flexible approach to process design is more able to accommodate change and learning as stakeholders engage with each other over time. Equally, an 'open' process is part of building trust between stakeholders. If the process is too rigid and constrains discussion then stakeholders are likely to withdraw support. In agreeing to participate, all stakeholders, including competent authorities, are under an obligation to listen and take note of others concerns. This may mean altering the process design over time.

7.2.6 Iteration and continuous evaluation

Iteration is about inviting participants to review the process, to reflect on what they have achieved so far and whether changes are needed to either process or content. It is part of the continuous evaluation of the process so that learning is incorporated into the process *immediately* and can inform current (rather than just future) ideas, negotiations and so on. This can be very effective, for example, where a new understanding emerges between stakeholders (such as a redefinition of the problem) and shifts the basis of participation onto a new level. Building continuous evaluation into a process can be as simple as identifying time for reflection at any stage – this creates a space in which participants can review what has occurred. The important point is that evaluation is not only just about an ex-post assessment or an evaluation of the outputs. It should be an on-going process.

7.2.7 Independent facilitation

This design factor is not always appropriate since some types of participation are not facilitated. However, independent facilitators can be particularly beneficial when relations between stakeholders are difficult and there is a lack of trust or respect between participants. Using a neutral third party can also help avoid concerns that the competent authority might dominate debates and agendas. Allied to this, it may be necessary for meetings to be held on 'neutral' territory. In any event, consider rotating the location of regular meetings between the different participants. This can keep ideas 'fresh' and new insights and understanding can be gained just by visiting offices of different stakeholders.

7.2.8 Ongoing

While large-scale one-off events have their place in participation, too often they either fail to have a lasting impact on the issues or they fail to generate large-scale ownership and commitment to act. Experience suggests that smaller scale, *ongoing* processes tend to provide more opportunities for stakeholders to establish trust and understanding between each other and are more likely to generate long term momentum. It also ensures that stakeholders who cannot make one particular meeting because of time pressures are not excluded, as they would be if the meeting was simply one-off.

7.3 Content Factors

Many of the **factors relating to content** are closely linked to the design of the process to the extent that many experienced practitioners of public participation often pay more attention to getting the process 'right' in the knowledge that the 'content' tends to follow naturally. As with other parts of this Guidance, it is impossible to be specific about the content of participatory processes. Even so, it is likely that the following factors will be important at some stage in the process:

- Valuing diversity of knowledges;
- Evidence, proof and uncertainty;
- Reporting and communication.

7.3.1 Valuing diversity of knowledges

As more stakeholders are involved, so the diversity of their experiences, views and knowledge is likely to increase. It is important to be aware of, and value, the different types of knowledge which stakeholders draw upon. These might include, for example, scientific expertise, and situated non-expert knowledges – often from stakeholders who live and work in the locality. It is important to realise that expert *and* non-expert knowledges can contribute to a better understanding of the root causes of the problem and lead to a more informed and relevant plan of action. Experience in the water resource sector has shown that generic 'expert' solutions have often been inappropriate for local conditions and have had unintended negative effects. Many of these could have been avoided if scientific expertise had been combined with local knowledge and experience. This is not least likely to be case with regard to defining the reference conditions, where knowledge on historic conditions - being equally distributed with authorities and other parts of society - may turn out to be of crucial importance, e.g. previous physical appearances of rivers and wetlands.

7.3.2 Evidence, Proof and Uncertainty

While valuing diversity is important, it can also create problems for determining what is accepted as 'evidence and proof'. Some stakeholders may insist that only 'scientific' evidence is acceptable as the basis of the decision-making process. Others might want to fill in gaps or qualify this information with their own personal experiences and observations. However, there will be many occasions where no scientific information is available or where considerable uncertainty exists either about the resource base of the consequences or of intended courses of action. There is no easy answer how to proceed under these conditions. However, if the process design is robust, then debates over uncertainty can be aired and decisions taken with this in mind. We suggest that competent authority should try to ensure that decisions are based on all the available evidence by accepting that non-scientific information can be a legitimate form of knowledge about the environment and can be used to compliment and inform expert opinion. In conditions of uncertainty, it will be necessary for the degree of uncertainty to be made explicit.

7.3.3 Reporting and communication

Non-technical summaries, which reflect the perceptions of the stakeholders and the broad public, are important in the reporting of the process. This also includes providing non-technical summaries of the RBD analysis for the local catchment situation. Thus, local stakeholders will be able to identify themselves with specific situations.

7.4 Conclusion

The preamble of the Water Framework Directive includes a very clear statement: active public involvement is most likely the key to success with regard to achieving the desired water quality objectives. This statement reflects several years of accumulated European water management experiences. In simple words: the water users and water polluters need to be turned into part of the solution, not being left outside the considerations as part of the problem. This Guidance has presented a range of recommendations on how to ensure active involvement. It is important, however, to take into account that no blueprint solutions can be provided. Each River Basin District has to find its own way to handle this, taking into account the prevailing cultural, socio-economic, democratic and administrative traditions. Careful planning, e.g. stakeholder analysis, is a particular recommendation, but each competent authority has to accept that a dynamic and learning process based on "trial and error" is the challenge to embark on. Experience show, however, that given sufficient time, it will pay off in the long run.

Annex I - Public Participation Techniques

November 2002

Why, who, when, how?

The first three fact sheets discuss the preparational steps of the participatory process:
1. Stakeholder analysis;
2. Problem and cause analysis;
3. Communication planning.

In the fourth fact sheet, the different communication techniques are listed, from two perspectives:
4. Interaction and communication tools.

The other fact sheets focus on specific techniques. In the future, e.g. after the Pilot River Basin testing, information sheets can be added:
5. Interviews;
6. Active listening;
7. Workshops;
8. Creative sessions;
9. Citizens' Jury;
10. Interactive Geographic Information Systems (Web GIS);
11. Public hearings (see also tool 9. Citizens'Jury);
12. Monitoring and participatory evaluations;
13. Computer tools for processing public comments.

Reference list
This list is currently empty but in future links and references to public participation tools can be added.

1. Stakeholder-analysis

When embarking on an interactive process it is of utmost importance to consider who will be participating in the process. To get an overview of all the relevant stakeholders (or actors) in the field of interest, a so called "stakeholder-analysis" can be performed. This analysis reduces the risk of forgetting an important actor and will give an idea about the different angles from which the subject can be viewed.

Stakeholder-analysis itself is a relatively simple and a methodological exercise. A possible methodology is presented in this Annex along with an illustration. However, it is left to the reader to assess how this can be adapted to her/his own situation and made relevant to the economic analysis process.

Background

A stakeholder can be any *relevant* person, group or organisation with an interest in the issue, either because they will be affected by the subject (victim, gainer) or because they have influence, knowledge or experience with the subject. The analysis will bring transparancy in what stakeholders already exist and which interests they represent. Types of stakeholders are: government, local authorities, non-governmental institutions, political organisations, research institutes, industries, agriculture, households or other businesses.

A stakeholder-analysis is usually performed starting from the contents of a project using the "who?" question (for example: we want to build a house, who knows how to build it?). Be aware that the problem definition must be clear from the beginning and that the problem shall be viewed from as many different angles as possible.

Besides analysing the stakeholders it can be uselful to map the environment of a project to identify external influences. The map could tell something about the interests, motives and relationships of the actors identified, the field of force they operate in and risks. For example: which stakeholders have a positive or negative influence on the project, who has power, who has the biggest monetary interest? Similar mapping can be done for factors influencing the process, often expressed as threats (e.g. weather, financial or human capacities).

Generally, a process consists of several stages (as illustrated in Figure 1). For every single stage, it should be reviewed which stakeholders are relevant to involve in the process and if the stakeholders have the same "rights". The role and involvement of the stakeholder can differ from stage to stage, and the stakeholder-analysis will make this more transparent.

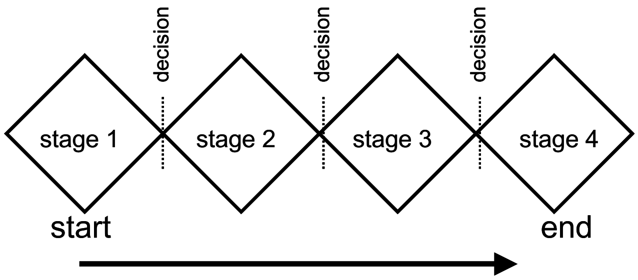


Figure 1: A process represented in diagram form

During the stakeholder-analysis the *degree of involvement* of every stakeholder (per stage) can be labelled as either (see Figure 2):

- *co-operating/co-working*: the stakeholder that will actually participate in and contribute actively to the process (i.e. active involvement);
- *co-thinking*: the stakeholder of which you want input with respect to content, it is a source of knowledge like experts (i.e. consultation);
- *co-knowing*: the stakeholder which does not play an active role in the process but should be informed of its progress (i.e. information supply).

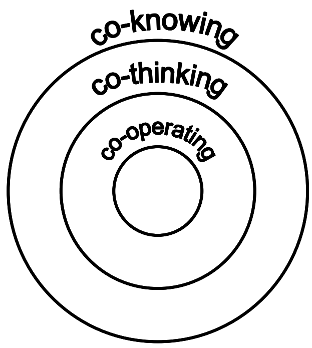


Figure 2: Target scheme to identify degree of involvement of stakeholder

If desired the identification approach can be refined by identifying the type of actor (see Figure 3):

- decision maker: stakeholders which decide about the project;
- user: stakeholders which use the result or are affected by it;
- implementer/executive: the stakeholders that have to implement the results or new policy;
- expert/supplier: stakeholders which put information, expertise or means at the disposal of the project.

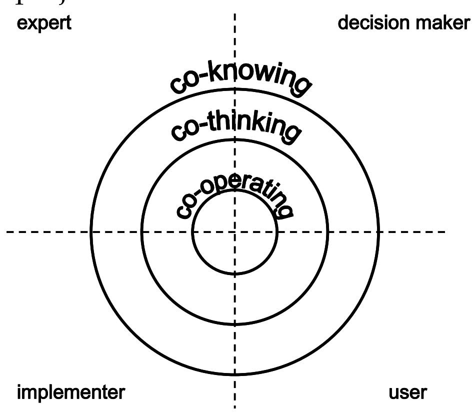


Figure 3: Refined target scheme to identify degree of involvement and type of stakeholder

Important! If the identified stakeholders are going to participate (actively or passively) in the project it is important to give feed-back to the stakeholder and specify clearly their role in order to avoid disappointments: management of expectations.

Stakeholder analysis: a simple methodology

Making the stakeholder analysis operational implies going through a series of steps of questioning and interaction. Although it needs to be adapted and refined to every situation, a simple methodology and series of steps is proposed below.

Step 1 - Define the stage of the process that will be subject to a stakeholder analysis. Putting the subject in question-form makes it usually more accessible and facilitate the identification of key issues/stages. It appears rather wise to invite stakeholders (of which it is obvious that they are involved) to take part in a brainstorming session;

Step 2 - A group of maximum 10 persons (the project team) including a chairman performs a brainstorming session in which as many stakeholders and perspectives or angles linked to the selected stages are mentioned.
Keep it rather general, name groups or organisations, not yet concrete names or people;
Every suggestion is written down without judgement.

Step 3 - Check if the main perspectives/angles can be split up into sub-units/organised in types;

Step 4 – Allocate to the stakeholders identified a concrete name (and address/contact information);

Step 5 - Check the result:

- Did we check all the stages of the process?
- Do we have the ones that benefit and the victims?
- Is the own project organisation included?
- Did we identify the people behind umbrella organisations?

Step 6 - Once the stakeholders are identified, the long list can be ordered by identifying the degree of involvement of each actor in each stage:

- Write down every actor on a Post-it notepaper;
- Draw up the "target"-scheme with circles on a flap over;
- Be clear about the stage in the process that is effectively analysed.

Step 7 - Put the notepapers in the right place in the "target"[2] (Figure 2 and if refinement is desired this can be repeated for Figure 3);

Step 8 - Check if there are no big gaps;

Step 9 - Use the result! e.g. for a communication plan to notify concerned stakeholders. Be very clear with each stakeholder about his expected role and involvement in the process (management of expectations);

Step 10 - The brainstorming session can be continued to identify relationships between stakeholders, their interests and motives and factors that influence the process.

[2] Keep in mind that the degree of influence of the stakeholders is a factor to be considered. It might be useful more closely to involve "big" actors with much influence to ensure commitment and a supporting basis.

Illustration of the stakeholder-analysis

A small case is presented for the illlustration of the methodology. Subject of the case is the pollution at the downstream part of the River Scheldt. The municipalities along the river recognise the problem and and want to improve the water quality, they are initiating this case. The process is described in Figure 4:

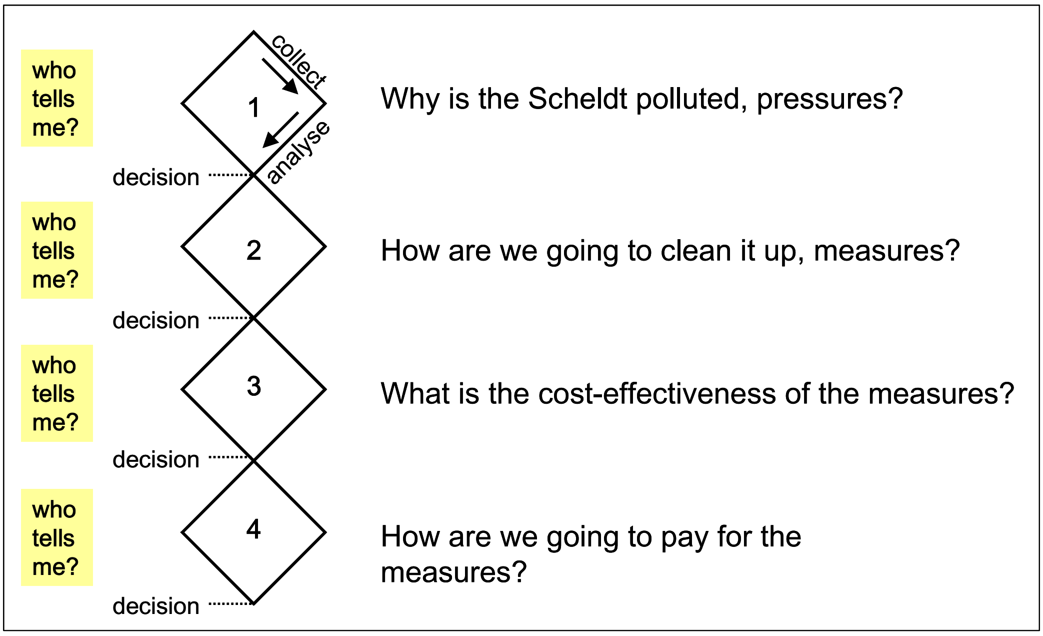


Figure 4: Different stages of a process concerning the pollution of the River Scheldt

Analogous to the presented methodology in the former sub-section, the possible results are presented below for the different steps of the stakeholder analysis and for the stage 1 of the process (i.e. why is the Scheldt polluter, pressures?).

Step 1 - Information is wanted about the pollution in the Scheldt, e.g. "Why is the Scheldt polluted?", who tells me that it is polluted?

Step 2 - The proposed project team will include the municipalities and they have decided to invite also representatives of the harbour of Antwerp and Vlissingen. As many different angles as possible are viewed during a brainstorming session. The output of this session is a (finite) list of stakeholders involved:

ICPS (Scheldt commission)	People in the neighbourhood
Agriculture	Harbours
Recreation	Municipalities
Dredging companies	Shipping traffic
Fisherman	Industries
Government	WWTP

Step 3 – More detailed discussions show that the type "Industries" can be split up into:
- Industries with emission to the air (deposit);
- Industries with discharge to the water.

Step 4 - The list is defined more precisely:

ICPS (Scheldt Commission)	People in the neighbourhood
Agriculture: - farmer A, B, C; - poultry farm D; - pig farm E, F.	Harbours: - Antwerp (B); - Ghent (B); - Terneuzen (NL); - Vlissingen (NL).
Recreation: - anglers; - canoeists; - cyclists.	Municipalities: Antwerp, Ghent, Terneuzen, Vlissingen.
Dredging companies: - company X; - company Y.	Shipping traffic: - EU umbrella organisation for shipping traffic
Fisheries	Industries: - emissions to air: industry G; - discharge to water: industry H.
Government: Belgium (Flandres, Wallonia, Brussels) The Netherlands	WWTP: Antwerp, Ghent, Vlissingen, Terneuzen.

For all stakeholders the contact person/competent authority should be identified and the address/contact information identified.

Step 5 - Checking the result shows that it is unclear which shipping companies are represented by the "European umbrella organisation for shipping traffic", as only shipping companies operating in the Scheldt area are seen as relevant. This will need further checks by the project team. It is also noticed that environmental NGO's are missing from the list of stakeholders identified so far, and the union for the "Protection of the Scheldt landscape" is added to this list.

Step 6 & 7 - The degree of involvement of the stakeholders is expressed by allocating stakeholders into the target scheme (Figure 5). For the first stage of the process (why is the Scheldt polluted, what are pressures?), much information needs to be collected. Thus many stakeholders end up in the second circle (co-thinking) of the target scheme. Some stakeholders are known to have a great socio-economic influence and are asked to co-operate together with the project team (inner circle). The outer border of the figure show the organisations that will be informed about the project.

Step 8 - Check for gaps in Figure 5, refine it.

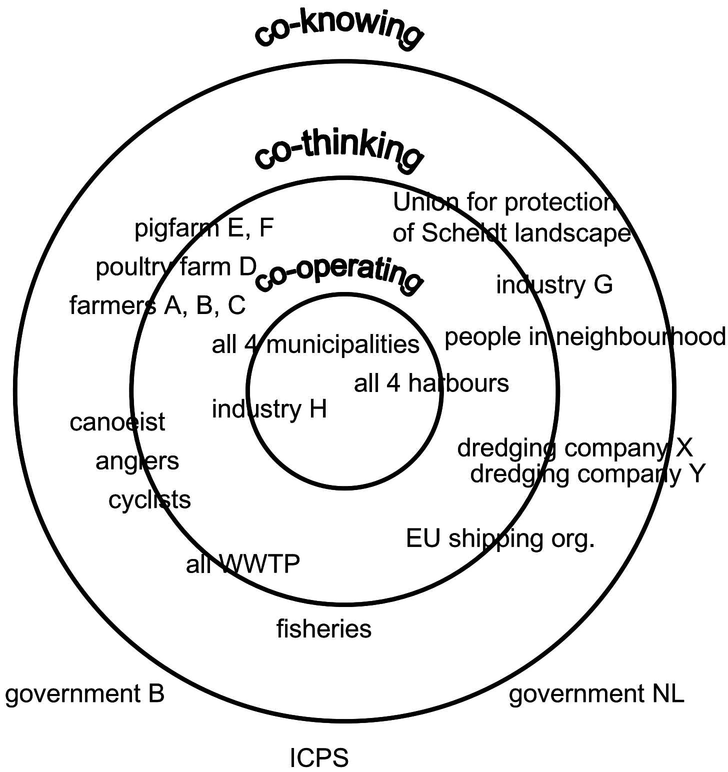


Figure 5: Target scheme with stakeholders who can tell about the pollution of the downstream part of the River Scheldt

Step 9 - The results of the brainstorming session are included into the project plan. Decision is taken that the harbours of Gent and Terneuzen and Industry H that are not yet part of the project team will be approached for co-operation.

Step 10 - The brainstorming session can be continued to refine the target scheme according to Figure 3 and/or to map the environment. Simple questions such as: What is the interest of Industry H?; What is the relationship between municipality A or harbour W? will help increasing the project team understanding of the role and stakeholder relationships.

References

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2000.

WWF's preliminary comments on Public Participation in the context of the Water Framework Directive and Integrated River Basin Management; *Adam Harrison, Guido Schmidt, Charlie Avis, Rayka Hauser*, WWF, June 2001.

2. Problem and cause analysis

Objective

Good policy starts with a good and divided analysis of the problems and underlying causes, for which the policy should be developed. For this purpose a problem and cause analysis can be applied. It is a schematic reproduction of a causal complex which is hidden under or behind a problem and it forms the conclusion of the exploration phase.
There will be no good basis to reflect upon the problem until there will be an explicit agreement on the issue as outlined in the analysis. In the first place, the analysis contributes as argumentation to the problem solving strategy. Next to this it will function as a ruling document for the competent authorities at their consideration to what causal level or in what area the most successful actions can be undertaken.

Amplification

In may cases the analysis will get the shape of a 'tree': the most penetrating causes are situated at the bottom, while the symptoms can be found at the top. For this reason the tree is to be read from below to above.

The circles are the recapitulations/summaries of groups of quotes from an anthology (possibly supported by small blocks of literal quotes) or literal quotes.

It is preferred to formulate these recaps as close as possible to the original statements; this will lead to more recognition rather than official formulations.

Procedure

The P&C analysis is to be set up by (a part of) the project team. The persons that have to deal with this should know the situation and context well and have some analytic abilities. It is advisable to call upon a person very well experienced in the making of these kind of analysis schedules.

Make 'in relay' an anthology of the quotes.

In an anthology the quotes have usually already been classified. Sometimes one can get quite far along by indicating the relations between and within the subjects. The analysis phase will require more or less arranging of the quotes, depending on the number of preparations that have already been taken place.

Separate the quotes or groups of quotes that belong together in the anthology. In doing this you should use your common sense. Dare to let loose the work of the anthology, but keep from doing unnecessary double work.

Tape the flap-overs together and put them on the ground. Put the quotes down and start arranging them: put the most thorough, most fundamental causes at the bottom and put the symptoms at the top. By doing this slowly but surely a (number of) schedule(s) will arise. It is not necessary for the whole group to join in this procedure A number of team members can do this by themselves and in a later stage the complete team can compare the 'cause/consequence-trees'. Be aware not to divide the quotes in stacks in a too early stage, as it is important for all team members that they will be able to draw from all quotes available.

Agreement

The P&C analysis will for the first time be submitted to the public for agreement: does everybody agree that this analysis presents a good diagnosis of the problems to which the conductors should take actions?

What does and what does not?

Furthermore a choice needs to be made on which items of the policy route the project team should concentrate. More often the analysis embraces a field to which the project has no influence. For that reason this part drops out, the policy cannot influence this part of the causes. It is important to communicate this conclusion to the public.

Priorities

Priorities can be made for the remaining items, with or without the public, but need to be authorised in all cases by the competent authority. At the conclusion of the exploring phase it needs to become clear on which causal level/in which field successful actions can take place. It should be the ambition to intervene as deep as possible into the causal complex, in order to prevent the symptom contest. However, the deeper and more fundamental the causes, the more difficult it will appear to solve them.

Policy formulation

During the phase of policy formulation the information from the analysis phase can be used as a basis for the shaping of ideas.

Presentation

In a very abstract and analytical way the P&C analysis will give a view of the problems to which the policy should take hold of. It forms the legitimation of choices that are to be made in a later stage of the route. The way of this presentation however will not be appreciated by everybody. Therefore it is advised to use the schedules in a direct way. Or look for an alternative way.

The schedules are adaptable for internal use, as 'evidence' or as input for conversations with some expert groups. For other objective groups images (cartoons, photos, ……….), metaphors, a story or a written text can give better results. It is therefore advisable to write down the problem and cause analysis in an accompanying, summarising text and eventually add the schedules in an enclosure, being a recap of the previous route and as a foundation of the conclusions.

Tips

Pay attention to blind spots: There may lack an important point of view. A number of additional interviews can fill this gap.

The stress for problems and causes may cause quite some resistance: 'how negative this is, while also positive things happen?!' In this case emphasise the objective of the analysis: the searching for the deeper causes of the bottlenecks, not yet for solutions. Essentially for this approach is not to be derived by a vision or being led into a problemsolving direction in an too early stage.

A way to deepen the analysis is the organising of expert meetings.

Be aware of the question or assignment you give at the presentation of the schedules. The question is not: 'Do you agree?', but: 'Is the analysis right. Does it give a good diagnosis of the problems to which the policy shout take action?'

It sometimes appears that the schedules are too rough or over-simplified to get good answers: a way to structure the discussions on the P&C analysis is to nominate tangible topics or conclusions, to which the project team should like to gather more information.

A combination of searching for solutions or policy options are at hand here. Moreover while a natural reaction of people will be: "This all sound very good, but what is your aim to this? Where is the link to what you would like to achieve: the policy objectives?"

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

3. Communication planning

Objective

Communication is an important instrument in public participation, it is the lubricating oil of the PP-process. The additional schedule can be a first step for the formulation of a communication plan.

Stake

The formulation of a rough communication strategy will take place during the early stages of the route, and preferably during the starting phase. At the entering of every next phase the plan will be adjusted, since the role and the dedication of the actors (and therefore their need for information) can change. The added schedule can be used a working document which can help in providing an overview of all communication activities. Naturally a flexible process also demands flexible communication: a continuous alertness for developments within the project which make communication possible or necessary.

Amplification

The basis of the planning schedule (see Figure 3.1) is the classification of the actors into their category of involvement. At this stage the actors are grouped into four main catagories, all of which ask for another communicative approach:

Co-operators: members of the project team and others who play an active role in the project (i.e. active involvement).
Communication objective: exchange of information on the performance of the activities within the project.
Means: project group meetings, lists of action points, working documents, etc.

Co-thinkers: actors who can, at any moment in the process, be consulted or who contribute in an active way (i.e. consultation).
Communication objective: to inform, interest and stimulate a positive, co-working attitude, and to give continuous back-up of the process steps.
Means: interviews and workshops, newsletters, comment rounds, etc.

Co-knowers: actors who need to be well-informed of the project (i.e. information supply)
Communication objective: informing and giving them the possibility to respond.
Means: a general brochure, intranet site, information meeting, etc.

Deciders: the competent authority (and their advisors), that can make decisions at critical moments.
Communication objective: to inform, and to stimulate, preferably, an active attitude.
Means: reports, presentations, etc.

Along the vertical axes in Figure 3.1 the steps of the process are stated.Here the most important data are implemented. In this way a matrix is being created, in which at any time the the means for every objective group can be filled in.

Procedure

Start making an inventory of the actors after dedication.
Fill in the process structure: which data are important?
Pinpoint in every sector of the matrix what you would like to achieve at that particular moment for each group (co—workers, co-knowers, etc.). What will be the communication objective and what is the main message in that particular phase of the project?

Now fill in the communication means at the proper point of time in the process structure
- take the existing communication means and – channels as a start
- search for combinations of written and oral communication.

Make a plan for each means of communication.

Tips

Appoint one member of the project team to be explicitly responsible for the communication
Adjust the grouping of the actors at the start of every new step in the process. It may be possible that a specific actor has been interviewed during the inventory phase, in this case they need only be informed at a later stage. On the other hand it is possible that a 'co-knower' will become a 'co-thinker' during the next phase of the project.

Make sure that no actor 'is being lost': every person that has ever played a role in the project should remain at least as a 'co-knower'. Radio silence (no feed-back, no response) appears to be an awful let down for actors in interactive processes.

Make use of as many existing communication channels as possible, such as existing consulting networks, internal newsletters, intranet site, etc. An additional newsletter may lead to an overload, while a small article in existing and well-known newsletter may be more appropriate.

It will be possible to set a number of broad communication channels, such as a general brochure, intranet site, a universal report cover, etc. On the other hand, be careful not too widely distrubute reports, anthologies, P&C analyses, etc. It is advisable not to send these kinds of reports to all co-knowers, but enable them to see to a summary. An excess in information will bring the opposite result.

The project team must always be available to respond to questions and suggestions and this interactivity must be done in a transparent way.

It can be useful to give all means of communication within the project its own prospect: a kind of house style, slogan, colour combination or image will make the project recognisable. However, always consider the (substantial) costs versus the benefits. And remember the house style of your own organisation!

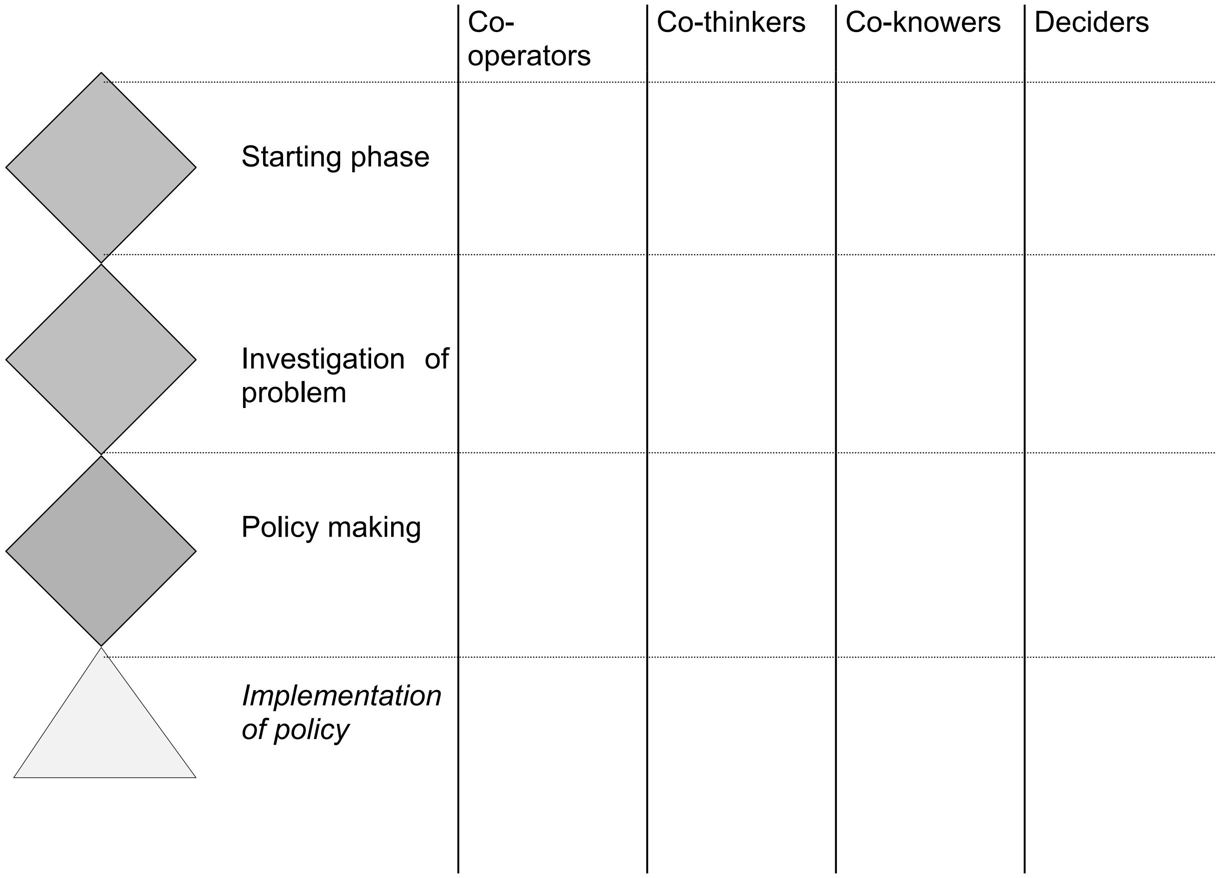


Figure 3.1: Important steps in the policy making process and the involvement of the different categories of actors

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

4. Interaction and Communication tools

Workshop, sounding board or interview... The interaction and communication with the environment can be designed in several concrete forms. But which means fits the objective? When to choose what? What are the considerations? This inforsheet offers inspiration for a diversity of means. Also it gives some oversight in the multiformity of choices which you need to take while making a proces design or communication plan.

- The first two pages offer a number of criteria that can be of help by choosing certain means;
- Page three offers a “stain chart” with several means, classified after objective;
- Page four and further offer a short description of the different means in alphabetical order.

Criteria: when which means?

What is the aim of the interaction, what do you expect of the parties?

Co-operating: asks for interactive media, such as working meetings, etc.

Co-thinking: asks for “tapping” means, like interviews, discussion groups.

Co-knowing: asks for advising media, like presentations, articles, factsheets.

Using a stakeholder analysis (see first sheet) you can answer this question.

Is it important to pay attention to relationships next to content? If so, choose as little as possible for written communication and as much as possible for personal contact. Do not leave this to third parties but do it yourself.
Is it mainly about communication between project and target group, or also about communication between actors? In the last case, choose group meetings with plenty of time for networking and information exchange.
How much money, time and capacity is available?
Will you use a permanent committee or will you organise a temporary one?
How large are the target groups? The bigger, the more difficult personal communication will be. In that case it is useful to look for liaisons.
Will you ask a selected company, or do you invite everybody to contribute?
Will the information get out of date soon? Do not choose for printed media, but for printing presentations and the internet.

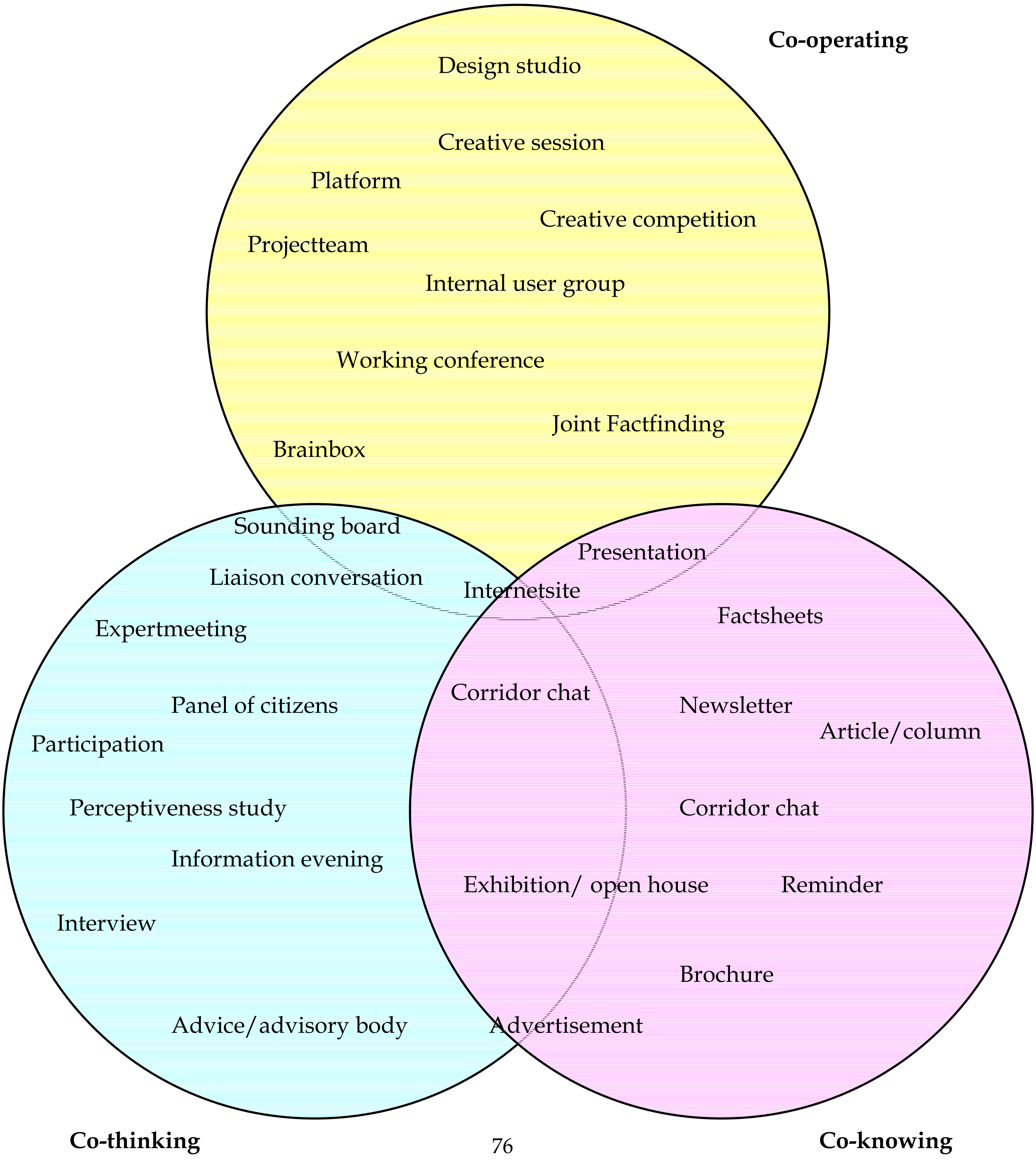
Tips

Do not underestimate the value of showing your face: personal contact will be the best way to establish bonds and to inspire confidence. It also shows that you value the other party.
In general people are bad readers and better listeners. Oral, personal communication is the most effective. Search for the combination: oral supported by written.
Management of expectations: be alwas clear about the status of a certain contact. Tell at the introduction of the day what the objective is and what will happen with the results.
Always state the name of a contact person, or point for reactions, on all communication means.

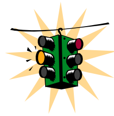
Do not 'forget' people: once communicating means to continue communicating.
Always provide minutes after a meeting, in which is stated what will happen with the results.
Read also the infosheets in this Annex on Communication Planning and Preparation of Workshops.

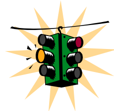
Stain chart for forms of interaction and communication

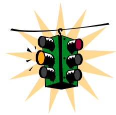
To put into action the different communication means is no hard core science. By presenting them slightly different a co-thinking day can transform into a co-operating day. Often these means are close to each other. The following arrangement gives broad outlines. All means can be found in alphabetical order and with an explanation in the tabel on the next pages.

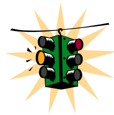


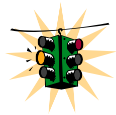
Interaction and communication ABC

Technique	***Description***	***Look out !*** 
Advertisement	Certainty that information is presented unchanged at a certain time in a certain medium. Suitable for bringing projects to the attention of for example people living in the neighbourhood of a planned construction project. Can be obligatory in official participation procedures. Can reach a wider public.	Only space for limited information, this can sometimes be understood as "sales talk". Expensive.
Advice/advisory body	An advisory body advises on request of for example the minister or out of their own.	An advisory body cannot be used directly in the project, but can advise in all stages of the policy making process and signalise issues to be put on the agenda or fulfil a canalizing or sounding board function.
Brainbox, electronic meeting, (ballot box)	IT supports participants of a brainstorm meeting, structures information and decision-making. Fast method to collect information with the possibility to give anonymous input.	Experienced facilitator is essential. Combine brainstorming in front of the computer with discussion around the table.
Brochure	Can be used to present a short summary of the project, indicates the most important issues and how to participate. Can be limited to one edition, can be made cheap but also very expensive. Informs many people and restricts misleading information.	Can be interpreted wrongly, contains limited information, no direct feed-back, sometimes hard to disseminate. Quickly out-dated. Always state contact person, telephone number, and e-mail address.
Corridor chat	Individual (informal) approach of people. Good means to ask attention for project, process or aspects from it and in reverse to see if something goes down well. Get an idea what is at stake.	Informal, person-dependent, sensitive to twaddle, does it fit your personal style? info could start to lead a life of its own. Do not forget to update your collegue next door or other departments.

Technique	***Description***	***Look out !*** 
Creative competition	Establish groups comprising people with different backgrounds. These groups look for innovative solutions in the policy making stage while "competing with each other". This method allows for retaining wider creativity over a longer period due to the different backgrounds. People seek a compromise and a range of different perspectives which prevents the drop-out of solutions in an early stage . (Groups of people of the same background would most likely strive to a uniform solution from the outset).	
Creative sessions	Formulation of groups to find and select solutions. See Section in Annex I "Creative sessions".	
Design studio	To work in small groups (max 5 p.) to elaborate solutions. "Informal" version of creative competition (see above).	
Exhibition, Infocentre, Infopillar, ***Open house, Reading corner, Posterpresentation,*** ***Stand at a fair***	To make accessible to interested parties the knowledge of participants. Gives general information at relatively limited costs, you might reach people who wouldn't participate otherwise. The project is made 'visible'.	One-way communication: gives info but does not receive. Use simple and accessible language, no jargon. Pay attention to anouncement. Give name of a contact person and telephone number.
Expert meeting	Meeting for collection of the commentary/observations of experts on ideas or proposals, or to collect specific information. Make sure that the participants do not feel 'drained' on information only: give them something in return.	Mobilising several experts and finding a date for the meeting can be difficult, invite far in advance. Participating experts can be (business) competitors and may not speak their minds. The panel chairman needs to know the subject well. Besides contents, think about inviting people with experience/empirical knowledge. If the aggregation of new ideas is the objective: do not limit to one and the same sector or discipline.

Technique	Description	Look out ! 
Factsheets	Give a summarised state of play on ±1 A4. Directed at people who are rather deeply involved in the subject or the proces of the project (co-operators/workers and co-thinkers, sometimes co-knowers). Quick and easy to make, also by having a format on A4 pre-printed which is filled in with up to date information. Relatively cheap.	Possibly requires repeated publishing. It would be good to receive feed-back on the factsheet from the relevant people. However this technique does not offer this possibility. The message should contain tailor-made information, reflecting the needs of the recipient. Always indicate a contact person.
Information evening	Provision of a meeting point to enable networking, a group of co-knowers/co-thinkers is informed.	Do not fill in the programme completely, leave some space. Plan long breaks to give opportunity for informal contacts.
Internal user group	Broad composition of sounding board, specifically for internal projects (in organisation of competent authority).	
Interview, personal or by telephone	A direct way to exchange information. Give people the feeling that someone is listening. Combine a in-depth conversation with a networking function. This can be a valuable investment.	Can be time consuming, reach is limited. Do not tender interviews: doing it yourself is likely to increase the involvement.
Intranetsite, Internetsite, Discussion group on internet, ***Electronic participation and on-line planning***	Gives the possibility to inform and interview people via a computer network or internet. Participation is made easier. The discussion can be protected against other internet users.	Computer infrastructure is the limiting factor. Some experience with computers is required. Target group is unverifiable. Maintenance and updating is labour-intensive. Pay much attention to communication to announce these actions. Discussion group can be a good preparation before a meeting.
Joint factfinding-guiding-group	Group of involved parties and interested parties which guides a process of joint factfinding. Group is involved in the formulation of research questions, selection of research bureau and assessment of interim results. Co-ordinated by initiator with scientific quality check.	

Technique	***Description***	***Look out !*** 
Liaison conversation, conversation with possible mediators	Conversation in which you address someone about his/her membership of other networks/fora and in which you make agreements about the transfer of information (back and forth). Part of the dissemination of information is outsourced and it offers entrance to neighbouring networks, which can be too far from the subject to involve closely.	Most likely you have to approach these liaisons several times. Often you assume implicitely that people inform their own party. However this hardly ever happens automatically (unless the value of the news is high). Provide with supporting information.
Panel of citizens /focus group	Qualitative research under citizens by means of group interviews, in which the project team/civil servants follow the interviews in a separate room via cameras. During the interview they can ask the interviewer to ask supplementary questions.	Interviews are done by professional agencies. To find out what citizens think is important with regard to issues such as "safety".
Participation	Can be a legal procedure to give citizens a chance to give their opinion about projects and decisions	
Perceptiveness study	Survey which has the aim to identify value judgement of citizens and the estimation of effects of policies or plans from the perspective of the citizen.	
Platform	More or less fixed committee of representatives of organisations, who meet regularly to exchange organised opinions about a certain theme. Can be used as societal thermometer, for competitive cooperation or for policy preparation.	
Presentation	Presentation for formal committees or for a working meeting, etc. You bring the subject to the people which increases the chance that they take note of it.	Timing is very important, even the projectplanning might be adapted to it. Tell clearly in advance why you have come to make a presentation (informative, to probe opinions and what are you going to do with it? will it be used in decision-making?)

Technique	***Description***	***Look out !*** 
Project team	Projectleader + team, often from the competent authority that take care of the organisation and steering of the project.	If possible involve people in the team that should play a role in the continuation of the project (next projectleader, more regional civil servants).
Reminder	Small present as a thanks, it works as a reminder for the project. A present of daily use keeps people alert at work.	Keep it austere, it might be governmental money. Try to be original, a stale present works contrarily.
Sounding board	Varied group of stakeholders which follows the policy process closely and which advices the decision-makers regularly about decisions to be taken or the progress.	Make good appointments about the status and the input of the sounding board. Take care of a good secretariat and timely information supply
Working conference (with simulation, brainstorm, priority of alternatives, scenario discussion, etc.)	Meeting with a limited amount of participants to deepen the insight in a problem or to map possible solutions. A lot of information exchange, images, arguments. Solutions can be tried.	Good selection of participants, recruitment, preparation, participation and follow-up take a lot of time. Determine the objective well. Is it diverging or converging? Is the input/ contribution of the participants really useful? See to an adequate facilitator and good reporting.

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

An overview of available tools[3]

The available tools can be grouped into five categories according to the main support of these tools : internet – Web, classical communication tools, groups meetings, visits and field observations, softwares.

They can be also categorised according to the phase(s) of the participation process at which they are the most adapted : starting and organisation phase, actors and context analysis, diagnostic of the current situation, search for solutions, implementation and evaluation.

TOOLS AND TECHNIQUES Categorised by main support and by aim or method.	**PHASES OF THE PARTICIPATION PROCESS**				
	Starting Organisation	**Actors analysis context**	**Diagnostic of the current situation**	**Search of solutions**	**Implementation, evaluation**
INTERNET – WEB					
- Interactive Geographic Information Systems (Web GIS).			*	*	
- Interactive Web Site	*	*	*	*	
- Informative Web Sites Web, polls via internet.	*	*	*		
- Tools for self-evaluation (Web Site, virtual information centre).					*
«CLASSICAL» COMMUNICATION TOOLS					
- Tools for passive information.	*				
- Tools for active information.	*				
- Collection of comments by poll or interviews.		*	*	*	
GROUPS MEETINGS, WORKSHOPS					
- Public audience.			*	*	
- Group for actors analysis.		*			*
- Group for „Participatory Rapid Appraisal“		* *	*		
- Group for „Evaluation of the Citizens Values“	*		*	* *	
- Thematic Round table				*	
- Prospective Conference					
- Workshop for participatory conception of solutions					*
- Participatory follow up and evaluation					

[3] This overview is made on the basis of a study recently ordered by the Water Department of the French Ministry of Ecology and Sustainable Development.
Source : « Comparative study of information and public participation means to water management in three countries : Quebec, The Netherlands and Denmark ». Dominique Drouet, Jean-Philippe Détolle, Michèle Sachs (RDI, Recherche Développement International)..

TOOLS AND TECHNIQUES Categorised by main support and by aim or method.	**PHASES OF THE PARTICIPATION PROCESS**				
	Starting Organisa-tion	**Actors analysis context**	**Diagnostic of the current situation**	**Search of solutions**	**Implement-ation, evaluation**
VISITS AND FIELD OBSERVATIONS					
- Observation network of fishes (ROPED).			*	*	
- School network for the study of water pollution, other networks			*	*	
- Visits on the field			*	*	
OTHERS TOOLS (SOFTWARES)					
- Software tools for the management of the comments.			*	*	

Recommendations for the choice of tools

The choice of the tools and techniques for information, consultation and participation depends on the objectives, available resources and the stage of the process.

Some tools result from many years of experience. This can be considered as a quality proof. Firstly a range of techniques and tools which are quite classical but which have proved themselves (numerous implementations, often positively judged) can be used (or testsed).

Anothergroup to take into account comprises emerging tools, which are based on communication technologies, such as the internet and the Web. Some of these new means must be studied in the viewpoint of the participation process which will be put in place for the implementation of the WFD (art 14)..

The use of the formal approach of public audience, even if it seems very efficient, arouses some reserves.

The scale issue appears as essential : it is needed to modulate the objectives according to the scale of the « project ».

5. Interviews

Objective

In public participation the opinion and/or knowledge of the parties concerned play an important part. The question however is how to trace these. A way of "tapping" the environment is to undertake 1-to-1 interviews with a number of the concerned parties. The target of the interviews seems to be easy: getting to know as much as possible on how the interviewed person thinks about the policy item. The right line of questioning can help to achieve this. The following text provides some tips on how to carry out the interview.

Main Issue

During the exploring phase taking interviews can be one of the ways to make an inventory of the opinions of the parties concerned. Besides that it is a good way to make personal acquaintance with the concerned parties. The results are gathered in an anthology, on the basis of which a problem- and cause analysis is made.

Amplification

A number of very open key questions form the backbone of the conversation. The emphasis lies in the identification of problems and causes.

Key questions:
- What kind of developments do you see?
- What kind of problems/bottlenecks do you foresee?
- In your opinion, what are the causes of these problems?
- In your opinion, what is the desirable situation?
- Why is this the desirable situation?
- What can you or what would you like to contribute in order to achieve the desired situation?

Help questions

The situation can arise that the questions are too open or that the lecturer has little to stimulate. In this situation it would be best to rephrase the question. However the essence (developments, bottlenecks, causes) of the question must always be maintained.
For example:
- Think of developments, both long andshort term;
- How do you qualify the problems mentioned: as serious, superficial, etc.?
- Suppose you would look upon your department/field/working area from another point of view/ …….; what kind of problems would you see then?
- When would you feel the policy in this field is being adjusted well and why?
- What would need to be changed?

Procedure

The project team, together with a number of others, will take the interviews themselves. The number of interviews depends of the outcome of the actor's analysis, but can vary from 15 to 100 interviews.

The preparation

Determine – by means of an actors inventory and analysis – which actors are the "co-thinkers". Regular summaries will bring structure to the conversation and helps the listener to check their understanding.

Send invitations in which the motive and the target of the conversation are mentioned:
- inform about the content of the conversation, but not about the actual questions;
- make sure the letter is signed by a high-placed person (the principal);
- make a telephone call after the letters have been sent in order to make a final appointment.

Provide a clear briefing of all interviewers beforehand, including a short training session in active listening.

The interview

Before the interview: Assure yourself and once more briefly recap the context in which the conversation needs to take place.
During the conversation:
- use the question list as a checklist and guiding principle, not as an inflexible must;
- keep track of the time (take one hour as a minimum);
- do not use a tape recorder, but take brief notes in shorthand;
- do not be too formal; treat it more as an informal conversation.

At the end of the conversation:
- check if all questions have been asked;
- ask whether the interviewed person has anything to add;
- write down the person's address;
- inform the person what will be done with the notes (e.g. that they will be treated confidentially and will be summarised in an anthology, which is to be subject to feed-back).

The report

Write up the notes immediatly after the interview; at that time it is still fresh in your memory.

The interview reports are only for your own use: deal with them in a confidential way and make anonymous quotations in the anthology .

Stay as close as possible to the statements of the interviewed person.

Rephrase in case the statements might be unclear for the project team.

Agree to a standard for the processing:
- on the computer;
- reward the statements you found of interest for yourself with a *;
- classify the answers after sequence of the questions.

Tips

Do not contract out the interviews. The interviews give you the opportunity to get acquainted with important contacts in your working field.

Dividing of interviews prevent interviewers taking interviews with their own contacts. Too great an acquaintance can easily result in assumptions being made. (i.e. "oh, you do understand what I mean by this") and there will be a great risk that the interview will give a poor result.

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

6. Active listening

Objective

The objective of the interviews in the exploring phase seems so easy: getting to know as much as possible on how the interviewed person thinks about the policy item. It however appears to be hard for the interviewers not to enter into the discussion themselves. This can be prevented when interviewers are aware of their own behaviour during these discussions. Some practical tips on listening skills, in order to get the best possible benefit from these interviews:

Main Issue

The below-mentioned guidelines can be used as a basis for a short training for the interviewers in how to listen actively, at the beginning of the exploring phase.

Tips

To do:
Ask open questions.
Ask questions to which the relater can give broad answers, for example questions that start with words like 'how', 'what', 'why', etc.

Summarise.
To summarise regularly will bring structure to the conversation and helps the listener to check whether or not he has understood the issue well: "When I get it well then …'

Ask through.
Questions like 'Do you see any more aspects?' or 'Can you give an example' explore the matter further.

'Humming'.
To 'hum' regularly or to confirm the lecturer ("yes", "indeed") stimulates the lecturer.

Drop a silence.
People have a silence tolerance of only a few seconds. After only four seconds someone will continue speaking. It motivates the lecturer if there are moments of silence from time to time: the lecturer will be stimulated to inform his audience further on the matter in question.

Non-verbal communication.
Regular eye contact, a slightly bent-forward position, approving nods from time to time, etc. demonstrate attention to the lecturer.

Not to do:
Do not ask closed questions.
Questions like: "Do you know the department?", "Do you like apple pie?" can only be answered by the lecturer with yes or no, and therefore will not provide much new information.

Do not ask multiple choice questions.
A variation on closed questions: "Do you or don't you like apple pie?" This kind of question also provides little information.

Do not ask suggestive questions.
Strictly taken, the answer is enclosed in this kind of question: "I take it you do like apple pie? ". The lecturer is being steered in a certain direction when posing this kind of question.

Do not present your own opinion.
The lecturer will be inhibited in telling his story in case you present your own opinion. It will also inhibit the interviewer from listening.

Do not enter into a discussion.
This is the biggest pitfall for listeners, especially when the lecturer mentions an item which is not in line with the interviewer's opinion. However, "yes-no" conversations are conversations with another aim than to gain information.

Do not interrupt.
Let the lecturer tell his story.

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

7. Preparation of workshops

Workshops – or whatever you call meetings – can be helpful in consulting stakeholders. But only if the contribution to and place in the process is well-considered.

Checklist preparation

1 - Consider the place in the overall process

- In which phase are we?
- Are we in a divergent or the convergent stadium?
- Is there a decision at hand?
- Do we want the people to react or to creatively invent?
- What is the position of the participants in the process?

2 - Determine the problem with regard to the contents

What is the objective of the meeting in terms of contents and relations?
Which questions have to be answered?
Is the group prepared to answer these questions?
Inquire after what is admitted for discussion and what not! Determine the boundary conditions of the conversation: which subjects are no longer under discussion?

Is the objective:

To develop a vision, to collect ideas, then:
pay attention to the human, postpone a judgement.
Decision making, then:
besides diverging also converging and formation of a judgement.
Transfer of knowledge, then:
emphasis on the contents, first establishing a good atmosphere (relations).
Co-operation, then:
build up relations from a common content (e.g. the working process).
Creating a common basis, support, then:
acknowledge and single out anger or resistance, make the boundary conditions for participation explicit.

3 - Explore the situation

The group:

What are the features of the group?
How many people are we dealing with?
What type of people are they?
Do they know each other?
Do they have any antagonism in their previous history?
Are they participating out of free will or is it compulsory?
Are they in a good mood (single out aversions or dislike)?
Have the participants the same level of thinking?

The location:

Is everything present (whiteboard, pens, overhead projector, beamer, etc.)?
Are there enough rooms in case of parallel workshops?
Can you move around the tables/chairs?

How is the atmosphere? It is better to keep the room as close as possible to the usual environment: no energy will be lost on that. A creative brainstorming session asks for a messy space.

Available time and moment:
Consider starting the evening before: evenings allow for informal items in the programme, the social rituals. Next day you can start immediately with the contents.

What type of facilitator fits in?
Meetings with objectives in terms of relations ask for different capacities than meetings which mainly address contents. The one facilitator can't work with lawyers and rather works with farmers, the other one rather works with policy makers. The type of meeting decides the choice of facilitator.

Basis for the programme-structure.
Whatever the objective of the meeting, as a basic rule:
from Abstract to Concrete, and;
from Conceptualisation to Judgement to Decision making.

This brings the following possible basic structure for meetings:

1 Preparation of the atmosphere
    a cup of coffee, etc.

2 Ritual dancing
    introduction round, networking, opening speech of the project leader, etc.

3 Laying eggs
    possible frustrations and dissatisfaction, but people also have to get rid of over-enthusiasm and pride with regard to recently achieved results before they can contribute to the meeting. For example by means of sticking memo's with their comments to a flip-over and spouting knowledge or venting criticism.

4 Warming-up
    a 'creative warming-up', a story teller, a catching presentation, cartoons, etc.

5 Diverge
    make an inventory of ideas, opinions, experiences, etc.
    often in sub-groups.

6 Converge
    combine and cluster of input, draw conclusions.
    plenary feed-back of the subgroups.

7 Planning of actions
    planning of actions with regard to the problems or the further process.

8 Planning of actions
    to agree about actions for the processing of the results of this meeting.

Tips

- Build in mobility in the programme (walking, to get up from the chair, etc.);
- Take into account the famous 'dip' after lunch;

- See to variety; for example between talking and creativity, or by plenary parts and working in sub-groups;
- Consider preparatory interviews with key-figures;
- Make clear agreements about the role of the projectleader/client during the sessions;
- Keep the project team free, so they can orientate on their role with regards to contents. Ask an external facilitator for the supervision of the process.

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

8. Creative sessions

The phase of the process in which future policy is formulated centralises the search for solutions. Creative sessions with groups of co-thinkers is a good way to generate creative and innovative ideas. Some possibilities:

Programme structure

Generally a creative session consists of two stages:
Diverging: to generate ideas, "fanning out";
Converging: to combine input, search for the leitmotivs, concluding, "bringing together".
(See also infosheet on prepartions of workshops)

A programme for a creative session often contains the following steps:
- Context;
- Clarity about the central question, to give the necessary background information;
- Explanation of working process and time schedule;
- Motivating kick-off;
- Diverging;
- Setting free of new ideas, individually or in a group;
- Inventory of ideas (see below);
- Converging: structuring;
- Look for connection/coherence between ideas, for example by means of clustering;
- Converging: put a name to it;
- Discussion and drawing conclusions, for example by naming or prioritising of clusters;
- Reflection;
- Take decisions about the incorporation of solutions in the process;
- Make agreements about the processing and dissemination of the results.

(co-source: The Institute of Cultural Affairs)

Diverging and converging

All creative sessions have generally the same structure: after a diverging stage (the real brainstorming) follows the converging (analysing and concluding). Several methods can be used. It is important to adapt the method of diverging to the one of converging.
Determine the desired result.
Estimate how widely you can diverge to later on converge to this desired result.
While diverging think about how you want to converge.

Diverging: ways of brainstorming

Some rules of the game are always valid:
- Everything anyone says is OK;
- Postpone judgements;
- Everything will be written down or recorded in another way;
- Everybody has to have his/her say.

Individual brainstorm

Participants write down for themselves a couple of ideas. Then they select the 5-7 best/funniest ones and give it as input into the group. A safe way of brainstorming, appropriate for groups with a 'hindering' hierarchy (i.e. people do not feel free) or if the group contains some participants who start controlling the conversation.

Brainstorming with a mindmap

The simplest way of brainstorming is to have people 'shouting' ideas, experiences, etc. The facilitator writes down everything, for example in the form of a mindmap: the central question or subject in the centre and put around (like a spider) the ideas of the group. Ideas that have interlinkages can be put together at once, and clusters are formed. This method works well with groups that have plenty of ideas and with hardly any hierachic thresholds (people feel free to speak).

'Small' design studio

Participants of the workshops are literally going to cut, paste, sing or dance what they actually mean. Size of (sub)group 5-7 people. Make sure you find a nice space with enough material to tinker with (i.e. old magazines, felt-tips, paper, glue, etc.) in order to stimulate creativity. Duration at least 2 hours. Appropriate for groups which need stimulation to become active, and you will strike new sources of creativity. Excellent for boring and sleepy times of the day like friday afternoon.

Associations

Participants are asked to reason from completely different subjects or things towards the subject which is central for the workshop. This method is often applied in the world of industrial design in order to find innovative solutions. For example: reason from a matchbox to a stadium. Result: an extending soccer field.

But this can also work for questions about organisation or innovative policy solutions. For example by taking the animal world as an example or to benchmark with completely different business areas and to look for differences and similarities. These sessions ask for a relaxed atmosphere.

Searching for images

For sensitive issues (such as the functioning of people or parts of the organisation) it can be useful to ask people about an image or metaphor which they find representative/fitting for themselves or the organisation. Make an inventory of the images and ask what it says about themselves or the organisation; which features are important? Sometimes it can be useful to give a lead for the metaphor, for example an animal or a (type of) car.

Brainbox

A Group Decision Room or Brainbox is a room in which the participants have a computer and are connected with eachother by a network. Everybody can at the same time give input/opinions/ideas (anonymously) and react on each others remarks. In a short time a lot of information will be generated and it stimulates creativity. The software should have the following possibilities: brainstorming, ranking/clustering of ideas, prioritising or voting and discussion. Suitable for both diverging and converging, for large groups with varying backgrounds, complex matters and settled habits of communication. An oral plenary session is necessary to evaluate and make agreements on follow-up.

Converging: clustering and prioritising

Clustering

By putting ideas on yellow Post-it memo's they are easy to move around on a board. Cluster from coarse to fine: firstly make general clusters under one expression (this is about...), later on look for refinements (positive-negative, short term-long term, etc.) and make sentences that summarise the cluster.

Give points, score

Everybody can give points or marks. For example 1x8, 2x4, 4x2 and 8x1 points to a list of items. The result is a kind of thermometer: the options with most points are accepted by definition, also drop-outs will be clear. Discussion can focus on the options with a mean score.

Stickering

Everybody can distribute 10 stickers to the options of his/her choice. The result will be more diffuse than giving points but also less confronting.

Feed-back and discussion

Methods of brainstorming like the design studio and associative exercises do not lead to lists of options which can be prioritised/ranked. In those cases plenary sessions are used for feedback of the results of (sub)groups and an evaluating discussion takes place under the supervision of a chairman.

Tips

Try as much as possible to work in smaller groups; the smaller the group the greater the chance that everybody joins in.
Creative sessions take at least half a day.
It could be useful to hire a facilitator/chairman so the project team can take part themselves.

Reference

ARB toolkit, Gereedschap voor het managen van open beleidsprocessen (tools for the management of open policy processes); *Adviesunit Resultaatgericht Beleid, Ministry of Public Works, Transport and Water Management*, The Netherlands, 2002.

9. Citizens' Jury

Objective

A citizens' jury (CJ) is a group of randomly selected people, who represent a microcosm of their community, and are paid to attend a series of meetings to learn about and discuss a specific issue and make public their conclusions[4]. Each juror is supposed to represent the public interest and not his/her own self-interest. The idea behind CJs is that given enough time and information, ordinary people can make decisions about complex policy issues. This method aims to strengthen the democratic process by including within it the considered views of a cross section of members of the public.

Amplification

A typical CJ might have the following characteristics[5]:

- The topic for the jury should be of public interest;
- The jurors should be selected on the basis of attitudinal or demographic quotas, or both;
- Jurors are paid to attend the CJ, which typically runs for 2-4 full days;
- The information presented to jurors should come from several points of view;
- A neutral moderator should facilitate all discussion;
- The jurors should respond to a "charge" or question;
- The jury should have review and approve all their findings and recommendations;
- The jurors must be allowed to evaluate the process and make public their views;
- The jurors must believe that their recommendations will have an impact or at least be considered.

The Procedure

A CJ will not be appropriate in all situations. Look at the following questions to decide whether this technique should be used[6].

- Can the issue be distilled into one key question?
- Is the issue complex, with various angles or key issues to be considered?
- Does the issue require background information?
- Is the issue of concern to the community?
- Is the sponsoring body open to change in response to the results of the jury?
- Can the issue be tackled and a conclusion reached in the time allowed?

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4 Crosby, N. (1995). Citizens' Juries: One Solution for difficult Environmental Questions. In O. Renn, T., Webler, & P. Wiedemann (Eds.), *Fairness and Competence in Citizen Participation* (pp. 157-174). Dordrecht: Kluwer Academic Press.

5 based on Crosby (1995: ibid) and James, R.F. (1999). *Public Participation in Environmental Decision-Making - New Approaches*. Paper presented at the Annual National Conference of the Environment Institute of Australia. Hobart, Tasmania.

6 Fife Council (1997). *How to Organise a Citizens Jury.* Corporate Policy. Fife Council. Scotland.

Jury Selection

Jury selection is crucial to the success of the process. Typically juries consist of between 12 and 24 participants who are selected to be representative of the relevant population. Jurors should be selected from the affected population in a fair and open way. Some juries are selected in an entirely random manner, for example by using the electoral register. Others use quotas so that representation from different income, racial or attitudinal groups is ensured.

Selection of Witnesses

The witnesses chosen should represent different points of view and extreme views from one side of the debate should be balanced with opinions from the other side. Typically witnesses are asked to speak for 15 minutes and answer questions from the jury for a further 30 minutes. Witnesses may appear alone in front of the jury, with another witness, or as part of a panel. An ideal jury would have a mix of these formats in order to vary the sessions and maintain the interest of the jurors.

The procedure

In order for a conscientious atmosphere to prevail, the jury must be carefully organised. There is usually one facilitator who chairs the plenary sessions, explains what is to happen in smaller groups session and aids the jury in coming to a decision at the end of the process. The facilitator may or may not have specific knowledge of the issue under discussion, but must, in all cases, be impartial in their words and actions.

The focus of the whole proceedings should allow the jurors to deliberate on the issue at hand, but in order for this to happen careful arrangements need to be in place, and staff are required to ensure the process runs smoothly. Other than the chief facilitator, additional staff are required to help facilitate smaller group sessions; meet, greet and brief the witnesses before their presentation; and take care of housekeeping arrangements.

The facilitator will meet the jurors in an introductory session. This is held before the start the jury to introduce jurors to each other, to indicate what they might expect to happen in the days of the jury and to introduce any staff involved in the process.

During the process a variety of sessions are usually scheduled. As well as sessions where witnesses make presentations to the jury and answer questions, there are usually sessions where the jury discuss issues together or in small groups. They may be given tasks, for example to identify and rank the benefits of a particular issue. This provides variety for the jury, and helps to break down the big task of the jury into manageable pieces.

Decision making

Consensus is the most desirable means by which to come to a final decision or set of recommendations, although this may not always be possible. In order to reach a consensus plenty of time is needed to work through disagreements, but in some cases no matter how much time is allocated a consensus may not be reached. In such situations a voting system may be used. The way in which a jury makes a decision is important, as exploration of minority views is a valuable feature CJs. Such views should always be reported in the final report.

The Report

The final product of a CJ process is a report, detailing the process and recommendations made by the jury. Typically reports contain all details of the process, including witness presentations, reports on discussion sessions as well as final recommendations, and details of any disagreement. In order to avoid bias in the final report a draft copy is sent to all jurors for comment and agreement before it is finalised. This ensures that any misrepresentation is eliminated before the report goes to the sponsoring body.

The report often also contains some evaluation of the process, from the jurors point of view. The evaluation provides a check to the report, and shows how the jurors felt about the process and the relevance of the findings.
Once the report has been finalised it is sent to the commissioning body, and what happens next depends on the jury process and recommendations.

What Happens Next?

One of the most important elements in a jury process is that the jurors feel their opinion is going to make a difference. It is important that the sponsoring body acts on the jury report. This may take the form of a written report, or a workshop, where the appropriate body discusses the recommendations, explains why it will or will not implement them and provides a timetable for further action.

10. Interactive Geographic Information Systems (Web GIS)

Tool implementation objective(s)	Record public reactions on the basis of locational specificity: the interactive Web site, built with a geographic information system (GIS) core, enables associating public comments with geographic positions or spatial coordinates.
Pertinent participation process phase(s)	Public information dissemination, public hearing, co-production of solutions, co-decisions; the tool may be of use during different stages of a process referred to as either "participatory planning" or "participatory physical planning".
Tool description	Having entered its experimentation phase, the tool has been named "LODERWeb" (for Location-Dependent Reaction" Web). A description is available on the site http://cgi.girs.wageningen-ur.nl/cgi/education. This tool (developed using "Mook Technology" and "ARCView IMS") features a set of videos that provide use instructions (via the "Lotus-Screencam" software), which explain how to generate a reaction connected with a specific location.
Implementation	The methodology employed has been set forth in detail in a Ph.D. dissertation written by R. Kluskens of Wageningen University (Geographic Information Center). The implementation of LODERWeb corresponds to step 6 of this methodology (input of citizen reactions associated with specific geographical locations). Step 7 consists of defining "problem zones" based on these reactions and then proposing these zones as a focus of discussion. ("The application of WebGIS in local participatory physical planning: Development of an interactive Web site to inform and consult citizens about physical plans", February 2000).
Eventual variants	Variants are created by the individual plans, and digitised geographical representations may be incited by this tool.
Implementation examples	Application to the design of a fictitious city called Zwuile containing a population of 23,000. This virtual experimental test involves developing a new industrial zone within the city limits.

Source: R. Kluskens (Wageningen University)

11. Public hearings (see also tool 9. Citizens'Jury)

Tool implementation objective(s)	Present the public with the full set of project components, provide a forum for answering all questions; collect opinions in the form of motions filed before the Hearing Commission, and then defended by their respective authors. This procedure satisfies legal requirements and allows officially recording public motions.
Pertinent participation process phase(s)	The entire project, yet most specifically during the diagnosis-building and solution-design phases.
Tool description	A two-step procedure: overall explanation, with questions from the public and responses from experts affiliated with the pertinent institutions (1); followed by the collection of opinions and reports. In the case of the Quebec water project, the hearing lasted a total of 3 days in each of the 17 regions (with 5 or 6 public sessions held each time). 370 motions were filed and heard before the Commission. All pertinent documents could be accessed and consulted simultaneously at 35 "consultation centers" (municipal libraries, town halls, etc.) (2). The Commission's budget amounted to 2 million Canadian dollars ($CAN) and covered the logistics (transportation, lodging) and salaries of the temporary staff hired for the occasion. ($CAN 200,000 were then added to compensate those who filed reports).
Feedback	For the water management hearing held in Quebec: importance of the role played by the Hearing Commission in stimulating public debate; complete transparency, extremely responsive to all participants; inclusion of the full diversity of opinions expressed; legal protection of Commission members. Chief among the difficulties encountered: the procedure tends to overemphasise the opposition, may become repetitive and may be monopolised by a minority interest (for the purpose of grandstanding). According to the International Association of Public Participation, this tool is one to be avoided if at all possible (otherwise, it should be preceded by a series of informal meetings). For this association, the presence of an audience allows freely expressing reactions, but does not incite dialogue and tends to polarise the competing views.
Implementation examples	Water resources management hearing in Quebec (see data sheet).

Sources: A. Beauchamp (Environ-Sage Inc.) - President of the Commission assigned the public hearing on Quebec water management issues, R. Beaudet - Public Hearing Office in Environmental Issues (BAPE), H. Marchand (BAPE)

Notes on the "Public hearings" tool sheet

(1) In the case of the Quebec public hearings, the first phase was actually conducted in two stages. BAPE started by producing a base document that served to frame the approach and initiate discussion. According to some participants, this document "lacked substance" and did not help sharpen the public's comprehension of the stakes involved. The

Environment Ministry then completed this document by drafting a profile of water-related issues specific to each of the 17 jurisdictions engaged in the hearing process. Next, all of the ministries with oversight in the field of water management attended a joint work session in order to file the necessary documents and handle questions from the public. This approach gave rise to a two-level probe:

- A global level dealing with the entire province of Quebec, where water resource protection problems due to private operations lie at the heart of the debate over exporting groundwater or surface water and privatising publicly-owned infrastructure;
- A more local and practical level concerning issues specific to each region: water quality, health risks, groundwater risks related to below ground disposal sites, agricultural production activities, etc.

(2) The Commission was composed of 3 commissioners (including the President), 2 analysts, a planning officer, an information officer and 11 experts.

The complexity of the issues were more pronounced in those territories under convention rule, i.e. the northern regions inhabited by native Inuit and Cris peoples, which are exempt from Article 31 of the law on environmental quality. It thus became necessary to set up a protocol agreement between these territories and the provincial government in order to integrate the BAPE-led consultation.

12. Monitoring and participatory evaluations

Tool implementation objective(s)	Enable a project evaluation to be performed by those most directly concerned (and not exclusively by project sponsors). This tool entails evaluating both the project and its results (plan, etc.) as opposed to merely evaluating the public participation aspect.
Pertinent participation process phase(s)	Evaluation phase.
Tool description	This tool differs from traditional monitoring and evaluation methods for several reasons: - The process has been designed and managed not by the project leaders or an outside expert, but rather by the stakeholders in conjunction with the project team (often assisted by a "facilitator"). - The stakeholders design and adapt the method, collect and analyse the data. - The indicators are defined by stakeholders. A number of supporting materials may be used when implementing this type of monitoring-evaluation: maps (for locating project-induced changes), relational diagrams (among groups, institutions, etc.), and scoring grids (for comparing preferences and results).
Feedback	The success of this approach requires involvement of both men and women, intermediary organisations (including NGOs), interested private companies and those assigned institutional oversight. The application example for this technique in the case of Local Agenda 21 monitoring and evaluation highlights the advantages of this approach in defining the set of monitoring and evaluation indicators (since selected indicators, in some instances, do allow revealing "unsuspected problems").
Implementation examples	"Citizen learning teams" in the United States set up to monitor and evaluate federal programs; Local Agenda 21 tracking in the United Kingdom.

Source: Institute of Development Studies (IDS Policy Briefing No. 12)

13. Computer tools for processing public comments

Tool implementation objective(s)	Procure elements contained within reports and documents filed as part of a public hearing process, in addition to any comments received. Acquire the capability to numerically handle all of these elements in order to analyse and then integrate them into the final report.
Pertinent participation process phase(s)	In the case of Quebec's public consultation, a software application was used during the report-writing phase, following the second public hearing phase.
Tool description	This software is distributed by the Quebec company AGIR, which has developed a new technology in the field of information tracking, one of whose original features pertains to the technique of searching by means of indexed language sequencing. This software is called "Naturel" (Marketing Director: Pierre-Paul Proulx, ppproulx@natquest.com). This tool corresponds to a conventional query-type instrument: digital archives are stored in the form of Word files (PDF files seem to cause problems). The tool builds an index from this databank of documents. The project manager is then able, using keywords, to access the set of documents in which these words have been found by the tool. (The user is directly referred to text passages where the keywords were identified.) The tool also allows for statistical processing (frequency of terminology, number of documents in which a particular keyword appears, etc.).
Implementation examples	At the time of Quebec's public consultation on water management, all 370 reports (14,000 pages of documents) filed in digital format were loaded into a database and queried using the "Naturel" software developed by AGIR.
Feedback	Use of a standard software application, which does not require any modifications to meet BAPE's needs: according to the BAPE project leader, the software is easy to use and does not necessitate any special training - one to be recommended. For further information, contact Stéphane Moreau: stephane.moreau@bape.gouv.qc.ca

Sources: S. Moreau, R. Beaudet and H. Marchand - Public Hearing Office in Environmental Issues (BAPE), Web site www.natquest.com

Annex II - Examples of Public Participation in water management projects

November 2002

Introduction

This Annex:

- Aims at providing and explaining examples of public participation in water management projects in some Member States and Eastern Europe;
- Demonstrates the range of possible approaches with regard to public participation on different scales and with regard to various issues;
- Aims at motivating competent authorities to try new tools and methods.

The matrix on page 5 will help to find the examples you are most interested in.

The examples are mostly from the past and do not deal especially with the Water Framework Directive (WFD). Others are current examples with regard to the implementation of the WFD, but of course are not finalised yet.

The examples are mostly positive, but some of them show also the difficulties and mistakes that may happen. Therefore the examples are about "lessons learnt"!

The list of examples is in no way exclusive, there are much more examples, of course also from outside Europe. In this context it should be mentioned that there are ongoing or just finalised research projects, which provide more examples and approaches with regard to public participation and WFD:

- French Study comparing public participation tools and techniques in the Netherlands, Denmark and Canada (finalised), for more information contact:
  Ministry of Ecology and Sustainable Development, Water Department - 20 avenue de Ségur - 75 302 PARIS Cedex 07, Madame Coralie NOËL - Bureau de l'économie de l'eau et de la programmation, phone: (00 33) 1 42 19 13 76 - Fax : (00 33) 1 42 19 12 94, E-mail : coralie.noel@environnement.gouv.fr

- Ongoing SLIM (Social Learning for the Integrated Management and Sustainable Use of Water at Catchment level) project in England/Scotland, France, Italy and the Netherlands, for more information contact: http://www.slim.open.ac.uk/

- Ongoing HARMONICOP project (preparation of a "Handbook on PP methodologies" (WFD), comparison and assessment of national PP experiences and their background), for more information contact:
  www.usf.uni-osnabrueck.de/~pahl/projekte/harmonicop

List of examples by country

The scale of examples and the degree of public participation

Level\PP	Active involvement	Consultation	Information
International	Danube River Commission (32.)	Danube River Commission (32.)	Danube River Commission (32.)
National	RBM plans in Flanders (1.) DEFRA Stakeholder Sounding Board (6.) National commission for Public Debate (15.) SEPA activities (22.) River Emå (28.)	DEFRA Stakeholder Sounding Board (6.) National Water Council (11.) National Commission for Public Debate (15.) SEPA activities (22.) Global flood defense plan Júcar (25.) River Emå (28.) Water association of river Fyrisån (30.)	RBM plans in Flanders (1.) National commission for Public Debate (15.) Information Letters in Thuringia (16.) SEPA activities (22.) River Emå (28.)
Regional	Westcountry Rivers Trust (5.) SDAGE (12.) Niers Regional forums (17.) IIVR project (20.) Balearic Islands (27.)	Regional Planning System (2.) Westcountry Rivers Trust (5.) SDAGE (12.) Niers Regional forums (17.) Integrated Reconnaissance (19.) Technical Annexes II and V of the WFD (24.)	Regional Planning System (2.) Niers Regional forums (17.) Integrated Reconnaissance (19.) IIVR project (20.) Technical Annexes II and V of the WFD (24.)

Level\PP	**Active involvement**	**Consultation**	**Information**
Local	The Tubaek Stream (3.)		
	Reducing water consumption in Graphics Corporate Sector (4.)		
	Wise Use Project, Somerset (7.)		
	Fens Floodplain project, East of England (8.)		
		Nõo rural district development of a municipal water supply and sewage system plan (9.)	
	Lake Pyhäjärvi (10.)		
	SAGE projects (13.)	SAGE projects (13.)	
	Drôme river, SAGE (14.)	Drôme river, SAGE (14.)	
	Erne Sustainable Wetlands Project (18.)		
	Municipal Water plan Hilversum (21.)		
		Ettrick project (23.)	Ettrick project (23.)
	Alcobendas - city of water (26.)	Alcobendas - city of water (26.)	Alcobendas - city of water (26.)
	River Emå (28.)	River Emå (28.)	
		Municipal Water Plan of Örebro (29.)	Municipal Water Plan of Örebro (29.)
	The Water Association of river Fyrisån (30.)		The Water Association of river Fyrisån (30.)
	Helcom MLW (31.)	Helcom MLW (31.)	Helcom MLW (31.)
	Lower Danube Green Corridor (33.)		

1. River sub basin management plans in Flanders, Belgium

Inspiration points/key points

Integral water management, planning at river basin level, participation in different phases of the process, stakeholders, participatory working groups, interviews, surveys,…

Aim/objective of the project

In Flanders, the water system is managed by several local (a.o. provinces, communities) and regional (Flemish) authorities. Because of different concerns and interests of these authorities on the one hand, and because of the role that stakeholders play in using the water system on the other hand, 11 river basin management plans will be made in a participatory manner. These management plans will include:

- A description of the water system and its surroundings;
- A description of the needs of the stakeholders;
- An analysis of these descriptions, the bottlenecks and expectations;
- A vision on the development of the water system (including goals);
- Programme of measures.

The ultimate goal is to create a more practical level for collecting and analysing information and to ensure more participation from all stakeholders. These sub basin plans will be used as an input for the making of (international) river basin management plans.

Scale/unit of planning

11 river (sub)basins in Flanders

Period: 2001-2006

Objective of Public Participation (Why PP?)

To involve all authorities and come to an agreement on the development of the water system;
To involve all stakeholders and public in general;
To inform the public in order to develop sustainable water management.

Who participated and how (Degree/form of public participation) in what phase of the planning?

A description of the water system and its surroundings: consultation of all authorities, universities and (some) stakeholders in a working group;
A description of the needs of the stakeholders: active involvement of the stakeholders, mostly by interviews with representatives of 12 designated sectors (written enquiries are not efficient);
An analysis of these descriptions, the bottlenecks and expectations: active involvement of authorities and stakeholders (done by several workshops and interviews with key players);

A vision on the development of the water system (including goals): active involvement of authorities and stakeholders;
Programme of measures : active involvement of authorities and stakeholders.

Methods and tools applied

Consultation of stakeholders (key players) by written enquiries, interviews, workshops;
Per sub basin, a working group with representatives from all authorities has been created to evaluate the results;
Website for communication with all stakeholders: www.bekkenwerking.be

Major input of stakeholders

Knowledge; indication of specific problems and solutions; feedback on proposed texts (support or disagreement).

Tangible result

PP is necessary for acceptance of regional planning process as an important tool. Once contacted and convinced, it is much easier to keep everybody focused on the (importance of) making regional management plans.

Lessons learnt

Personal contact with key players of stakeholders is very important and creates added value to the planning process. This personal contact ensures a continuous interest. Thus, it is best to keep them well informed of all stages in the process.

Formal procedures for PP

For the time being, no formal procedures exist. There is however a manual made (that is being continuously updated).

Cost of the project

A minimum of 4 persons per sub basin is required. For the sectoral analysis, support by an external partner is useful (cost: appx 75.000 euro per sub basin)

For more information contact:

Didier D'hont
Ministry of Flanders
Aminal, Water Dept. (E. Jacqmainlaan 20 box 5, 1000 Brussel)
Didier.dhont@lin.vlaanderen.be

Available reports:

www.bekkenwerking.be

2. Regional Planning System, Denmark

Inspiration points

Integration of land-use and water use; public consultation procedures.

Aim/objective of the project

Regional planning in Denmark integrates land-use and water management and provides the framework for agriculture, forestry, assignment of areas sensitive to groundwater, areas assigned for nature corridors, location of large infrastructure and urban development.
The system is linked closely with the EIA requirements as well as all activities related to wastewater treatment planning, drinking water supply and nature restoration.
Thus, the strength of the system is its high degree of integration between land-use and water management.

Scale/unit of planning

Regional planning system, Denmark, up to 5.000 km^2

Period: Since 1970ies

Objective of Public Participation (Why PP?)

PP is provided at consultation level through public hearing procedures.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The number of people attending public meetings, though, is not very high. Stakeholders – organisations, industry, farmers etc. – provide their opinion through letters as well as bi-lateral meetings with the County.

Methods and tools applied

Formal public hearing rounds via electronic media, local and regional press, publications available in public buildings etc.

Major input of stakeholders

Knowledge. Support or disagreement communicated.

Tangible result (effect) of PP?

Opportunity provided for the broad public as well as key stakeholders to influence the process. Acceptance of the regional planning system as the most feasible approach for linking water use and land use.

Lessons learnt

Lessons learned: integration of coastal waters in the regional planning has to take place across watershed boundaries; this is organised through county co-operation structures, but measures may vary from county to county; the Danish Water Action Plan is implemented through the counties, but has still difficulties in addressing non-point sources.

Formal Procedures for PP

Described in the Law on Regional Planning.

For more information contact:

Danish Ministry of Environment
Henrik Dissing, WWF Denmark, h.dissing@wwf.dk

Available reports:

www.mem.dk

3. Tubaek Stream, Denmark

Inspiration points

Involving farmers as partners in water management.

Aim/objective of the project

A 3-year project involving 1 person from the county and 1 from the farmers union aimed at involving all farmers (approx 50) in the 15 km Tubaek Stream in voluntary agreements regarding reducing excessive use of nutrients and pesticides. Through a carefully planned dialogue, a positive and constructive co-operation was established with the farmers, leading to substantial cuts in run-off of nitrogen, full cut of excessive use of phosporous and pesticides. The basis for the voluntary agreements was the existing framework for supporting environmentally-friendly farming, which has its origin in the 2nd pillar of the CAP.

Scale/unit of planning

A 15 km stream and its catchment within the county of Storstroem.

Period: 1998-2001

Objective of Public Participation (Why PP?)

To establish a win-win situation, which involves farmers as partners in water management.

Who participated and how (Degree/form of public participation) in what phase of the planning?

Farmers in a local water catchment together with representatives from county and farmers advisory service.

Methods and tools applied

The key to the constructive dialogue was that public meetings were organised through the farmers union and that meetings took place at the farm – the "kitchen-table model".

Major input of stakeholders

Knowledge on local issues, resources in terms of pro-active participation and commitment. Willingness to imply changes in their production practices to ensure environmental quality.

Tangible result (effect) of PP?

Local farmers accepting environmental objectives, contributing pro-actively in implementation of programs perceiving it as a win-win situation, establishment of relations between farmers and the county build on trust.

Lessons learnt

Lessons learned: farmers can be mobilised for implementing environmentally-friendly practices, provided the dialogue chosen respects the farmer and it meets him at his premises The approach is time-consuming, but prevents conflicts. The results are incorporated into he daily farming activities, hereby creating a win-win situation. The approach builds on existing co-operation structures within the farmers' community.

For more information contact:

Storstroems County, Annette Larsen, ajl@npk.stam.dk
Henrik Dissing, WWF Denmark, h.dissing@wwf.dk

Available reports:

Forthcoming.

4. Reducing Water Consumption in the Graphics Corporate Sector, Denmark

Inspiration points

Cooperation with business companies. Knowledge on day-to-day business practices. Co-funding in terms of staff time allocated for demonstration activities. Sharing knowledge with other companies from the sector, which in fact are also their competitors. Cleaner practices in the Graphics Sector.

Aim/objective of the project

Aim: to reduce water consumption and environmental impact from companies in the Graphics Corporate Sector through demonstration activities – the result was an impressive 70-90% reduction in water consumption.

Scale/unit of planning

Company / business sector.

Period: 2000

Objective of Public Participation (Why PP?)

For the corporate sector as such to engage in cleaner practices investments, several barriers must be dealt with: lack of information about their environmental problems and related improvement opportunities (knowledge on benefits), lack of interest / motivation (incentives), lack of access to financing. Demonstration of concrete opportunities and providing of win-win examples allows for a new business paradigm to spread. Further, through this co-operation the Competent Authorities also get input on how to establish a feasible planning and incentives framework.

Who participated and how (Degree/form of public participation) in what phase of the planning?

Danish Environmental Protection Agency unit for cleaner production, consultancy company, selected companies from the Graphics Sector, Graphics Business Sector Association
PP: several companies as well as the Graphics Corporate Sector organisation were involved comprehensively throughout the entire process shaping the improvements within the daily activities of the companies and testing new equipment, supported economically by the project.

Methods and tools applied

Direct involvement of selected companies in concrete activities, elaboration of main results in the evaluation report, dissemination through Danish EPA and Graphics Business Sector networks.

Major input of stakeholders

Knowledge of day-to-day business practices. Co-funding in terms of staff time allocated for demonstration activities. Sharing knowledge with other companies from the sector, which in fact are also their competitors.

Tangible result (effect) of PP?

Significant environmental improvements, positive attitude from the Business Sector to implementation of Cleaner Practices.

Lessons learnt

With rather limited funding schemes, demonstration activities can successfully be conducted with the results being extracted for later inclusion in revision of environmental regulation of the sector's environmental impact. Through this approach, the new regulation is fully in line with what is possible in the sector, while at the same time the organisation can communicate results as well as the future legislative changes in advance to their members. The investments made from the State budget are later saved in costs for wastewater treatment plants.

For more information contact:

Danish EPA, +45 32660100, Danish Technological University, Christian Poll, cp@ipu.dk
Henrik Dissing, WWF Denmark, h.dissing@wwf.dk

5. Westcountry Rivers Trust, England

Inspiration points

Environmental charitable trust. Development of catchment management activities.

Aim/objective of the project

The Westcountry Rivers Trust (WRT) is an environmental charitable trust established in 1994/5 to conserve, maintain and improve the natural beauty and ecological integrity of rivers, streams and wetlands. The WRT regards appropriate land management and the restoration of sympathetic flow regimes as central to the recovery of biodiversity. The WRT works both as a leader and facilitator in the region to effect change through the development and delivery of catchment action.

WWF-UK identified the WRT as a partner in 2000. The partnership, still in its early stages, is intended to demonstrate WWF's key policy messages on the ground and to take some of the lessons from WRT's work to national and European level policy arenas. Work on focuses primarily on freshwater conservation, sustainable rural development and other key land use policy areas.

Scale/unit of planning

The Westcountry Rivers Trust focuses its activities in the south-west of England (the counties of Devon and Cornwall). Specific projects are largely focused at the catchment level (e.g. the Tamar 2000 project was focused on the River Tamar catchment).

Period

The Westcountry Rivers Trust has been in existence since 1995. Several projects have undertaken since its formation with varying durations. The Tamar 2000 project was funded by the EU under its Objective 5b scheme – it lasted three years.

Objective of Public Participation (Why PP?)

- awareness raising;
- to use the knowledge and experience of stakeholders for the sustainable development of river catchment areas;
- improved water quality through comprehensive involvement of farmers.

Who participated and how (Degree/form of public participation) in what phase of the planning?

Participation has largely focused on farmers and key regional stakeholders (e.g. statutory environment agencies, the local water company, other NGOs).
The WRT works both as a leader and facilitator in the region to effect change through the development and delivery of action. For instance, WRT has recently used WWF-UK funding to bring together key regional stakeholders in a workshop to begin the process of agreeing a

long term vision for the landscape of the south-west. The workshop has been followed by a questionnaire exercise which asks stakeholders to identify their priorities for rural land-use. Further follow-up activities are planned.

Major input of stakeholders

Vision on the long term development of the landscape.
Priorities for rural land use.
Knowledge on local issues, resources in terms of pro-active participation and commitment.
Willingness to imply changes in their production practices to ensure environmental quality.

Tangible result (effect) of PP?

WRT projects have resulted in:

- Improved river water quality through reduced use of farm chemicals (fertilisers, pesticides etc.). In time this will contribute to enhanced aquatic ecosystems.
- Improved farm incomes: more efficient use of water, improved farming practices and reduced chemical use have resulted in net direct benefits of approximately £2,700 per farm per year in two catchments. Indirect benefits have yet to be measured.
- The implementation of proposed activities with tangible results. For example Salmon is back, being able to swim in the river , etc.

Lessons learnt

One of the most important lessons learned is that farmers are the best people to communicate messages to other farmers. In addition, messages on how to improve rivers and the environment carry more weight if there are clear benefits for farmers.

For more information please contact:

WWF UK, Dave Tickner
Henrik Dissing, WWF Denmark, h.dissing@wwf.dk

Available reports

www.wwf.uk

6. DEFRA Stakeholder Sounding Board, England

Key- words

National stakeholder involvement.

Aim/objective of the project

The terms of reference for the Stakeholder Sounding Board says that it is a forum for stakeholders to:

- provide input to DEFRA (Department for Agriculture, Food and Rural Affairs) thinking on transposition, and related policy issues, of the Water Framework Directive (WFD);
- raise issues relating to the WFD of concern to the group;
- provide input into development of a long-term strategy for the environmental quality of water - what it should cover, in what detail, risks and opportunities.

Scale/unit of planning

National – the Stakeholder Sounding Board considers WFD-related issues for the whole of England. To date, no similar groups have been established in Scotland, Wales or Northern Ireland.

Period

The Stakeholder Sounding Board was established in early 2001 after a request from a group of stakeholder organisations (including WWF-UK). There is no fixed timescale for the group's existence.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The organisations represented on the Stakeholder Sounding Board are:

Government
DEFRA (Department for Agriculture, Food and Rural Affairs)

Statutory agencies
Environment Agency (the government's statutory agency for environmental protection in England and Wales)
English Nature (the government's statutory advisor on, and agency for, nature protection in England)

Private sector
Confederation of British Industry (CBI)
Chemical Industries Association (CIA)
Crop Protection Association (CPA)
Country Land and Business Association (CLA)
National Farmers' Union (NFU)
Water UK (the trade association for UK water companies and water authorities)

NGOs
Royal Society for the Protection of Birds (RSPB)
WWF-UK

Other stakeholders
UK Centre for Economic and Environmental Development (UKCEED)
Office of the National Consumer Council (ONCC)

Participation takes the form of regular meetings (approximately 3 or 4 a year), hosted in turn by different stakeholder Sounding Board members. The meetings are chaired by a senior official from DEFRA. DEFRA also undertakes a secretariat function.

Major input of stakeholders

Individual stakeholder organisations, or small groups of stakeholder organisations, can flag up issues for discussion. They are then invited by the Stakeholder Sounding Board to prepare a paper on the issue. The paper is discussed at subsequent meetings.
DEFRA may also raise agenda items.

Thus, WWF and UKCEED have prepared a paper on public participation; the RSPB and others have prepared a paper on Wetlands and the Water Framework Directive; the RSPB, WWF, Water UK and the NFU are currently preparing a paper on diffuse pollution.

Outstanding issues

It is not clear what status these papers have within the government. Although the papers include recommendations for action by government and other stakeholders, DEFRA have not made clear whether they will act on those recommendations, even if all stakeholder organisations agree with them.

The relationship between the Stakeholder Sounding Board and the UK government's internal technical advisory group on implementing the WFD has yet to be clarified.

Lessons learnt

A national forum that allows stakeholders to input directly into policy thinking is genuinely useful. It allows direct access to government officials and provides a mechanism by which government can assess the most important issues. For relatively little cost and effort this enhances the traditional methods of consultation and individual meetings with each stakeholder organisation.

However, it is important that there is full transparency so that stakeholder organisations can see how their ideas and concerns are considered and acted on (or not) by the Government. At the moment, we are still working on this in the Stakeholder Sounding Board.

For more information contact:

WWF UK, David Tickner, DTickner@wwf.org.uk

7. The Wise Use of Floodplains Project in Somerset, England

Our work was made possible through the award of a 50% grant from the EU LIFE Environment Fund programme.

Inspiration points – this example is inspiring because:

In partnership with other initiatives this project facilitated a creative and positive dialogue on the future management of flood events in a catchment, where previously stakeholder views had been polarised for decades to the extent where the conflict had become notorious in national environmental circles.

Aim/objective of the project

The WUF Project's aim was to encourage the wise use of water resources in river catchments to benefit, people, their livelihoods and their environment. We set out to achieve this by:

1. Generating new options for the sustainable management of flood events across the catchment and annual water levels on the floodplain;
2. Testing public participation methods to find out what were the economic, social and environmental costs and benefits of different options for managing flood events and floodplain water levels.

The project, through its participatory approach helped to find out how the policies of the government and European Union needed to be changed to promote sustainable management of the catchment and its floodplain. Findings were passed to managers of river catchments across Europe to enable their governments to implement the WFD.

Scale/unit of planning

The River Parrett Catchment in the county of Somerset, South West England. It is the largest river system in Somerset covering 1665 km^2, about half of the county area and containing five major rivers: the Parrett, Isle, Tone, Yeo and Cary. The floodplain forms a significant part of the Somerset Levels & Moors: - an area of international importance for wildlife.

Period: January 2000 – March 2002

Objective of Public Participation (Why PP?)

In Somerset, the WUF Project developed new ways of helping stakeholders in the River Parrett Catchment to find sustainable solutions through participation for the management of water, both in flood events and throughout the year.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The Project sought to involve "stakeholders" - anyone or any organisation, at whatever level, with an interest in the management of water resources in the Parrett Catchment. Above all, it offered an opportunity for local concerns to be heard. Since the first participatory workshops started in 2000, a wide range of representatives of communities, local interests and organisations ranging from local to national government-level were involved.

Methods and tools applied

The WUF Project responded to what communities and individuals wanted. Working closely with an existing and (in the United Kingdom) unique forum for local democracy, the Levels & Moors Partnership*, we held participatory workshops to encourage stakeholders to share views and address problems in partnership. Workshops were managed through facilitative leadership: with the help of group management techniques, stakeholders were helped to work together in a non-conflict environment. The WUF Project Officer was the facilitator for all participatory workshops. Contextual information such as new research on the effectiveness of present flood management practices was introduced to help all stakeholders to develop a common understanding of issues.

Participatory working has to be product-orientated to be worthwhile. If a process is not guided by the need to reach a common goal then it will drift and is unlikely to achieve results.

Stakeholders came to agree that no one solution would solve the problems of flood and water management, but that a comprehensive package of measures was needed. Facilitated dialogue provided the bridge to enable a wide variety of interests to work jointly towards a common goal.

To reach the desired goal of integrated flood and water management, a variety of solutions were generated in a series of participatory workshops. These solutions were built into a Parrett Catchment Action Strategy, which sets out what community and organisational stakeholders wanted to be achieved by 2050".

As collaborative working developed between local initiatives, the WUF Project and LAMP managed participatory workshops under an umbrella initiative, the Parrett Catchment Project.

It is estimated that the approximate cost of facilitating the dialogue over two years is approximately €30,000.00 (salary costs of project officer/facilitator). Workshop costs were additional but low at approximately €150 – 180 for each event (hire of the venue and catering for around 40 participants). The overall cost is difficult to estimate accurately, because staff from a variety of organisations donated their time to the initiatives involved. For the LIFE Project, the budget used to commission new research in Somerset was approximately €75,000.00 and partnership organisations provided around €36,000 of in-kind time in support of the Wise Use of Floodplains Project. (Note: all of these figures are provisional.) In conclusion, the total cost of facilitating such a complex dialogue over a two-year period was remarkably low and the gains are far greater than the financial investment.

*LAMP serves 86 parish councils with wetland habitats on the Somerset Levels & Moors, who in turn represent all local community and organisational interests.

Major input of stakeholders at participatory events

We invited 85 representatives of local communities and organisations to our workshops and regularly saw 30 – 40 people at each event. The organisations ranged from the major government agencies to single-issue lobby groups. It was the first time in Somerset that participatory working had taken place on such a scale.

Tangible result (effect) of PP?

A series of 27 facilitated participatory workshops, which began in May 2000, produced:

- A statement of the consensus between all stakeholder interests, which forms the basis for a vision for the future management of the catchment and floodplain;
- Eleven "components" or potential solutions to manage flood events, a combination of which will make up an Integrated Flood Management approach;
- A detailed analysis of the policy, funding, administrative and technical barriers and opportunities involving implementation of the eleven components;
- Appraisal of the social, economic and environmental costs and benefits of each of the components;
- Enhanced understanding among stakeholders of the implications of the conservation management objectives necessary to achieve "favourable condition" of the Special Protection Area (Birds Directive);
- Initiated a productive dialogue on finding a new balance between agriculture and environmental interests to achieve favourable condition of the Special Protection Area and Ramsar sites, while helping agriculture and other rural industries to work towards sustainable management of an internationally important wetland;
- Produced practical sustainability indicators to monitor the effectiveness of changes in water and land management.

Many of these outcomes are continuing to be implemented beyond the end of the Life Project and are resulting in practical land management and integrated catchment management for the area.

Lessons learnt

<u>Positive Lessons</u>

- Make dialogue relevant to people's lives.

In Somerset the project centred on a major environmental issue that affected a wide range of stakeholders.

- Dialogue should be gradual and often.

Frequent small-scale dialogue is better than big one-off events. More flexible processes are better at accommodating changes in views and developing consensus. Continuing dialogue is better at establishing and maintaining trust and helps to manage participants' expectations of outcomes more realistically.

- Maintain the momentum of the process.

Ensure that the next stage in the participatory process can move on from the last one. Discuss issues, generate solutions, appraise them, test them for sustainability and evaluate their effectiveness once implemented.

- Create trust through impartiality.

This was critical to the success of the process in Somerset. It was the first time that water management had been discussed in a neutral public forum. The WUF Project existed between its sponsoring organisations (the LIFE Project partners): it was not seen as part of them. The role of the WUF project officer as an impartial facilitator gave stakeholders confidence that that they were taking part in a truly participative process and independent process.

- Work to invest time.

Constantly remind participants or potential participants of the need to invest time: without commitment the energy of the process will dissipate. Participants have been very committed to the Somerset process: thirty to forty key stakeholder representatives regularly attended workshops.

Negative Lessons:

- Expensive one-off events can bring dialogue to a halt by delivering a "verdict" and may not be appropriate in making progress on a particular issue in a particular context;
- Don't become a discussion forum without a purpose – manage expectation;
- Avoid any one organisation leading a process so that the process does not have the necessary impartiality needed to create trust amongst stakeholders.

Contacts for further information:

Barry Phillips, Rural Environmental Facilitation Service, b.phillips@tiscali.co.uk,
+44 (01934) 713864

See also www.floodplains.org

8. The Fens Floodplain Project – East of England

Inspiration points

Active involvement can be sampled effectively by involving communities in a few villages within a river basin.

Aim/objective of the project

To involve the community in determining options for floodplain restoration and integrated management.

Scale/unit of planning

Sub- Regional – 2 villages within a river basin.

Period: 1999-2002

Objectives of Public Participation (Why PP?)

To involve local people directly in making floodplain restoration proposals for their local area and to trial new participation and appraisal methods in a few villages to assess how well they reflected wider concerns across the river basin. Participation helped gain a broad understanding of how the public wanted their floodplain developed without the expense of consulting large numbers of people. Results of community participation were compared with the views of other stakeholders obtained through other participation techniques (e.g. workshops, seminars) so as to assess how well the public proposals matched those of key organisations.

Who participated and how (Degree/form of public participation) in what phase of the planning?

A range of local people from school students to adults and retired people in two representative villages. They were invited to make any proposal they wished about making the floodplain more sustainable, socially, economically and environmentally.

Methods and tools applied, plus resources

A method called "planning for floodplains" was developed. This involved local people putting symbols onto a model to indicate floodplain restoration projects they wanted, for example, new wetland nature reserves, riverside cycleways, more boat moorings for tourists. In both villages three main sets of proposals emerged from the groups of symbols on the model such as:

- establishing a wetland nature reserve;
- more boat moorings for tourists;
- constructing cycleways along the riverside.

Training for a project officer and an assistant to run the "planning for floodplains" exercise cost 800 euros each. 20 days of an assistant's time to prepare, run and write up the community sessions cost 5500 euros. Materials cost around 620 euros. 6 days of project officer time were already accounted for in the project budget. This method assumes there is an officer in place to run and manage the process.
Major input of stakeholders
2% of the population in the two villages sampled made 200 proposals.
A model of each village and its floodplain was made available for people to put proposals on over 2 days in public locations such as the library and school.

Tangible result (effect) of PP?

200 different proposals to contribute to sustainable development of the floodplain were made in each village. Most proposals aggregated into 3 main proposals in each village. The results supported proposals for floodplain restoration from an existing project called "Wet Fens for the Future". This was valuable validation of the "Wet Fens for the Future" project for the organisations which had invested in its development.

This validation of the Wet Fens Project has encouraged organisations involved to go ahead with practical floodplain restoration projects aimed at 15,000 hectares over 50 years at a cost of 15,600,000euros. In UK terms this is a large-scale restoration programme.

Lessons learnt:

Positive:

- That even just sampling participation in 2 villages in the sub-region can produce useful data to confirm existing proposals or to assess whether it is worth investing in a larger scale participation process;
- The "Planning for Floodplains" methodology enables any member of the public to indicate easily and quickly the floodplain management proposals they would like to see in their area;
- The Planning for Floodplains method enables public views to be sampled relatively quickly and inexpensively.

Negative

- Lots of time and effort needs to be invested in choosing villages typical or representative of communities in the river basin e.g. in terms of size, location and characteristics. Criticisms can always be made chosen villages are not sufficiently typical. Ideally a project would have as many "samples" as possible;
- The disadvantage of using samples is that statistically they are small numbers of people and therefore may not reflect wider views across the river basin. The results need to be corroborated against the results of other participation methods in the same river basin (workshops/seminars).

Further information contact:

www.floodplains.org or via jac.cuff@virgin.net for the European Environment Bureau.

9. Nõo rural district development of a municipal water supply and sewage system plan, Estonia

Inspiration points

Effective public consultation techniques in preparation of municipal water management plans in rural areas help to develop economically feasible plans and to pull together social and economic objectives of local development with environmental protection objectives.

Aim and scale of the project

Nõo rural district government worked to develop a water supply and sewage system plan using different techniques of public consultations for preparation and development of the plan. The plan included two parts – a part for development of a centralised water supply and sewage system (50% of the inhabitants use the centralised water system) and a part for water use and sewage system for the areas that are not connected to centralised water systems.

The rural district occupies 170 square km, includes 20 villages and is located in Tartu County of Estonia. 4000 people live in the Nõo rural district.

Period: 1998 - 2001

Objective of Public Participation

The local municipality organised consultations with inhabitants of the rural district using different techniques during preparation of its water supply and sewage system development plan.

Who participated and how (Degree/form of public participation) in what phase of the planning?

Local officials; local stakeholders, mostly farmers, and general public – inhabitants of the rural district. Information to the general public was provided through publications in the local newspaper and people had an opportunity to react and comment to the local government. Interviews and meetings/consultations with local stakeholders and public were held that included personal meetings of experts with farmers at farms and group meetings with inhabitants regularly organised by the local government.

Methods and tools applied

At the beginning the local government:

- Informed about a start of preparation of the water management plan in the local (district) newspaper;
- Students of sociology conducted long non-structured interviews with stakeholders and interviews using open-end questionnaires with representatives of public. The study helped to clarify perceptions by local inhabitants of the situation with drinking and waste waters;

- results of the study complimented an assessment of a state of drinking and wastewaters conducted by water engineers.

After the initial assessment was made, the local government:
- Published the results of the studies in the local newspaper and asked for comments through the newspaper to the study. Inhabitants were rather passive in their reaction to the published texts.However, publishing a map of the area with specific information on water quality in wells and location of the wells brought much more interest in the water quality issues from land owners where wells were located. As a result of the publication, the district government environmental department got requests for details on water quality in some of the wells;
- Local government conducted a series of meetings with local people to discuss water quality in the wells and other issues that concerned development of the municipal water management plan.

Major input of stakeholders

The consultations allowed a more detailed and precise mapping of the problems related to drinking and wastewaters in this rural district to be made that might have not been noticed without the public consultation. The last helped to elaborate a more detailed, realistic and economically feasible water management plan.

Result (effect) of the PP

Estonian national water legislation requires that after 31 December 2007, 95% of wastewaters be treated in villages connected with the central sewage system in the rural district. The study showed that this goal is not realistic given low incomes of the population in the area and specific problems with water infrastructure in different parts of the rural district. A tailor-made investment plan is being developed to ensure that the Nõo rural municipality water management plan is economically feasible and realistic. Communication with the local stakeholders also allowed cost-effective solutions for resolving specific water management problems to be developed.

Lessons learnt

Local stakeholders gain awareness about local environmental issues through their practical experiences of using natural resources but also partially this awareness is derived from mass media. For example, the everyday experience of using water from a local well and then reading information about its quality in the media creates awareness and promotes participation. The local newspaper is the main way of obtaining information about the local issues of concern in the district. Local meetings were shown to be important to develop a dialogue between local authorities and the inhabitants.

Surveys and active consultations with local people using different tailor-made approaches are critically important in the process of the development of economically feasible and realistic municipal water management plans, especially in countries in transition, where municipal budgets are very limited and priorities according to social and economic needs of the population have to be defined.

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10. Lake Pyhäjärvi: local water management, Finland

Inspiration points

Close co-operation and participation of the local authorities and residents as the basis for lake restoration.

Scale/unit of planning

Local

Period: 1990 – 2000

Objective of Public Participation (Why PP?)

Encouragement of the residents to participate in the development and planning of their local environment and to draw their attention to water and environmental protection in order to reduce the land-derived nutrient load (eutrophication) and improve the water quality of Pyhäjärvi and the rivers Yläneenjoki and Pyhäjoki.

Who participated and how?

Local municipalities, organisations and industry together with local and national authorities founded the Pyhäjärvi Protection Fund (PPF) to guarantee the resources for protection of the lake. In 1996-2000 seven village plans were conducted at the Pyhäjärvi drainage area. The plans are based on the residents' own ideas and the residents themselves are responsible for the implementation of the village plan.

Methods and tools applied

The planning started by contacting the local village associations and organising information meetings for the residents. After the village association had decided to conduct the plan, all the village residents were actively informed about it. Residents selected the planning team (5-6 persons) who innovated and progressed the plan. However, the planning team meetings were open for all the interested residents. The representative of the project mainly worked as an assistant and secretary.

Major input of the stakeholders

The plans are based on the residents' own ideas and the residents themselves are responsible for the implementation of the village plan.

Tangible result (effect) of PP

Since the external nutrient load originates from agriculture, rural waste-waters and air pollution, a multitude of water protection measures have been implemented in the drainage basin since the 1990s, resulting in some reduction of P loads, but the effects cannot yet be seen in lake water quality. The water quality of the ditches running to rivers Yläneenjoki and

Pyhäjoki has improved during the project. Some of the village associations are willing to make new village plans.

Lessons learnt

Village planning brings benefits to both permanent and temporary residents of the villages as well as for the authorities as the interaction and communication between the residents, authorities and the planners increases and it is easier to turn existing ideas into concrete initiatives and to apply funding for further projects. The environmental consciousness of the residents increases and individual residents and the entire village have a better opportunity to get their voices heard. Resident-oriented planning results in a manual of the residents' own ideas, which will be taken into account and committed to.

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11. National Water Committee, "Comité National de l'Eau", FRANCE

Elements of inspiration

The diversity of the members of the National Water Committee allows for deep and rich debates. On the basis of a participatory approach, the final advice is established after having reached a consensus. Debating important water-related issues increases the transparency of the national water policy.

Key words

National level ; advisory body ; stakeholders ; debates ; consensus ; transparency.

Background

The National Water Committee was created by the 1964 Water Act, its composition was defined by a 1965 Decree. The advice of the National Water Committee is obligatory for the elaboration of Water Acts, the application texts for Water Acts and the decrees determining the lists of activities subjected to prior authorisation or declaration.

Scale/unit of planning

National – 550 000 km^2 –– 77 members for 60 000 000 inhabitants.

Period

In existence since 1965. 43 plenary meetings in the past 10 years (several meetings per year).

Objective of Public Participation

- To give advice on river basin planning, large development projects and water distribution schemes, problems shared by two or several basins, issues related to water laws or decrees;
- To discuss the preliminary definition of national water policy;
- To propose solutions to the issues related to the water acts of 1964 and 1992.

Who participated and how

Under the Prime Ministers responsibility, the National Water Council is composed of 77 members, divided into 5 clusters :

- 23 water users (chambers of agriculture, fishers' associations, industrialists, associations of consumers or for environmental protection, tourism associations, water suppliers, etc.);
- chairmen of the basin committees;
- competent people (scientists, experts, specialists, etc.);
- 18 state representatives (representatives of the Ministers in charge of water issues);
- 22 elected officials (deputees, department or regional councils, etc.).

Methods and tools applied

Before the meetings, the Committee's Office, hosted by the Water Department of the Ministry of Ecology, prepares information papers and sends them to the Committee members.

During the meetings, a debate takes place for each point of the agenda meeting and any member of the Committee can give his own point of view. The consensus approach is prefered to the voting.

After the meetings, the Committee members can send supplementary comments to the Office, which adds them to the minutes of the meeting. The minutes are examined and approved at the next meeting.

Major input of stakeholders

For example, the National Water Committee gave recently inputs for the draft river basin management plans for Guyana, Martinique and Reunion and for the transposition of the Drinkwater Directive. It will be consulted for the transposition of the Water Framework Directive.

Tangible result (effect) of PP?

The large representation of stakeholders in the NWC improves the dialogue between interested parties and ensures a central function for advice or proposition to the Minister. Comments on the texts are useful and allow a real improvement of them. But above all, the most important result consists in the possibility to organise a real debate on and for water issues.

Lessons learnt

Positive Points

- The National Water Committee has become an important tool for the transparency of water policy;
- It has found a real place and plays a major role in the water policy – related decisions. It has no juridical power but its role is essential : its advice is taken into account when the final decision is taken;
- Concerning draft laws, prior debates within the Committee help to improve the texts and bring a consensus before the presentation to the legislative assemblies;
- Complementarity between co-ordination of measures at national level & planning process at district level.

Negative Points

- Major emphasis on economic uses & interests of water compared to environmental protection.

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12. River basin management plans (S.D.A.G.E., "Schémas Directeurs d'Aménagement et de Gestion des Eaux", FRANCE

Elements of inspiration

- Active involvement of stakeholders at basin / sub basin levels;
- Iterative planning process (alternation of writing draft plan and stakeholders consultation);
- Reporting process of stakeholders comments and competent authorities answers.

The success of the dialogue and participation of interested parties will make the success of the SDAGE. To be used by the State services, the municipalities and the users as a reference document, the content of the SDAGE must be well discussed and negotiated, well understood and well accepted.

Key words

River basin scale ; long-term planning ; active involvement ; stakeholders ; iterative process ; reporting ; initial status ; objectives and measures ; reference document ; public information

Background

The French Water Law of the 2nd January 1992 instituted decentralised water planning tools : river basin management plans (the so-called SDAGE) at the level of the 6 large metropolitan river basins and local water management plans (the so-called SAGE) at the level of sub-basins.

Aim/objective of the project

Assess the initial status and main problems, define quality and quantity objectives, guidelines and priority measures. Elaborate the river basin management plan (SDAGE) defining the main orientations of an integrated and balanced management of aquatic environments and their uses and representing a framework for the planning process in the whole River Basin.

Scale/unit of planning

'Regional', river basin level (about 100.000 km^2 – 5 to 15 000 000 inhabitants – 800 to 1500 stakeholders involved.

Period: 1992 - 1997

Objective of Public Participation

- To obtain a reference document for all questions all over the great basin (from flooding to water quality …) defining management objectives, strategy and actions;
- To reach consensus between all categories of users / stakeholders;

- To use the elaboration phase to create a common understanding, a common vision at the scale of the river basin between State services, communities and users;
- To involve people in the definition of the rules of the game : the more people we involve in the process, the more chances we have to see the rules respected.

Degree of PP and stakeholders involved

The Basin Committee is composed of the representatives of all stakeholders and users in the River Basin (about 100 members): 1/3 local elected officials (i.e. mayors, local communities), 1/3 users, consumers, NGOs and 1/3 representatives of the State. The Basin Committee defines the river basin management plan (SDAGE) and co-ordinates the coherence between local water management plans (SAGE). It arbitrates water conflicts, decides on the taxes to be paid by the users and defines action programmes.

Methods and tools applied : Iterative planning and reporting processes:

Each Basin Committee created a Planning Commission and several Geographic Commissions (implanted at sub basin level or for specific issues : inter-regional aquifer or coastal areas) in which a number of debates and meetings took place. Hundreds of interested parties were able to voice their opinion in the meetings of these geographic commissions.

For example, we can describe the planning process used for the elaboration of the management plan of the Adour Garonne Basin to illustrate the stakeholders involvement and the reporting on the results of the consultation.

Basin level: Coordinator Prefect Basin committee (120 stakeholders) Planning board (36 stakeholders) Operation board (District Public Services	Sub basin level (8 in Adour Garonne District): Geographic Commissions (about 1000 stakeholders in a whole)

Step 1: The Operation Board prepared a Draft V0 for the SDAGE, based on experts' knowledge. The diagnosis, main issues, objectives and measures were described at each sub basin level in a "sub basin notebook" with a synthesis for the whole basin level.

Step 2: The Draft V0 was mailed to all stakeholders of the geographic commissions, who could give their comments during a meeting in every sub basin. Consultants made a synthesis of these comments and addressed it to the Operation board.

Step 3: The Draft V0 was improved by the Operation Board taking these comments into account. The Draft V1, containing the SDAGE (70 p) and the "8 sub basin notebooks" (25 p with a lot of maps), were endorsed by the Planning board.

Step 4: The SDAGE and sub basin notebooks were mailed to each stakeholder and presented during another meeting in every sub basin. Stakeholders were asked to mail their comments within 2 months, giving their name and function and explaining the point of the Draft in discussion. The same procedure was conducted specifically with all the Public Services concerned with water policy.

Step 5: All the comments were handled the same way:
a) a draft answer was prepared by the Operation Board;
b) it was endorsed/modified by the Planning board;
c) all the information was reported in a "registry of comments" with a page for every discussed section of the Draft, describing : the issue discussed, all the stakeholders' and civil servants' comments on this issue, the answer of the Operation board and the final decision of the Planning Board;
d) All the registries were made available to the public at the Public Service Office hosting each Geographic Commission.

Step 6: Taking into account about 600 stakeholders' and 1000 civil servants' comments, a new Draft was written (V2 : SDAGE and Sub Basin notebooks) with a new iteration of consultation and reporting of the stakeholders' comments (There were less reactions during this third consultation).

Step 7: The draft V3, endorsed by the Planning board was presented as the « SDAGE draft » for consultation to a wide range of other stakeholders (regional and departmental assemblies, councils of main towns …) and during 50 public meetings. There were very few demands for modification of the project during this step.

Step 8: The draft was endorsed by the Basin Committee and signed by the Coordinator prefect.

Three documents were published for public information: the whole SDAGE (110p), an executive summary (25 p) and a 4p leaflet. A web site was implemented, from which everybody can download all these papers. Sub basin notebooks are available on demand.

Nowadays, the Operation Board publishes an annual report (plus an executive summary and a leaflet accessible on the web), describing what is the state of the basin, compared with the initial objectives. The public can ask questions or react by e-mail.

Major input of stakeholders

- All stakeholders discussed in details all the components of the plan, the preliminary reports and the final report, which were modified in consequence and finally accepted by all;
- A real involvement of the water users in the decision-making process, including 'polluters';
- A lot of exchanges between stakeholders, giving some "social learning" about water management (understanding of the diversity of stakes, better acceptance of the different expectations and water uses);
- For example, as regards the associations concerned with environmental protection, they have been a real stimulus for different issues : management of alluvial plains, hydroelectricity, granule extractions from the rivers, etc.

Tangible result (effect) of PP?

- The river basin management plan (SDAGE) was elaborated and discussed between all categories of stakeholders within the Basin Committee and the Geographic commissions;
- The decentralisation of the Basin Committee through geographical commissions, users & consumers commissions, allows the involvement of local people;

- Associations have been stakeholders in the thinking and the decision-making, which is essential. For example they achieved great progress as regards the protection of wetlands, flood-prone areas, riparian forests, alluvial groundwater, etc.;
- Socially more accepted measures.

Lessons learnt:

Strong points :

- Necessity to implement training and information all along the process;
- Consultation and effective participation of users needs sufficient delays in order to allow the different consultations to actively take place;
- Time is necessary so that the stakeholders of a river basin know and understand each other, speak together, ratify together the diagnosis of the river basin status and think together about the possible solutions to solve the problems identified.

Weak points :

- The SDAGE was elaborated and discussed by representatives: it is a representative and not a direct participation of the public in general;
- The SDAGE document is made available to the general public only after its approval;
- The cost of the project is difficult to assess, but in every basin, a staff of 2 to 5 people was dedicated to the stakeholders involvement and public information for 2 years.

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13. The local water management plans (S.A.G.E., "Schémas d'aménagement et de gestion des eaux"), FRANCE

Elements of inspiration:

Active involvement of stakeholders at a local level – capacity building.
The scale of these local management plans (about 1000 km^2) allows them to be closer to people and concrete problems. It gives more place for participation than larger scale plans. This example shows that time and pedagogy are needed to reach a consensus between interested parties. According to the case, interested parties can decide in the final document to apply the existing water law only or to go a little further.

Key words

Local scale ; local wishes ; long-term planning ; active involvement ; stakeholders ; initial status, objectives and measures ; reference document ; public consultation

Background

The French Water Law of the 2nd January 1992 set up decentralised water planning tools : river basin management plans (the so-called SDAGE) at the level of the 6 large metropolitan river basins and local water management plans (the so-called SAGE) at the level of sub-basins. The SAGE is drawn by a Local Water Commission and then submitted to the Basin Committee, local government institutions, chambers of commerce and agriculture and the general public for consultation before being voted by the Local Water Commission and finally officially approved by the State prefect.

Scale/unit of planning

'Local', sub-basin level - about 1.000 km^2 – about 100 stakeholders involved for 100 000 inhabitants

Aim/objective of the project

- To start from a local wish and progress towards a large consensus between users;
- To involve local people;
- To refine the guidelines defined in the SDAGE and to adapt them to local circumstances;
- To be closer to concrete questions and implement concretely the guidelines defined in the SDAGE.

Period: About 5 years

Objective of Public Participation (Why PP?)

- The elaboration of this type of planning document needs a collective approach, based on the local solidarity at the level of the basin or sub-basin. The most important success factor is to create dynamics round the definition of a common project;

- To obtain a reference document for important water issues all over the sub basin (from flooding to water quality…) defining management objectives, strategy and actions, by reaching a consensus between users;
- To use the elaboration phase to create a common understanding, a common vision at the scale of the river basin between State services, communities and users;
- To involve people in the definition of the rules of the game : the more people we involve in the process, the more chances we have to see the rules respected.

Degree of PP and stakeholders involved

Diagnosis, objectives and measures are discussed between all categories of stakeholders within the Local Water Commission (from 50 to 100 members) : ½ local elected officials, ¼ users, consumers, NGOs and ¼ State representatives. The SAGE is the end product of the works undertaken by the Commission, completed by a consultation of all the citizens, who have access to the draft during 2 months.

Methods and tools applied

- A facilitator (a technician or an engineer) is employed at the beginning of the project in order to manage the whole process;
- At the beginning, the facilitator organises information meetings for the members of the Local Water Commission on water issues and the role of the SAGE document. He/she also informs the elected officials and raises the awareness of the different partners and stakeholders within the river basin;
- A lot of meetings of the Water Local Commission take place, in which the people concerned can debate to produce the plan from the beginning to the end of the elaboration process;
- Thus, the members of the Local Water Commission work on a co-ordinated way from one step to the next. Preliminary reports are discussed in detail, modified and finally accepted by all stakeholders: assessment of the initial status of the basin and tendencies, definition of water quality and quantity objectives, determination of the rules for the preservation of aquatic environments and the actions to be planned;
- When the SAGE project is elaborated by the Local Water Commission, it is made available for comments to the general public for 2 months;
- The project can be modified by the Local Water Commission to take into account the comments of the public before adoption by the Prefect;
- After the adoption of the plan, the Local Water Commission follows the implementation of the plan and for this purpose it has 2 meetings / year; and,
- During the whole process, communication tools are used to raise and maintain the motivation of both the stakeholders and the general public (some booklets are regularly distributed to all homes).

Major input of stakeholders

- ll stakeholders discuss in detail all the components of the plan, the preliminary reports and the final report, which are modified in consequence and finally accepted by all;
- Involvement of the water users in the decision-making process, including ‘polluters’;
- At the local level of the sub-basin and in the SAGE preparation, local associations can speak on behalf of the river itself.

Tangible result (effect) of PP?

- A lot of exchanges between stakeholders, giving some "social learning" about water management (understanding of the diversity of stakes, better acceptance of the different expectations and water uses);
- Progress towards a shared culture;
- Decentralisation of the decision;
- Concrete implementation of the existing water law and definition of some supplementary water regulations at the level of the sub-basin;
- Socially more accepted measures.

Lessons learnt:

Strong points :

- With regard to the SDAGE, the SAGE is closer to concrete questions and is at a more adequate scale for participation;
- It is necessary to implement training and information throughout the process;
- It is necessary to have clear ideas on the common objectives, to put in place a solid but also open institutional organisation;
- It is essential to work at an adequate scale and adapt to the context;
- The Local Water Commission is a place for the dialogue between the different stakeholders of the territory. The representiveness of the composition of the Commission is an essential success factor;
- Importance of human resources : the staff must be adapted to the stakes and the context;
- It is essential to maintain the motivation of everybody all along the process and to show the progress realised with the concrete actions made during the whole elaboration of the SAGE.

Weak points :

- Discussions between (local) representatives of the same organisation/authority;
- The asymmetry of information among stakeholders;
- The slowness of the process, mainly for legal, political and institutional reasons;
- The consultation of the general public is only formal, when the draft is already developed and complete;
- The cost of the project is difficult to assess precisely. It needs a facilitator and a secretary for 2 to 4 years, and consultants for the diagnosis and the first draft of plan.

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14. The Drôme river management plan, FRANCE

Elements of inspiration

Active involvement of stakeholders at the local level – capacity building.

Key words

Local scale ; local wishes ; long-term planning ; active involvement ; stakeholders ; initial status, objectives and measures ; reference document ; public consultation.

Background

The Drôme river management plan was the first SAGE to be completed, implementing the procedure established by the 1992 Water Act (see previous example).

Aim/objective of the project

- Protect the Drôme valley area characterised by a beautiful countryside and varied heritage value through the rivers of the catchment, their underground water tables, and their dependent wetland ecosystems;
- Solve the priority problems of the catchment which are the quantity management of the water resource and the maintenance of beds and river banks; and,
- Refine the guidelines of other aspects of the water management.

Scale/unit of planning

Local / catchment - 83 municipalities concerned - catchment area of 1,640 km^2. 42,500 inhabitants.

Period: 1994-1997

Technical studies, discussions and local meetings from 1994 to 1997 (3 years).
Consultation and approval in 1997 ; implementation since 1997.

Objective of Public participation (Why PP)

The objective was to protect the river heritage and to ensure a better appreciation of it, taking into account the different water uses and ensuring preventive action against risks. For that purpose, a process of local consultation, negotiation and consensus was implemented to reach agreed objectives regarding water management between the different interested parties and river users.

Who participated and how (Degree/form of public participation) in what phase of the planning?

Active participation of the stakeholders :

- The Local Water Commission for the Drôme river was composed of 44 members : 50% local elected officials, 25% representatives of State services and departments, 25% representatives of local water users groups (agricultural irrigation, gravel extraction, leisure activities, associations, etc);
- The Basin Committee (consulted);
- Local elected officials (consulted);
- Chambers of commerce and agriculture (consulted);
- The State Prefect (final decision).

Methods and tools applied

- Meetings of the Local Water Commission at the level of the basin;
- Sub-basin meetings;
- A specific facilitator (who was also a technician) was in charge of the preparation of meetings, the communication during the whole process concerning the progress of the works, the technical secretariat and the co-ordination of the writing of the SAGE;
- The draft was made available to the general public for comments in public places (for 2 months);
- The Local Water Commission published a journal regularly during the process to inform the population living in the basin of the different activities carried out in the catchment;
- The planning document is now under implementation and the Local Water Commission still publishes regularly this journal.

Major input of stakeholders

About 20 meetings of the Local Water Commission ; Numerous sub-basin meetings ; Consultation of the general public.

Tangible result (effect) of PP

The process has gone through three main steps at which a consensus between all categories of stakeholders and users was reached : assessment of the current situation, definition of management priorities, evaluation of necessary measures to achieve these objectives. The SAGE objectives were translated into 6 actions plans related to : water resources, river channels and banks, water quality, risk management, natural heritage ecosystems, tourism and leisure activities.

Lessons learnt

<u>Positive points</u>

- Agreement on the SAGE was possible through a local will to make public interest a priority;
- The Drôme river was perceived as a linking factor and gave an identity to the whole valley area and to the whole consultation process;
- The consensus obtained on the SAGE document ensures the implementation of the SAGE since 1997, the co-ordination between existing structures and a sustainable presence in this field.

<u>Negative points :</u>

- The asymmetry of information among stakeholders;
- Problem of capacity building for some stakeholders;

- The slowness of the process mainly for legal, political and institutional reasons;
- The consultation of the general public is only formal, when the draft is already developed and complete.

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15. National Commission for Public Debate (CNDP), FRANCE

Elements of inspiration

The public debates organised by the CNDP are open to every citizen. At the moment, the CNDP has not adressed any issue related to water management but for each public debate it has organised, a combination of methods and tools for public information and participation were used. The most innovative tool consists in the gathering of the public contributions into comprehensive "stakeholders' books", these documents being distributed to all participants for discussion, in the same way as the documents realised by the project leader.

Key words

Public debates ; early participation ; broad public ; combination of tools ; stakeholders' books.

Background

The National Commission for Public Debate (CNDP) was created by law on the 2nd February 1995 to reinforce the environmental awareness in big development projects (motorway networks, airports, harbours, etc). The Commission is composed of members of the Parliament, local representatives, magistrates, representatives of civil society and experts.

Aim/objective

When it is requested to do so by a petition, the Commission organises itself a 4-month public debate, or it asks the project leader to organise it. The public debate has to deal with the objectives and characteristics of the project, so it means that it takes place at the very beginning of the process. A specific commission, composed of competent people in the field, is put in place to coordinate the debate.

Scale/unit of planning

The projects usually concern several French regions. For example, the public debate organised between March and June of 2000 for the TGV Rhin-Rhône (southern part of the high-speed rail line between East and South) concerned 4 regions : Alsace, Bourgogne, Franche-Comté and Rhône-Alpes, which represents 4,5 million people from Strasbourg to Lyon.

Period: 4 months (possible extension to 6 months in certain cases).

Objective of Public Participation

The public debate can help to reach a consensus on the objective and characteristics of the project and particularly, it can help to identify the potential impacts for the environment and for the inhabitants which may be affected by the project and then to propose to the project leader some measures to reduce these impacts and improve the project.

Who participated and how (Degree/Form of public participation) in what phase of the planning?

For example, for the TGV Rhin-Rhône project, the CNDP was requested by a federation of environmental NGO (France Nature Environnement) to organise a public debate on this project. The special commission was composed of the French Rail Network as the project leader, the "organised public" (representatives, departments'chiefs, economic authorities, etc.), the press, the users and environment protection associations and individuals ("non organised public"). These people represent the very first circle of participants. But the public meetings are open to all citizens and concern thousands of participants.

Methods and tools applied

The methods used to inform the public:

- "Supporting dossier": provided by the project leader, gives to the public the necessary information to participate - general description of the objectives and the main characteristics of the project, estimation of the economic and social stakes, identifications of the main environmental impacts and evaluation of the economic and social costs of the project - for the TGV Rhin-Rhône project, 6000 were distributed;
- Internet web site : to have information on the project and the organisation of the public debate (for the TGV Rhin-Rhône project : 6500 visits, 70 per day);
- "Information letters of the debate" or "lettres du débat: to inform the public on the debate, mobilise it regularly to participate and communicate information on the evolution of the debate " (for the TGV Rhin-Rhône project: 2 700 000 were distributed);
- Visits to the headquarters of the specific commission to consult more detailed documents on the project;
- Prepaid cards: distributed with the information letters, to ask for further information.

The methods used for public participation

- Public meetings (TGV Rhin-Rhône project : 10 meetings in different cities);
- Question-answer system (TGV Rhin-Rhône project : 2000 questions received);
- Prepaid cards + toll-free number : to ask for information and questions;
- Mail: for sending remarks, opinions or thoughts;
- E-mail: from the Internet web site, to ask questions and consult all the answers already given;
- "Contributions" : mails received at the commission which showed one particular and developed position – (TGV Rhin-Rhône project : 85);
- "Stakeholders book" : selection of some of the observations from the public were published in so-called "stakeholders books" ("cahiers d'acteurs") and distributed (TGV Rhin-Rhône project : 10 books in total);
- Press (example, for the TGV Rhin-Rhône project : 163 articles published in the regional press, 26 in the national press and 10 press meetings in the 10 cities where the public meetings took place).

Major input of stakeholders

Essentially through public meetings, questions-answers system, contributions and stakeholders' books.

Tangible results of PP

The public is invited to express itself but the project leader is not legally bound by its answers given to the public. However, the project leader takes into account the opinions of the public who participate in the debate and the project might be modified in consequence. The assessment report of the public debate is made available to the public.

Lessons learnt

<u>Strong points</u>

- Participation of individuals who are given the same importance as the representatives;
- Question-answer system : allows everyone to ask questions, with the assurance of having an answer;
- "Stakeholders book" : innovative tool creating further considerations between stakeholders and public;
- Interest of the public for these types of democratic consulting processes at a time where the project is not totally defined and where there is still place for making modifications;
- Very important role of the regional and local press as a support for information supply to the public;
- Taking into account the lessons learnt, the CNDP will be able to give advice and recommendations to public authorities to favour and develop public participation (Local Democracy Law, 27th February 2002).

<u>Weak points</u>

- Superficial interventions sometimes ; not the same level of participation in all meetings;
- Not enough meetings (reasons of costs, time and availability of stakeholders).

Contact for further information:

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16. Information letters with regard to the implementation of the Water Framework Directive Germany (Thuringia)

Elements of inspiration

This example shows one possibility to inform stakeholders and the broad public continuously about the contents of the WFD and the implementation process.

Key Words

Continuous and current information on the implementation and planning process, stakeholders and broad public.

Background

The WFD is a new approach, also in the 16 Lander (regions) of Germany which have competences concerning water management. Thuringia is part of several river basins and has the task to implement the WFD in the parts of these river basins in its territory. The environment ministry of Thuringia wants to inform stakeholders and also the broader public continuously from the beginning of the implementation process in the region in order to encourage acceptance and provide transparency.

Aim/objective of the project

Early and continuous information is seen as the basis in order to enable and encourage the active involvement of the public as required in Article 14 WFD. The information letters are distributed in order to explain the implementation steps and the work to be done and in order to enable stakeholders and public to be informed, to follow the implementation process and to be prepared when the programme of measures is discussed and when the consultation on the river basin management plan takes place.

Scale/unit of planning

Thuringia (one of the 16 German Lander), national/regional/sub-basin level. Thuringia is part of the river basins of the Elbe, the Weser and the Rhine. The Land covers 16 171,5 km^2 and has 2 449 082 inhabitants.

Period

During the whole implementation process, i.e. at least until 2009. Three information letters have already been published up to October 2002.

Objective of Public Participation (Why PP?)

Not all stakeholders are members in the implementation groups in Thuringia and it is also important to reach the broader public. This can be done by the information letters. The letters provide detailed information on e.g. the content of the WFD with regard to the actual implementation steps (at the moment e.g. with regard to Article 5 WFD (description of the status quo), on pilot projects in Thuringia, information events etc. The public can become acquainted with the objectives and necessary steps of the WFD early in the process and can express ideas and proposals.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The target group are especially the persons or organisations interested in water management issues, but also the broad public. The information letters are particularly intended to inform stakeholders and persons who are not members of the WFD implementation groups in Thuringia. The information letters are sent to the environment ministries of the other German Lander, to all district authorities and to other regional environment, agriculture and planning authorities in Thuringia, all sorts of industrial, environmental, agricultural etc. associations and NGOs in Thuringia and on federal level, political parties in the parliament of Thuringia, but also to private persons, private planning institutions and universities.

Methods and tools applied

At the moment the information letters (six pages) are published twice or three times a year (available in printed form or via internet (www.thueringen.de/tmlnu, see: Europäische Wasserrahmenrichtlinie, only in German). There is a list for the distribution of the printed form (number of copies: 3000) by mail. Additionally there is a big list of Email addresses to which the information letters are sent automatically. Everybody can ask to be inserted in this Email list. At the end of the letters a contact person is named (phone and email) in case of questions or proposals. The information letters are also made available during water management related seminars, workshops etc. organised by Thuringia's authorities or other institutions.

Major input of stakeholders

The WFD implementation process has just started, so there is less input than a huge interest from the stakeholders in as much information as possible.

Tangible result (effect) of PP?

There is a clear interest in information on the WFD and its implementation. The public wants to be informed, even more specified than in the last three information letters. The environment ministry of Thuringia feels encouraged in its approach and plans to expand it in the future.The information letters and the contact to the ministry will be used also as platform with regard to other Thuringian ministries and to other of the 16 German Lander. The information should become intensified and specified, e.g. by information on special issues. Therefore also other authors than from the competent authorities themselves will have the possibility to deliver texts for the information letters.

Lessons learnt

There is already a huge demand for detailed information on the WFD and its implementation which was perhaps underestimated in the beginning. Early and open information and communication is the key for a coherent implementation of the WFD within the given timescales.

For more information please contact:

- www.thueringen.de/tmlnu (EU-Wasserrahmenrichtlinie, only in German)
- Heide Jekel

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17. River Basin Management Plan Maas/sub-basin Niers, Germany (North Rhine-Westphalia)

Elements of inspiration

This example shows one possibility to involve stakeholders on regional level in the implementation of the WFD from its beginning on in order to get hold of their knowledge and in order to discuss the relevant implementation steps and its consequences.

Key- words

Information and consultation of the public, organised public, regional forums, non organised public.

Background

The WFD is a new approach, also in the 16 Lander (regions) of Germany which have competences concerning water management. North Rhine-Westphalia is part of several river basins (e.g. Rhine, Maas) and has the task to implement the WFD in the parts of these river basins in its territory. The Land covers 34.079 km^2 and has more than 18 million inhabitants.

Aim/objective of the project

Pilot project with regard to Article 14 WFD in North Rhine-Westphalia. Involvement of the organised public/the stakeholders in the first implementation phase until 2004 (Article 5 WFD: inventories, review, analysis) on regional level. Information of the broad public in the relevant region with regard to WFD in general (objectives, implementation steps etc.).

Scale/unit of planning

Sub-basin level (the sub-basin of the Niers is divided in three parts in order to have three regional discussion and information forums (upper, middle and lower Niers)). The river Niers is part of the Maas river basin. The Niers sub-basin covers 1382 km^2 mostly in Germany and for a small part in the Netherlands, 715.000 people are living in this area. The environment ministry of North Rhine-Westphalia was interested to create a structure which allows to involve the relevant stakeholders in the implementation process.

Period

For 2 years until 2004 (end of first implementation phase). At the moment it is likely that public participation by regional forums will be continued until the end of the implementation process.

Objective of Public Participation (Why PP?)

To enable information, stakeholders' input and a consensual approach from the beginning of the implementation process on.

Who participated and how (Degree/form of public participation) in what phase of the planning?

In the three Niers forums: Municipalities, districts, water companies, water associations, chambers of agriculture, forest authorities, nature conservation NGO's, biological planning units, the Dutch authorities and stakeholders (all of the relevant region), 30 – 40 persons per forum. Round Tables: Information, discussion, distribution of relevant materials, exchange of experience, involvement with regard to data collection.
Broad public on regional level: Internet site (www.niers.nrw.de), possibility to ask questions.

Methods and tools applied

In the three Niers forums: Meetings at the moment once a year (sufficient for the first implementation phase, later on perhaps more frequent), internet site for each forum (only accessible by password, with all relevant information and discussion material).
Broad public on regional level: One information flyer until now (general information with regard to the WFD), Internet site (www.niers.nrw.de), press reports.

Major input of stakeholders

Stakeholders in the three forums delivered the necessary data for the first implementation phase until 2004 (Article 5 WFD: impacts, pressures etc.). Stakeholders delivered their view on the WFD and the implementation process. At the moment there is mainly a huge demand to get informed and involved.

Tangible result (effect) of PP?

In the three regional forums none of the stakeholders feels discriminated, it is a balance of to give and to take, open and positive discussions, good atmosphere with regard to the next implementation steps.
Experiences could be used for the North Rhine-Westphalia Guidance paper on pp.
The data delivered by the stakeholders are used to fulfil the requirements of Article 5 WFD and as basis for the WFD planning process.

Lessons learnt

Huge interest of the stakeholders to participate in the implementation. Positive reactions because they are involved early and get a lot of useful information. The regional approach and the discussion in smaller groups proved their worth (it was already useful in the past before the WFD with regard to alluvial water programs) , they enable useful discussions and create acceptance and common understanding as a basis for the next implementation steps.

This approach is already used in some other parts of North Rhine-Westphalia and because of its benefits is likely to be taken over in all sub-basins or parts of them in the territory of North Rhine-Westphalia.

On the other hand this approach is a lot of work (preparing and organising the meetings) and requires staff and time.

For more information please contact:

- www.niers.nrw.de (only in German)
- Heide Jekel

Federal Ministry for the Environment,
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18. Erne sustainable wetlands cross border Ireland and Northern Ireland

Inspiration points

Erne Sustainable Wetlands was an inspiring example of public participation because it carried out a range of participation methods at a range of scales. This resulted in a shared vision for the area as well as specific projects.

Aim/objective of the project

Erne Sustainable Wetlands aim has been to identify ways of achieving integrated and sustainable, or 'wise use', of water and land resources for the benefit of people and wildlife within the Erne catchment.

The project has achieved its objectives through:
- Development of a framework, or process, to help demonstrate, in practical ways, how the public could be engaged in a decision making process within the catchment;
- Development of a common vision and set of values that sets out the 'desired future condition' for the future of the Erne catchment. It describes stakeholder values for river, floodplain and catchment management for which measurable objectives can be developed subsequently;
- Exploration of issues and management proposals for sustainable management of water and land resources that are practical and have public support;
- Development of criteria and impact indicators to help assess the sustainability and impact of management proposals;
- Application of the Local Sustainability Model to assess economic, social and environmental sustainability of the management proposals;
- Development of a catchment scale, impact assessment methodology;
- Examining how policies need to be changed to promote integrated and sustainable management of the catchment.

Scale/unit of planning

The Erne Project tested participation at three different scales:
- Catchment;
- Sub-catchment;
- Cross-border partnership (c1000 km^2).

Period

The project took place over a two and a half year period, from November 1999 to March 2002.

Objective of Public Participation (Why PP?) Who organised it?

The Project Officer, Janie Crone, trained as a facilitator, developed principles for participation, designed the participatory process and facilitated all the workshops and training events. The participatory process was designed to help demonstrate, in practical ways, how the public could be engaged in a decision making process within the catchment. The process initiated was open and inclusive so that anyone with a management responsibility, stake or interest in the catchment could contribute to discussions, and each workshop started with, in a sense, a blank sheet of paper.

To help encourage informed action, the process involved elements of education, awareness raising, information sharing and training. The project used Participatory workshops and events. Training and capacity building were key elements to: Increase commitment to the process; develop ownership of the process; develop lasting skills at all levels; be cost-effective.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The Erne Sustainable Wetlands participatory process involved different levels of participation at different times. Some of the process (Questionnaires, Community Mapping) was concerned with gathering information and public awareness, while other parts of the process, (themed workshops and prioritising workshop), asked stakeholders, together with statutory and non-statutory organisations, to prioritise and make choices that gave stakeholders an equal role in decision making.

Every person living within the Erne catchment should be considered a stakeholder. A stakeholder is any person, group or organisation who can impact on or be impacted by decisions made about land and water management. The population of the Erne catchment is approximately 150,000 people over an area of 4340 km^2. The population is mainly rural and dispersed with an average density of 29 people per km^2.

The process in the Erne tried as far as possible to include anyone who wanted to get involved. All workshops were publicly advertised through local newspapers, local newsletters, leaflets/posters and direct mailings.

In the time constraints of the project (effectively the bulk of participation had to run from September 2000 to Feb 2001) it would have been impossible to get full participation, and even the 10% (which would have been 15,000) required for a true representative sample, would have been difficult to reach. However, over 150 stakeholder groups, community organisations and development associations were contacted in the course of the project. Each group has a stake in the future of the Erne wetlands through, either, economic considerations, social life of communities or environmental concerns. In terms of inclusivity, therefore, many of the organisations and groups involved represented large numbers of people, for example, the local wildflower group that was involved has a membership of over 400. Also many elected councillors were at the meetings and have representative status. In these terms therefore, though the figures for 'individuals' present would suggest low percentage involvement true representation was much higher.

Methods and tools applied; Include resources used if known (time, money)

Participatory Methods included: Facilitative Leadership, Stakeholder Dialogue, Participatory Appraisal, Community Survey, questionnaires, and the Local Sustainability Model. Members of the community, stakeholder organisations and project Steering Group have been trained themselves in some of these methods.

Indicative costs of some of the methods

- Facilitative Leadership £3098 (pounds);
- Participatory Appraisal Training £3960 (pounds);
- 5-day training programme for 10–16 participants.

Major input of stakeholders

Stakeholders were central to the success of the Erne Sustainable Wetlands project. An early decision in the project was to include stakeholders in the process at a very early stage so that they were involved in shaping the outcomes in a

Tangible results (effect) of PP?

Within the time constraints of a project, it is difficult to give a true estimation of the tangible results of public participation.
There area several measurable results:

- There is more understanding of public participation within statutory and non-government organisations;
- PP has been put on the agenda of many organisations, if only at a discussion level;
- An expectation and momentum has been created within the Erne catchment;
- A long term vision has been created;
- A management model has been created for continued participation.

Lessons learnt

<u>Positive</u>

- The initial process was designed to provide a framework for participation at the scale of the river basin / catchment. The process was successful in achieving its objectives. There was good discussion and debate, and each workshop developed issues into management proposals;

- People relate to the environment immediately around them, and to issues that impact on their lives. Experience of working within a focus area, (between Newtownbutler and Belturbet, an area of c100km^2), has highlighted that:
    - People feel a sense of local ownership and pride;
    - Have a lot of local knowledge;
    - Can often make the link between local actions and local impacts;
    - Feel more able, and have the capacity, to take action at a local level.

This is not to say that the public are not capable of providing valuable contributions to a decision making process at the scale of the catchment. They are, but the process of engagement needs to start at a more localised level to help build capacity and confidence.

<u>Negative</u>

A deeper analysis of the participants of the workshops showed that the process did not attract wide support and participation at community level.

By initiating the process at catchment level, many community stakeholders did not feel they could contribute to discussions because:

- They could not relate their local experiences to a catchment / river basin scale;
- There was often a lack of knowledge and awareness about catchment issues and the ability to make the link between action and impacts;
- They were not always confident about sitting around the table with 'specialists and experts;'
- There was a real feeling that statutory agencies do not listen to the communities needs and it would be a waste of time.

Summary findings

There is a need to build a catchment management structure that people feel confident with and able to participate in. To successfully engage people in a decision making process at river basin / catchment scale requires a structure of localised groups.

Contacts for further information:

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European Environment Bureau via jac.cuff@virgin.net

See also www.floodplains.org

19. Integrated Reconnaissance of the river Rhine, Waal and IJssel (so-called RVR and IVB projects), The Netherlands

Inspiration points

Consultation of experts, NGO's and other governmental organisations in a reconnaissance study at River Basin Level.

Aim/Objective of the project

The Dutch government has developed its policy "room for water", but asked the regional offices of the Ministry of Public Works to develop in an open approach, in close cooperation with the other government organisations, to give advice on the possibilities of water management with a waterflow of 16.000m3/s (till 2015) and with a situation of 18.000m3/s or more afterwards (with further climatic changes…) Four projects are initiated of which two RVR and IVB are discussed below.

Scale/unit of planning

Regional level (involving 2 provinces).
Scale 1: 375,000.

Period: 1998-2001

Objective of PP

To use the knowledge and experience of other government organisations for the development of water management options in the coming decades and hence improve the quality of the national policy.

To develop commitment and support for the formulation and implementation of this national policy.

Who participated and how (degree/form of public participation) in what phase of the planning?

The open interactive process is formed by:
- A steering committee;
- A close cooperation with other governmental organisations. In steering committees, the 2 provinces, municipalities, the regional office of PW, VROM and LNV as well as the waterboards are represented. They are responsible for the decisionmaking and the advise to the government on further policies. (Before only the regional office of PW developed such studies and gave advice);
- An expert group (of government staff (and representatives of NGO's).

In the IVB project the project team has been supported (in a later phase) by three "working groups"of experts per theme: 1. waterflow, use and land use 2. juridical and governmental issues 3. communication. The juridical aspects are of large importance as room for water demands a number of changes in the current laws and procedures. The RVR project organised reflection groups with representatives of NGO's).

Open communication

From the start the project team showed a positive attitude towards interviews, questions by stakeholders and took care to produce clear reports, and leaflets to inform about the progress and results.

Symposia (IVB).

The IVB project has organised two symposia. One for the governors and the other one for NGO's and interested citizens. The aim was to explain about results of the screening study so far, to create understanding and support and to seek reactions and advise on the proposed measures.

Information evenings for the general public (IVB)

A (DVD) film putting water management in a historical perpective, bringing interests together under the flag of security and illustrating all proposed measures and its consequences . The objective is to inform people, provide them the knowledge they need, generate understanding for the necessity and gain insight on the different perceptions and ideas people have. What are the consequences of these measures for the user, inhabitants and local governors?
"Kitchen table" conferences with the ministry and farmers in the area. Which measures are possible?
Consultation rounds (interviews) among the parties involved on how to proceed.

The government has based is decision on policy making on the results of the study on "water management in the 21th century" (so-called WB21). This study has also been interactive in a sense that it formulates a strategy by organising:

- Expert meetings focusing on different topics (like agriculture, nature conservation, recreation, shipping, town planning and international aspects);
- Expert meetings and research on different policy instruments;
- Research on the coherence between regional- and the national water systems.

Methods and tools

See above: expert groups; working groups per issue; open communication; interviews; symposia; information evenings; DVD film; "kitchen table conferences"; consultation rounds.

Experience and lessons learnt

Only after a thorough problem analysis and the generation of guidelines for water management, the project organised discussions with NGOs. The idea was that the government should have a sense of direction before other parties become involved in the discussion. The topic is difficult as the problem is security and national interests are at stake.

However, in retrospect, the consultation of other parties and stakeholders would have been useful half-way the process in order to share problem ownership and invite people to generate solutions.

The province is eager to take the role as process manager. They are responsible for the integral area development and fear that the Ministry has a dominant say in the plan development (see reaction minister).

A reconnaisance study becomes more effective if combined with proposals for alternative measures or scenario's. The latter makes conflicting interests but also chances for new solutions clear. For example, the measures as proposed by IVB made the interest of the different parties clear and evoked the development of new alternatives by these stakeholders. The RVR project decided not to come with a plan but provides a kind of toolkit with 1000 measures, without indicating the location of possible measures and its effects. Discussion on what where, when and for whom was postponed and thus agreements among parties was still missing.

The strategy that is currently being developed on water management in the next century was still missing at the start of the study. Hence, pre-conditions and directives were not clear. The IVB project took initiative and developed new pre-conditions which could (with approval of the Hague) could be used in the further development of measures.

Communication towards citizens about progress and results is poor in the RVR project. People do not see the necessity of this study yet.

Projects were implemented (funded by EEC) in the riverbeds while the policy on water management in the coming century is still being developed. This resulted in one project in a confusing situation where the government appeared to be unreliable. In the other project "no-regret" measures were formulated to be financed by these EEC funds.

(Tangible) Result

1. A new style of government

The steering commitee wants to continue its cooperation and appreciates the atmosphere of trust, good relationship and the working together. *"we want to continue this cooperation like wise people that make sense"."it is a form of careful decision making in a phased approach"*
Other government organisations and NGO's like the department of agriculture and nature conservation have gained understanding for the interests of PW and the importance that is being attached to security ("nature is more flexible than security"). Hence, they search for alternative policies like security in "wet nature". The feeling of mutual understanding and trust has grown among the different organisations involved.
NGO's showed new initiatives, e.g. a waterboard developed their own alternative solutions (and published it in a newsletter).
Also farmers came up with constructive alternative solutions for water management in specific areas.

2. Water management issues

General outline for water management in the riverbasin (of the river Rine).

Development of a vision on spatial planning in relation to water management by Provincial Government and Department of VROm in the region.
Different alternatives are developed and the effects of each are indicated.
The question has been answered; within the existing watersystem the river water can be accomodated (16.000 m3/s) through improved maintenance and measures within the system
The weak parts in the watersystem (with respect to security) are indicated in the region
No alternatives, but different measures are developed that can be implemented sequential (IVB):

- In between dikes;
- Flowing through the Biesbosch;
- Green rivers (after 2015);
- No regret"measures are proposed (that are subsidised by EEC) , which can be directly implemented (and shows direct results to those who have been involved);
- "It is no longer a study on civil-technical measures, but an organic process, focussing on security through creating room for water…. Measures need to be flexible in order to anticipate further changes and the effects of measures…..All relevant parties (organisation) share the problemperception and measures!" (project leader).

20. IIVR project, Integrated Planning of the Veluwe Lakes, The Netherlands

Inspiration points

This project shows an example of shared responsibility among several authorities in developing an integral plan. This shows a number of institutional challenges and gives examples of different forms of participation in different phases of the process.

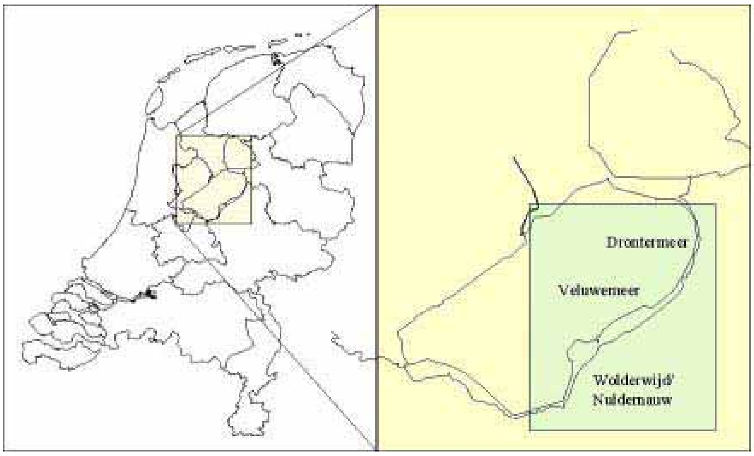
Aim/objective of the project

The Veluwe lakes are managed by several authorities, each with its own policy and instruments to manage the different parts of the water and its border. Besides these local and regional authorities (in total 20), also non governmental issue groups, have their concerns and interests. Hence a situation has occurred where plans are not in line with each other and often have conflicting interests, like those of nature, recreation, fishery and transport by water.

In 1996 an integral planning project was initiated by the Ministry of Public Works and water management (PW) in the region.

Scale/unit of planning

Hundreds of stakeholders, 3 provinces, 10 municipalities, 4 national ministries worked together on a plan for the Veluwe Lakes (about 64 km^2). See Figure below.



Period: 1996-2010

Objective of Public Participation

An open planning approach was chosen with the following objectives:
- To achieve more consistency in existing and future development;
- To develop a high quality plan which is feasible and widely accepted.

Who participated and how (degree/form of public participation) in what phase of the planning?

The project has chosen for a co-operative style (see Section 2) in which the different authorities and non-governmental organisations (NGO) (or interest groups) work together and have an equal say in the final outcome. The interaction is organised through:

- A steering-committee, formed by governors of the different government authorities. They gave direction to the process and take decisions The steering-committee is supported by the initiative-group;
- An initiative group. This groups of experts; government employees en members of NGO's, discussed the content of the planning process;
- Consultations of citizens and interest groups. In addition, several sessions are organised to consult citizens and interest groups and give them an chance to share their problem perception and generate ideas.

A project team facilitates the planning process. This team consists of staff of ministry of public works. However they have a separate office, their own name and logo and work independently. An important motive of the project team for this approach is that citizens should not be burdened by the fact that the government is divided in state, provincial and other government organisations.

In the process the four steps of start, problem inventory, generating solutions and action can be recognised. After each steps decisions are made on how to proceed.

1. Start

- Process plan (1996),
- Developing a terms of agreement with all authorities (1997),
- Organising team and steering committee, task assignment.

2. Exploration of current situation

- Inventory of all problems, issues and first ideas (summer 1997);
- Government Authorities in 3 provinces, NGO and citizens (total 300) participated by attending one of eight sessions. 400 issues came up. During the sessions an atmosphere for brainstorming and an open mind has been stimulated by all kind of exercises;
- Cartoon artists visualised and hence stimulated the discussion (see illustration);.
- Experts participated in the sessions but were asked not (yet) to react;
- Also, non-participants were consulted, to verify the outcome. After the sessions all problems were clustered and analysed with the help of the expert-centre. A report with results has been sent to all participants.
- The steering committee approved the outcome and the continuation of the process.

3. Generating solutions

- Generation of ideas and solutions (summer 1999);
- During sessions with 170 participants ideas and solutions are developed for the problems. Creativity has been stimulated with different tools and techniques (a/o

varying from artist performance, brainwriting techniques to the use of GIS design to indicate the location of problems and solutions). During this session all kinds of knowledge and ideas are brought together and induces citizens, interest groups, project team, experts and authorities to look at solutions from a different point of view. After the sessions the expert-centre analyses and further develops the ideas into "building blocks".

- Inventory of actual situation and on-going projects, a structure analysis and zone map;
- scenario development;
- Impact analysis;
- The effects were indicated per scenario during a 2-day session where experts and users indicated criteria and effects using objective arguments and their own experience and knowledge;
- Decision making by the Steering Committee on the strategy to follow (end'99).

4. (Preparation for) implementation

- Development of a plan indicating what, where, when and by whom have been implemented;
- 8 working groups consisting of members of the intitiative groups and key-persons have developed in 3 sessions of a day a detailed plan for the different aspects like nature, recreation, economic development etc;
- Setting up of a terms of agreement (on the responsibility for the implementation);
- Decision by the steering committee on the implementation of the plan (Nov 2000);
- Implementation of the plan in 3 phases, starting in 2002 . Moments for reflection were planned in order to be able to adjust the plan to new developments and insights.

The results:

- Governors were enthusiastic. They took their responsibility by dividing the costs for implementing the proposed 38 measures;
- The response of all participants in the process has been positive;
- New forms of cooperation have started among government authorities (at different levels), within their offices and with NGO's;
- NGO's have improved the quality of the plans. They introduced new perceptions and arguments and kept others sharp (e.g. by posing questions like what is at the interest of the users?);
- NGO's have broadened their scope and got feeling for the interests of the others parties involved. They formed on their own initiative a new consortium of recreation and nature conservation groups have developed a plan (or vision) indicating their mutual interests as well as disputes (on their own initiative);
- The central office of PW in The Hague appreciated the outcome of the process as it gives an integral plan with an overview of different measures, arguments and priorities. It also shows the (financial) contributions of the other parties involved;
- The plan consisted of long-term measures but also activities that can be directly implemented, which motivates the different parties.

Lessons learnt

Lessons learnt with respect to the process are:

- Take time for the start;

- The start took almost two years, as the authorisation of the project and the co-operation of authorities took time;
- Indicate the pre-conditions and/or a sense of direction before starting interactive sessions with citizens and interest groups;
- The large amount of information gathered during the inventory was another reason for delay. It took a considerable amount of time to process all data and compress it into a number of clusters that could be used in the next step of generating solutions. In retrospect the interactive sessions were too open in a sense that no restrictions, preferences or pre-conditions were indicated. For the citizens it may have been easier if there was a sense of direction (as developed by the steering committee, showing their ambitions and scope;
- Make a tailor-made process design during the start of the process;
- Only half-way, a total process design for plan development has been made. At the start of the problem inventory it was not clear how to proceed with the large number of problems (sometimes even contradicting each other);
- Integrate the interactive planning process in the formal decisionmaking procedures;
- Involve the governors actively and support them in their new role;
- The major role of governors is to provide a clear assignment. They need to be involved in the problem definitions, to make sure they are committed and see the necessity to act;
- Governors do not want to be involved in sessions to generate solutions (they don't feel secure nor capable to do so…). They rather discuss the generated options and directions how to proceed (and choose). Informal meetings help to get a feeling for their political context and their attitudes towards possible solutions. They need time to discuss proposals and generate support within their own organisation. The attendance of governors during public "information-evenings" is positive as they can indicate their role and dilemma's;
- It is the role of the project leader to keep all governors committed to the process and major outcomes;
- Work with an independent project team;
- Although it consisted of staff of the ministry of public works (PW), they have gained the support and trust of the other parties as care takers of their interests. Since there were two different provincial governments involved and the central topic was water, the project team of PW appeared to be the logical process manager. Provincial's authorities have showed a growing interest in the role of process manager (as integral spatial development has become their major concern).

More information:

www.iivr.nl (only in Dutch)

21. Waterplan for the municipality of Hilversum, The Netherlands

Inspiration points

It shows an example of consultation of stakeholders in the process of developing an integral water plan for a municipality. Collaboration is based on common sense of urgency.

Aim/Objective of the project

A municipality-waterplan is an integral plan, which indicates the policy on the management and use of water in the city. In the municipality of Hilversum the existing plan did not get the support from all other organisations involved. Moreover, the political situation was even more sensitive as the municipality was in financial problems and in ward under the central government. Also physically the situation was complex. Deep water levels led to a shortage of water, while an old-fashioned water sewage system caused problems of flooding and pollution. Complexity was augmented due to the responsibility of different organisations for water management (the province for deep groundwater; the water board for surface water, bottom and banks; the service for water management and sewage system, for policy preparation and maintenance, while the municipality cares for the water quality below ground surface). Hence, the local governor decided that an alternative approach for the plan development was necessary.

Scale/unit of planning; Municipality

Period; *1995*

Objective of PP

- To de-politicise the situation;
- To create a high quality plan;
- To strengthen new forms of co-operation; and
- To create understanding and support for the integral use of water within the municipality by developing a sustainable plan.

Who participated and how (degree/form of public participation) in what phase of the planning?

- The participatory style was a "consultative" one. When considered necessary the project team consulted interest groups and organisations (in total 25);
- The project team was formed by the Municipality responsible for developing the plan. They were supported by a Steering Committee consisting of members of the other organisations involved; the province, the waterboard, and an institution responsible for clean water. Whenever necessary governors were consulted as well as interest groups.

Methods and tools applied

Participation was organised through:

- Discussion sessions per theme;
- Rounds of information supply;
- Consultation evenings a/o to enable interest groups to give comments and indicate priority;
- To proposed measures.

Tangible Result (effect) of PP

- The solutions were no longer solely found in technical measures like bigger pipes and pumps, but a shift in attention took place towards increasing the human capacity to find solutions for the source of problems;
- A waterplan was developed in combination with a plan for a new sewerage system;
- The high quality plan drew all the attention, while the battle for competence among different organisation was put on the back bench;
- Close cooperation between municipality, waterboard and province in a political sensitive situation with strong competition among parties. They all supported the final plan.

Lessons learnt

- The well structured process helped creating clearity on when and how which persons or organisations could participate;
- The governors gave room to the project leader to manage the process with authority (which was useful in the political sensitive situation);
- The latter requires that both governors and process manager have a good working relationship and keep constantly in touch on when the governor should play what role and the other way around;
- Governors want to be able to choose and need to know the effects of the different alternative solutions.

22. Participation, Consultation and Capacity Building in WFD Transposition Processes; Scottish Environment Protection Agency and Scottish Executive, Scotland

Key words

Scottish Executive, SEPA, transposition, capacity building, key issue/ stakeholder /sectoral workshops

Inspiration points – this example is inspiring because:

During the past 2.5 years a number of events were organised to increase organisational capacity and understanding of the WFD across a range of bodies in Scotland. This process helped inform debate and discussion of key WFD issues and enhanced mutual understanding of issues of agreement or concern. A wide range of public and private organisations actively engaged in and contributed to this process.

Aim/objective of the project

In Scotland many of the component parts of the WFD are not presently in place e.g. water abstraction or impoundment controls, controls on river engineering or an equivalent of River Basin Management Planning. WFD implementation, therefore, presents major challenges to many organisations and stakeholders.

The general aims of the activities undertaken and described were:

- To inform a range of public authorities, NGOs, sectoral interests and other stakeholders of WFD transposition and implementation processes in Scotland, notably around periods of formal public consultation;
- To increase organisational capacity in respect of WFD understanding to allow meaningful input to, and engagement in, key WFD transposition and consultation exercises;
- To inform a range of organisations and interested parties of present interpretations of key WFD issues, and to discuss and debate these;
- To encourage meaningful discussion of WFD issues by interested parties to increase mutual understanding of positions and views;
- By the encouragement of participation in these early WFD stages to build capacity across a range of organisations and interested parties to benefit future RBMP and Characterisation processes and activities;
- Scale/unit of planning.

These information sessions, seminars and workshops were undertaken at a range of different scales and levels of input including:
- National (as part of national preparations for WFD transposition);
- Sectoral (individual sectoral groups were involved in specific events);
- Issue specific (individual WFD issues were identified for specific discussion).

Period: Spring 2000 – Ongoing.

Degree of public participation and stakeholders involved

The information and participation exercises undertaken in Scotland were organised in different ways to allow different sectors, issues and geographic scales to be considered. Ranges of stakeholders were, thereby, brought into the process at different stages and in situations in which they were confident and comfortable.

Stakeholders engaged in the process included

- Local Government;
- "Industry";
- Rural Land Use (agriculture, forestry etc);
- Freshwater Fisheries;
- NGOs;
- Environmental Groups;
- Public and Government Agencies and Departments;
- Other interested parties via inclusive and open events.

Methods and tools applied

This example was essentially a sequence of information session, workshop and conference events undertaken throughout preparations for WFD consultation stages.

In order to be most effective a range of approaches were taken which are summarised below:
- Events were sectoral (to allow key audiences to be met) or;
- Issue specific (to allow key issues to be considered) or;
- Wider events (to allow open discussion and resolution of issues and differing opinions from, for example different sectoral groups);
- Stakeholders participated in all of these event types.

A range of groups made presentations on particular WFD issues and aspects of particular relevance to them. This direct and public involvement reduced the perception that these events were the sole responsibility of individual organisations. Events were organised and managed by different partnerships according to subject matter.

Many events were jointly organised by the Scottish Executive and SEPA. Other partnerships, however, organised different events. e.g. the Scottish Executive and WWF were responsible for the provision of a workshop specifically considering WFD public participation .

By using different approaches to different events to encourage engagement with different groups an extensive WFD public participation process was generated.

Major input of stakeholders

Stakeholders were involved in different ways within the process. Some made presentations reflecting their particular expertise, concerns or responsibilities, some debated technical interpretations of particular WFD areas while others played key roles in managing events. Particularly in the early stages of this process general information on the WFD was required to inform later debate and discussion; initially SEPA and the Scottish Executive fulfilled this role. Facilitated sessions allowed the active involvement of parties not specifically leading or presenting any of the events or topic discussions.

Participating numbers ranged from 30 – 40 for sectoral seminars and workshops to in excess of 100 for more general events or where a sector or issue of particular significance was considered.

The sequencing of events around formal consultation processes and stages allowed the introduction of key consultation questions for debate. In this way the consultation responses of stakeholders could be informed by open debate and discussion of issues and on a greater understanding of WFD implications for themselves and of other groups. An increased mutual understanding of WFD issues was delivered.

Tangible results of public participation exercises

The series of events produced, or helped to produce:

- Increased organisational capacity and understanding of WFD issues;
- Enhanced mutual understanding of respective organisational positions, concerns and interpretations;
- Provided opportunities to resolve issues of concern and to re-assure groups of interpretations;
- Helped inform responses to WFD formal consultation exercises;
- Introduced many of the new WFD concepts and requirements (to Scotland) to key groups at the start of the process;
- Started the WFD process of public participation at an early stage in Scotland and provided a start point on which to build future processes, procedures and trusted relationships.

Project costs

It is not possible to quantify the costs involved in providing the participative and consultative opportunities available within the described process. However, significant staff resource from organisations managing events was allocated from SEPA, Scottish Executive, WWF and others. Additionally, time allocated from a range of stakeholders in attending and presenting at events was significant.

Lessons learnt

A number of key lessons have been learned during and as a result of this process in Scotland. Some of these are summarised below:

It is clear that participative approaches similar to that summarised can be hugely beneficial in building organisational capacity of all bodies involved. It is certainly the case that by opening the WFD debate in Scotland throughout the transposition process more informed and valuable contributions from a wide range of groups were received and generated.

Where the approach taken in Scotland has been particularly successful has been in targeting input both sectorally and at appropriate times within the process, e.g. linked to SE consultation periods. That participative and consultative exercises, processes and opportunities should be focussed and targeted and meaningful in order to deliver most benefit to the overall process is perhaps the key lesson.

The continual and ongoing engagement of stakeholders during the past years has improved and developed the dialogue and relationships between organisations. This continued commitment to engagement in the process is better than single events.

The WFD is an ongoing and iterative process so participative and consultative opportunities must be provided on an ongoing basis to allow continued meaningful engagement in the range of WFD processes.

It is apparent that what is delivered is never enough! There remain calls for a wider and more inclusive approach still to WFD implementation. In many cases these are reasonable expectations and aspirations that SEPA and the other Responsible Authorities must try to meet, address and manage.

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23. Ettrick floodplain restoration project by Borders Forest Trust in the Scottish Borders, Scotland

Inspirational points

Several techniques have been used by the Borders Forest Trust (BFT), who manage the project, to ensure meaningful public and stakeholder participation. These include an initial public meeting, the establishment of a local community steering group and a technical (stakeholder) steering group. A citizens' jury was also conducted involving members of the wider community to help guide the process. The project continues to be guided and assisted by the community steering group.

Aim of the project

The aim of the project is to restore floodplain characteristics by removing and ameliorating intensive forest and agricultural practices together with the establishment of large areas of semi-natural habitat to produce a functioning floodplain of national and international quality.

The project has developed a matrix of linked elements along the upper Ettrick Water to create an extended mosaic network of woodland and associated habitats. The restoration work has involved the creation of appropriate riparian scrub, wetland, and woodland on species poor unimproved grassland and areas previously afforested with exotic conifers. The removal of exotic conifers and reinstatement of natural flooding patterns has increased the upper Ettrick's flood buffering capacity and the biodiversity value.

Scale/unit of planning

The Upper Ettrick valley contains tributaries of the main Ettrick River which feeds the River Tweed. The project area is in excess of 2 square kilometres, extends for some 6 kilometres along the main watercourse and has involved a number of private landowners and Forest Enterprise (the State forest managers) in the management of: hay meadows; wetland (rush pasture); willow scrub and alder carr; native broadleaved woodland and species poor grassland.

Period

The project has been running for 5 years from 1998-2002 and will continues to run for the next five years.

Objective of public participation

Borders Forest Trust is a community-based organisation originally formed by community groups and individuals. It is designed to serve communities in the South of Scotland. In the Ettrick project the objectives of the community consultation were:

- To identify public aspirations and fears of environmental projects related to floodplains;
- To encourage greater community involvement and ownership within environmental restoration projects;

- To identify problem issues at an early stage of the project;
- To encourage the sustainability of the project by mobilising the local community;
- To benefit from local knowledge.

Who participates and how?

Stakeholders and the local community participate in the planning and implementation of the project through two groupings. The technical steering group comprises a range local bodies and agencies (such as Scottish Environment Protection Agency, Scottish Natural Heritage, Forestry Commission) who advise on the technical aspects of the project. The local community is provided with a voice via the community steering group where dedicated members have an input to the planning and implementation of the project. The wider community also had the opportunity to participate in the development of the project through a citizens' jury.

Methods and tools applied

At the start of the project the local community was invited to a public meeting where the details of the project were discussed. Community members were invited to volunteer to sit on a steering group. The community steering group meets project managers on a regular basis to discuss progress and feed into the planning and implementation of the project.
A citizens' jury was also held to allow wider members of the community to learn about and feed into the project. The jury was made up of citizens drawn from across the Scottish Borders. Stakeholders from different perspectives such as NGO government agencies etc attended the jury as witnesses, presenting information to the jurors, and answering questions. The jury made recommendations on the benefits of the project and management of the site.

Major input from stakeholders

A technical steering group made up of local stakeholders and government agency representatives also meet project managers on a regular basis to advise on technical aspects of the project.

Stakeholders also participated in the citizens' jury as witnesses. This facilitated dialogue between members of the community, stakeholders, and project managers.

Tangible results (effect) of Public participation?

Tangible results of the participatory nature of the project have included:
- Ensuring the sustainability of project, for example members of the community are keen for the project to continue and have volunteered to work as project wardens;
- The ability to iron out difficulties and allay fears early on in the project timetable;
- Encouraging farmers to manage their land in complementary way; and
- Changes made to aspects of the project. For example, the entry points to, and the access paths within sections of the project area were decided by the Community Steering Group, and are different from the original ideas of the BFT staff involved in the management of the project.

Lessons learnt

Community involvement is an essential component of this floodplain restoration project and has contributed to the design and execution of most elements. Without adequate public involvement and consultation the project would have run into many objections and much hostility. Potential objections were likely to stem from confusion as to the nature of the project and sensitivity of people to practical works associated with flooding.
One of the major lessons learned by BFT was the importance of early positive engagement with communities and an ability to respond quickly and flexibly to areas of concern and misunderstanding.

Formal procedures for public participation

There were no formal requirements for public consultation, however, since the BFT is a community led group, a participatory approach was considered vital for the success of the project. Although many participatory processes were designed within the project plan much of the interaction has been led by the community itself. As the project progressed the public consultation and engagement became less structured and formal, and more dynamic as the community began to take the lead with respect to access planning and project interpretation.

For more information contact:

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Available reports:

http://www.bordersforesttrust.org/projects/ettrickhabitat.htm

24. Consultation on Technical Annexes II and V of the WFD, Scotland, England and Wales

Inspiration points

In the summer of 2002 the Scottish Environment Protection Agency (SEPA) in Scotland and the Environment Agency (EA) in England and Wales issued public consultation documents on "The Guiding Principles on the Technical Requirements of the Water Framework Directive". These documents outlined the principles and requirements of technical Annexes 2 and 5 following:

An inclusive drafting process and Stakeholder input at the outset of the production process and launch of the consultation documents.

Participative approaches related to the technical requirements of the Directive are difficult to formulate, manage and make meaningful but this example shows how progress can be made on such issues where a will to do so exists.

Aim/objective of the project

The general aims of the consultation exercise were to:
- Help stakeholders understand the technical context provided by Annexes 2 and 5 to the administrative and regulatory provisions required of transposition;
- Allow comment on the proposed principles to be adopted in implementing these Annexes as these provide the basis for allowing the sustainable use of water resources and the efficient achievement of the Directive objectives while delivering real environmental benefits;
- To gather views as to how and when stakeholders would wish to be involved in technical implementation processes.

Scale/unit of planning

The respective SEPA and EA consultation documents were issued on a Scottish and England/Wales scale respectively.

Period

The consultation documents were issued in early summer of 2002 with comments to be provided by August/September 2002. Stakeholder workshops were held at the document launches.

Prior to this stakeholder workshops were held at the process outset (2001) to allow initial input at early formative stages of drafting and highlight issues of concern and interest.

Objective of public participation

The technical annexes of the WFD are complex and not easily understood or interpreted. They do, however, provide the basis and instruction as to how the water environment will be assessed, monitored and classified. These tasks inform Objective setting, the development of Programmes of Measures and regulatory regimes. As such it is important that, as far as possible, the principles being adopted, or being considered for adoption, are understood and supported by the range of stakeholders, authorities and organisations potentially affected by these assessment or related activities.

The objectives of this exercise were to:

- Allow stakeholders to input their priorities and concerns as to how technical annex interpretation might affect them;
- Allow stakeholders to comment on proposed WFD technical interpretations and principles;
- Provide a framework by which a range of public bodies across the UK could input to the development of a common interpretation and understanding of Directive requirements.

Degree of public participation and stakeholders involved

Stakeholder participation was encouraged and facilitated within the stages as below:

- At the launch of the Annex 2/5 process stakeholder workshops were organised and attended by a range of industry and environmental interests as well as other public and non-public bodies. At these events views, concerns and issues were gathered from stakeholders to inform later drafting exercises and to provide a context for later discussion and interpretation debate;
- Document drafting required input from a range of public bodies and agencies to fully gather and capture expertise from across sectors and interests. In Scotland participating organisations included SEPA, Scottish Water, Scottish Natural Heritage and Fisheries Research Services. In addition, the EA and the Environment and Heritage Service (EHS) from Northern Ireland participated in the Scottish process. Similarly, SEPA and EHS participated in the EA led process in England and Wales to help ensure UK wide consistency of content and interpretation;
- At the launch of the Annex 2/5 documents stakeholder workshops were organised and attended by a range of industry and environmental interests as well as other public and non-public bodies. At these events initial responses, concerns and questions raised by the publications were aired and discussed openly;
- A consultation period following the document launch allowed a period for formal stakeholder comment to be provided.

Major input of stakeholders

At the organised workshops the views and concerns of stakeholders were:

- Gathered for inclusion and consideration during the drafting process;
- Highlighted by stakeholders to inform others of these views thereby encouraging debate of these, potentially informing the consultation responses of other consultation respondees and allowing mutual understanding of concerns.

Tangible results of public participation exercises

Consultation periods for these documents have now closed and a wide range of responses received by SEPA and the EA. These will be used to help shape ongoing interpretations of the technical annexes, inform principles to be taken forward during this process and allow the balanced consideration of the concerns of stakeholders.

It is likely that ongoing involvement and input from stakeholders in many aspects of Annex 2/5 and general WFD interpretation will be provided following this exercise and process. It is hoped that SEPA and the EA, supported by arrange of other public organisations, will benefit from the adoption of transparent and inclusive approach to WFD interpretation in the coming years. The Scottish Executive in Scotland and the Department this approach for Agriculture, Food and Rural Affairs in England and Wales supported and allowed this SEPA and EA approach.

Lessons learned

A number of key lessons are summarised below:
- It is possible to develop and provide participative opportunities associated with WFD technical processes and issues;
- Attempt to involve stakeholders in such issues and processes are appreciated by them and deliver benefits to prospective competent authorities in terms of both transparency and trust and through the valuable and insightful contributions made by stakeholders;
- The collaborative working of agencies and public bodies in both Scotland and England and Wales is beneficial in increasing national understanding and co-working relationships;
- Similarly the reciprocal involvement of SEPA, EA and RHS in each others drafting processes increased UK wide shared understanding while providing reassurance to stakeholders that common interpretations were being applied and proposed.

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25. Global flood defense plan in river Júcar, Spain

Elements of inspiration

Information to the public in this case has been a two way, iterative process. Authorities of the river basin district not only transmitted information of the results of the floods assessment but at the same time involved representatives of the community in the design phase of the flood control related strategies

Key- words

Floods, risk perception, transparency, co-responsibility.

Aim/objective of the project

Development of a global floods control plan.

Background

Jucar River Authority has carried out different hydrological and hydraulic studies in the river Jucar with the ultimate objective of reducing the damage produced by floods in a plain with a very important social and economic relevance. The objective of the participation process has been mainly to involve stakeholders and public in general on the decisions taken, coordinating measures at river basin, regional and local levels. River Júcar flood plain is about 4000 km^2 with a population of more than one million people.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The public participation process started in 1998 with the creation of an ad hoc committee including water authority members and representatives of the municipalities located in flood prone areas. This committee was enlarged in order to incorporate representatives of ministries belonging to the Spanish central administration, departments of the regional government, NGOs and users associations. A permanent secretariat of the committee allowed the management of the consultancy process and capacity building was provided by the Jucar river authority. In order to present the process to the public in general, several workshops and meetings were organised. Risk maps were presented in a workshop in Valencia in April 2002 after a long consultation process with the affected administrations and public in general. These maps together with other basic documentation have been included in a CD with GIS tools that allows their visualisation and analysis. All this information has been distributed to the public free of charge.

Major input of stakeholders

One key element was to agree that the idea of "zero risk" culture can not be accepted. It has to be admitted that a certain degree of danger is present and thus the acceptable level of risk has to be decided. Flood risk maps can be a good tool to apply these principle serving as the first information source of information in order to look for a compromise between urban development and flood control that means important economical implications.

Tangible result (effect) of PP and lessons learn

- Publishing and distribution of risk maps;
- Identification of priority actions;
- Understanding by the community of the degree of vulnerability and assimilation to what extent they can be affected by floods;
- Increasing the transparency and legitimacy as well as underlining the economic and social relevance of flood control policies.

For more information please contact:

- www.mma.es (Oficial web page of the Spanish Ministry of Environment);
- teodoro.estrela@chj.mma.es (river authority manager of the project and process facilitator);
- manuel.menendez@cedex.es (technical studies)

26. Alcobendas - city of water for the 21st century, Spain

Inspiration points

Awareness raising on water consumption and change of attitude towards water consumption.

Aim/objective of the project

To raise awareness of the population, local authorities and SMEs in Alcobendas, a Madrid suburb, on water consumption in order to create a culture of treating water with respect.

Scale/unit of planning

Alcobendas, a satellite town at the outskirts of Madrid, with 90.000 inhabitants.

Period: 2000-2001

Objective of Public Participation

To engage the public in water savings.

Who participated and how (Degree/form of public participation) in what phase of the planning?

A broad range of the inhabitants, authorities and local SMEs.
A wide range of activities, information and media coverage: just for publicising the results (see below),the following was carried out:

- Press conference attended by 30 representatives from press, radio and TV;
- The project office received more than 1.000 calls and visits by media-rep's;
- 4 TV reports on water-saving systems;
- 17 programs on "Olca Alcobendas";
- 14 interviews on other radio stations;
- 113 articles published in various magazines and graphic media;
- A total of 250 journalists were informed about the project.

Methods and tools applied

A comprehensive package including:

- Exchanging technical and scientific information to encourage the introduction of effective water-saving technologies and programs and water demand management;
- Promoting new regulations;
- Stimulating the water-saving technology market;
- Promoting changes in the productive sectors;
- Increasing public awareness of the need to participate actively in saving water;
- Offering an example of the introduction of effective water saving measures in new homes;
- Publicising the results and methodology so that they can be adapted to other towns.

Tangible result

Estimated water savings for Alcobendas: 102.200.000 litres per year.

Lessons learnt

The most important aspect of the "Alcobendas - city of water for the 21st century" is not the savings in absolute terms, but the creation of mechanisms that produce a permanent change of attitude towards saving in the use of water in cities.

For more information contact:

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Available reports

http://www.wwf.es/

27. The Water Forum in the Balearic Islands, Helcom, Spain

Inspiration points

This example is inspiring because is promoted directly by the Environment Council of the Balearic Government and designed and organised by the Development and Ecology Foundation (ecodes), a member of the EEB and a serious and responsible organisation. Also, the perception of the participant stakeholders seems to be very positive regarding the first two initiatives encouraged:
- the Pitiusic and Menorca workshops.

Aim/objective of the project

The main objective of the Water Forum in the Balearic Islands is the participation of citizens in drawing up an analysis of the current situation as regards the management of water and the construction of a basic consensus for water policies in the Balearic Islands. This consensus would contribute greatly to moving the management of water towards a sustainable model, which the population of the islands desires, in this case with reference to the management of hydrological resources.

Scale/unit of planning

Balearic Islands (Eivissa, Formentera, Mallorca and Menorca, 5.016 sqKm), Western Mediterranean, Spain

Period: 2001-2003, as a minimum.

Objective of Public Participation

The main objectives of this initiative are as follows:

- To achieve, in a context of neutrality, communication between business, social and institutional groups without the habitual intervention of the news media;
- To create informal environments for meetings between the leaders of social sectors often involved in confrontation;
- To make sure, in a context of negotiating, that parties receive information on the conflicts from the appropriate technician in the local government;
- To ascertain, without the intermediation of the news media, and without bilateral negotiating tensions, the main concerns of the principal community leaders of the sectors most relevant to the management of water on the three islands;
- To ascertain shortfalls in the focuses of social organisations in relation to the management of water;
- To detect the main sources of conflict, and the position held by the range of sectors in this regard, and the nuances of these confrontations;
- To ascertain points for a basic consensus for water in the Balearic Islands in order to construct a new culture of water in the Balearic Islands.

Who participated and how (Degree/form of public participation) in what phase of the planning?

In 2001, the project aimed at the participation of the full range of stakeholders, including individual citizens, local, insular and autonomous administrations, NGOs, representatives of political parties, land owners, water supply, water treatment and desalinisation technicians, consultants, etc. The aim was for the groups to be as heterogeneous as possible, ensuring the presence of women and old and young people, who still appear to be under represented sectors in the water management field. 32 people were invited to every workshop, and 23 on average attended each of them.

Methods and tools applied

For the first phase (Pitiusic Islands and Menorca workshops in 2001) the Logic Framework method was used. This method consists mainly in discussing within the whole group or 4-5 people the proposals of every participant and their appropriate setting in a certain diagram. The final results are a series of logical trees reached in consensus by the whole group. In this case, the proposals represent the main problems and main solutions for solving them regarding water management in the three islands, Ibiza, Formentera and Menorca.

In Mallorca, during the 2002 phase, the EASW (European Awareness Scenario Workshop) methodology may be applied. This is a more complex group method, following in essence the same path but in a more closed and fixed way. The EASW Initiative was launched by the European Commission DG XIII D in 1994 as a pilot action to explore new possible actions and social experiments for the promotion of a social environment favouring innovation in Europe.

For more information see http://www.cordis.lu/easw/home.html

Both methods require skilled consultants. For the Logic Framework Workshops, one facilitator was in charge, helped by three assistants, also skilled, and, in this case, an abbreviated version was implemented, lasting only a whole day (from 09:00 to 20:30, including lunch and several coffees in between). The usual version usually takes 2 days.

The EASW method requires a larger number of consultants (4 to 6), and cannot be successful if shorter than one day and a half.

Indicative costs

The first phase of the Balearic Forum cost about 30,000 euros.

A EASW workshop costs about 13,000 euros to run.

Tangible result

Until now, some encouraging initiatives have arisen from a few stakeholders who organised themselves to push the Administration on specific topics. For example, in Menorca, a member of Menorca Reserve of the Biosphere and a technician from the Sant Lluís Towhall, were freely assigned by the rest as responsible for asking the insular authorities about the project to organise an Insular Water Administration, against the Balearic existing one.

Despite this initiative not being *a priori* positive for the Balearic Government (who promotes the Forum), it is seen as a good movement within the whole participation process.

Contact for Further information:

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* Direcció General de Recursos Hídrics, Conselleria de Medi Ambient, Gran Via Asima, 4ª, 07009 Polígon Son Castelló. Palma, Mallorca, Balearic Islands (Spain). Tel. +34 971 177141. www.caib.es

28. Co-operation on the Catchment Level in the Emån River Basin, Sweden.

Elements of Inspiration

River Basin wide co-operation to achieve sustainable development by encouraging commitment and support from local people in restoration of the area and implementing environmental measures. Catchment area management.

Key words

Stakeholders, broad public, measures, co-operation.

Background

There are several ongoing conflicts between different stakeholder groups in the Emån river basin. The entire main channel and several tributaries are Natura 2000 areas. This part of Sweden is suffering from decreasing population and low educational levels. River basin co-operation, on a broad scale, is used as a method to achieve the following objectives:

- Better water quality within the Emån watershed;
- Pollution should not restrict the use of the water resources for drinking water production, fishing, bathing, industrial purposes etc.;
- Better environment for Trout and Salmon;
- High environmental values existing within the watershed shall be preserved and developed;
- All natural species shall exist in sustainable populations;
- Economic and environmental sustainability in the region.

Scale / unit of planning

Catchment area of 4 500 km^2.
Population involved – more than 2000 (=2%)

Period: 1994 -- ongoing

Objectives for public participation

In the Emån watershed they are paving the way for environmental sustainability by means of involving the public in water management. The stakeholder association is encouraging voluntary action, commitment and support from the local population and industry in restoration and development of the area. The objectives of the public participation in the different projects are:

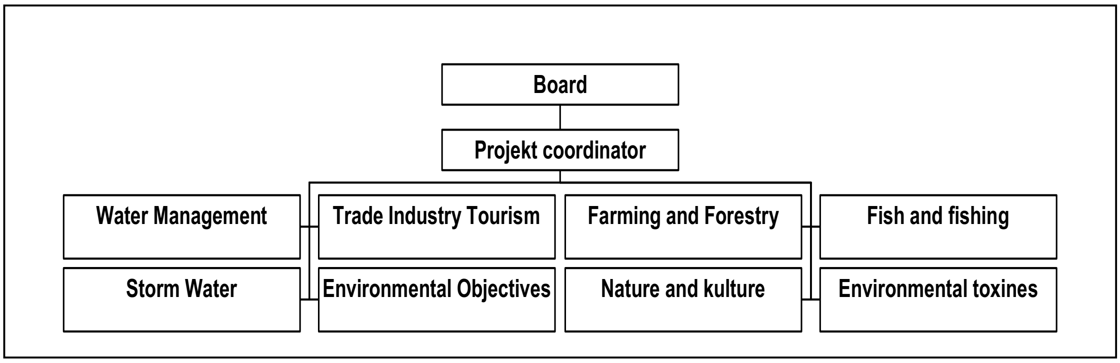
- To make use of the knowledge and experience from NGO's and other stakeholders;
- Avoid or solve conflicts that arise between different groups of stakeholders;
- Increase the awareness of, and knowledge about, the environmental values in the Emån region;
- Increase co-ordination between different enterprises and stakeholders within the watershed;

- Increase interaction between different stakeholders to find strategies for how natural recourses may be exploited from a holistic and sustainable perspective.

The Emån model for public participation - who participated and how?

Eight municipalities, two Regional Administrative Boards, the Emån River Council, The Federation of Swedish Farmers, owners of fishing waters, angling associations, local history associations, nature conservation associations co-operate in the Emån Stakeholder Association. All of the above mentioned have representation on the board of directors. Different task groups perform the work. Each task group has its own chairman and 6 – 15 members representing different stakeholders and with specific knowledge about the tasks at hand.

Different authorities and NGO:s take part in the work in the task groups .



The organisation of the Emån Stakeholder association

Methods and tools applied

Public participation is achieved by holding seminars, information meetings and hearings, circulation of documents (e.g. objective documents) for comments, forming task groups (those in the group bring information back to their organisation and vice versa) distribution of newsletters, press conferences etc. Minutes from the various meetings were taken and distributed. There is always a discussion possibility on the web site.

Major input of stakeholders

Stakeholders have been involved in the planning process, in formulating the environmental objectives and in the negotiation for restoration measures. All stakeholders, including the NGOs have provided input for the information documents and have given their view on all suggested plans of measures.

Tangible results of public participation in the Emån river basin

New fish by pass at the Finsjö hydropower station

The following measures are the result of co-operation between the general public and other stakeholders:

- Two new, well functioning, fish by passes, have reintroduced sea trout (*Salmo trutta*) and Salmon (*Salmo salar*) to 20 kilometres of the main channel. More bypasses are planned further up the river;
- Spawning grounds for stationary stocks of trout have been restored in several sections of the river system;
- A complete inventory and risk assessment of storm water in towns and on the road net. Two storm-water dams are being built in 2002;
- Seventeen working groups of more than 200 farmers have been established to improve water quality and biodiversity;
- One abandoned industrial site has been remediated. 35 000 tons of cadmium- and 9 000 tons of lead-contaminated material has been removed. There are also plans to remediate two mercury-contaminated lakes;
- As from 2002, the water flow from nine hydropower dams is co-ordinated in accordance with a new drought protection plan (flow management plan). Stakeholders have assumed economic responsibility for necessary investments;
- A fishery plan on sub-catchment level has been presented for the whole catchment area.
- Biotope mapping of all rivers and streams (a total length of 800 kilometres) has been performed;
- A plan for nature conservation and cultural history preservation was another result of public participation.

Lessons learnt

- It is important for the general public to derive local benefits and see tangible results of their input and involvement;
- People are more interested in providing input and being involved if the problem concerns their own neighbourhood;
- PP takes a lot of time and involves education and information initiatives as well as the exchange of ideas;
- It is important to create different arenas for participation and discussion;
- It is also important to remember that positive results, big and small, from the PP process must be celebrated;
- The involvement of the media is another important success factor.

Summary

The river basin co-operation started as a means to resolve conflicts. Many people are or have been involved on different levels in the process. The public has been involved in tangible measures. It is, however, difficult to get everybody to participate. Often no more than 10-15 % of the people that are invited to take part in seminars or hearings actually show up. Different forms for participation attract different groups of stakeholders. Therefore there must be several possibilities for communication. The Internet is one good example. Good media coverage is helpful when we want to involve more people in the process. The fact that, in some cases, the stakeholders were involved at the sub-catchment level was useful. It is easier to discuss a problem or a possibility close to people's homes.

The cost of the project

The total budget for the objective 5b projects that were carried out from 1997-2000 was 2,02 million EURO. The cost for public participation during this time may be estimated to 150 000 EURO.

The cost for public participation from 2001-2002 is estimated to about 100 000 EURO most of this cost refers to the work in the farmer project. A smaller portion refers to the planning of fish bypasses, information and lectures in schools and the administration of the Emån stakeholder association.

For more information please contact:

- www.emaprojektet.h.se
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29. The Municipality of Örebro's water management plan, Sweden.

Inspiration points

A total of about 70 different authorities and organisations upstream of the catchment area and within the municipality's borders have been consulted on a draft plan.

Key words

Experiences, long tradition on information and public participation.

Aim/objective of the project

To develop a water management plan as a complement to the municipality's overall land and water use plan. A further aim is to fulfil the regional and national environmental objectives for surface and groundwater.

Scale/unit of planning

The area of the municipality is 1600 km^2 divided into several catchment areas.

Period

Pre-1990 - ongoing.

Public participation objectives

The aim is to get people involved in planning process so they can react and give input, but also to fulfil the requirements for public participation under the Swedish Planning and Building Act of 1987 concerning consultation with the public in the development of overall plans. It is also inspiring that Sweden has had this system for public participation for a very long time and has routines for it.

Who participated and how (degree/form of public participation) in the different planning phases

A working group and steering group consisting of civil servants have been implementing the project.

A total of about 70 different authorities and organisations upstream of the catchment area and within the municipality's borders have been consulted on a draft plan. Their opinions and comments were acknowledged by the working and steering groups. The adjusted document was circulated again for consultation.

Those involved included farming and water conservation associations along with Örebro University.

Methods and tools applied

Consultation was effected by holding seminars, information meetings and hearings and by circulating proposed land use plans for consideration by the parties involved.

Major input of stakeholders

Input from farming associations concerning voluntary versus compulsory measures for farmers. Input from the water conservation associations concerning their present role in monitoring and nature conservation associations regarding species protection measures. Örebro University indicated how sensitive areas should be defined and protected and supported the project by disseminating information to the general public.

Tangible result (effect) of PP?

The steering and working groups met with stakeholders to answer questions and justify their actions. Much of the latter's input is important so that the water management plan can be revised. This will also affect the development of the land-use plans.

Lessons learnt:

It is important for the public to see tangible results and direct benefits from their input and involvement.

Formal procedures for PP

Consultation on advisory overall plans and detailed development plans is compulsory in Sweden under the Planning and Building Act of 1987. The public also has access to reports and documents in the public domain under the Swedish Administrative Procedure Act of 1986.

For more information please contact:

The municipality of Örebro.
stadsbyggnadskontoret@orebro.se

30. The Fyrisån River Water Association, Sweden

Inspiration points

Involvement of many relevant stakeholders in the water association board and the close connection between the association and the public.

Key words

Stakeholders, broad public.

Aim/objective of the project;

To protect and restore the river and provide information for the general public by monitoring water management activities (extraction, aquaculture, etc.) and thus use the river's resources in an economical and sustainable way.

Scale/unit of planning

Catchment area: 2 000 km^2.

Period

1962 – 1983 -- ongoing

Public participation objectives (Why PP?)

To involve relevant stakeholders in the water association board and to get measures done.
To inform the public and hence promote sustainable water management

Methods and tools applied and major input of stakeholders

The association consists of a board and three working groups for monitoring, measures and water management. Members of the water association board and the working groups represent municipalities, industrial plants, irrigation associations, drainage associations, angling association and dam-owners. They represents people from different sub-catchment areas. Many actors such as schools, farmers, NGO's etc., are involved in different projects in sub-catchment areas on the very local level and are supported by the association. Several environmental projects (one of them supported by WWF) have been started and are connected to the water association. The water association has one half-time employee for administrative service and the time for monitoring.

Seminars, information meetings and hearings were held.

Activity days were organised when local people took initiative and helped to restore the lakes by e.g. clearing reeds along the riverbanks to create better conditions for animal life.
Meetings with landowners on the implementation of the proposed measures were also held.

Tangible result (effect) of PP?

The public take initiative and show endurance and are really involved in the job and get measures done. They feel involved. Reconsideration of some of the water permits awarded to avoid too low a water-flow in the lake system.
Restored wetlands by landowners and others. Measures have been implemented at the local level.

Lessons learnt

A positive way of working in the water association is to initiate (small) water projects and ensure the involvement of the public in these projects on the sub-catchment level.
Summary: PP limits the costs of tangible measures. People do various forms of voluntary work within different non-profit associations.

<u>Positive and negative points</u>

The close connections between the board the public through the system with the water association. The board have the main responsibility and everyone know their own role.

Cost of the project?

60 000 euro (excluding administrative costs) for environmental measures and for water analysis.

Formal procedures for PP

Water associations are regulated by the Swedish Water Association Act as legal entities.

For more information please contact:

www.uppsala.se/miljokontoret (in Swedish only), Anders Larsson,
Anders.Larsson@mk.uppsala.se

31. Helcom MLW, Baltic Sea Region

Inspiration points

Trans-boundary co-operation on river restoration, elaboration of sustainable development strategy, coastal catchment planning and management.

Aim/objective of the project

Co-operation at coastal catchment level in 5 large areas on nature conservation, wetlands restoration, water management and community development within the framework of joint demonstration project “Helcom MLW” based on ICZM approach.

Scale/unit of planning

Some of these several thousand km^2 (and linked to the largest river catchments in Europe - Nemunas, Odra, Vistula); 3 of the areas being transboundary.

Period: Ongoing since 1995 (1999)

Objective of Public Participation (Why PP?)

Mobilising of local communities for contributing to international environmental objectives.

Who participated and how (Degree/form of public participation) in what phase of the planning?

The core of PP was the establishment of locally based advisory groups, including in principle all relevant stakeholders in a round-table approach throughout the various stages of the planning process. Combined with various communication efforts directed at the broad public.

Methods and tools applied

Round-table group discussions with all stakeholders. Media, information boards, leaflets, public meetings, consultation on draft plans.

PP include awareness raising activities regarding the role and functions of wetlands (and the areas’ international importance to biodiversity conservation) on one hand, on the other hand particularly support for development of alternative income sources on the other hand.

Major input of stakeholders

Knowledge on local situation, local development context, co-ordination with other relevant programs, ideas for demonstration activities.

Tangible result (effect) of PP?

Local community and several stakeholders committed to continue the process - regrettably halted due to lack of external financing (international donors as well as national funds).

The locally based NGOs (e.g. "Rusne Fund for Nature" and "Kintai Sailing Club" in the Nemunas Delta shared by Lithuania and Russia) has benefited substantially from participation in the process, while at the same time has contributed through disseminating key information to the own networks (e.g. local farmers).

Lessons learnt

Lessons learned: in these areas, poverty is widespread and it is impossible to raise local attention and support for delivering these "environmental services" to the international community without a trade-off in terms of development support.

A local, holistic sustainable development process is imperative for sustaining an adequate contribution and accepts of international environmental objectives. It is possible BUT also time-consuming to establish such a process, and its context must inevitably be in the shape of a trade-off: what does the local community get from the national / international community in return for accepting certain development regulations and restrictions?

The locally based NGOs (e.g. "Rusne Fund for Nature" and "Kintai Sailing Club" in Lithuania) consisting of environment-interested farmers constitutes the core in maintaining at least some type of process following the withdrawal of the project-funded process momentum.

Establishment of a local sustainable development structure will in the long run be imperative for sustaining such a process as well as constituting the local capacity for interactions between international / national environment objectives and local development needs. Further, particularly in resources-weak rural communities (which are of particularly relevance in an Eastern European context) such a structure will also contribute significantly in a broader sense to strengthen local development opportunities and capacity. One such example could be the Solway Firth Partnership in Scotland.

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- Lennart Gladh, WWF Sweden, lennart.gladh@swipnet.se
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32. Danube River Commission / Danube Environment Forum

Inspiration points

Planning at river basin level. Linking between district, basin and local level.

Aim/objective of the project

Dialogue on trans-boundary River Basin Planning, establishment of WG on WFD, development of Issue Paper on WFD, ensuring public participation in the Danube River management and co-ordination through setting up the *Danube Environmental Forum (DEF)*. DEF is an NGO platform with combined local and regional structure, established in 1999 to promote NGO participation in government fora, programmes and initiatives. The DEF network and operation is still under development.

Scale/unit of planning

Planning of the Danube River basin 'occurs' at a range of levels from sub-catchment/communities to international commissions. Participation of stakeholders happens in different ways at different levels in the overall process. The cascade of approaches to public participation from working with communities directly at one level to ensuring that representative organisations are involved at an international level is a good illustration of how public participation means different things at different levels but should have a common set of principles of transparency of process and inclusion.

Period: Ongoing since 1994

Objective of Public Participation (Why PP?)

- Danube Regional Project supports Danube Environment Forum (Assembly of NGOs)
- Linking between district, sub-basin and local level.

Who participated and how (Degree/form of public participation) in what phase of the planning?

- Stakeholders are observers to the Commission, which implies full participation, no voting rights.
- Involvement of international stakeholders, e.g. WWF as observer to the ICPDR. A large number of smaller (national and local) NGOs are connected with this through co-operation platforms, notably the Danube Environment Forum.

Methods and tools applied

Observer status granted to NGO representatives at meetings of the Commission. *The International Commission for the Protection of the Danube River (ICPDR)* is the co-ordinating body for international aspects of the Directive's implementation. ICPDR is promoting public participation in the planning process, through financial support to the ICPDR Information System, including the Danube Watch, as well as operating networks such as the Danube

Environmental Forum (DEF), MLIM and AEWS. NGO observers attend the ICPDR Meetings, and provide significant input to the work of the Commission (for example in the establishment of an Ecological Expert Group).

Major input of stakeholders

- Development of Issue Paper on WFD;
- Participation in several WGs under the ICPDR;
- Providing of knowledge on local issues as well as trans-boundary dimension.

Result (effect) of PP?

International co-operation on sharing of experiences and joint focusing (MS+ACs+nonACs) on river basin planning and WFD implementation.

Lessons learnt

Co-ordination structures are needed in order to provide small (national and local) NGOs direct or indirect access to international river basin co-operation, e.g. through representatives appointed from joint NGO platform. Larger NGOs with international program may play a facilitating role for linking smaller NGOs with the international structures.

Formal procedures for PP in the river basin

NGOs can be granted observer status to the ICPDR.
Considered most feasible way of handling public participation at river basin district level.

For more information contact:

ICPDR Secretariat
Charlie Avis, WWF DCPO, charlie.avis@wwf.hu

Available reports

www.icpdr.org

33. Lower Danube Green Corridor, Bulgaria, Romania, Ukraine, Moldova

Inspiration points

Trans-boundary co-operation on wetlands restoration, role of NGOs, large-scale RBM, involvement of international stakeholders, ensuring coherence with local level participation through pre-project interviews on environmental awareness and social assessments.

Aim and scale of the project

4-country trans-boundary co-operation on wetlands restoration, management and protection aiming at nutrient retention from the Danube River, totally encompassing 700.000 ha (here of some 200.000 ha for wetlands restoration).

Period

Preparations started end of 1990'ies, LDGC officially endorsed in 2000, ongoing - expected to be a multi-year program.

Objective of Public Participation (Why PP?)

Awareness raising among the broad public as well as selected target groups, e.g. local municipalities. Mobilising local community in order to ensure preparedness for utilising new development opportunities.

Who participated and how (Degree/form of public participation) in what phase of the planning?

- NGO-participation in the drafting of the concept and concrete activities;
- Strong local participation in the detailed design at local level anticipated within the framework of a joint overall project steering group;
- NGOs involved in development and implementation of Communications Strategy for the LDGC;
- Involvement of international stakeholders, ensuring coherence with local level participation through pre-project interviews on environmental awareness and social assessments;
- Local NGOs involved in development and implementation of Communications Strategy for the LDGC, a.o. Green Balkans (Bulgaria) and After School Club (Romania).

Methods and tools applied

Travelling exhibition, local events, press and media work, leaflets, meetings with local municipalities and other stakeholders, fundraising with international donors.

Major input of stakeholders

Fundraising, personnel, knowledge, motivation, commitment, international contacts, pictures, creativity, local contacts.

Result (effect) of PP?

Increased public support at local level for the wetlands' restoration activities.

Lessons learnt

Trans-boundary commitment and actions on using wetlands restoration as a measure (nutrient retention) for addressing non-point source pollution, the interviews showed a positive attitude to wetlands restoration while at the same time revealing lack of basic knowledge on wetlands functions leading to the need for a Communications Strategy.
International and local NGOs can play a significant role in mobilising the public for e.g. wetlands' restoration activities.

For more information contact:

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Annex III - Drafting Group and other Contributors

November 2002

The working process of the drafting group on public participation

Practice what you preach, is what we believe. Therefore the drafting group has organised the development of this Guidance on public participation in a participatory way. The working process until November 2002 is set out below:

Phase 1: Initiation and defining the Terms of Reference	
Interviews with members of the Working Group, EC	
Brainstorm session; drafting the issues paper	October 24 2001
Workshop	March 6,7 2002
Phase 2: Internal writing process "state of the art" concept guidance:	
Bringing existing information together per section	March/May 2002
Collection of examples of public participation in water management projects	
Meeting with WG 2.9 in Madrid	April 15 2002
Development concept 01 during workshop 2	May 21, 22 2002
Adjustment, additional data collection	June 2002
Development of draft Guidance and presentation at meeting WG in Brussels	July 4,5 2002
Phase 3: Consultation and adjustments	
Consultation of experts and target groups per country (including accession countries)	July/Sept 2002
Workshop with experts and target groups from Member States and Accession Countries in Amsterdam	October 7,8 2002
Adjustments and development of draft Guidance	October 2002
Presentation Guidance to the Water Directors	November 2002

From the beginning of 2003 to 2005, the Guidance Documents produced by the different working groups under the Common Implementation Strategy will be tested in a range of pilot river basins through the European Community, to assess the practicability of all the Guidance Documents and the coherence between them. The issues related to 2004-steps will be tested first (2003-2004), the issues related to later steps being tested afterwards. The so called « horizontal Guidances », will be tested in all the pilot river basins in the first phase. This Guidance on public participation is likely to be tested as such.

Another further development of activities could be to establish contacts and exchanges of experiences with the International Association of Public Participation (IAP2) situated in North America, Denver[7]. All the work done for producing this Guidance Document and the results merging from experiences through the establishment of an European experts network could be valorised by providing input concerning the European area, for which currently no data exist.

7 IAP2 was created in 1990 and gathers practitioners of public participation and people interested by this topic. The association has currently 1000 members, essentially North Americans ; it is organised into 18 chapters, among these are 1 Australian and 1 South-African but any European chapter. IAP2 disseminates documents on best practices and methods (see www.iap2.org).

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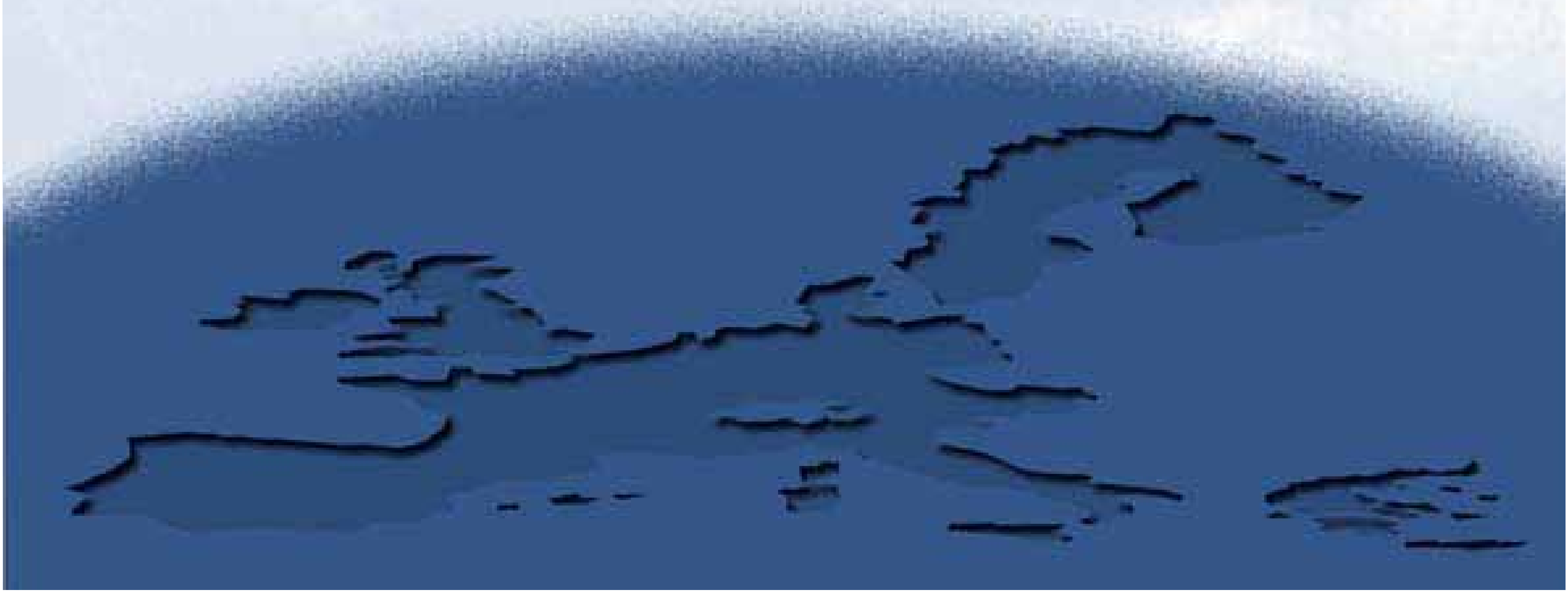
Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 9

Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive



COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 9

Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive

Produced by Working Group 3.1 – GIS

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, a working group dedicated to the development of technical specifications for implementing a Geographical Information System (GIS) for the reporting needs of the Water Framework Directive has been established in September 2001, referred to as GIS-WG. The Joint Research Centre (JRC) had the responsibility to co-ordinate and lead this working group, which included representatives from most Member States, some candidate countries, the Commission, Eurostat, and the EEA.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the GIS-WG activities and discussions. It builds on the input and feedback from a wide range of experts that have been involved throughout the process of guidance development through workshops or electronic communication media, without binding them in any way to its content.

We, the Water Directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this guidance during our informal meeting under the Danish Presidency in Copenhagen (21-22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leader, Dr. Jürgen Vogt (JRC), for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a *living document* that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

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Introduction - A Guidance Document: What For?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the implementation of its GIS elements in the broader context of the development of integrated river basin management plans as required by the Directive.

To whom is this Guidance Document addressed?

If this is your task, we believe the guidance will help you in doing the job, whether you are:

- ***Preparing the geographic datasets for the preparation of maps required by the Directive;***
- ***Preparing the final maps as requested under the Directive; or***
- ***Reporting the maps and GIS layers to the European Commission as required by the Directive.***

What can you find in this Guidance Document?

The common understanding on terms and on the role of GIS in the WFD

What are a map, a dataset with geographic datatype, a table, and data?
What are the GIS elements of the Water Framework Directive?
Where in the Directive are these elements made explicit or referred to?

The maps and GIS layers requested for reporting under the WFD

Which maps are to be reported to the European Commission and when?
What are the different GIS layers that make up these maps?
What are the level of detail and spatial accuracy expected from the data?
Which is the reference system to use for reporting the data?

How to validate the GIS layers

Which validation procedures should be employed in the validation step?
Which standards should be followed when validating data?

How to document the GIS layers

What are the metadata fields to deliver with each GIS layer?
Which standards are to follow when preparing the metadata?

How to report GIS layers to the European Commission

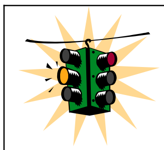
What is the format for transferring layers to the Commission in the short-term?
What is the way forward for the development of a distributed reporting system in the long-term?

How to harmonise data at borders and how to co-ordinate the reporting process

Which aspects should be considered for harmonising data at national borders and at borders of River Basin Districts?
How can a vertical integration between the various GIS layers be ensured?
How should the reporting process be co-ordinated?

How to introduce a European feature coding system

What are the advantages of implementing a European feature coding system?
What is the way forward for implementing a European feature coding system?



Look out! What you will not find in this Guidance Document

The Guidance Document focuses on the thematic content and technical specifications for the GIS layers to be prepared for reporting to the European Commission. The guidance does not focus on:

- *How to make maps out of the various GIS layers (layouts, symbols, generalisation procedures,…);*
- *How to use GIS in the analysis of pressures and impacts;*
- *How to use GIS in the preparation of river basin management plans.*

Historically, georeferenced data have been reported to the Commission in the form of analogue maps. With the introduction of Geographic Information Systems, these maps or the underlying GIS layers can now be reported in digital form.

In the European context experience with digital reporting is limited and standards are still under development. This Guidance Document, therefore, makes suggestions for best practices for the immediate reporting needs of the WFD and at the same time formulates strategies for the long-term needs. The recommendations will have to be tested and further developed over the next few years.

1 Implementing the Water Framework Directive

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

1.1 December 2000: A Milestone for Water Policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water quality management that today form the foundation of the Water Framework Directive.

1.2 The Water Framework Directive: New Challenges in EU Water Policy

What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater), which:

- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of available water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

… and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (*Article 2 (22), Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).

Look Out!

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation, at the latest by 2006;
- The overview of the significant water management issues in the river basin, at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept of the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering a unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

1.3 What is Being Done to Support the Implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

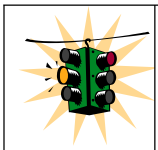
May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding guidance. A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall guiding body for the Common Implementation Strategy.

The GIS Working Group

A working group has been created for dealing specifically with issues related to the implementation of a Geographical Information System. The main objective of this working group, short-named GIS-WG, was the development of a non-legally binding and practical guidance for supporting the implementation of the GIS elements of the Water Framework Directive, with emphasis on its 2003 and 2004 requirements. The members of the GIS-WG are experts from European Union Member States, from candidate countries to the European Union, from Eurostat, form the EEA, from the JRC and from DG Environment.



Look out! You can contact the experts involved in the GIS activities

A list of the GIS-WG members with full contact details can be found in Appendix XI. If you need input into your own activities, contact a member from the GIS-WG in your country. If you want more information on specific scoping and testing in pilot studies, you can also contact directly the persons in charge of carrying out these studies.

Developing the Guidance Document: an interactive process

Within a very short time period, a large number of experts have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- *Organisation of* ***four workshops*** *of the 30-plus experts of the GIS-WG;*
- *Drafting and discussing of individual sections in task-groups;*
- *Exchange of documents for discussion and comments through email and the dedicated CIRCA web site;*
- *Inclusion of the opinion of a wide range of experts in the participating countries through their national representatives;*
- *Regular interactions with experts from other working groups of the Common Implementation Strategy through the participation of experts from other working groups in the WFD-GIS meetings, through the participation of WFD-GIS representatives in other WG meetings, or through email contacts;*
- *Set-up of a prototype GIS for testing the feasibility of some of the proposed specifications;*
- *Throughout the development of the guidance, the chairman of the working group attended regular meetings of the Strategic Co-ordination Group and of the Working Group Leaders in Brussels.*

2 GIS in the WFD: Developing a Common Understanding

This Section introduces the general basis for the detailed specifications as outlined in the following chapters. It reflects the common understanding of the working group experts on the purpose and the structure of the GIS elements to be developed as a basis for the reporting obligations under the Directive.

2.1 Terminology

In order to avoid ambiguity in terms, it is important to note that the following terminology will be used throughout this document:

Map: A graphical representation of a section of the Earth's surface. The Directive refers to a number of maps, each one with a specific thematic content (e.g., a map of the River Basin Districts). A map can be made up of one or many datasets with a geographic datatype. Using GIS software, maps can be presented in digital form from which an analogue map can be plotted. In this document, we assume that maps are produced in such a GIS environment and that they are made up of a set of digital datasets with a geographic datatype.

Dataset with a geographic datatype: A collection of data describing similar phenomena that can be represented with reference to the surface of the earth (e.g., the groundwater monitoring stations in a given River Basin District). In this document a dataset with geographic datatype is assumed to be a digital dataset in a GIS. The terms dataset, GIS layer or layer are used as synonyms for a digital dataset with a geographic datatype. The representation can be as pixels, points, lines, arcs and polygons or combinations of these.

Table: Most software systems require the organisation of datasets in one or more tables. In order to make information comparable between organisations, the structure of these tables must be similar.

Data: Tables are made up of digital data. The data will be stored using common typologies like geometry (e.g., points, lines, polygons, networks), strings (e.g., name, codes), numbers (e.g. amount of monitoring stations in a region), or dates (e.g., reporting date).

The relationship between these different levels of information is shown in Figure 2.1.1:

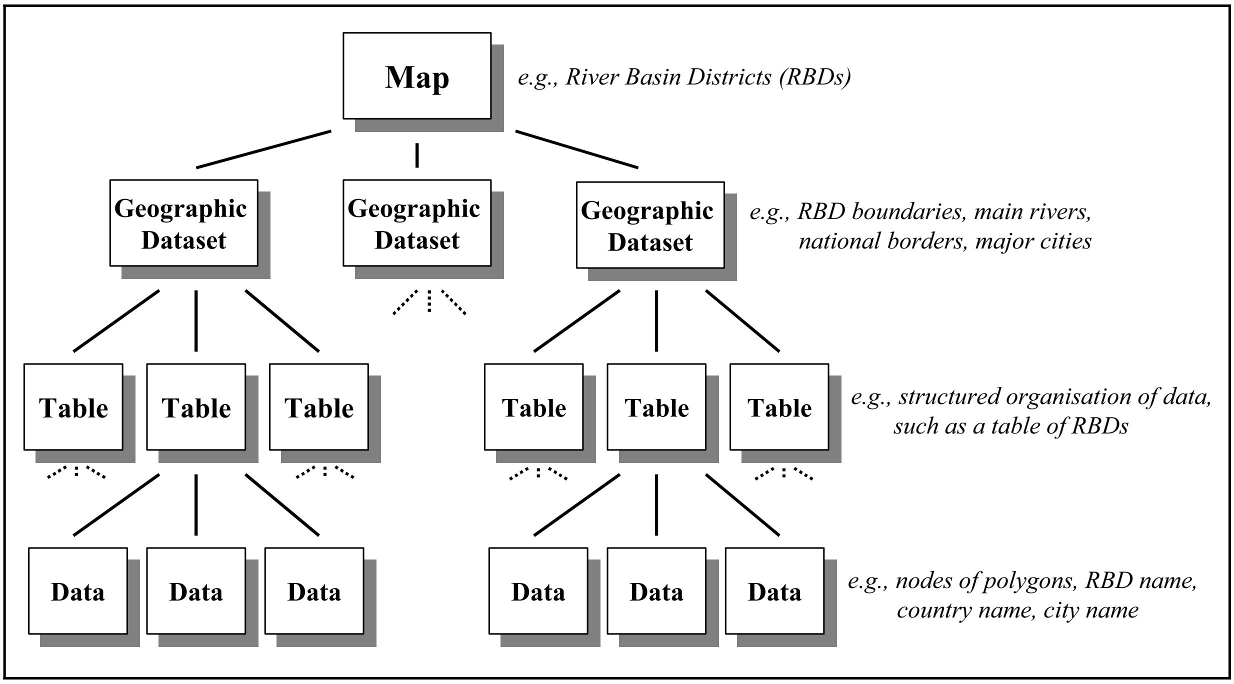


Figure 2.1.1: Relationship between a map, geographic datasets, tables and data.

2.2 GIS Requirements under the WFD and Scope of the Working Group

The WFD requires that Member States report a considerable amount of information in the form of maps. Even though only annex I and annex II of the Directive explicitly state that the respective maps should as far as possible be available for introduction into a GIS, it is obvious that the best way to provide most of the requested information will be in the form of GIS layers. This is due to the fact that most of the data is to be presented in its spatial context and that questions like ‘where are the critical areas?’, ‘how much area is involved?’, or ‘which points are in a designated area?’ can easily be answered when the data are kept in their spatial context and when the background database has the appropriate design.

The provision of (or access to) the requested GIS layers will not only facilitate the reporting of the Member States themselves; it will also facilitate the further compilation and analysis of the information as a basis for the Commission’s own reporting obligations under the WFD. Such development is also in line with current efforts under the INSPIRE (Infrastructure for Spatial Information in Europe) initiative of the Commission and the Member States, aiming at the development of a harmonised European spatial data infrastructure.

Many parties are involved in the implementation of the WFD, ranging from local water authorities to the European Commission. Regarding this wide range of parties, having different practices for water management, different reporting obligations and different levels of technical abilities, this Guidance Document strives to keep specifications as simple as possible, based upon standards where feasible, and according to best current technical options.

While the Directive clearly specifies which information should be provided in the form of maps (see appendix I of this Guidance Document), it gives little information on the technical specifications for these maps. The goal of the GIS working group under the Common Implementation Strategy, therefore, was to elaborate such specifications and to make them available in the form of this Guidance Document. The Guidance Document should help the Member States with the preparation of the GIS layers in such a way that they follow a common and agreed standard. This will not only facilitate the compilation of a European-wide picture, but it will also be a first step towards a more integrated spatial data infrastructure for Europe.

The implementation of the WFD requires the handling of spatial data both for the preparation of the River Basin Management Plans and for the reporting to the Commission. In the first case GIS techniques will be essential for the derivation of various information layers (e.g., on the characteristics of river basins and water bodies, on the chemical and ecological status of water bodies), while in the second case GIS will be the tool for the preparation and delivery of the GIS layers required for the reporting. Considering the limitations in time, the fact that many aspects of the analysis are still under discussion in other working groups, and the immediate needs stemming from the WFD implementation, it was decided that the current focus of the GIS Working Group should be on the WFD reporting obligations.

While this is a short-term goal, it is noted that in the long-term the development of specifications for a system including the possibility to access underlying measurements and statistical data or even for performing the various analyses as required for the preparation of the River Basin Management Plans might be considered. The elaboration of guidelines for these long-term options would, however, require substantial time and effort and is subject to a request by the Strategic Co-ordination Group for the Implementation of the WFD.

2.3 Reporting under the Water Framework Directive

The WFD is specifying which information should be reported in the form of maps and time schedules. This Guidance Document identifies these maps, the various GIS layers that are needed to make up these maps, their content and structure and how to document and to access or transfer them.

The WFD itself falls short in giving more detailed technical specifications with respect to the requested GIS layers. As a consequence, a common understanding had to be achieved on issues such as the contents of the various maps, the scale and positional accuracy of the data, and the reference system and projections to use. Given the fact that the various GIS layers will be part of a European picture, it was further necessary to consider issues such as the harmonisation at boundaries and the use of common identifiers. Recommendations are further given on the standards to be implemented for data exchange and data access and on the content and structure of the metadata to accompany each layer.

Technical possibilities nowadays allow the required GIS layers to be provided in two different ways. One option is to transfer them into a centralised system, where they will be stored, quality checked and analysed. The other option is to leave them at their place of origin (i.e. to store the data sets locally in each river basin district or country) and to guarantee access to these data through common standards and protocols. While the first option is easier to implement, the second option will reduce the burden of transferring data. However, it also asks for detailed technical specifications for the set-up and maintenance of a distributed system, which is more complicated. The GIS Working Group has explored both options. Given the limited time available to prepare the first GIS layers that need to be reported to the Commission in 2004, the Guidance Document gives specifications for a short-term centralised option and indicates the way forward for the implementation of a de-centralised system in the long-term. The GIS Working Group underlines that the preference is for the set-up of a de-centralised system in the long-term. The firm implementation of the outlined data model will strongly support this goal.

Since the GIS layers provided by the various River Basin Districts (or countries) will be collated to a European picture, it was further considered to be of importance to agree on a European feature coding system for river basins, water bodies (according to the definition of the WFD), monitoring stations, and pressures. In the long-term, this system should be smart enough to actively support the spatial analysis of pressures and impacts across Europe. The implementation of such a European feature coding system might prove a complicated task, since all Member States have historically implemented their own feature coding systems, adapted to their specific requirements. In view of this situation, the Working Group proposes the short-term implementation of a system that ensures unique feature identifiers across Europe, allowing to maintain national systems and to link them up to the European level. At the same time, the implementation of a feature coding based on the Pfafstetter system is recommended for countries without a dedicated national system. This approach is seen as a first step towards the set-up of a more intelligent European feature coding system, which will need more in-depth study before a definite proposal can be made.

While the WFD as such does not require the introduction of a European feature coding system, the Working Group considered it to be of major importance in the long-term. The main advantage of a European feature coding system would be the possibility for a more targeted analysis of pressures and impacts at the European level and the facilitation of a further integration of water-related monitoring efforts in Europe.

In order to test the feasibility of the distributed structure proposed for the long-term, the working group further implemented a prototype GIS. This prototype is conceived as a testbed for verifying the practical implementation. Examples from this prototype testing phase will be made available on a dedicated web site. Detailed testing of the specifications given in this Guidance Document is further foreseen in the Pilot River Basins, co-ordinated by Working Group 4.1 (Integrated Testing in Pilot River Basins) of the Common Implementation Strategy.

Finally, the Working Group decided not to include specifications for the map making process in this document. This decision is based on the fact that maps will be made at the River Basin District (RBD) level according to the specific needs of each RBD, and at the European level adequate maps can be made from the individual GIS layers. The Working Group, therefore, recommends that in addition to the maps as specified in the WFD, the GIS layers related to these maps should also be transferred to the Commission. The Commission would then have the possibility to make maps out of the GIS layers as required.

In a more general context, it should also be noted that information, consultation and participation are requirements of the Directive, since it will ensure a more efficient and effective implementation. The *Guidance on Public Participation* will tell more about these forms of participation. In particular WFD Article 14 promotes the active participation of all interested parties in the development of River Basin Management Plans and requires Member

States to inform and consult the public. The latter can most efficiently be done through maps, GIS technology and web mapping.

3 Technical Specifications of the GIS

This Section provides detailed specifications for the development of a GIS, compatible with the WFD reporting needs. It outlines the requested GIS layers, the time sequence for reporting and discusses the general aspects of data quality, data geometry and data documentation.

3.1 Timetable for the Preparation and Delivery of Maps and GIS Layers

The following table (Table 3.1.1) indicates when individual maps or GIS layers have to be made available either internally to a River Basin District (⊗) or externally to the Commission (•).

Table 3.1.1: Time Schedule for Reporting Maps

Actions related to GIS	Related Map (App. II)	Year 20..												
		03	04	05	06	07	08	09	10	11	12	13	14	15
Assigning individual river basins, groundwaters and coastal waters to individual river basin districts (RBD)		⊗												
Provide the Commission a list of the competent authorities for RBD	2		●											
GIS layer containing names of the main rivers and boundaries of the river basin districts	1		●											
Map of the geographical location of the [surface water body] types consistent with the degree of differentiation required under system A	4**		●											
Summary report of the analyses required under art.5 (*)				●[1]										
Summary report of the analyses required under art.8 (*)						●[2]								
Publishing of river basin management plans:								●						
Map of the location and boundaries of surface water bodies	3		⊗					●*						
Map of the ecoregions and surface water body types	4**		⊗					●*						
Map of the location and boundaries of groundwater bodies	5		⊗					●*						
Summary of the register of protected areas (location and description of the legislation under which they have been designated)	11		⊗					●						
Map of the surface water monitoring networks	6				⊗			●						
Map of the groundwater monitoring network	10				⊗			●						
Map of the results of the monitoring programmes for protected areas	12							●						
Map for each river basin district illustrating the classification of the ecological status for each body of surface water	7							●						

Actions related to GIS	**Related Map (App. II)**	**Year 20..**												
		03	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
Map for each river basin district illustrating the classification of the ecological potential for each body of surface water	7							●						
Map for each river basin district illustrating chemical status for each body of surface water	8							●						
Map of groundwater quantitative status	9							●						
Map of groundwater chemical status	9							●						
Review and updating of the analysis of the characteristics and of the review of the impact of human activity on the status of surface waters and on groundwater whithin a river basin district												⊗		
Review and updating of the river basin management plans														●
Presentation in map form of the monitoring results for the period of the previous river basin management plan														●

⊗ Deadline at Member State level

• Deadline for reporting

(1) 22 March 2005

(2) 22 March 2007

(*) The Directive does not specify whether the "summary report", which has to be delivered in 2005 should contain maps. The Expert Advisory Forum on Reporting will clarify this question. If it is decided that the summary report needs to contain maps, then maps No. 3 and 5 need to be delivered in 2004 instead of 2009. Map No. 4 needs to be delivered both in 2004 and 2009.

(**) Map No. 4 is requested twice: in 2004 according to article 5 and annex II-vi, and in 2009 according to article 13 and annex VII-1.1.

3.2 Overview on the GIS Layers, their Scale and Positional Accuracy

The technical specification of the GIS-layers needed for WFD reporting obligations is based on a detailed analysis of the content of the Water Framework Directive and as far as possible on the documents of the other working groups under the Common Implementation Strategy. All of the maps presented here are explicitly mentioned in the WFD. These maps are translated to GIS-layers, which make up the content of the map. Working with GIS-layers effectively supports the reporting obligations of the Member States and the Commission's needs to access and internally report the information. With the GIS-layers described below and the applied data model, all the requested maps can be made.

The relation between the required maps and the layers is presented in appendix II. GIS-layers are assigned to maps based on the strongest relation. For example, the layer 'River Basin District' is assigned to the map 'River Basin District - Overview'. Some layers can also be part of other maps, which is also indicated. Besides the background layers used for readability of the maps, 15 layers are necessary to make the 12 required maps. Table 3.2.1 presents a summarised view of the maps and layers.

Data collection and map making are the responsibility of the River Basin Districts and the Member States. It is recognised that for data collection an input scale of 1:250,000 or better should be a common goal in the long term. The reporting scale of the maps, however, may either be 1:250,000 or 1:1,000,000 in the short term and should be 1:250,000 in the long term. Only the very general maps No.1 (*River Basin Districts Overview*) and No.2 (*Competent Authorities*) might be reported at smaller scales of up to 1:4,000,000.

To describe the specifications, the GIS-layers are divided in three main groups:

1. Basic information and characteristics of the river basin district;
2. Monitoring network;
3. Status information of surface- and groundwater bodies and protected areas.

The requirements in terms of positional accuracy and input scale and output scale are further described in Section 3.2.4. All the required GIS datasets are vector or point datasets.

Special attention should be given in case of transboundary harmonisation of GIS datasets. In this context, the possibility to use as far as possible already harmonised data is recognised. This is especially true for the case of large international river basins (e.g. the Rhine or the Danube river basin), where the harmonisation work could be substantial. An example of such a database could be EuroGlobalMap at a scale of 1:1,000,000, which is currently under development. For the short-term reporting, this EU-wide database could be an option. In the long term, the scale of reporting may be 1:250,000, as far as an identical and harmonised database (e.g., EuroRegionalMap) is available.

Table 3.2.1: Summary of Maps and GIS –Layers (continued on next page)

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates[1]
1: RBD-Overview				
	SW1	River basin district (RBD)	polygon	12/2003 (RBD) 06/2004 (CEC)
	SW2	River basin, sub-basin	polygon	
	SW3	Main Rivers[2]	line	
2: Competent Authorities				
	D7	District of competent authorities	polygon	12/2003 (RBD) 06/2004 (CEC)
3: Surface Water Bodies (SWB) – categories -				
	SW4	Surface water bodies - Rivers - Lakes - Transitional waters - Coastal waters if applicable, indicated as artificial SWB or heavily modified SWB	 line polygon polygon polygon	12/2004 (RBD) 12/2009 (CEC)*
4: Surface Water Bodies (SWB) – types -				
	SW4a	Types of Surface Water bodies	attribute of SW4	12/2004 (RBD) 12/2004 (CEC)* 12/2009 (CEC)*
	D6	Ecoregions	polygon	
5: Groundwater Bodies				
	GW1	Bodies of groundwater	polygon	12/2004 (RBD) 12/2009 (CEC)*
6: Monitoring Network for Surface Water Bodies				
	SW5a	Operational monitoring sites. Inclusive monitoring sites for habitat and species protected areas	point	12/2006 (RBD) 12/2009 (CEC)
	SW5b	Surveillance monitoring sites	point	
	SW5c	Monitoring sites drinking water abstraction points from surface water	point	
	SW5d	Investigative monitoring sites	point	
	SW5e	Reference monitoring sites	point	

(1) RBD: The date when the map or layer needs to be available within the River Basin District.
CEC: The date when the maps need to be reported to the European Commission. Note: The date of December 2009 is the publication date of the River Basin Management Plans. They should be reported to the Commission within 3 months of their publication.
(2) Main Rivers: selection of the rivers from the Water Bodies Layer of map No. 3.
(*) Date of reporting for maps No. 3 and 5 might change to 2004. See also the time schedule in Section 3.1. Map no. 4 needs to be reported in 2004 and 2009 (see also Table 3.1.1)

Table 3.2.1: Summary of Maps and GIS –Layers (continued)

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates[1]
7: Ecological Status and Ecological Potential of Surface Water Bodies				
	SW4b	Ecological status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
	SW4c	Ecological potential	attribute of SW4	
	SW4d	Bad status or potential causes by (non-) synthetic pollutants	attribute of SW4	
8: Chemical Status of Surface Water Bodies				
	SW4e	Chemical status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
9: Groundwater Status				
	GW1a	Quantitative status of groundwater bodies	attribute of GW1	12/2009 (RBD) 12/2009 (CEC)
	GW1b	Chemical status of groundwater bodies	attribute of GW1	
	GW1c	Pollutant trend	attribute of GW1	
10: Groundwater Monitoring Network				
	GW2a	Groundwater level monitoring network	point	12/2006 (RBD) 12/2009 (CEC)
	GW2b	Operational monitoring network chemical	point	
	GW2c	Surveillance monitoring network chemical	point	
11: Protected Areas				
	PA1	Drinking water protection areas	polygon	12/2004 (RBD) 12/2009 (CEC)
	PA2	Economically significant aquatic species protection areas	polygon	
	PA3	Recreational waters	point	
	PA4	Nutrition-sensitive areas	polygon	
	PA5	Habitat protection areas (FFH)	polygon	
	PA6	Bird protection areas	polygon	
12: Status of Protected Areas				
	PA7	Status of protected areas	attribute of PA1-PA6	12/2009 (RBD) 12/2009 (CEC)

(1) RBD: The date when the map or layer needs to be available within the River Basin District.
CEC: The date when the maps need to be reported to the European Commission. Note: The date of December 2009 is the publication date of the River Basin Management Plans. They should be reported to the Commission within 3 months of their publication.

3.2.1 Basic Information

The basic information contains those entities for which the WFD applies. These are the surface water bodies, the groundwater bodies and the protected areas. Furthermore the river basin districts, the river basins and the areas of competent authorities are regarded as basic information.

For the co-ordination of administrative arrangements within river basin districts, and the arrangements within and between Member States, the boundaries of the river basin districts and the competent authorities have to be reported (maps No. 1 and No. 2). The following GIS-layers are required:

- *River basin districts:* The geographical coverage of the river basin district presented as a polygon layer. In cases where the national border is the same as the district border, the national border is leading;
- *River basins and sub-basins:* A polygon layer with the main catchment areas within the river basin district. All the basins and sub-basins taken together fully cover the river basin district. The basins and sub-basins are derived from the hydrological system, whereas the river basin district is designated as the main unit for the management of river basins. While this layer is non-mandatory it provides the basic entities for the river basin management and its delivery is recommended;
- *Main rivers:* A selection from the dataset with surface water bodies, used for general overview purposes;
- *Areas covered by the competent authorities within the river basin district*: A polygon layer with no overlapping features and without uncovered areas and if necessary synchronised with the national border layer and the river basin district layer.

The attributes of these GIS-layers are specified in the description of the data model (see Section 3.3) and in the data dictionary in appendix III.

The environmental objectives of the WFD cover all water bodies as well as areas designated as requiring special protection of their surface and groundwater bodies or for the conservation of habitats and species depending on water. The reporting obligations, therefore, require a general description of the characteristics of the river basin district, including information on surface water bodies, groundwater bodies and all protected areas (maps No. 3, 4, 5, and 11). The requested level of detail of the GIS-layers for surface water bodies and groundwater bodies is based on the essential discussion about the term water body. The outcome of this discussion, presented in the *Horizontal Guidance on the Application of the Term Water Body,* defines which elements should be included in the layer. In the following list we describe the composition of the various layers.

- *Surface Water Bodies*: Surface water bodies are first discriminated into the following categories: rivers, lakes, transitional waters, coastal waters, artificial surface water bodies, and heavily modified surface water bodies. Within each category discrimination is made based on type (according to system A or B). Rivers are represented as line features and lakes, transitional waters or coastal waters as polygons.
- *Groundwater Bodies*: Groundwater bodies are presented as polygon features. The outcome of the Working Group on Groundwater determines the characterisation of the groundwater bodies.

- *Protected Areas falling under specific Community legislation:* they include the following GIS-datasets:
    - Drinking water protection areas (polygons);
    - Economically significant aquatic species protection areas (polygons);
    - Recreational waters (points);
    - Nutrition-sensitive areas (polygons);
    - Habitat protection areas (FFH) (polygons);
    - Bird protection areas (polygons).

Some protected areas may have partially the same geometry as the water bodies, but the main part of the protected areas will have their own geometry. Therefore, the protected areas need to be represented as separate feature layers. The geometric representation of the features is based on the related specific Community legislation.

3.2.2 Monitoring Network

This paragraph deals with the requirements for mapping monitoring stations for reporting and presentation (maps No. 6 and 10). Further information on the requirements for the number of monitoring sites, the size of the related catchment, the sampling frequencies, etc. can be found in the *WFD CIS Guidance Document No. 7 on Monitoring*.

For the purpose of establishing a coherent and comprehensive overview of water status, surveillance monitoring sites will be considered first, since operational monitoring has to be performed in water bodies being at risk of failing to meet the objectives. Modifications of the sites, therefore, are likely.

The monitoring network will serve different purposes according to the water body type:

(i) for surface water:
monitoring the ecological and chemical status and the ecological potential;

(ii) for groundwater:
monitoring the chemical and quantitative status;

(iii) for protected areas:
supplementing those specifications contained in Community legislation under which the individual protected areas have been established;

(iv) for biological reference conditions:
reference conditions can be derived from a spatial network of high status sites (thus more stations per water body may be required);

(v) for drinking water abstraction:
monitoring the chemical and quantitative status.

The location of monitoring points does not statically follow a fixed size of the catchment but depends on sufficient information to assess the overall surface and groundwater status of each catchment, based on knowledge of the environment (region) and on expert judgement. Also stretches of coastal waters, significant international trans-boundary waters and pollutants discharging into the marine environment need to be considered.

The monitoring networks should be delivered in two datasets: one for surface water and one for groundwater. So even if a given monitoring station is used for both surface and groundwater monitoring, it should be considered as two objects. The different kind of monitoring types and purposes are registered in the attributes of the dataset. For surface water these are surveillance monitoring, operational monitoring, and investigative monitoring, or reference sites and sites for drinking water abstraction. For groundwater sites the monitoring types are quantitative monitoring and chemical monitoring. The chemical monitoring sites for groundwaters are further split-up into surveillance and operational sites (see also the data model in Section 3.3). The monitoring network will be presented as point features. The relation between a monitoring station and the represented water bodies is implemented in the data model.

It further needs to be considered that the information on monitoring points (number and location) is dynamic.

3.2.3 Surface Water Bodies, Groundwater Bodies and Protected Areas (Status)

Additionally to what has been mentioned in Section 3.2.2, the maps for status information (maps No. 7, 8, and 9) shall illustrate for a river basin district the classification of the ecological and chemical status of water bodies, colour-coded according to WFD Annex V, 1.4.2. Similarly, this applies to the status of good ecological potential of artificial or heavily modified surface water bodies.

For groundwater bodies or a group of groundwater bodies, both the quantitative and the chemical status shall be shown colour-coded according to the colour scheme given in the WFD Annexes V, 2.2.4 and V, 2.4.5. The status of protected areas shall also be mapped.

The datasets containing the information about the status of the water bodies and protected areas will not be required as separate feature layers but can be delivered as attribute information in tabular format using as a key the unique code of the water body.

3.2.4 Scale and Positional Accuracy

The scale of digital data or, more precisely, the scale of the underlying input data can be regarded as both, an indicator of spatial detail (which level of detail is available for map making), and as an indicator of positional accuracy (what is the possible difference between the true real world co-ordinates and the co-ordinates of the data). The 'spatial detail' determines both the minimum mapping area and the number of co-ordinates used to describe an element. On a large-scale map (i.e. 1:250,000) a river is presented with more points than on a small-scale map (i.e. 1:1,000,000), where, for example, small meanders may not be visible.

While in theory a dataset at 1:1,000,000 scale might contain the same amount of elements (objects) than a dataset at 1:250,000 scale, the latter can present the information in a better way (the positional accuracy is higher and the shapes of the elements are represented with more detail).

The main factor determining the necessary spatial detail of data gathering under the WFD is the size of the smallest feature to be shown on the maps. In the WFD the only direct indication in this context are the size thresholds given for the typology according to system A (WFD Annex II). These thresholds are set to a 0.5 km^2 surface for lakes and to a 10 km^2 catchment area for rivers. Although these thresholds do not imply that all water bodies larger than these numbers need to be reported (see the horizontal guidance on the application of the term “water body”), these figures can be used to estimate the required detail of data gathering or the input scale.

From theoretical considerations of cartography, these thresholds lead to a recommended scale of 1:250,000. On a map with this scale, water bodies with a minimum size of the given thresholds will be clearly visible. A map of 1:1,000,000 scale, to the contrary, will normally not contain lakes with an area of 0.5 km^2 or rivers with a catchment size of 10 km^2. However, digital data with this input scale might contain lakes or rivers of this size, even though they can only be shown as a point or very simple feature.

EuroGlobalMap (EGM) is a dataset that is under development in several Member States. EGM has a scale of 1:1,000,000. As a consequence, not all rivers and lakes larger than the thresholds mentioned above are incorporated in EGM. This implies that, if a Member State wants to use EGM for reporting under the WFD, EGM has to be extended, adding more lakes and rivers. The difference to a 1:250,000 dataset will be that the shape of the objects (rivers, lakes, etc.) will be less detailed or not available at all and that the positional accuracy will be worse. While EGM aims at a positional accuracy of 1000 metres, data layers with an input scale of 1:250,000 generally present objects with a positional accuracy in the order of 125 metres.

Considering both the WFD needs and the practical constraints of data availability, the GIS Working Group recommends that the required positional accuracy for the reporting is set to a minimum of 1000 metres (corresponding to an input scale of approximately 1:1,000,000) in the short-term, while at the same time it is strongly recommended to strive for a positional accuracy of 125 metres (corresponding to an input scale of approximately 1:250,000) in the long-term.

With a minimum requirement of 1000 metres, existing national or European datasets could be used, if amended with the necessary detail. In many cases, problems related to the data policy of such datasets might be less severe than problems related to a stringent requirement of 125 metres of positional accuracy in the short-term. However, in cases where data availability and data policy do not pose a problem, datasets with the highest possible positional accuracy are preferred. In the long-term, these datasets should in any case be the target.

3.2.5 River Basin Management Plans and Summary Reports

Among the various maps, registers, and reports listed as elements of the River Basin Management Plan in Annex VII of the WFD, the following are mentioned:

“*A register of any more detailed programmes and management plans for the river basin district dealing with particular sub-basins, sectors, issues or water types, together with a summary of their results*” (Paragraph 8), and

“*The contact points and procedures for obtaining the background documentation and information referred to in article 14(1), and in particular details of the control measures* *adopted in accordance with Article 11(3)(g) and 11(3)(i) and the actual monitoring data gathered in accordance with article 8 and Annex V*" (Paragraph 11).

These two paragraphs indicate that there is a distinction between "information included in the river basin management plan" (summaries) and more detailed information to be obtained from the national contact point.

In addition, Article 18 of the WFD refers to the Commission's report on progress in the implementation of the WFD based on "summary reports" that Member States submit under Article 15(2).

The above mentioned quotations indicate that a distinction should be made between the rate of detail to be used in reporting to the Commission (small scale) and the rate of detail Member States should have available upon request (large scale).

However, at this moment there is no clear guidance on the level of detail (input scale and spatial accuracy) to be used by Member States in order to fulfil the WFD summary based reporting obligations. This question will be further elaborated in the EAF on Reporting together with the future GIS Working Group.

3.3 Data Model

3.3.1 Purpose of the Data Model

The Water Framework Directive expresses a set of requirements for geographic information. Ultimately, this information will be stored in a number of databases. Data modeling is the first step in database design – it is the blueprint from which the GIS will be built. By modeling, complexity is reduced so that all actors should be able to understand the essence of the system. This provides the basis of development of a common understanding of which objects should feature in the geographic database, and how they should be represented. The model also aims to encourage consistency in data structures to facilitate data sharing.

Key activity 3: Improved Data and Information Management, Project 3.1 – "Development of a Geographical Information System (GIS)" states that "*the data model proposed needs to be defined in such a way that it can accommodate the information resulting from the national obligations of the WFD or that it can be linked to national systems via the coding system.*"

3.3.2 The Unified Modelling Language

The Unified Modelling Language (UML) is a modeling notation that provides tools for modeling every aspect of a software system from requirements to implementation.

UML has become a standard methodology, and is increasingly being applied to the modeling and design of Geographic Information Systems and Databases. In line with the position of the INSPIRE Architecture & Standards Working Group, a UML diagrammatic notation is used here to present an overview of the logical model, together with a detailed data dictionary (Appendix III) describing the attributes of the tables that will be created from the model.

Whilst UML can be applied in many aspects of system design, in the context of the WFD GIS Data Model only a restricted subset of static structure diagrams are used.

3.3.3 Data Model Overview

The data model aims to satisfy the requirements, primarily as defined by the Directive itself, but also based on commonly agreed definitions resulting from discussions in the GIS-WG and other Working Groups. Wherever appropriate, relevant definitions from the Directive itself are given.

Within the model, logically related features are grouped together. Thus, the model extends the basic distinctions in the Directive between "Surface Water" and "Groundwater" and "Protected Areas", adding the "Monitoring Network", "Management/Administration" and "Ecological Status".

Wetlands

Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in the WFD CIS Guidance Document No. 2 on *Water Bodies* and further considered in the guidance on *Wetlands (under preparation)*.

Pressures on wetlands (for example, physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can, in appropriate circumstances, offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal guidance paper on wetlands.

Given the role wetlands can play in achieving the environmental objectives of the WFD, it is recognised that it would be important to identify and include wetlands as objects in the GIS, including their key attributes. Wetlands will be related to groundwaters, surface waters and protected areas. As soon as relevant information on the definition and attributes of wetlands are available, the data model should, therefore, be extended accordingly.

The following three figures (Figures 3.3.1 to 3.3.3) show the core components of the model – Water Bodies, Monitoring Stations, Administration and Status:

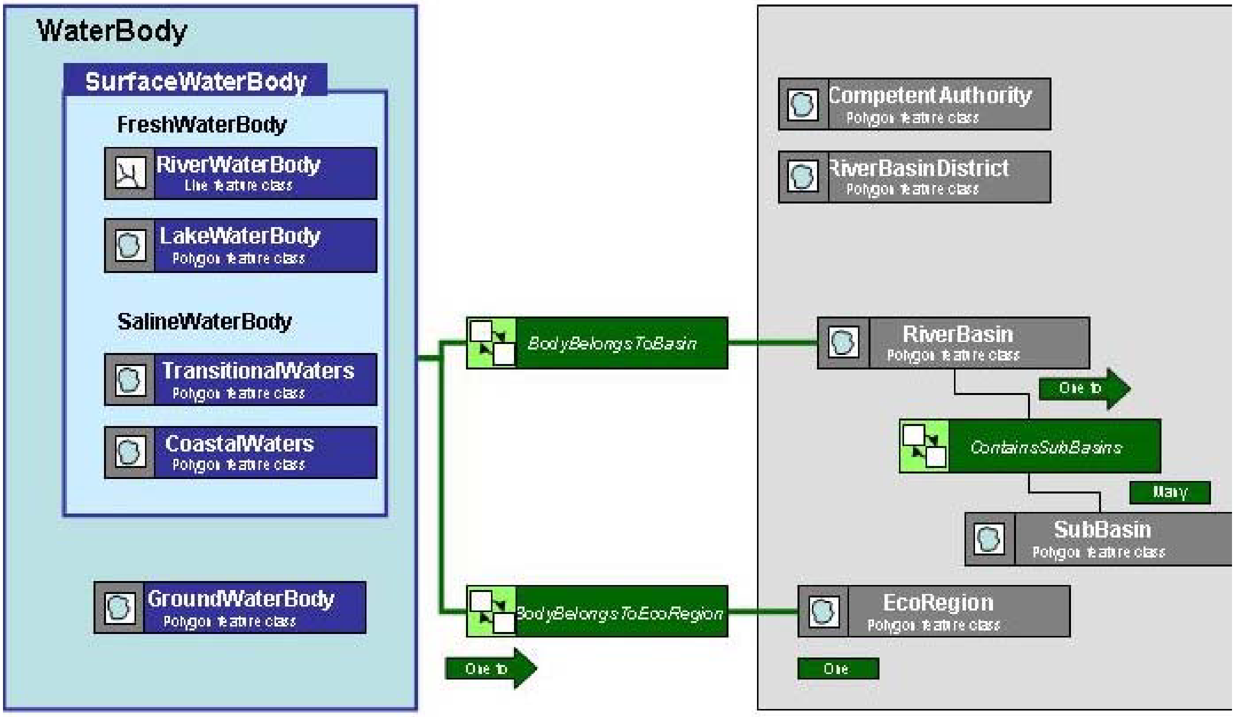


Figure 3.3.1: Water Bodies and Management Units.

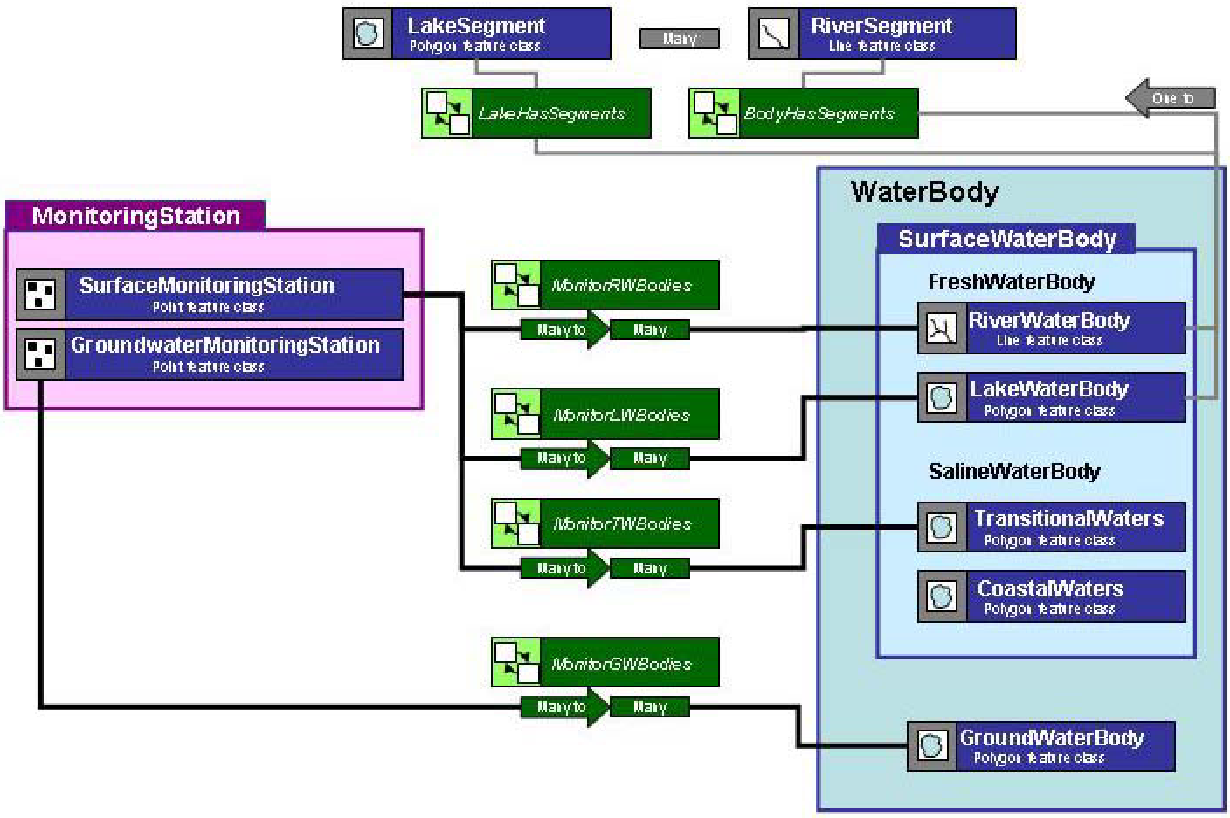


Figure 3.3.2: Water Bodies and Monitoring.

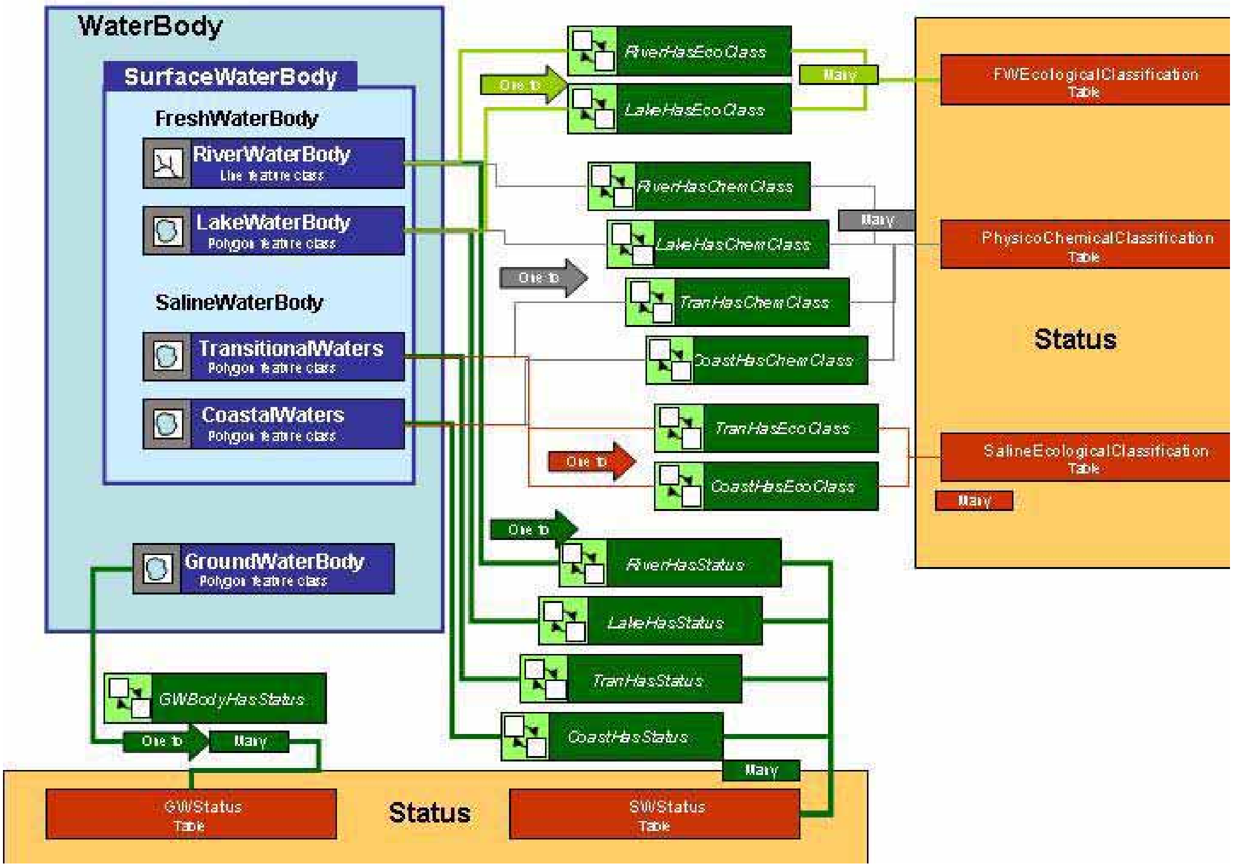


Figure 3.3.3: Water Bodies and Status.

Geometric Representation

In the simple approach presented here, features are represented as simple features only (i.e. points, lines, or polygons). Optionally, the same set of real world features could be modeled as a simple or complex network. Since the main objective of the Directive is reporting, not analysis, this may not be a priority, but should not be excluded at this stage and is discussed further below.

Linear measuring systems are in use in some, but not all, Member States. Instead of explicit x,y locations, data are recorded with reference to relative positions according to a known feature. For example, river segment 2800, kilometer 23.1 identifies a position in geographic space without the use of x,y co-ordinates. Because such measurements refer to relative positions, they can be updated easily without having to edit the underlying geometry of the river network.

Whilst this may become a standard approach in the future, the current release of the model provides a simple feature based approach. Thus, in the case of river lines, any status categorization (for example, poor quality symbolized in red) will apply to the entire line feature, from node to node. The identification and representativity of the segments is therefore crucial, and presents problems if the status values are dynamic. Given that reporting is on a six yearly basis, this problem is not significant. Clearly it is the Member States responsibility therefore to define water bodies, and their segmentation into individual features, according to the following principles:

> To enable "water bodies" to act as **compliance checking units**, their identification and subsequent classification must provide for the accurate description of the status of the water environment.
>
> The Directive only requires sub-divisions of surface water and groundwater that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of surface water and groundwater into smaller and smaller water bodies that do not support this purpose should be avoided.
>
> A "water body" must be capable of being assigned to a single ecological status class… (source "*WFD CIS Guidance Document No.2 on "Water Bodies"*").

The option of using linear referencing merits further discussion as to the feasibility and desirability of such an approach.

3.3.4 Feature Classes

Feature classes, i.e. those classes in the model which contain explicit geometry, and are thus point, line or polygon features, are as follows. All these classes inherit from the class feature, in that they have geometry and will have a unique internal identifier in the database. Feature classes cannot mix geometry types – they must be exclusively points, or lines, or polygons.

Feature
- SubBasin
- RiverBasin
- RiverBasinDistrict
- CompetentAuthority

Feature — *MonitoringStation*
- SurfaceMonitoringStation
- GroundwaterMonitoringStation

Feature — *WaterBody*
- GroundwaterBody
- *SurfaceWaterBody*
  - *FreshWaterBody*
    - RiverWaterBody
      - RiverSegment
    - LakeWaterBody
      - LakeSegment
  - *SalineWaterBody*
    - TransitionalWaters
    - CoastalWaters

Feature
- ProtectedArea

Feature
- EcoRegion

Inheritance allows classes to be related to parents through generalization. The more specific class inherits attributes from the more general class.

In practical terms, every UML class becomes a table. Every UML attribute in a class becomes a column in a table. Appendix III (Data Dictionary) provides a physical description of the tables and columns, which complements the discussion of each of the classes which follows.

3.3.4.1 General

EcoRegion

Polygon features, with a Name and a unique EcoRegionCode. Two systems are defined according to WFD Annex XI –A for rivers and lakes, and WFD Annex XI – B for transitional waters and coastal waters.

WaterBody

All surface water (SW) and groundwater (GW) bodies inherit from the WaterBody abstract class, which defines the following attributes:

- **EuropeanCode**. A unique identifier at European level, including the 2 character ISO Country Code;
- **Name;**
- **MSCode**. The unique code for the water body defined in the Member State;
- **EcoRegionCode.** The relationship between a water body and its parent EcoRegion is via the EcoRegionCode;
- **InsertedWhen;**
- **InsertedBy;**
- **RiverBasinCode.** The relationship between a water body and its parent RiverBasin is via the EcoRegionCode;
- **StatusYear.**

3.3.4.2 Surface Water

From the Directive definitions, "*Surface Water means inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters*."

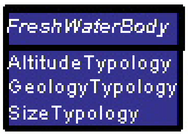
Thus the abstract class SurfaceWaterBody is classified into FreshWater and SalineWater, according to the different sets of attributes.

SurfaceWaterBody

A SurfaceWaterBody abstract feature class defines the following attributes:

- **HeavilyModified** True/False. Heavily modified water body means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II;
- **Artificial** True/False. Artificial water body means a body of surface water created by human activity;
- **System**. Whether the water body is Type A or Type B.

FreshWaterBody



The abstract feature class FreshWaterBody inherits from the SurfaceWaterBody class, and defines the following additional attributes:

- **AltitudeTypology**. Whether the body is in a high, mid-altitude or lowland area;
- **GeologyTypology**. Basic geological type of the area;
- **SizeTypology**. Size categories will differ between rivers and lakes.

SalineWaterBody

The abstract class SalineWaterBody inherits from SurfaceWaterBody and defines the following additional attribute:

- **SalinityTypology**. Based on the mean annual salinity.

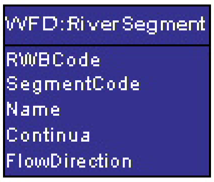
RiverWaterBody

RiverWaterBody means a body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course. The term RiverWaterBody is used to correspond with the WFD CID Guidance Document No. 2 on Water Bodies, where it is indicated that a single water body may consist of several component river segments. A RiverWaterBody is not therefore required to be a feature class, instead it is a list of the RiverSegment features which make it up. The RiverWaterBody class inherits from the FreshWaterBody abstract class. For the remaining attributes, which are to be completed in the case of a Type B River, the Directive does not give any indication of their definition or allowable values.

A RiverWaterBody is related to its component RiverSegments through the one-to-many relationship *BodyHasSegments*.

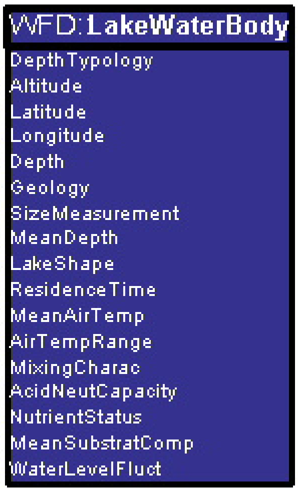
RiverSegment

The Directive does not explicitly state how to identify individual stretches of river (i.e. the concept of river reaches). It defines rivers, as other surface water bodies, as "*a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal*". As a minimum requirement, river segments should be defined between confluences, and will probably be split additionally at point locations in the Monitoring Network. This is in line with the Horizontal Guidance on water bodies. In this model, river segments are simple line features with nodes at the endpoints.



- **RWBCode** The unique code of the RiverWaterBody to which the segment belongs.
- **SegmentCode** The unique code of the RiverSegment.
- **Name** The locally applicable name for the RiverSegment.
- **Continua** Whether the river segment is a true river reach, or an imaginary *continua* created in order to maintain network connectivity. *Continua* are, for example, imaginary stretches of a river under a lake.
- **FlowDirection** Whether or not the flow direction along the segment is the same as the direction in which it was digitized.

LakeWaterBody



According to the Directive, "*Lake means a body of standing inland surface water*". Lakes are termed as LakeWaterBody in the model to allow for the subdivision of individual lakes into distinct bodies. A LakeWaterBody is not therefore a feature class in itself – it is rather a list of the individual LakeSegments (polygons) which make it up. The LakeWaterBody class inherits from the abstract class FreshWaterBody and defines the following additional attributes:

- **DepthTypology**. Based on the mean depth of the lake.

For the remaining attributes, which are to be completed in the case of a Type B LakeWaterBody, the Directive does not give any indication of their definition or allowable values.

A LakeWaterBody is related to its component LakeSegments through the one-to-many relationship *LakeHasSegments*.

LakeSegment

A LakeWaterBody is composed of one-to-many LakeSegments. A LakeSegment shall be an area (polygon) feature, and should have nodes at inlets and outlets, thus providing connectivity to the RiverSegment (line) features and to any internal "*continua*" segments defined.

- **LWBCode** The unique code of the LakeWaterBody to which the segment belongs;
- **SegmentCode** The unique code of the LakeSegment;
- **Name** The locally applicable name for the LakeSegment.

TransitionalWaters

Transitional waters are "*bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows*".

The TransitionalWaters feature class inherits from the abstract class SalineWaterBody and defines the following additional attributes:

- **TidalTypology.** Based on the mean tidal range.

Transitional waters will typically be estuaries, and modeled as polygon features. The use of river segments (as lines), to reach as far as coastal outlets, will maintain the network connectivity (see Coding Systems).

For the remaining attributes, which are to be completed in the case of Type B TransitionalWaters, the Directive does not give any indication of their definition or allowable values.

CoastalWaters

Coastal water means "*surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters*".

The CoastalWaters feature class inherits from the abstract class SalineWaterBody, and defines the following additional attributes:

- **DepthTypology** Based on the mean depth.

For the remaining attributes, which are to be completed in the case of Type B CoastalWaters, the Directive does not give any indication of their definition or allowable values.

For the feature classes which inherit from the abstract class SurfaceWaterBody, a number of attributes are in common (e.g. MeanSubstratComp). In the model these are not passed to the parent class simply to clarify the distinction between Type A and Type B categorization (e.g., the attribute SalinityTypology is a minimum requirement for Type A, both for TransitionalWaters and CoastalWaters, and is therefore presented as an attribute of the SalineWaterBody class. WaveExposure is an example of an optional Type B attribute, and is therefore presented at the feature class level).

3.3.4.3 Groundwater

GroundwaterBody

The GroundwaterBody feature class inherits from the WaterBody abstract class. Body of groundwater means "*a distinct volume of groundwater within an aquifer or aquifers*".

The Directive does not provide standard criteria for the characterization of groundwater bodies, although Member States should provide information on pressures, overlying strata and dependent surface water and terrestrial ecosystems. For groundwater bodies considered to be at risk, further detail on these geological and hydrogeological characteristics can be provided. Information concerning the impact of human activity may also be collected.

The model does not deal with these parameters, but this might be an area that merits increased standardization of the information gathered.

Discussion continues on how such bodies should be delineated, and subsequently represented. For the purposes of the present model, it is assumed that groundwater bodies will be 2-dimensional (i.e. planar) polygon features. Unlike surface water bodies, the delineated boundaries of groundwater will rarely coincide exactly with river basins. Thus the Directive requirement that groundwater bodies must be assigned to a River Basin District will have to be achieved through a relationship in the database, which should be the approach for all water bodies.

The GroundwaterBody feature class defines the following attributes:

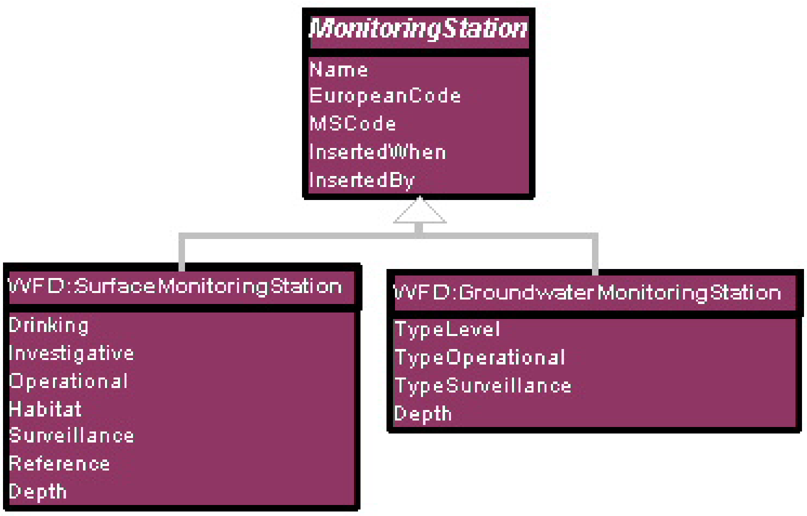
- **Horizon** – For groundwater bodies, reported separately but which are overlying, the horizon attribute provides a distinction of the individual strata.

3.3.4.4 Monitoring Network

Monitoring Stations shall form the basis of the monitoring of water status. The Directive distinguishes between Surface Water Monitoring and Groundwater Monitoring. The monitoring is the basis for subsequent classification of water bodies, but it is not a requirement from a GIS perspective to access the underlying data used to arrive at these status characterizations. Annex V, Article 1.3 states that "*Member States shall provide a map or maps showing the surface water monitoring network in the river basin management plan*". Similarly, Article 2.2.1 states that the groundwater monitoring network shall also be provided as a map or maps.

Thus the model defines an abstract class "MonitoringStation", further subdivided into SurfaceMonitoringStation and GroundwaterMonitoringStation.

MonitoringStation



The abstract class "MonitoringStation" defines the following additional attributes:

- **Name**. If appropriate, a name can be provided for the station;
- **EuropeanCode** A unique code, incorporating the ISO Country Code plus the MSCode below;
- **MSCode** A unique code for the monitoring station.

Monitoring stations are point features. They are further categorised into SurfaceMonitoringStations and GroundwaterMonitoringStations. Since a station may serve multiple functions, it is not appropriate to define distinct subtypes (e.g. a Groundwater station may perform any or all of the functions level (quantity), operational and surveillance monitoring).

The feature class **SurfaceMonitoringStation** inherits from the abstract class MonitoringStation, and defines the following additional attributes to identify the functions it performs:

- **Drinking –** Y/N if the station is a drinking water abstraction;
- **Investigative –** Y/N if the station is an investigative station;
- **Operational –** Y/N if the station is an operational station;
- **Habitat –** Y/N if the station is a habitat monitoring station;
- **Surveillance –** Y/N if the station is a surveillance station;
- **Reference –** Y/N if the station is a reference station;
- **Depth** – Depth in metres.

The feature class **GroundwaterMonitoringStation** inherits from the abstract class MonitoringStation, and defines the following additional attributes to identify the functions it performs:

- **TypeLevel**– Y/N if the station is an operational station;
- **TypeOperational**– Y/N if the station is an operational station;
- **TypeSurveillance**– Y/N if the station is a surveillance station;
- **Depth –** Depth in metres.

Monitoring stations may have multiple functions, as described above, and also may monitor multiple water bodies. They therefore have a many-to-many relationship with WaterBodies, as follows:

The feature class SurfaceMonitoringStation participates in the many-to-many relationships MonitorRWBodies, MonitorLWBodies and MonitorTWBodies.

The feature class GroundwaterMonitoringStation participates in the many-to-many relationship MonitorGWBodies.

3.3.4.5 Status

For each SurfaceWaterBody, ecological and chemical status categories are reported. However, a further level of detail is possible, in which individual ecological, hydromorphological and chemical quality parameters are recorded (Annex V, Article 1.2).

Again, a distinction can be made between Fresh and Saline waters. For each of these elements reported, the StatusDate is recorded.

Status parameters are also reported for groundwater bodies, again with a StatusDate allowing multiple status reports to be made for the same body over time.

All status parameters are linked to the relevant water body via the unique EuropeanCode.

GWStatus

The GWStatus class provides status reports for a given date for a given Groundwater Body, identified by the EuropeanCode. In addition, the following specific quality attributes are defined (see Data Dictionary Appendix III for allowable values):

- **QuantitativeStatus**. For good status, the level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction;
- **ChemicalStatus**. The chemical composition of the groundwater body as determined by pollution concentrations;
- **PollutantTrend**. The long-term trend in anthropogenically induced pollutants;
- **ConfidenceLevel**. The level of confidence associated with the PollutantTrend assessment above (Annex V, Article 2.4.4).

SWStatus

The SWStatus class provides status reports for a given date for a given surface water body, identified by the EuropeanCode. In addition, the following specific quality attributes are defined (see Data Dictionary Appendix III for allowable values):

- **EcologicalStatus**. Ecological status is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V;
- **EcologicalPotential** (for Heavily Modified or Artificial bodies) according to the categories in the *QualityClassification* domain;
- **NonCompliant**. True/False. For those bodies which may be at risk of failing to meet quality objectives;
- **ChemicalStatus** is either Good, or FailingToAchieveGood (Annex V, 1.4.3). Good surface water chemical status means the chemical status required to meet the environmental objectives for surface waters established in Article 4(1)(a), that is the chemical status achieved by a body of surface water in which concentrations of pollutants do not exceed the environmental quality standards established in Annex IX and under Article 16(7), and under other relevant Community legislation setting environmental quality standards at Community level.

FreshwaterEcologicalStatus

The FWEcologicalClassification class is related to a particular water body by the EuropeanCode. This class defines the following attributes (Annex V, Article 1.2.1, 1.2.2):

- **Phytoplankton;**

- **Macrophyto**. Macrophytes and Phytobenthos;
- **BenthicInvertebrates;**
- **Fish;**
- **HydrologicalRegime;**
- **RiverContinuity;**
- **MorphologicalConditions.**

PhysicoChemicalClassification

The PhysicoChemicalClassification class is related to a particular water body by the EuropeanCode. This class applies to all surface water body types, and defines the following attributes (Annex V, Article 1.2.1, 1.2.2):

- **GeneralConditions;**
- **SyntheticPollutants;**
- **NonSyntheticPollutants**.

3.3.4.6 SalineWater Ecological Status

For Transitional and Coastal Waters, the SalineEcologicalClassification class defines the following attributes:

- **Phytoplankton;**
- **Macroalgae**. Merged with angiosperms for coastal waters;
- **Angiosperms**. Merged with angiosperms for coastal waters;
- **Benthicinvertebrates;**
- **Fish;**
- **TidalRegime**. According to the QualityClassification domain;
- **MorphologicalConditions**. According to the QualityClassification domain.

3.3.4.7 Management / Administration

River basin district means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins.

A WaterBody or a MonitoringStation may belong to a single RiverBasinDistrict (even if this may not physically be the case – ref. CIS-WFD Project 2.9 "Guidance on Best Practices in River Basin Management Planning").

SubBasin

Sub-basin means "*the area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence)*."

The SubBasin feature class defines the following attributes:

- **Name;**
- **RiverBasinID**. The relationship between a SubBasin and its parent RiverBasin is via the RiverBasinID;
- **SubBasinID**. Each SubBasin shall have a unique code, which should link to the coding used for the river network.

The SubBasin feature class shall be defined as polygons.

RiverBasin

River basin means *"the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta*." RiverBasins shall be assigned "*to individual river basin districts"*.

The RiverBasin feature class defines the following attributes:

- **Name;**
- **MSCode;**
- **EuropeanCode;**
- **DistrictCode**. The relationship between a RiverBasin and its parent RiverBasinDistrict is via the DistrictCode;
- **AreaKM2.** Reported area in square kilometres.

The RiverBasin feature class shall be defined as polygons.

An important geometric rule is that river basins shall not overlap.

RiverBasinDistrict

RiverBasinDistricts can be collections of RiverBasins, TransitionalWaters and CoastalWaters. Thus, despite duplication of some geometry, they are defined as a separate polygon feature class. In addition, the following attributes are defined:

- **Name;**
- **MSCode;**
- **EuropeanCode;**
- **CompetentAuth**. The code of the parent Competent Authority.

CompetentAuthority

Competent Authority means an authority or authorities identified under Article 3(2) or 3(3). Because in some cases it is not possible to aggregate RiverBasinDistricts to form the boundary of the CompetentAuthority, they are defined as a separate polygon feature class.

- **Name;**
- **Address;**
- **AuthorityCode.**

3.3.4.8 ProtectedAreas

Annex V of the WFD states that the river basin management plan "*shall include maps indicating the location of each protected area and a description of the Community, national or local legislation under which they have been designated*".

No further specifications are provided by the Directive which might assist data modeling. Activities related to the other Directives and legislation concerning these protected areas may result in further specifications. However, at the present time ProtectedAreas are modeled as simple geometric features, each with a name and, where appropriate, a unique European Code allowing them to be distinctly identified. Whilst certain protected areas may currently be reported as point locations, it is strongly recommended that they are reported as polygon features whenever possible.

ProtectedArea

The feature class ProtectedArea defines the following subtypes:

- **DrinkingWaterProtection;**
- **RecreationalWater;**
- **EconomicSpeciesProtection;**
- **NutrientSensitiveArea;**
- **HabitatProtection;**
- **BirdProtection.**

Each subtype shares the same attributes:

- **Name;**
- **EuropeanCode.**

3.4 European GIS Feature Coding

3.4.1 Introduction

GIS feature coding is the assignment of unique identification codes to each spatial feature that will be referenced by GIS. This assignment needs to be managed to ensure uniqueness at national and international levels. Standard code formats will ease electronic data transfer and enhance the possibility of central querying against distributed storage.

3.4.2 Unique European codes

Unique European codes are provided by the following format

MS$\#_1\#_2\ldots\#_{22}$ where:

MS = a 2 character Member State identifier, in accordance with ISO 3166-1-Alpha-2 country codes, and

$\#_1\#_2\ldots\#_{22}$ = an up to 22 character feature code that is unique within the Member State.

For example:-
a *Groundwater Body in Germany* might have the identifier DE45734
or a *Lake Monitoring Station in Spain* might have the identifier ES67003800958730

Special advice given is that:

- Alphabetical characters should always be in upper case, as systems will be case sensitive;
- Special characters must be avoided, such as '$', '!', '&', 'ë', 'á', etc.;
- Digits should be used where practical to help avoid the above problems.

Use of the MS$\#_1\#_2\ldots\#_{22}$ is the only requirement for unique European feature identification codes. The Data Dictionary in Appendix III allows for these identification codes. Codes of this format should be used for initial and subsequent references to features when reporting to the Commission.

3.4.3 Managing Codes *within* Member States and RBDs

The above mentioned up to 22 alphanumeric string, $\#_1\#_2\ldots\#_{22}$, should be as short as possible to avoid keying mistakes, yet as long as is required to support unique code maintenance at local operational levels. Precise structures are a matter for each Member State to decide upon. However, some guidance is provided here to establish principles that may be adopted to assist code management within Member States.

3.4.3.1 Unique Identification of Coding Authorities

Some features will be identified on a one off basis, by a single agency acting at a national level. Others may be frequently established and identified by multiple organisations. In the latter case, a structured approach can ease the assignment of identifiers locally while automatically forming unique European identification codes. Examples are provided here in order to clarify this point.

There may be a number of authorities, such as counties, regions or Länders, responsible for the establishment of monitoring stations. Each may have sub-authorities such as urban district councils with similar responsibilities. In such a case, it is useful if coding authorities are first assigned unique identifiers at Member State level. For example the initial two digits of a four digit authority code 'AAAA' might be used, e.g., '**40**00', '**17**00' or '**23**00'. The last two digits might be used to identify sub-authorities or regional offices. For example '17**10**', '17**14**', etc. These authorities can then easily generate locally unique codes. A local code becomes nationally unique by the addition of the AAAA code as a header, and internationally unique by the further addition of the MS code. For example, if a monitoring station is locally given the unique identifier of '12345' by coding authority 1700 in Denmark, then that station would be uniquely identified as DK170012345 when reporting to Europe.

This approach is strongly recommended where multiple agencies are, or will be, involved in the ongoing identification of features. Exact coding structures to be used will be a matter for individual Member States to decide upon and these are likely to vary by feature type.

3.4.3.2 Unique Identification Coding at Operational Levels

The above technique can be taken further within coding authorities, where appropriate. For example, if drinking water abstraction monitoring is managed at drinking water scheme level, then a coding authority may first assign unique identifiers to drinking water schemes. The scheme managers can then easily assign unique identifiers to monitoring stations at a local level.

3.4.3.3 Using the River Network for Unique Code Assignments

Once the river network has been uniquely coded, it can be used to assign unique codes to features that are connected to it. This provides another mechanism for assignment of unique codes at a local level without having to cross check against national assignments.

River segment identification codes can be used locally to assign unique codes to:

- river water bodies;
- lakes;
- lake water bodies;
- transitional water bodies; and
- the monitoring stations for all of these.

As explained later, the outlet river segment code should generally be used for hydrologically connected features that are associated with multiple river segments.

For example, monitoring stations can be identified with codes that are an extension of river codes. The first two digits of a 4-digit monitoring station code 'MMMM' might be used. The last two digits could be used at a later stage to allow further stations to be inserted, while maintaining a sequence to the order of stations. Such a sequence would be important for the purpose of visual confirmation of uniqueness.

Thus, for example, if a river segment has 3 monitoring stations, these might be identified as '0100', '0200'and '0300' as we move upstream. If at a later date we want a station between the first and second, then it would have a station code of '0150'. If the river water body code was 'IE54321', then the full unique monitoring station code would be 'IE543210150'.

Practiced variations on this approach include the use of upstream distance. This has the benefit of providing exact location. It has the disadvantage of requiring prior distance analyses and GIS can maintain location in any regard. Again, this is a matter for individual Member States to decide upon and is very dependent of the capabilities and structures of code management organisations.

3.4.3.4 Monitoring Stations

As described above, monitoring stations may be uniquely identified by extending identification codes for river segments or coding authorities. It is very important that monitoring stations retain their initial identification codes regardless of subsequent changes in river water bodies and coding authorities. If monitoring stations were re-coded to reflect such changes, then the link to historic data relating to these stations would be lost.

The extension of feature and coding authority codes provides a mechanism for data validation. This is an added bonus gained from such code extensions. If such validation is used, the database will need to allow relaxation where the monitored features or coding authorities have changed.

However, it must be remembered that the primary purpose for such code extensions is not data validation; it is to help with the management of unique code assignment at local levels.

3.4.4 Structured Hydrological Unique River Identifiers

3.4.4.1 Coding Approach

If rivers are already substantially identified, it may be pragmatic to extend existing coding. However, the number of rivers to be identified may amount to multiples of the number already coded. Codes may also need to be reviewed to achieve harmonisation with Member States involved in shared RBDs. Coding could be as simple as sequential identifiers; however, structured hydrological codes are recommended. This enables rapid manual or automated analyses without the need to refer to GIS. Hierarchical structured coding also tends to ease long-term unique code maintenance.

Many existing river coding systems are reviewed in a document to be found at http://193.178.1.168/River_Coding_Review.htm. The Pfafstetter system is the generally preferred system. Its benefits are addressed at the above web address. Pfafstetter implementation issues are addressed in Appendix IV. However, it is felt that further consideration is required in order to produce a system that adequately caters for rivers, lakes and marine waters in an integrated way.

In the mean time, structured hydrological codes are preferable to random or non-hydrological codes. And thus, where extensive further river coding is expected, a modified version of the Pfafstetter system is proposed as an interim solution pending the possible adoption of a further modified or alternative system.

3.4.4.2 The (Interim) Modified Pfafstetter System

The code takes the form

MS MW N_1 N_2 N_3 N_4, ….

MS = Member State responsible for code assignment (outlet state for cross-border river segments). Use a 2-character Member State identifier, in accordance with ISO 3166-1-Alpha-2 country codes.

MW = Marine Waters identifier. (In accordance with the International Hydrographic Organisation delineation[1], with possible further local sub-divisions per regional marine agreements).

N_1 N_2, .. = Pfafstetter code[2]. This is a series of 1 digit nested codes. These codes are generated by the following process (see Figures 3.4.1 – 3.4.4)

Moving from river exit to source, the 4 most significant rivers are identified and assigned consecutive even numbers (e.g. 2, 4, 6 and 8.). The use of '0' is reserved for closed basins, i.e. with no outlet.

Each significant river has its own catchment. The remaining areas of the overall catchment are the inter-catchments. These are numbered using consecutive odd numbers, starting with '1' being the inter-catchment between the sea and the first significant tributary and ending with '9', being the headwaters or upper catchment area.

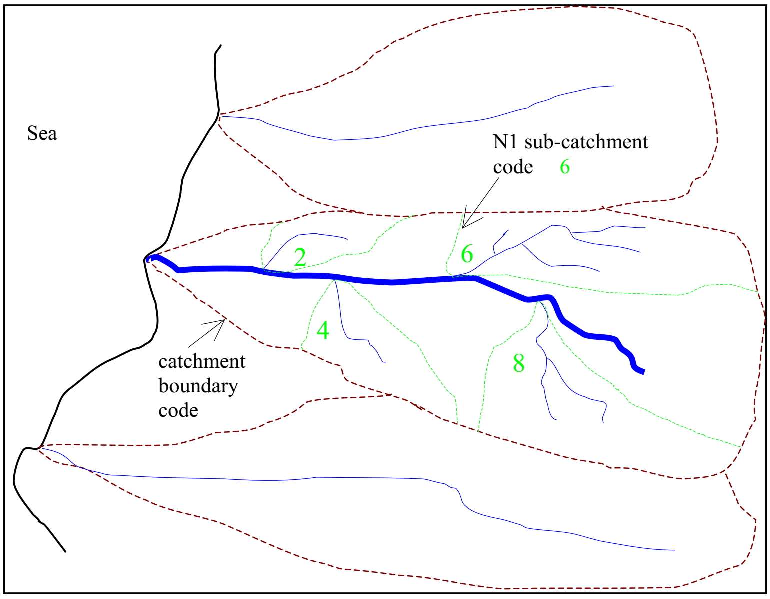


Figure 3.4.1: Pfafstetter numbering of main rivers and tributaries.

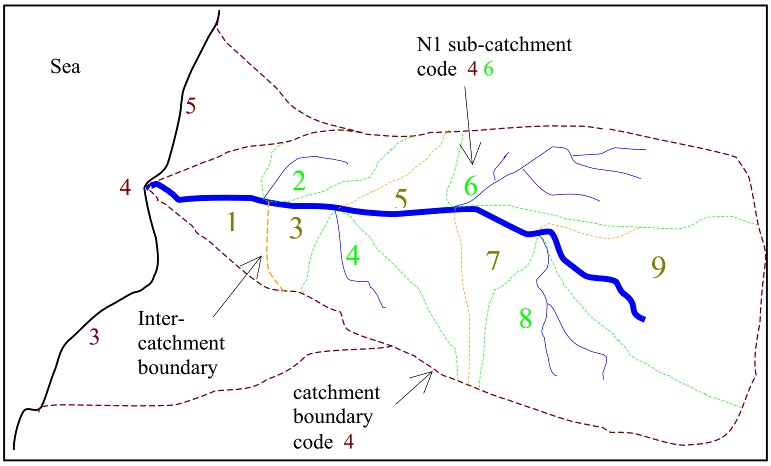


Figure 3.4.2: Defining and numbering the inter-catchment areas

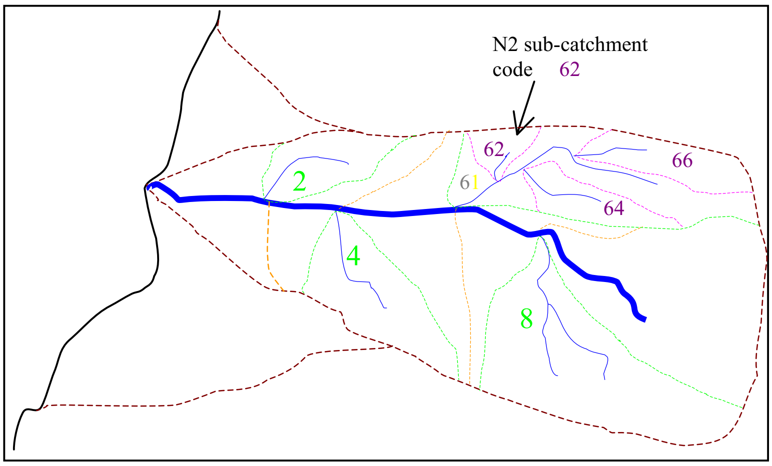


Figure 3.4.3:. Second level tributaries and inter-catchments.

Notes:
1. Use a temporary 2-digit code as IHO decimal codes are not presently suitable. These will need to be mapped to new standard 2-digit codes.

2. Portugal found that between 5 and 9 digits were required for Pfafstetter coding of the river network.

Each catchment and inter-catchment can then be broken down further in the same manner, by the use of N2. This nested process can continue into further levels. If, near the headwaters, four tributaries cannot be found, then the process continues with less catchments and inter-catchments. Alternatively, more detailed mapping is required.

Areas draining directly to sea (with diffused drainage or small rivers), will have odd numbered inter-catchment codes and can use N2 to identify the most significant rivers, then N3 for the most significant tributaries, etc.

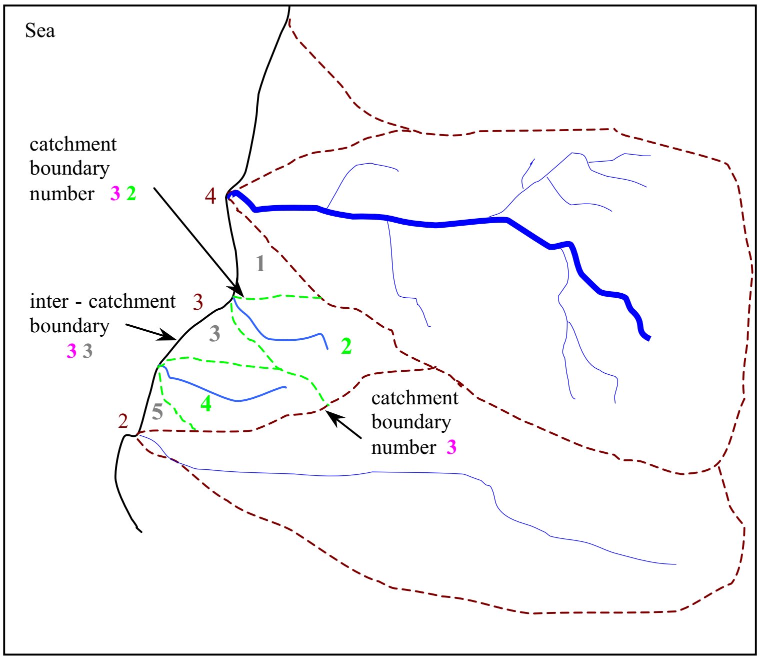


Figure 3.4.4: Sub-division of coastal catchments

The Pfafstetter approach can be used across adjacent Member States in combination with the marine waters code. Pfafstetter codes can be used directly to determine if discharge in a sub-catchment impacts on a potentially downstream channel. This can be achieved without the need for GIS analysis and is demonstrated at http://193.178.1.168/River_Coding_Review.htm.

Practical implementation issues and the impact of lakes on river coding are discussed in Appendix IV.

3.4.5 Structured Hydrological Coding for other Water Bodies

As mentioned already, the modified Pfafstetter system is an interim solution, which requires further study before it is either fully adopted as the recommended hydrological coding system or it is further modified or replaced by an alternative system. Regardless of which system is used, the river network provides a means to

a) assign unique codes to further features, and
b) assign structured hydrological codes to further features.

For example, as demonstrated in Appendix IV, if lakes, transitional water bodies and river water bodies use the same code as the downstream or outlet river stretch, then the assigned feature codes carry some level of hydrological information. This will enable rapid connectivity tests based on codes alone. Coding anomalies will arise on occasion and these will need some level of manual code assignment.

3.4.6 Protected Areas

Protected areas layers are addressed by Natura 2000 which uses a two character Member State identification code followed by a 7-character code to identify SCI's (Sites of Community Importance) and SPA's (Special Protection Areas) within a Member State.

3.4.7 Segmentation

Division of rivers or water bodies into sub-sections requires additional code management. This will not be required for initial reporting, but will be a consideration at river basin district levels. Rivers can be divided into subsections using either the sequential identifiers or the distance approaches referred to when dealing with monitoring stations in Section 3.4.3.3: *Using the River Network for Unique Code Assignments*. Similar strategies need to be put in place for coastal and lake shorelines and sub-regions.

3.4.8 Conclusion

Unique European codes should be generated by placing a 2-character Member State code in front of up to 22 characters unique identifier codes generated within Member States. This is the only requirement for compliance with an agreed common format.

Further advice is provided regarding the structure of codes; but this requires local interpretation and decision making to establish appropriate optimal formats. Member states should initially establish coding structures that suit their particular needs and that support efficient management of unique code.

It is suggested that the following be considered:

- Member states should initially assign identification codes to coding authorities;
- A decision should be made with respect to the use of structured hydrological codes;
- River segment codes should be established for all rivers likely to be used for reporting;
- Coding authority and river segment codes should then be extended to assign further unique feature identification codes at a local level;
- Monitoring station identification codes, generated by such code extensions, should not change once assigned, even if associated authority or feature identification codes do change;
- Agreement should be reached with neighbouring countries regarding harmonised cross-border codes, particularly for river network coding.

Unique European codes of standard format are of a higher priority than structured hydrological codes. However, where computers are used to identify and code features, then for little extra effort, hydrological codes can be assigned. These will facilitate rapid connectivity tests without reference to GIS.

The following tables show some example codes, all of which comply with the MS plus 22 character string format. Suggestions are made with respect to possible coding strategies. However, it will be up to Member States to determine the best approach to adopt for local use and for application in international river basin districts.

3.4.9 Tables of Example Codes

Final code formats should be determined at Member State level, subject to existing data, local practices, organisational structures and long-term code maintenance strategies. The tables below should then be redrafted, at Member State level, to summarise local coding standards.

3.4.9.1 Water Bodies

Water Bodies (GIS Layers)	EXAMPLE ONLY		
River Segments & Catchments (Basins & Sub-Basins) (SW2, SW3 & SW4)	MS $\#_1,\#_2 .. \#_{22}$ or MS, MW, $N_1,N_2,\ldots N_{22}$ (Modified Pfafstetter)	IE12873 a river, GB12874 a catchment	MS = member state, at river section or catchment outlet. Non-Hydrological Approach: $\#_1,\#_2 .. \#_{22}$ = an up to 22 character string. Hydrological Approach: MW = marine waters codes according to a modification of codes for IHO delineations. ($N_1,N_2, N_3\ldots N_{22}$ are nested codes, each consisting of 1 digit With Pfafstetter, rivers use odd numbers, catchments or basins use even.)
River Water Body (SW2, SW3 & SW4)	MS $\#_1,\#_2 .. \#_{22}$	IE12873	For a hydrological approach use the same code as outlet river reach.
Lakes (SW4)	MS $\#_1,\#_2 .. \#_{22}$	SE13873	For a hydrological approach use the same code as outlet river reach.
Transitional (SW4)	MS $\#_1,\#_2 .. \#_{22}$	DE035411	For a hydrological approach use the same code as outlet river reach.
Coastal (SW4)	MS $\#_1,\#_2 .. \#_{22}$	IE10001230	This code may be an extension of a coding authority identification code, or it may relate to IHO marine water delineations.
Groundwater (GW1)	MS $\#_1,\#_2 .. \#_{22}$	GB30002310	This code may be an extension of a coding authority identification code.

3.4.9.2 Water Body Monitoring Points

Points (GIS Layers)	EXAMPLE		ONLY
River Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	GR5730800	MS = Member State $\#_1,\#_2 .. \#_{22}$ = is an up to 22 digit code, but kept as short as possible to avoid keying errors. This code may be an extension of the river segment, catchment or water body code.
Lake Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	GE5730300	This code may be an extension of the lake or lake water body code.
Coastal Water Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	GE100003001230	This code may be an extension of a coastal water body identification code.
Transitional Water Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	IT5730300	This code may be an extension of a transitional water body identification code.
Groundwater Body Station (GW2 & GW3)	MS $\#_1,\#_2 .. \#_{22}$	IT200001500305	This code may be an extension of a groundwater body identification code.

3.4.9.3 Water Usage Monitoring Points

Points (GIS Layers)	**Code Format** EXAMPLE	**Example Code**	**Comments** ONLY
Drinking Water, Groundwater Abstraction Station (SW5 & GW3)	MS $\#_1,\#_2 .. \#_{22}$	LT124000000120	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the ground water body code. The decision should depend on the member state ongoing code maintenance strategy.
Drinking Water, Surface Water Abstraction Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	ES130001010002	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the surface water body code. The decision should depend on the member state ongoing code maintenance strategy.
Bathing Point Station (SW5)	MS $\#_1,\#_2 .. \#_{22}$	PT130000100002	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the surface or coastal water body code. The decision should depend on the member state ongoing code maintenance strategy.

3.4.9.4 Point Pressures – Discharges

Points (GIS Layers)	**Code Format**	**Example Code**	**Comments**
	EXAMPLE ONLY		
Discharges (SW4 & SW5)	MS $\#_1,\#_2 .. \#_{22}$	FR130002500004	This code may be an extension of a coding authority identification code. Monitoring stations could be a further extension again. Discharges may be managed by type, such as Industrial, Treatment Plant, Solid Waste Leachate, etc.

3.4.9.5 Point Impacts

Points (GIS Layers)	**Code Format**		
	EXAMPLE ONLY		
Pollution Incidents (SW5 d)	MS $\#_1,\#_2 .. \#_{22}$	IE130020020123	This code may be an extension of a coding authority identification code.

3.5 Data Validation

This chapter describes the principles for quality assurance related to the GIS layers that are transmitted by the Member States to the European Commission. As pointed out earlier, the working group decided to deliver GIS layers and maps. The focus will be on reporting rather than spatial analysis. Hence the requirements on data quality are less strict compared to spatial analysis requirements. Nevertheless, there are some demands that can be derived from producing good cartography. Additionally, the GIS layers should be in a state that allows using as much as possible automated procedures for quality control. In general the data quality procedures should be applied by the Member States and be reported as part of the metadata. When compiling the national GIS layers, the EC will apply additional procedures that aim at creating homogenous GIS layers within the specifications of this Guidance Document. The framework for applying quality assurance procedures and reporting the results is set by the draft ISO standards on quality principles (19113), evaluation procedures (19114), and metadata (19115).

3.5.1 Data Quality Overview

Every GIS layer should be complemented with overview information on data quality. It consists of descriptions of the purpose, the usage and information on the history (lineage) of the GIS layer. Purpose describes the original objectives for creating the GIS layer, usage illustrates the actual usage(s) of the layer by describing related applications. The lineage gives information on the history of the dataset. It covers the total life cycle of a dataset from initial collection and processing to its current form. The lineage statement may contain the component "source information" that describes the origin of the dataset and the component "process step" that records the events of transformations in the lifetime of the dataset. Lineage also includes information on the process and the intervals to maintain a dataset.

The overview elements on data quality should be transmitted by the Members States and will be continued by the EC when applying further data processing steps.

Table 3.5.1: *Data quality overview*

Element	**Obligation**	**reported by**
Lineage statement Either a general explanation on the history, a more detailed description on the processing steps applied, or a description of the source of the GIS layer.	mandatory	MS, EC

3.5.2 Data Quality Elements

In addition to the general statements on data quality in the overview elements, the GIS layers should include information on selected data quality elements. These are completeness, logical consistency, positional accuracy and thematic accuracy.

Table 3.5.2: Selected data quality elements and sub-elements

Quality Element	Quality Sub-Element
Completeness	Commission Omission
Logical consistency	Conceptual consistency Domain consistency Topological consistency Format consistency
Positional accuracy	Absolute or external accuracy
Thematic accuracy	Classification correctness

3.5.2.1 Completeness

Completeness is assessed relative to the GIS data model specifications, which defines the desired degree of generalisation and abstraction. All features that are described in the specifications should be present in the dataset, more features would lead to a situation of over-completeness. The related attributes should sufficiently describe the feature and the values of the attributes should be filled. Relationships between the features should be established and valid according to the product specifications.

The Member States should report on methods, which they have applied to guarantee the completeness of features in the GIS layers. This refers especially to the number of river basins and sub-basins, the number of main rivers, the surface and groundwater bodies, the monitoring stations, and the protected areas. The completeness of features is normally tested by comparing them to a universe of discourse, i.e. a GIS layer that is considered as being complete. The results of the applied procedures should be reported as part of the metadata by the Member States.

Table 3.5.3: Completeness of Features Elements

Element	Obligation	reported by
Completeness of features in GIS layers	mandatory	MS

3.5.2.2 Logical Consistency

Consistency refers to the absence of apparent contradictions in the dataset, database or transfer file. Consistency is a measure of the internal validity of a database, and is assessed using information that is contained in the database.

Due to the lack of reference data, the most important part of the quality assurance process will be the assurance of the logical consistency of the data. The consistency applies to the features, the attribute-tables as well as to the attributes, and to the relationships. The relationships comprise the defined relationships between feature classes and attribute classes as well as to geometric relationships, e.g. sub-basins are covered by river basins.

Conceptual Consistency

The checks for conceptual consistency should include checking for the existence of the feature classes, the attribute classes, and the relationships that are defined in the model. The next step is to verify the existence and the correct definition of the features, attributes, domains, and relations in the database. Then it should be verified that attribute values exist, where these are defined, and that the relations are valid. The cardinality of the relations should conform to their definition. These quality checks will be applied by the EC when integrating the national GIS layers into the EU geographical database.

In the data model it is expressed that simple features are stored in the feature classes. Consequently it should be verified that the features in the database are consistent with the definition of simple features. This includes, for example, that polygons are closed, that boundaries of the polygons must not intersect, and that holes and exclaves ?? are considered correctly. Quality assurance on the validity of simple features are vital for the consistency of the database and should be applied by the Member States and reported by the EC.

Table 3.5.4: Conceptual Consistency Elements

Element	**Obligation**	**reported by**
Existence of GIS layers, attribute tables, relationships, domains	mandatory	EC
Definition of attribute	mandatory	EC
Existence of attribute values, where mandatory	mandatory	EC
Verification of cardinality of relationships	mandatory	EC
Simple features definition	mandatory	EC

Domain Consistency

In the data model, a number of domains are defined. It should be verified that the definition of the domains is correct. Then it should be checked that the attribute values in the feature and attribute classes are consistent with the domain values. In addition to the existing domains, so-called value range domains should be set up, as soon as the dimensions for the items concerned are defined. The checks on domain consistency should be applied by the Member States and will be verified during the integration process that generates the European database.

Table 3.5.5: Domain Consistency Elements

Element	**Obligation**	**reported by**
Comparison of attribute values with domain definitions	mandatory	EC

Topological Consistency

There are a number of GIS layers and attributes that can be tested for topological consistency. Some of the GIS layers have a country indication. The Member States should ensure that the appropriate country code is used.

The water bodies have an attribute indicating the relation to the EcoRegion GIS layer. The relation between water bodies and its parent river basin district can be verified by overlaying the water bodies with the river basins. The EC will test the correctness of the assignment by overlaying the respective layers.

The Appendix V contains a set of topological rules applicable to the GIS layers. The rules will be tested by the EC when merging the national GIS layers. The correctness should be reported as part of the data quality element topological consistency.

The WFD database will be set up as a collection of data sets provided by the EU countries. It is recommended that the features crossing boundaries should be coherent. This principle should apply to the geometry as well as to the attributes, e.g. the boundaries of river basins should meet at the border. The coding of the basin should be the same. The feature classes which could cover more than one country are in principle all polygon and line features, i.e. water bodies and river basins, sub-basins. This situation will be analysed by the EC when integrating the national GIS layers into a European database.

It is recommended that the hydrographical GIS layers should constitute a network. The directions of the lines should indicate flow directions. Flow lines should connect the incoming and outgoing river lines through a standing water body (e.g., lake). These connecting flow lines are termed *continua* in the data model. The data will be analysed by the EC when integrating the national GIS layers.

Table 3.5.6: Topological Consistency Elements

Element	**Obligation**	**reported by**
Coherence of features crossing country border	mandatory	EC
Country attribute values	mandatory	EC
Indication and verification of water flow	optional	EC

3.5.3 Accuracy

Positional Accuracy

Positional accuracy describes the difference between the location of features in a dataset and the location recognised as being true. The product specification in the Appendix V includes values for the minimum positional accuracy of the different GIS layers. The assessment of the positional accuracy can be done through sampling procedures.

The Member States should include information on positional accuracy and on the validation procedures applied as part of the metadata information. If there is no information on the positional accuracy, we recommend applying the method of the Federal Geographic Data Committee for geospatial positioning accuracy standards[1].

Table 3.5.7: Positional Accuracy Element

Element	Obligation	reported by
Positional accuracy	mandatory	MS

3.5.4 Descriptors of the Data Quality Sub-Elements

The results of the quality assurance for the above mentioned data quality sub-elements should be described using seven descriptors. The descriptors comprise the

- scope;
- measure;
- evaluation procedure;
- result;
- value type;
- value unit; and
- date.

of the data quality sub-element.

Quality measurements are only valid for defined scopes. The scope can be a geographic or a temporal extent, or a certain level of the data hierarchy (i.e. dataset series, dataset, features, or attributes). The scope may even be different within a single dataset, e.g. if the dataset is merged from different data providers.

The data quality measure describes briefly the test that is used for measuring the quality within the defined scope. The evaluation procedure should be described or, alternatively, there should be a reference to where a detailed description of the procedure can be found. This description is very important because it is necessary to understand the result of the applied test. Each test yields a certain result that is part of the data quality report. In order to understand the result, it is necessary to give information on the type of the value and on the unit of measurement. The reporting is completed with the date on which the quality test is performed.

3.5.5 Reporting of Quality Information

The results of the applied quality tests should be reported as part of the metadata. The DIS 19115 provides a defined structure, that follows the logic of the above described data elements, sub-elements and descriptors. The metadata standard distinguishes between data quality information as a report and as information of the history (lineage) of the data. The report comprises information on quality measurements, grouped according to the data quality sub-elements.

[1] see : http://www.fgdc.gov/standards/status/sub1_3.html

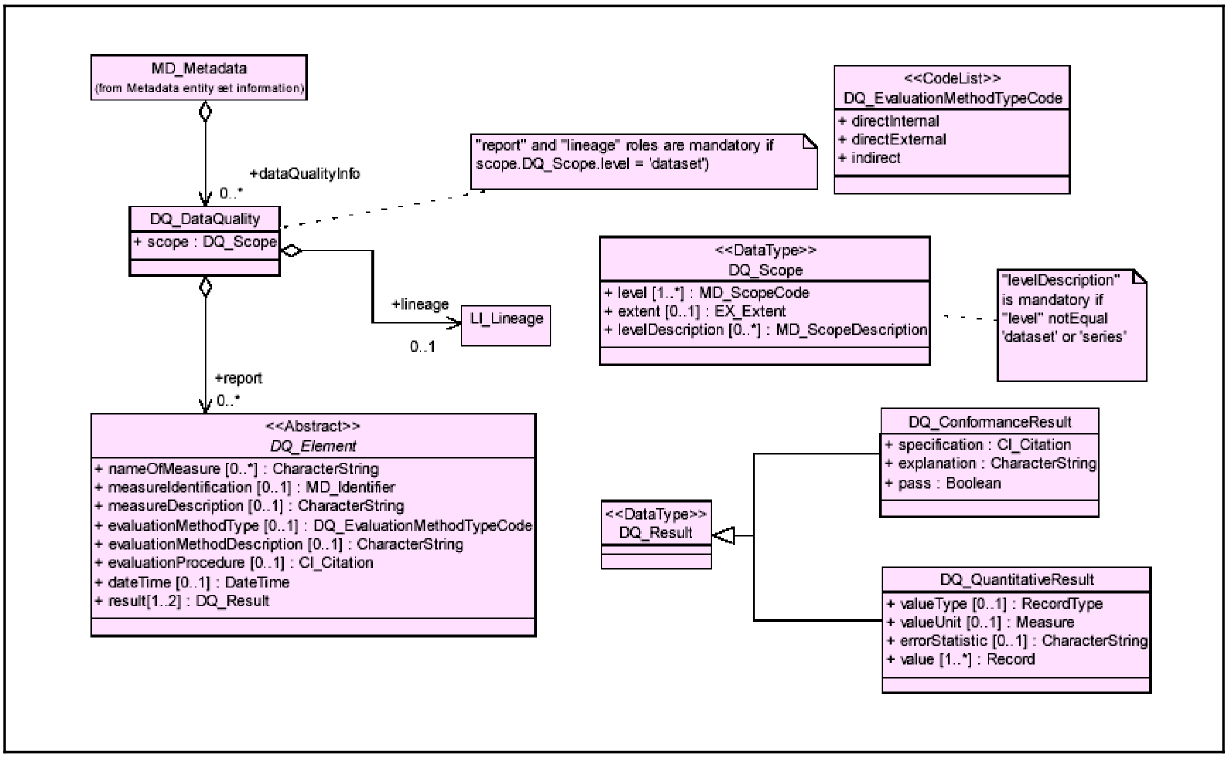


Figure 3.5.1: Conceptual model of metadata description on data quality

Appendix V contains topological rules, applicable to the GIS layers and some examples for reporting on data quality according to ISO 19115. The proposed elements of the DIS 19115 on metadata for reporting on data quality are described in the metadata part in Appendix V.

3.6 Reference System

The use of a common geodetic datum (horizontal and vertical) is a first step towards the harmonisation of geographic information across Europe. The adoption of a common reference system makes it possible to maintain seamless distributed geographic data, assigned to different custodians and avoiding or simplifying the work of geometric harmonisation. A common geodetic datum is particularly important for geographic information system users that require a "seamless" dataset. Furthermore, the fact that spatial data provided by Member States are often insufficiently documented (e.g., the used Datum is unknown or only partially or ambiguously described), is a source of errors when national data are converted to a European system. To avoid these problems, it will be the responsibility of Member States to provide data according to the proposed European datum.

ETRS89[2] is recognised by the scientific community as the most appropriate European geodetic datum to be adopted. It is defined to 1cm accuracy, and is consistent with the global ITRS[3]. ETRS89 is now available due to the creation of the EUREF[4] permanent GPS station network and the validated EUREF observations. It is already part of the legal framework of some EU Member States. Since 1989, ETRS89 co-ordinates, fixed in relation to the European

[2] ETRS : European Terrestrial Reference System
[3] ITRS : IERS Terrestrial Reference System (IERS : International Earth Rotation Service)
[4] EUREF : European Reference Frame

Plate, have regularly shifted from their values expressed in ITRS. However, this shift is well known, monitored by IERS[2] and EUREF, and transformations from one to the other are possible for most part within a 1 cm accuracy [1][2]. Appendix VI contains the full description of ETRS89 following the ISO19111 "Spatial Referencing by co-ordinates" standard [5].

The IAG[5] sub-commission for Europe (EUREF) has now defined a European vertical datum based on the EUVN[6] /UELN[7] initiative. The datum is named the EVRS[8] and is realised by the EVRF2000.

The National Mapping Agencies (NMA) or comparable Institutions / Organisations provided the information for the descriptions of the national Co-ordinate Reference Systems and for the transformation parameters between the national Co-ordinate Reference Systems and the European Co-ordinate Reference System ETRS89. Formulae can be requested from the NMAs or are directly accessible at http://crs.ifag.de/.

We give the following recommendations, partly described in the INSPIRE Architecture & Standards Final Position Paper [4]:

Geodetic framework

- *To adopt ETRS89 as geodetic datum and to express and store positions, as far as possible[9], in ellipsoidal co-ordinates, with the underlying GRS80 ellipsoid [ETRS89;.*
- *To use official formulae provided by NMAs or comparable National Institutions for the transformation between National Co-ordinate Reference systems and the ETRS89;*
- *To document National Co-ordinate Reference systems according to ISO19111;*
- *To further adopt EVRF2000 for expressing practical heights (gravity-related).*

Projection systems

There is a need for co-ordinate reference systems for pan-European applications for many statistical purposes (in which area should remain true) or for purposes such as topographic mapping (where angles or shapes should be maintained). These needs cannot be met through usage of the ETRS89 ellipsoidal co-ordinate reference system alone, and some map projections are required to supplement the ellipsoidal system (because the mapping of the ellipsoid cannot be achieved without distortion, and because it is impossible to satisfy the maintenance of area, direction and shape through a single projection).

[5] IAG : International Association of Geodesy
[6] EUVN : European Vertical Reference Network
[7] UELN : United European Levelling Network
[8] EVRS : European Vertical Reference System
[9] For some data (e.g., cadastral data), the adoption of geographical co-ordinates is not feasible in the short term and projected data should be accepted.

For applications we recommend the following projections [3]:

- for statistical analysis and display: a ETRS89 Lambert Azimuthal Equal Area co-ordinate reference system of 2001 [ETRS–LAEA], which is specified by ETRS89 as datum and the Lambert Azimuthal Equal Area map projection;
- for conformal pan-European mapping at scales smaller or equal to 1:500,000: ETRS89 Lambert Conic Conformal co-ordinate reference system of 2001 [ETRS–LCC], which is specified by ETRS89 as datum and the Lambert Conic Conformal (2SP) map projection;
- for conformal pan-European mapping at scales larger than 1:500.,000: ETRS89 Transverse Mercator co-ordinate reference systems [ETRS–TMzn], which are specified by ETRS89 as datum and the Transverse Mercator map projection.

Within the reporting activity of Water Framework Directive, the use of projected data could be necessary if some raster data (or maps) must be provided. In this case, and if a unique projection system is desirable, the use of ETRS–LCC seems the most appropriate.

3.7 Metadata

The aim of this Section is to clarify the position of the WFD GIS Working Group on geographic information metadata standards, and to provide practical technical guidance for the implementation of metadata.

Metadata is the information and documentation, which makes data understandable and shareable for users over time (ISO 11179, Annex B).

We can distinguish different types of metadata of increasing detail:

- Metadata for Inventory (i.e. internal to an organisation);
- Metadata for Discovery (i.e. necessary for external users to know who has which data, where to find them, and how to access them); and
- Metadata for Use (i.e. a fuller description of an information resource that enables users to make a judgement about the relevance and fitness-for-purpose of the resource before accessing it).

Appendix VII provides more information about standardisation activities in this field as well as more precise specifications for this standard.

Metadata standards are important as they unify the way in which data can be inventoried, discovered, and used. At the time of writing , no international standard on metadata is available. The resolution of the 14th plenary assembly of ISO TC 211 (Bangkok, 24-25 May 2002) has stated that the ISO standard No. 19115 Geographic Information – Metadata will be kept in the status FDIS[10] and the date of publishing of this standard was postponed to December 2002 [1].

[10] FDIS: Final Draft International Standard

However, taking into account the timeframe for the implementation of the Water Framework Directive, it seems reasonable to make the following proposal:

It is proposed to adopt the final draft international standard *ISO/FDIS 19115 Geographic Information - Metadata* and also to suggest some measures for the transition phase in order to minimise the impact on those countries using National or CEN pre-standards (TC 287 ENV 12 657).

It is recommended that in the mean time both the current draft of *ISO/TC211 19115 Geographic Information - Metadata*, and the suggestions of the Dublin Core (DC) metadata initiative for cross-IT searching are used.

Until the ISO 19115 standard is "officially" available and translated in all European languages, existing standards or pre-standards are acceptable. The countries deciding not to adopt ISO 19115 in the FDIS status should, however, adapt their metadata to ISO when the official standard is available. They should at least provide the mapping of the used standards to ISO 19115.

3.7.1 Scope of ISO 19115

The ISO 19115 defines the Scheme required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

This ISO 19115 is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

This ISO 19115 defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialised needs.

3.7.2 Core and Mandatory Elements of ISO 19115

The ISO 19115 consists of 22 core elements of which 12 are mandatory to comply with the international standard. The elements are described in Table 1 in Appendix VII. The mandatory elements focus on the discovery aspect of the metadata (catalogue purposes). Despite information on the metadata itself, they provide information on the title, the category, the reference date, the geographic location, and a short description of the data and the data provider.

The core set expands the mandatory elements with additional information on the type, the scale, the format, the reference system and the data lineage. These elements give rough information on the potential usage of the data.

For shared usage of the WFD spatial data, additional information on the data is necessary. The additional elements should include more detailed information, for example, on data quality or legal aspects of data usage.

3.7.3 Metadata Profile

The ISO 19115 for metadata comprises about 300 elements that exhaustively describe an information resource. Most of these elements are defined as being optional, i.e. they are not needed for compliance with the international standard but are defined for helping users to understand exactly the described data. Individual communities, nations, or organisations may develop a "community profile" of the standard according to their needs by selecting a set of metadata elements to be considered mandatory. A profile consists of the core metadata elements, and an additional set of optional elements that are then declared as a mandatory part of the profile. Additionally, a profile may add elements, i.e. extensions that are not part of the international standard.

The ISO 19115 describes rules for defining community profiles and extensions. A profile must not change names, the definition or data types of metadata elements. A profile must include all core metadata elements of a digital geographic data set, and all mandatory elements in mandatory and conditional sections, if the data set meets the condition required by the metadata element. Relationships between the elements have to be identified. Finally, the profile has to be made available to any user of the metadata.

A profile has to follow the rules for defining extensions. Metadata extensions are used to impose more stringent obligations on existing metadata elements. In addition, an extension can limit or extend the use of domain values for describing metadata elements.

The specific needs of reporting are not fully covered by the ISO 19115 mandatory elements neither by the core elements because they are not sufficient to describe data quality and legal aspects of data usage (see also Appendix VII).

There is agreement in the WFD GIS working group that the creation of a specific metadata profile for the Water Framework Directive is necessary.

The creation of a specific profile for the Water Framework Directive is highly recommended. The profile shall include the core elements and additional elements that are identified as necessary. The profile shall be mandatory for the data provided under the WFD reporting scheme.

The metadata profile to be developed:

- shall follow the rules laid down in ISO 19115 for creating metadata profiles;
- shall include a model for metadata;
- shall define common methods and formats for metadata exchange;
- shall be applicable to data sets and in addition to other appropriate levels of the data hierarchy;
- shall include the core elements and additional elements that are identified as necessary;
- shall include the data quality elements and the legal aspects elements described in Appendix VII;
- shall cover multilingual aspects.

Code lists shall be defined in all official languages of the European Union.

A thesaurus shall be generated to define the relationship between corresponding names in the different languages. Also text presentation should be possible in all European languages. As an alternative the adoption of a common language should be considered.

The metadata profile will be developed under the INSPIRE initiative. National WFD representatives should participate in the definition of the INSPIRE profile. This profile should be available by mid 2003 and should preferably be formally endorsed by CEN.

The metadata profile shall be reviewed in regular time intervals and if necessary adapted to new needs or developments in the GIS field.

In a later stage, the Member States shall also identify a competent authority for co-ordinating the national producers of data, for collecting and for managing the metadata. Metadata shall be kept up-to-date. Whenever data changes occur that might affect the current metadata content, the metadata have to be updated as well.

It is recommended that the metadata shall be implemented within a geographic data service (clearinghouse) on a wide area network and that Member States shall allow access to metadata via catalogues (INSPIRE will define the standard to be used for catalogue services). It is further recommended that a direct link between metadata and the described data should exist.

Acknowledgement

This Section and Appendix VII contain terms and definitions taken from ISO/DIS 19115, Geographic Information – Metadata [1]. They are reproduced with the permission of the International Organisation for Standardisation, ISO. This standard can be obtained from any ISO member and from the Web site of the ISO Central Secretariat at the following address: www.iso.org. Copyright remains with ISO.

Some of the ideas/proposals presented in this Section are drawn from documents produced by European projects like ETeMII [2] and Madame [3], from software manuals [4] and from the collaboration between JRC, Eurostat GISCO and the EEA.

3.8 Standards for Data Exchange and Access

The way data is collected and stored, its quality and coverage will vary from organisation to organisation. In order to reduce the likelihood of data being unusable by the Commission, common exchange formats need to be agreed. This also speeds up the quality assurance issue and makes the data readily available to other Member States. It is not sensible to nominate any one proprietary format as this may limit the software options of the Member States.

There is also the need to explore the options available to allow the enhancement of data delivery in the future. The priority however is the reporting needs in the short term. In this document short term refers to the delivery of data to the Commission in 2004. The longer-term goals are targeted at data delivery in 2009.

3.8.1 Short-Term Data Exchange and Minimum Long-Term Requirements

The **best practice** will be data exchange using Geography Markup Language (GML). GML is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. Many of the current commercial GIS packages offer the facility to import data in a GML format. The current versions of most GIS's do not offer the ability to directly export in GML. There are however, several data translators on the market which provide this functionality (an example is "Feature Manipulation Engine", more information at www.safe.com).

Using GML removes many of the problems caused by file conversion by some commercial and non-commercial GIS programmes. This also supports the long-term goal of using OpenGIS or other web based technologies for data transfer. The current version is GML Version 2.1.1. Later versions (as and when they become available) may be used. However the default will be 2.1.1. For further information see http://www.opengis.net/gml/02-009/GML2-11.html.

Conforming to the OGC Simple Features model, GML provides geometry elements corresponding to the following Geometry Classes:

- Point;
- LineString;
- LinearRing;
- Polygon;
- MultiPoint;
- MultiLineString;
- MultiPolygon;
- GeometryCollection.

In addition, it provides a Co-ordinates Element for encoding co-ordinates, and a Box Element for defining extents. The details of the encoding for each of these types of geometries can be found in Appendix VIII.

The **minimum** data exchange standard for vector data will be in a recognised open published standard file format. An example is the 'shape file' format (www.esri.com/library/whitepapers/pdfs/shapefile.pdf) that is compatible with the systems operated by the Commission or their nominated third parties. The exchange format will need to support points, lines and area features. Each feature must also have corresponding attribute data. This format will consist of at least the following:

- *Main file*: This is a direct access, variable-record-length file in which each record describes a shape with a list of its vertices;
- *Attribute file*: This contains feature attributes with one record per feature. The one-to-one relationship between geometry and attribute is based on record number. Attribute records in this file must be in the same order as the Main file. The attribute file is best supplied in a tabular format that can be read by most software packages including text processors. An example of an open standard format is Dbase IV.

The main file and the attribute file must have the same prefix. It is important in the shape file format that the first record in the main file contains the geometrical extent of the whole dataset.

The file must be able to handle integer (signed 32-bit integer (4 bytes)) and double-precision numbers (signed 64-bit IEEE double-precision floating point number (8 bytes)). The floating point numbers must be a numeric value.

The main file should contain a fixed-length file header (100 bytes) followed by variable-length records. Each variable-length record is composed of a fixed-length record header followed by variable-length record content.

The attribute file contains feature attributes. Fields present in the table should reflect the requirements of the data model. Another requirement is that the file name must have the same prefix as the main file. The table must contain one record per shape feature and the record order must be the same order as in the main file.

When non-geometric data are to be exchanged, the recommended standard is the ASCII COMMA DELIMITED format. In this format tabular data are written down per row. Fields are separated by comma (,) and strings are recognised by double quotes (""). Dates are reported in the YYYYMMDD format as a numeric value. The first row contains the fieldnames. The advantage of this format over a fixed position format is its flexibility. Also the use of reserved characters like 'TABs' or '@' tends to fail in user communities crossing various borders and languages.

3.8.2 Long-Term (Data Access)

The proposal for the long-term is to apply state of the art Geographic Information Technology focussing on accessing geographic data through custom internet browsers directly from the Member States.

Currently the technology is based on the Web Mapping (WM) standard for data transfer, focussing on maps as set by the International OpenGIS Consortium. Within the European Commission as well as some Member States this standard is currently successfully applied and appreciated for it simplicity and extendibility. However, the weakness of this system is the fact that it only delivers raster maps and is not feature oriented. There is also a need to ensure that the requirements of the INSPIRE initiative are considered, along with any developments in the technology providing this service.

Any web application requires at least two computer systems. The Client and the Server. The Server delivers data, the Client requests data. Typically a client needs a protocol to request a given selection of data which are available on the Server. In the WM standard, the clients primary interface will be the web browser. The request protocol is resolved in a so-called URL (Uniform Resource Locator). The latter can be specified in a manner as defined in the protocol.

The URL consists of two basic components:

- The URI or the Uniform Resource Identifier, which is commonly known as the web address. On this address (the Server) the software is running that can respond to the request. Example is http://www.opengis.org/cgi-bin/getmap?

- The request part in the WM standard consists of a group of parameters that is typically needed for mapping problems.

Using this standard, an interface be can set up that allows the user to map data from various sources in one interface. The server delivers an image containing the map. The client takes care of the ability to create a user-defined request.

Along with ?compliance to the standard, the following considerations are also important:

- A data source is identified by the URI part of the URL. All other components should be named equal;
- Important in this equality is especially the naming and corresponding standard symbology of the various layers;
- Note that one layer can have more 'styles';
- While mapping data for a giving bounding box with height and width, the client implicitly requests for data at a certain map scale. The symbology should account for this property. For example small rivers should not be displayed when viewing a map on 1:1000,000 scale. When zooming-in these small rivers should appear.;
- All data sources must be mutually consistent in geometric space. Thus a river mapping in Spain should not occur in a data source from France. Most polygon layers may not overlap in space and most line layers must connect both in horizontal space as well as in vertical space. For specific modelling issues it might be necessary that data is sent

from an upstream data source to a downstream data source in order to proceed with correct calculations of cumulated values;

- For ease of use all data will be served by default in geographic co-ordinates. Later versions might explore the various national or regional projection systems;
- In order to allow geometric overlap of various datasets, specific requirements might apply on the large-scale geometric quality of two bordering data sources.

The use of Web Mapping for the delivery of data to the Commission and beyond is hoped to become best practice. It is understood that there may be some technical or political difficulties, which may make this impossible for some Member States. In this case the minimum standard of data exchange to the commission will be GML as described above.

3.8.3 File Naming Conventions.

These are discussed in detail in the introductory Section of the data dictionary (Appendix III). File naming conventions facilitate the creation of automatic procedures to generate and upload datasets. Therefore, they are an asset in themselves.

File naming conventions are important in the short-term solution. They could become trivial in the long term, when the Member States provide an access service for the Commission to their map data instead of sending files out every six years.

4 Harmonisation, Co-ordination and Organisational Issues

This Section highlights some issues on the harmonisation and co-ordination necessary in order to arrive at a seamless product for Europe. It is not possible at this stage to specify the precise steps required for a full harmonisation, both because a preliminary evaluation is required for each layer and then because the process of harmonisation hugely depends on existing data, databases and information services. The precise knowledge of the state of the play is a prerequisite for a cost/benefit analysis as well as a more precise definition of all user requirements.

We propose to adopt the pragmatic approach foreseen in INSPIRE. The long-term vision of INSPIRE is to guarantee the access to information collected and disseminated at the most appropriate level (local, regional, national and European).

However, for the successful implementation of INSPIRE a stepwise approach is proposed. The various steps could partly be carried out in parallel, depending on the WFD user needs and the degree of availability and harmonisation of existing information. All these steps involve actions of standardisation, harmonisation and integration of data and services as illustrated in Figure 4.0.1.

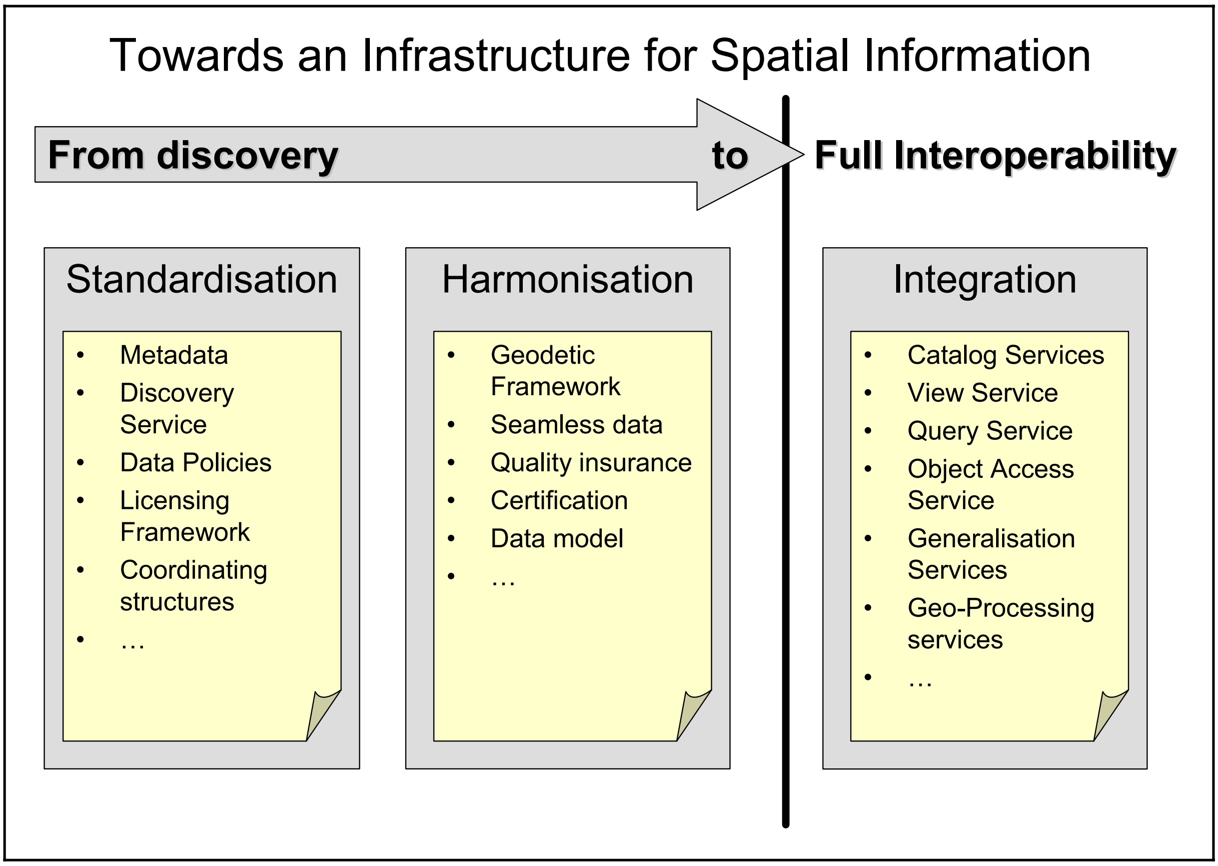


Figure 4.0.1: Towards an Infrastructure for Spatial Information

4.1 Harmonisation

The term harmonisation is used in this Section as the set of measures to be taken in order to develop a European product of comparable quality, starting from information (and services) available in the countries concerned by the WFD.

In this context we make distinction between 3 different European products:

- European seamless data;
- European database (centralised system);
- European federation of spatial data servers (de-centralised system).

The federation of servers is the final goal to be achieved in the long-term. The related harmonisation aspects will be developed under INSPIRE and should be adopted for the second reporting. These will, therefore, not be discussed here.

4.1.1 Geometric Harmonisation of Data

The need to harmonise the geometry is strictly related to the topological consistency within and between different features classes (data quality issues). This means that rivers crossing several countries should be connected and coherent in geometry and that features represented by polygons should not overlap (e.g. river basins, sub- basins and surface water bodies).

Figure 4.1.1 illustrates problems of possible overlapping or void areas in case of non-harmonised river basin district boundaries.

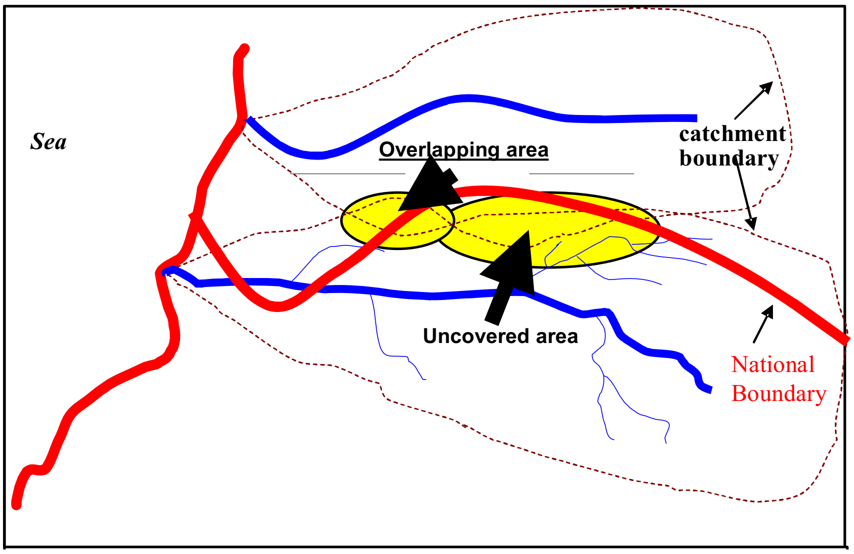


Figure 4.1.1: Possible problems due to the lack of a harmonised geometry

Geometric harmonisation is not a trivial task. We should profit from existing experiences such as SABE [1] (Seamless Administrative Boundaries of Europe) and ABDS [2] (Administrative Boundary Data Services) that show the difficulties to develop a full European operational seamless data set or service.

To obtain a common geometry, the adoption of common standards (e.g., same geodetic reference system, same positional accuracy) is not enough. Two countries should discuss and agree on the geometry to be used in the cross-boarder areas. Under the WFD, this is already foreseen as an obligation for International River Basin Districts.

To prepare a fully connected network we strongly recommend:

- The connection at the borders should be under responsibility of the Member States;
- The tolerance for connection at borders and the related accuracy should be better or equal to 1/10 of the accuracy of the dataset;
- The cartographic generalisation of data should be done at the level of the Member States;
- The use of common political boundaries (e.g., SABE) as well as of a European common layer for a coastline is strongly recommended in order to support the geometric harmonisation in the border areas.

After an evaluation of the two following options for data harmonisation:

1. Agreement on a common geometry at the beginning of the implementation phase; or
2. Harmonisation of the data at each reporting phase,

the GIS Working Group agreed to recommend option no. 1.

The adoption of the option "Agreement on a common geometry at the beginning of the implementation phase" is recommended because:

- it makes it possible to adopt a de-centralised solution in the future (in fact harmonisation is a prerequisite to do it);
- it makes it possible to have a full coherent picture of the European status (same data at European and National level); and
- in the long-term it is saving costs (the initial investment to agree on a common geometry will be recovered by the lower costs of updating and maintenance).

The main disadvantage is the initial effort to co-ordinate the harmonisation process. The following steps are necessary:

1. to agree on common data quality for reporting;
2. to discuss and harmonise the boundaries of trans-national river basin districts, including the connection of the river network;
3. to use/adopt the harmonised boundaries for national purposes;
4. to maintain the agreed boundaries as long as possible;
5. to re-start the process of harmonisation in case of changes;
6. to check that the agreed boundaries are used/maintained.

This level of harmonisation will be under the responsibility of National authorities that should apply, as far as possible, available ISO 19100 [3] series of standards for geographic information. It should be highlighted that all technical and harmonisation proposals strongly support the future implementation of a de-centralised reporting system.

In case of changes between two reporting periods, a harmonised geometry should be guaranteed at each reporting date.

4.1.2 Harmonised European database

The layers provided by the countries under the Water Framework Directive should be initially integrated in a European database (centralised system). This raises the issue whether or not to perform the vertical integration between layers (i.e. the logical and topological consistency between different features classes that refer to each other).

For the purpose of reporting, the vertical integration is not strictly required but for further analysis of the data it is a prerequisite.

The vertical integration requires these preliminary steps:

1. to adopt a common European geodetic framework (ETRS89);
2. to harmonise the geometry of different layers (harmonisation and eventually generalisation is under responsibility of Member States);
3. to connect the layers along the borders (under responsibility of Member States);
4. to adopt/support a European data model;[11]
5. to verify the topological consistency of different layers according to predefined geometric relationships.

It is recommended to use seamless harmonised reference data[12] in order to facilitate the vertical integration. The availability of such data is addressed and specifically perceived as a priority under INSPIRE (when the European Spatial Data Infrastructure will be in place, reference data will be easily available to support the "full" process of vertical integration). Until this happens other European reference data (such as EuroGlobalMap (1:1,000,000), EuroRegioMap (1:250,000) if available, or IMAGE2000) could be used as European reference for the thematic information and to support the vertical integration.

It is recommended to start the process of vertical integration limited to the layers relevant for the Water Framework Directive (excluding background layers). At the same time it is recommended to INSPIRE to consider the background layers of the Water Framework Directive as a priority for the short-term implementation.

4.2 Co-ordination

Co-ordination is a key issue for the implementation of the Water Framework Directive. The responsibilities and tasks of the Co-ordination Body or Task Force will be different in the various phases of the implementation.

It is recommended to establish a close co-operation within international River Basin Districts. This is necessary for a successful implementation.

[11] *Adoption means to use the same data model at National and European level, support means to guarantee the semantic interoperability between the National and the common European data model*

[12] According to the definition of the ETEMII white paper *"reference data is a series of dataset that everyone involved with geographic information uses to reference his/her own data as part of their work"*

4.2.1 1st Phase of Co-ordination (before the end of 2004)

In the first phase, co-ordination will be required to develop more precise specifications in collaboration with INSPIRE and to co-ordinate the harmonisation process.

It is recommended to set-up an office in charge to investigate user requirements and to support the implementation and maintenance of a de-centralised reporting system.

It is also recommended to install a thematic WG on water linked to INSPIRE that should:

1. follow-up INSPIRE developments;
2. contribute to the development of a dedicated metadata profile;
3. ensure a liaison with Framework Directive on Reporting;

5. follow-up of emerging standards for data exchange/access;
6. prepare guidelines for data product specifications;
7. ensure link to the case studies in the Pilot River Basins and integrate feedback into the Guidance Document;
8. prepare for the implementation of a European hydrological coding system, including a link to marine waters through a dedicated sub-group studying the issue;
9. investigate problems related to the analysis of underlying data and/or problems related to the analysis of pressures and impacts (subject to a request of the SCG).

Points 1-7 are related to reporting,
Points 8-9 are related to the access to underlying data and to the analysis of pressures and impacts.

Centralised system

The centralised system can be described as the European repository containing all data and some functionalities to access the information. It could be seen as the system in which the received data should first be harmonised and verified in order to correspond to the pre-defined requirements in terms of consistency (see chapter on data validation procedures).

The tasks for the Custodian of the centralised system will be the following:

1. Design and implement the centralised GIS;
2. Upgrade the centralised GIS to take into account new user requirements (e.g., resulting from the Pilot River Basin testing);
3. Data loading;
4. System maintenance;
5. Data dissemination.

Tasks 1 and 2 are mainly related to the initial stage.
Tasks 3, 4 and 5 are permanent work (heavier at each reporting phase).
Tasks 3 and 5 could be partly or completely automated, if necessary.

It is recommended to set-up an office for receiving, handling and validating data in the short-term (Custodian).

The custodian of the European database should be defined at an early stage in order to start with the system design and in order to define the procedures for data uploading and data access and dissemination.

It is also recommended to enforce the links with other WFD CIS working groups in order to consider the whole set of user requirements in the phase of system design.

4.2.2 2nd Phase of Co-ordination (2005 – 2006)

In parallel with phase 1, several steps should start in order to develop a more comprehensive and de-centralised system in the future. These steps should be co-ordinated and must involve the participation of all countries involved in order to support the implementation of the agreed European data model and to select and test the architecture of the Federation of Spatial Data Servers.

De-centralised system

While the co-ordination for a centralised system mainly implies the work of collection, harmonisation and dissemination of the data coming from Member States, a shared de-centralised architecture requires a strong co-ordination. This includes the checking of the compliance of connected systems with the technical specifications and their availability in operational mode.

The adoption of a de-centralised system implies different rules and responsibilities to guarantee the security and confidentiality of the data.

A de-centralised system in which the data (located on national servers) are directly made available by Member States, which should commit themselves to operationally run the services, is the preferred option in the long-term and is in line with INSPIRE principles.

It is recommended to adopt INSPIRE specifications for the national systems to be connected.

It is recommended to extend the mandate of the co-ordination Office or of the Custodian or to identify a new Agency to cover the additional tasks of the technical co-ordination. The tasks of this co-ordination body will include the checking of the compliance of connected systems with the technical specifications and their availability in operational mode.

5 Practical Experiences from the Prototype Exercise

This Section reports on different tests made in the frame of a prototyping exercise.

5.1 Introduction

The Water Framework Directive concerns a significant group of people involved in preparing maps and digital data to be reported to the European Commission as well as a currently less well defined user community involved in the analysis of these datasets. Both groups are hybrid in their knowledge and feeling at ease with computer technology.

Since both data preparation and analysis require advanced skills of computer technology, the GIS-WG tested some of the aspects discussed in this document in order to get deeper insight into the opportunities and problems to be expected during actual data preparation and analysis.

The prototyping effort has addressed the following topics:

1. Testing the emerging data exchange standards of ISO and OPENGIS;
2. Testing of parts of the common data model;
3. Testing the feasibility of the proposed coding mechanisms.

5.2 Emerging Data Exchange Standards of ISO and OPENGIS

During the GIS-WG meeting in March 2002 the so-called OPENGIS web mapping testbed facility was demonstrated to the GIS-WG. This technique allows generating maps on a remote server that can be visualised in common web-browsers. As a follow-up of this meeting, visual data integration was successfully demonstrated through a collaboration of JRC and Portugal. In this particular case study, a map of Portuguese river data (generated at the Portuguese web server) was overlaid with commune boundaries generated on a web server of the Commission. The example shown in Figure 5.2.1 refers to the Lisbon Area (data were projected using a Cylindrical Projection).

Following this demonstration, the members of the working group agreed that the evolving OPENGIS technology could be seen as a future aim. For the first WFD reporting period, most Member States felt, however, more at ease by sending GIS-layers or maps. Within the user communities of most Member States, the set-up of up-to-date web (map) server technology was not seen as a requirement of the Directive.

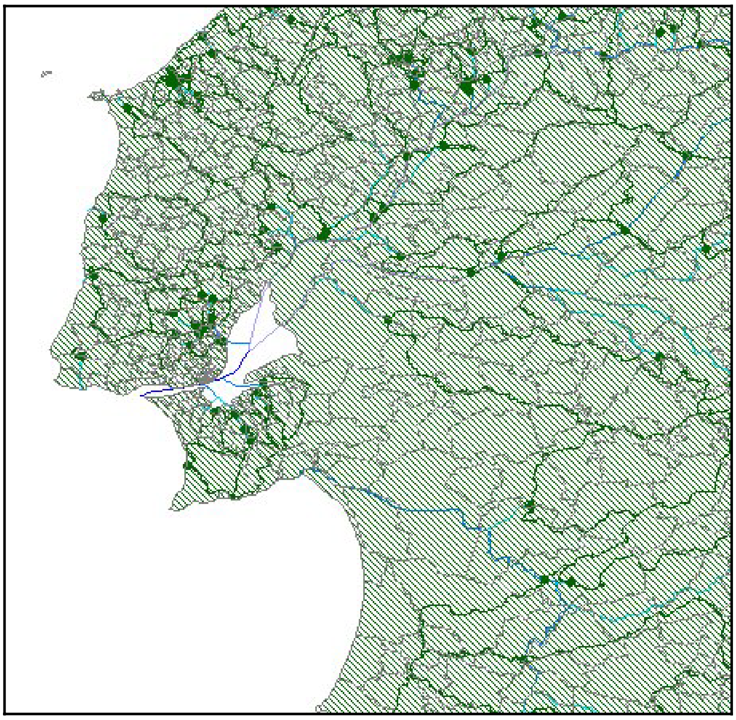


Figure 5.2.1: OpenGIS Web mapping example.

5.3 Testing of Parts of the Common Data Model

In the early discussions of the GIS Working Group, digital maps were seen as the most urgent deliverable. However, in the course of the discussions it became evident that in view of future developments more advanced solutions should be searched for.

Even though the reporting of digital maps has several advantages with respect to the delivery of analogue maps, it still prohibits the automatic analysis of the information provided. To support the latter, a common data model is needed, and the reported data need to be formatted accordingly. Such a data model is proposed in this document. Within the prototype activity, the working group defined an example web page with part of the physical model to be filled in by Member States (see Figure 5.3.1). Such web pages could help the organisations charged with sending in datasets.

By providing empty shapefiles, or ASCII delimited text files with examples, end users can be supported in setting-up the technical part of the dataset preparation. A robust finalisation of such a physical data model, in close conjunction with at least 3 pilot Member States and the presumed data custodian is an obvious recommendation that can be distilled from this activity.

Definition : Area covered by the *competent* authority, the member state part of a river basin district.
Delivered : Once by Reporter except for errors or significant change.
Implementation example : authorities.shp
Entity use in layer preparation : D7, SW1, SW3, SW4
Annex reference : I

Field name	Definition	Field type	Field length	Restrictions
MS_CD	Member state code, code allowing to refer to databases in use in the reporting organization, concatenated with the member state ISO code.	String	6	Mandatory, Primary
NAME	Locally used name, spelled in allowable characters Annex I.i	String	100	Mandatory, Unique
ADDRESS	Address for correspondence Annex I.i	String	200	Mandatory
POLYGONS	Geometric description of the district(s) managed by the competent authority, Annex I.ii	Geometry	resolution 250 meter	Mandatory, not outside territory of member state, exclusive, matching geometrically with the river basins
EU_CD	Code to be given by the data receiving organization	String	5	Feedback in 2005
INS_WHEN	Moment of insertion in the database	Date	8	Mandatory, YYYYMMDD
INS_BY	Acronym of operator responsible of insertion	String	15	Mandatory

Figure 5.3.1: Part of the example web page.

The set-up of a comprehensive inventory of the existing datasets in the Member States is a further recommendation resulting from this exercise. By giving precise guidelines on how to reformat existing datasets, Member States could be supported during data preparation.

The first data reporting will be based on so-called shapefiles and ASCII comma delimited text files. Depending on the evolution of recently introduced standards, one might expect that before 2009, when the larger parts of datasets are to be reported, most standards now mentioned have emerged to best practice.

5.4 Testing the Pfafstetter Coding Mechanism

As a perfection of the data model, it was proposed to develop a robust coding mechanism for the main entities to be reported under the WFD. The analysis of entities like river segments, lakes or catchments could benefit from a coherent coding, valid throughout the continent and its surrounding isles.

The so-called Pfafstetter coding was proposed as a means to obtain a unique numeric code at the level of each entity (e.g., river segment). The advantage of this coding is that it can be derived automatically from a consistent river network. Consequently, a user reading the Pfafstetter code of any segment can immediately understand the position of this segment in relation to other segments of the river network. Pfafstetter codes are based both on the area drained by a segment, and on the position of the segment within the network.

In the frame of the prototyping activity, an algorithm to generate this coding was developed, using the AML language. The algorithm proved that automatic generation is feasible even at detailed level. However, the river network has to be of high internal quality, especially with respect to the so-called topological relations between the segments. In addition for every river segment the area being drained is required before a Pfafstetter code can be determined. The algorithm consists of about 10 pages of AML code.

Next to coding the river segments it became evident that also the landmasses or seas are to be coded in a logical manner, in order to provide a unique code for each river segment. During the working group meeting of October 2002 a landmass coding was demonstrated as an example (see Figure 5.4.1). Note that in this example small islands within 3 km from a landmass have been coded with the same number as the adjacent landmass. It became, however, clear that a consistent sea-coding would be required, in-line with the WFD needs. The recommendation that evolved from this activity is that it is necessary to delineate sea areas in line with established international conventions, and to promote the sea code at the coastal outlet as an identifier to the upstream river network.

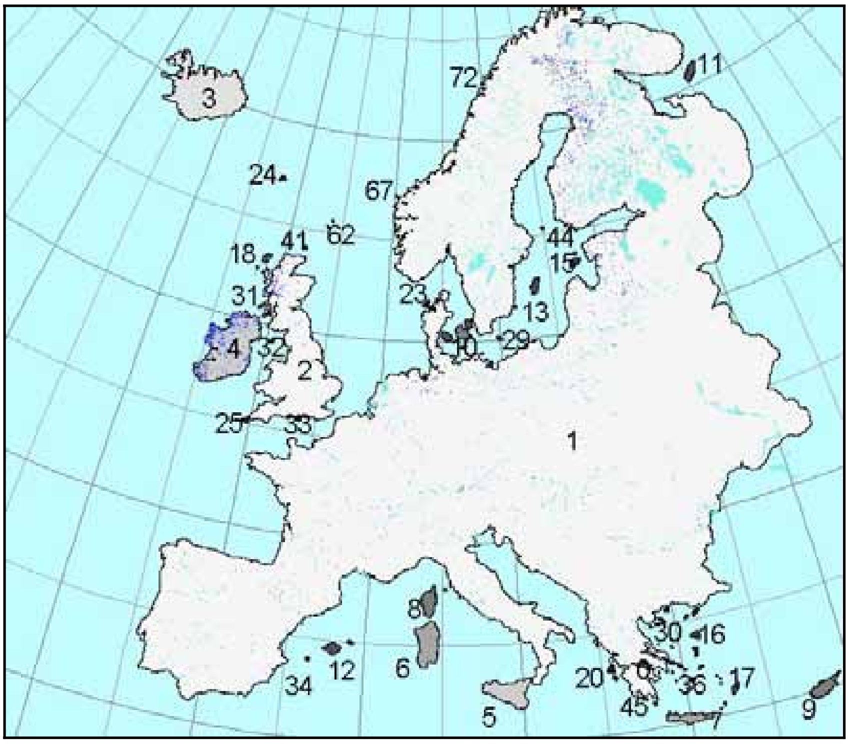


Figure 5.4.1: Example of Landmass coding based on surface area.

Figure 5.4.2 shows an example of the Pfafstetter coding for the river Thames in SE England. The outlet of the Thames in the Centre East of the map is coded '1', while the source in the North West is coded '99'. In line with the landmass coding, the full unique code of the source of the Thames would be 2299. The first '2' standing for the second largest landmass in Europe. The second '2' signifying the southern-most of the 4 largest watersheds on that landmass. The fourth '9' means that the source segment is subdivided one time. If we substitute the landmass code for a sea code, the first '2' in the Pfafstetter code needs to be exchanged for the code of south-western North Sea, for example. Assuming that this sea code would be '42', the full code would become 42299.

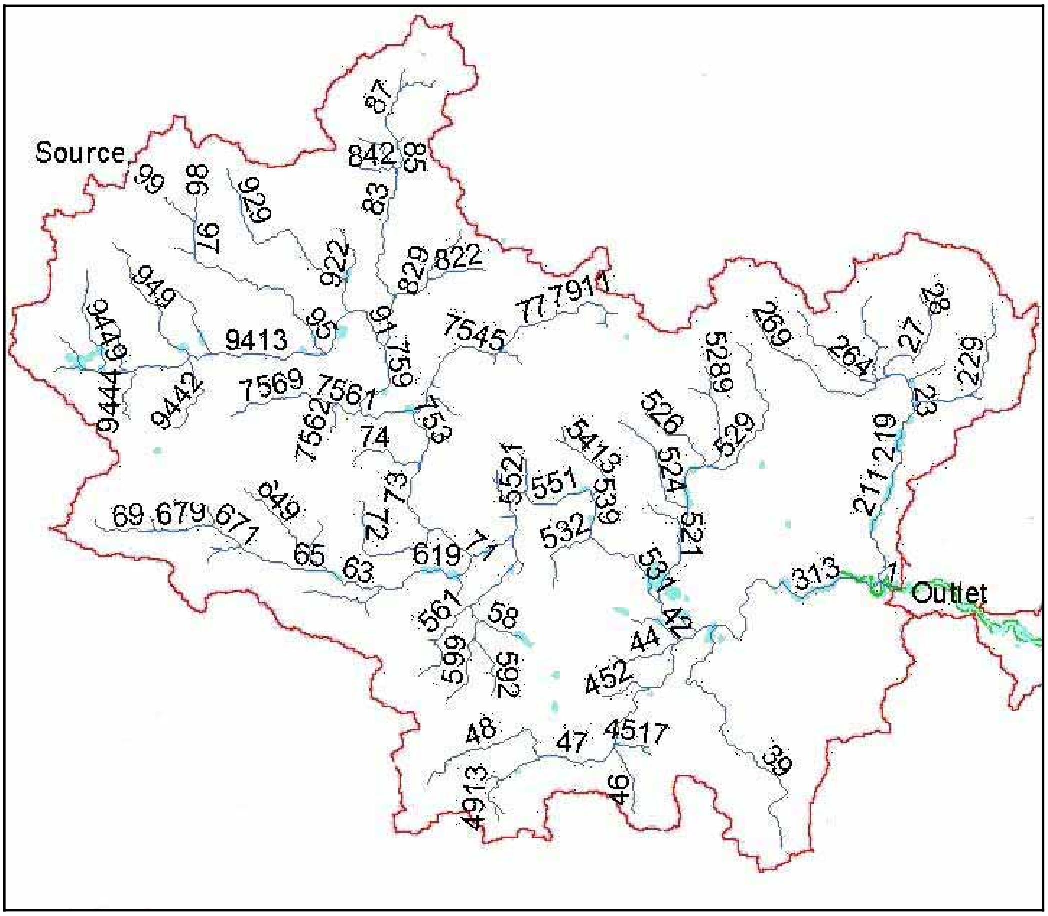


Figure 5.4.2: Example of the Pfafstetter coding of the river Thames and its tributaries.

Besides the Pfafstetter coding, other coding mechanisms are also documented in the literature. During the WG meetings, the Horton/Strahler system has been mentioned as being a valid alternative to the Pfafstetter coding, for example.

Most coding mechanisms assume flowing water along channels from the source to the sea. As a consequence, lakes, groundwater and coastal waters are not well or not at all represented. It became evident that a comprehensive coding of all water bodies covered by the WFD will require some further study, before a definite recommendation can be given.

It should be noted that any code must be regarded as a mechanism to ease analysis and to enhance communication between people about river segments. Computer systems, to the contrary, will always prefer system-generated identifiers that are in most cases logically meaningless and non-transparent to an end-user.

The JRC is about to finalise a new pan-European dataset of river segments, lakes, and catchments, automatically derived from a digital elevation model and ancillary data. This dataset, at a nominal scale of about 1:500,000, will include Pfafstetter codes and will be included in the Eurostat GISCO database. While it is not expected that this dataset can fully fulfil WFD needs, it will be a useful example for a possible implementation and an additional test. It might also help to fill important holes in the WFD generated datasets, such as the area of Switzerland.

5.5 Recommendations Resulting from the Prototype Activity

In the work of the GIS WG, the prototyping activity proved to be an important support to the theoretical discussions. Practical issues concerning data modelling, river coding and standardisation were put to the test, thus contributing to more realistic final recommendations. In a group representing more than 20 countries, cultures and manners, to organise water management, practical examples proved to stimulate discussions and to create a common awareness of the options that are available to everyone.

The coding algorithm, the example web pages for the custodian, and the practical experiences with OPENGIS map serving standards can form a starting point for an organisation yet to be defined. The set up of such an organisation will be a complicated task, not to be underestimated.

The most pertinent recommendations resulting from the activity are the following:

1. To test the proposed data model in collaboration with several Member States as well as with the data custodian;
2. To set-up a comprehensive inventory of the existing datasets currently available in the Member States;
3. To delineate sea areas in line with established international conventions and to agree on international codes for these areas.

6 Conclusions and Recommendations

The Water Framework Directive provides a legal framework for a wide range of actions, aiming to achieve good status for all waters in the European Union by 2015. Many of these actions require the handling of spatially distributed data and as such can potentially benefit from the use of Geographical Information System (GIS) technologies. In addition, the Directive explicitly calls for the reporting of most of the (spatial) information in a GIS compatible format.

Out of the range of possible GIS applications, this Guidance Document gives emphasis to the immediate reporting needs of the Water Framework Directive. As a consequence, it calls attention to the GIS layers to be prepared under the Directive and defines their characteristics (contents, spatial accuracy, time of reporting, etc.). It also underlines short-term and long-term possibilities for data exchange (i.e. centralised vs. de-centralised system), specifies how the GIS layers should be documented (i.e. metadata) and what should be done for harmonising the data across Europe. While the immediate needs of the Water Framework Directive require the set-up of a centralised system for reporting, it is noted that various initiatives at the European level, including the EAF on Reporting, strongly support the future implementation of a de-centralised system. The GIS Working Group, therefore, underlines the preference for the set-up of a de-centralised WFD reporting system in the long-term.

With respect to the level of detail of the data to be reported, the GIS Working Group strongly recommends an input scale of 1:250,000 as the common goal in the long term. However, current limitations in data availability and access require that data with an input scale of 1:1,000,000 can be used in the short-term, if they are complemented with additional objects in such a way that they meet the reporting requirements of the WFD. More detailed specifications with respect to the reporting requirements in terms of summary reporting to the Commission (small scale) and in terms of what Member States should have available upon request (large scale) will be further elaborated in the EAF on Reporting.

In addition, a European feature coding system for water bodies and catchments is proposed. The implementation of this feature coding system will be an important asset in the long-term, since it will allow for a more targeted analysis of the monitoring data and, in turn, will enable the development of a GIS with true analytical capabilities. In fact, feature coding is considered most important since it provides the link between reporting and analysis.

Due to limitations in time and due to the fact that some relevant information is not yet available for all elements of the Directive, other GIS-related aspects of the implementation could not be covered. These aspects include:

(i) the use of GIS in the analysis of pressures and impacts; or
(ii) the potential of GIS in supporting the establishment of River Basin Management Plans (e.g. the modelling of scenarios, the publication of spatial information).

It is further important to realise that also different aspects related to the reporting could not yet be definitely resolved. An example is the development of a specific metadata profile for

GIS layers emerging under the WFD. This is due to the fact that a number of international standards, which should be respected, are still under development.

The GIS-WG also decided not to include specifications on the map making process per se. This concerns not only cartographic details such as the layout, the colour codes, or the font types, but also issues of generalisation according to the map scale. We believe that the cartographic generalisation should be done at the Member State level and that the map production is best done at the level of the individual RBD authority, which will produce specific maps according to the RBD needs. At the European level, maps can be generated from the GIS layers according to the needs of the Commission. We would still recommend the set-up of a platform for exchanging experiences between the Member States and for publishing tools and colour specifications as a support to the map making process at all scales.

In addition, information technology develops at a very fast pace. As a consequence the long-term options could only be roughly outlined. As time progresses these options (e.g. the set-up of a distributed system for data reporting) will have to be further specified in accordance with evolving technical capabilities and standards.

The full implementation of an electronic reporting system will require a clear organisational structure, including the installation of a co-ordination body, capable to formulate clear requirements, to solve problems arising from the variable organisation of water management bodies in Europe, and to respond to technical questions arising from the implementation.

Finally, it should be noted that the specifications given here should be seen in the larger context of both the INSPIRE (Infrastructure for Spatial Information in Europe) initiative and the emerging Framework Directive on Reporting. The developments under these initiatives should be followed closely.

The successful implementation of the Water Framework Directive will require a close collaboration within international river basin districts. In order to ensure a harmonised data set, the GIS-WG strongly recommends using a common layer of national boundaries as well as one coastline. Also the adherence to the proposed data model is seen as an important asset in this direction.

Based on the experiences gained during the lifetime of the GIS-WG, the working group has formulated the following recommendations for the future implementation of GIS aspects under the Common Implementation Strategy:

1. It is recommended to rapidly install the office in charge of short-term receiving, handling and validating the maps and GIS layers requested under the reporting scheme of the WFD (Data Custodian). This body will be able to further co-ordinate the preparation of the requested data.

2. It is recommended to install an office in charge of investigating the user requirements and of supporting the long-term implementation and maintenance of a de-centralised reporting system. This office should enable the further development of the data model and of a European GIS for reporting.

3. It is recommended that a dedicated Thematic Working Group be installed under or linked to the INSPIRE initiative. This working group should:

   (a) follow the developments in the horizontal working groups under INSPIRE and should translate them into further guidance for the implementation of the WFD;

   (b) ensure a close liaison with the upcoming Framework Directive on Reporting;

   (c) contribute to the development of a dedicated metadata profile;

   (d) propose details for the data harmonisation process;

   (e) follow emerging standards for data exchange and access;

   (f) ensure a link to the Pilot River Basins and integrate the feedback from these case studies into the Guidance Document;

   (g) prepare for the long-term implementation of a European hydrological coding system, including a link to marine waters. This could be done through a dedicated small sub-group, studying the issue;

   (h) investigate problems related to the analysis of impacts and pressures and the analysis of underlying data, if so requested by the Strategic Co-ordination Group.

It is the hope of the members of the GIS-WG that the presented specifications will be a valuable support to the practitioners in the Member States, which are responsible for the preparation of the GIS layers and maps required under the WFD reporting scheme. In this sense, the presented Guidance Document could serve as a basis for the development of national Guidance Documents, taking into account the specific needs and circumstances of each Member State.

7 Appendices

Appendix I:The Elements of the WFD Relevant to GIS (original WFD text)

This appendix lists those parts of the Directive which directly or indirectly refer to the reporting of maps or data in a GIS compatible format. The excerpts from articles 3, 5, 13 and 20 as given at the beginning and shown in italics, are given for completeness. They do not directly refer to maps or GIS, but form the basis for the more detailed specifications in the appendices to follow.

Article 3: Co-ordination of administrative arrangements within river basin districts

1. Member States shall identify the individual river basins within their national territory and, for the purpose of this Directive, shall assign them to individual river basin districts. [...] Where groundwaters do not fully follow a particular river basin, they shall be identified and assigned to the nearest or most appropriate river basin district. Coastal waters shall be identified and assigned to the nearest or most appropriate river basin district or districts.

Article 5: Characteristics of the river basin district, review of the environmental impact of human activity and economic analysis of water use

1. Each Member State shall ensure that for each river basin district or the portion of an international river basin district falling in its territory:

- *an analysis of its characteristics,*
- *a review of the impact of human activity on the status of surface waters and on groundwater, and*
- *an economic analysis of water use*

is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.

[...]

Article 13: River basin management plans

[...]

4. The river basin management plan shall include the information detailed in Annex VII.

[...]

Article 20: Technical adaptations to the Directive

1. Annexes I, III and Section 1.3.6 of Annex V may be adapted to scientific and technical progress in accordance with the procedures laid down in Article 21, [...]. Where necessary, the Commission may adopt guidelines on the implementation of Annexes II and V in accordance with the procedures laid down in Article 21.

2. For the purpose of transmission and processing of data, including statistical and cartographic data, technical formats for the purpose of paragraph 1 may be adopted in accordance with the procedures laid down in Article 21.

Annex I: Information required for the list of competent authorities

As required under article 3(8), the Member States shall provide the following information on all competent authorities within each of its river basin districts as well as the portion of any international river basin district lying within their territory.

[…]

(ii) Geographical coverage of the river basin district - the names of the main rivers within the river basin district together with a precise description of the boundaries of the river basin district. This information should as far as possible be available for introduction into a geographic information system (GIS) and/or the geographic information system of the Commission (GISCO).

Annex II

1.1 Characterisation of surface water body types

Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies in accordance with the following methodology. Member States may group surface water bodies together for the purposes of this initial characterisation.

[…]

(vi) Member States shall submit to the Commission a map or maps (in a GIS format) of the geographical location of the types consistent with the degree of differentiation required under system A.

Annex IV: Protected Areas

2. The summary of the register required as part of the river basin management plan shall include maps indicating the location of each protected area and a description of the Community, national or local legislation under which they have been designated.

Annex V:

1. Surface Water Status

[…]

1.3. Monitoring of ecological status and chemical status for surface waters

The surface water monitoring network shall be established in accordance with the requirements of Article 8. The monitoring network shall be designed so as to provide a coherent and comprehensive overview of ecological and chemical status within each river basin and shall permit classification of water bodies into five classes consistent with the normative definitions in Section 1.2. Member States shall provide a map or maps showing the surface water monitoring network in the river basin management plan.

1.4. Classification and presentation of ecological status

[…]

1.4.2. Presentation of monitoring results and classification of ecological status and ecological potential

(i) For surface water bodies […] Member States shall provide a map for each river basin district illustrating the classification of the ecological status for each body of water, colour coded in accordance with the second column of the table set out below to reflect the ecological status classification of the body of water […]

Ecological status classification	Colour Code
High	Blue
Good	Green
Moderate	Yellow
Poor	Orange
Bad	Red

(ii) For heavily modified and artificial water bodies […] Member States shall provide a map for each river basin district illustrating the classification of the ecological potential for each body of water, colour-coded, in respect of artificial water bodies in accordance with the second column of the table set out below, and in respect of heavily modified water bodies in accordance with the third column of that table […]

Ecological potential classification	Colour code	
	Artificial WBs	Heavily Modified WBs
Good	Equal green and light grey stripes	Equal green and dark grey stripes
Moderate	Equal yellow and light grey stripes	Equal yellow and dark grey stripes
Poor	Equal orange and light grey stripes	Equal orange and dark grey stripes
Bad	Equal red and light grey stripes	Equal red and dark grey stripes

(iii) Member States shall also indicate, by a black dot on the map, those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants (in accordance with the compliance regime established by the Member State).

1.4.3. Presentation of monitoring results and classification of chemical status

[…]

Member States shall provide a map for each river basin district illustrating chemical status for each body of water, colour coded in accordance with the second column of the table set out below to reflect the chemical status classification of the body of water:

Chemical status classification	Colour code
Good	Blue
Failing to achieve good	Red

2. Groundwater

[…]

2.2.1. Groundwater level monitoring network

[…] Member States shall provide a map or maps showing the groundwater monitoring network in the river basin management plan […]

2.2.4. Interpretation and presentation of groundwater quantitative status

Member States shall provide a map of the resulting assessment of groundwater quantitative status, colour-coded in accordance with the following regime:

Good: green

Poor: red

2.4.5. Interpretation and presentation of groundwater chemical status

[…]

Subject to point 2.5, Member States shall provide a map of groundwater chemical status, colour-coded as indicated below:

Good: green

Poor: red

Member States shall also indicate by a black dot on the map, those groundwater bodies which are subject to a significant and sustained upward trend in the concentrations of any pollutant resulting from the impact of human activity. Reversal of a trend shall be indicated by a blue dot on the map.
These maps shall be included in the river basin management plan.

2.5 Presentation of Groundwater Status

Member States shall provide in the river basin management plan a map showing for each groundwater body or groups of groundwater bodies both the quantitative status and the chemical status of that body or group of bodies, colour-coded in accordance with the requirements of points 2.2.4 and 2.4.5. Member States may choose not to provide separate maps under points 2.2.4 and 2.4.5 but shall in that case also provide an indication in accordance with the requirements of point 2.4.5 on the map required under this point, of those bodies which are subject to a significant and sustained upward trend in the concentration of any pollutant or any reversal in such a trend.

Annex VII: River Basin Management Plans

A. River basin management plans shall cover the following elements:

1. a general description of the characteristics of the river basin district required under Article 5 and Annex II. This shall include:

1.1. for surface waters:
- mapping of the location and boundaries of water bodies,
- mapping of the ecoregions and surface water body types within the river basin,
- identification of reference conditions for the surface water body types;

1.2. for groundwaters:
- mapping of the location and boundaries of groundwater bodies;

2. a summary of significant pressures and impact of human activity on the status of surface water and groundwater, including:
- estimation of point source pollution,
- estimation of diffuse source pollution, including a summary of land use,
- estimation of pressures on the quantitative status of water including abstractions,
- analysis of other impacts of human activity on the status of water;

3. identification and mapping of protected areas as required by Article 6 and Annex IV;
4. a map of the monitoring networks established for the purposes of Article 8 and Annex V, and a presentation in map form of the results of the monitoring programmes carried out under those provisions for the status of:

4.1. surface water (ecological and chemical);
4.2. groundwater (chemical and quantitative);
4.3. protected areas;

[…]

B. The first update of the river basin management plan and all subsequent updates shall also include:

[…]

1. an assessment of the progress made towards the achievement of the environmental objectives, including presentation of the monitoring results for the period of the previous plan in map form, and an explanation for any environmental objectives which have not been reached;

[…]

Appendix II: Table of GIS Datasets and Layers Requested by the WFD

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes (see Data Dictionary for complete list)	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
1	**River Basin District -overview -**			D1, (D3)	annex I, ii) Geographical coverage of the river basin district- the names of the main rivers within the river basin district together with a precise description of the boundaries of the river basin district			1:4,000,000 Larger scale is also possible: 1:2,000,000 or 1:1,000,000		2004
		SW1	River Basin District		art 2, annex I, ii) River basin district means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins.	Name of river basin district, European code	Recommended: 125 metres Minimum: 1000 metres		This layer is required in digital format by the WFD. The boundaries of the river basin district are not only based on catchment boundaries, and are therefore separated from the layer river basin, sub basin	
		SW2	River Basin, Sub-Basin		art 2, annex I, ii) River basin means the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta. Sub-basin means the area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence)	Name of the river basin district Name of the basin/sub basin National code European code	Recommended: 125 metres Minimum: 1000 metres		Definition as in Art. 2, No. 14 WFD e.g., Mosel (G), Drau/Drawa (A)	
		SW3	Main Rivers		Main rivers of the river basin district used for general overview (selection of rivers from SW4)	Name of river European ID of river	Recommended: 125 metres Minimum: 1000 metres		Not only a selection of the rivers of SW4, but also a generalisation	

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes (see Data Dictionary for complete list)	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
2	**Competent Authorities**			SW1, SW3, D4,				Recommended 1:4,000,000 Larger scale is also possible: 1:2,000,000 or 1:1,000,000	The reporting scale of 1: 1,000,000 can be necessary if the size of competent authorities is small	2004
		D7	District of competent Authorities		annex I Area covered by the competent authority, the Member state part of the river basin district	Name of competent authority Address of competent authority Name of river basin district	Recommended: 125 metres Minimum: 1000 metres			
3	**Surface Water Body - categories -**			D1, D4, (D3), (D5)	annex II - 1.1, 1.2, VII - 1.1 Surface water bodies are first discriminated based on categories - rivers, lakes, transitional waters or coastal waters - or as artificial surface water bodies or heavily modified surface water bodies. Within each category a discrimination is made based on type (system A or B)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Map of types described in annex II - 1.1 2) Map of waterbodies described in annex VII - A.1.1 3) Map of ecoregion and types described in annex VII - A.1.1	2009 (*)
		SW4	Surface Water bodies - rivers - lakes - transitional waters - coastal waters if applicable, indicated as artificial surface water body or heavily modified surface water body			Category (river, lake, transitional water, coastal water) Name European Code National Code	Recommended: 125 metres Minimum: 1000 metres		Categories are described. This layer is required in digital format by the WFD.	

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
4	**Surface Water Body - types -**			SW4, D1, D4,	annex II - 1.1 - vi Same as map 3			Recommended: 1: 250,000 Minimum: 1: 1,000,000	1) Map of types described in annex II - 1.1 2) Map of waterbodies described in annex VII - A.1.1 3) Map of ecoregion and types described in annex VII - A.1.1	2004
		SW4a	Types of Surface Water Bodies, differentiated for each category			Type, number of values and underlying attributes can be different per category and between River Basin Districts	n.a. (linked to layer SW4)		Differentiation according to type (system A/B) is still in discussion by other working groups, the outcome effects layer SW4. This layer is required in digital format by the WFD.	
		D6	Ecoregions			Ecoregion code Name of Ecoregion	Recommended: 125 metres Minimum: 1000 metres		Ecoregion only required for map described in annex VII - A.1.1, can also be interpreted as an attribute of SW4	
5	**Groundwater bodies**			SW1, SW3, (SW2) D1, D4,	annex II - 2.1, VII - 1.2 Location and boundaries of groundwater bodies			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009 (*)
		GW1	Bodies of groundwater		Location and boundaries of groundwater bodies	Name of groundwater body ID of groundwater body	Recommended: 125 metres Minimum: 1000 metres		European coding - if accessible	

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
6	**Monitoring Network of Surface Water Bodies**			SW4 D1, D4, D5, (D2)	annex V - 1.3, VII - 4 Surface water monitoring network in the river basin management plan, the network contains also the points in the protected areas (map 12)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Possibly classified by categories	2009
		SW5 a	Operational monitoring sites Inclusive monitoring sites for habitat and species protected areas		annex V - 1.3.2, V - 1.3.5	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres		Inclusive monitoring sites for habitat and species protected areas (annex V - 1.3.5) and intercalibration sites	
		SW5 b	Surveillance monitoring sites		annex V - 1.3.1	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		SW5 c	Monitoring sites drinking water abstraction points from surface water		annex V - 1.3.5	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		SW5 d	Investigative monitoring sites		annex V - 1.3.3	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		SW5 e	Reference monitoring sites		annex II - 1.3 (iv)	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
7	**Ecological Status and Ecological Potential of Surface Water Bodies**			SW4, D1, D4, D8	annex V - 1.4.2 For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in High= Blue, Good=Green, Moderate=Yellow, Poor=Orange, Bad=Red. For heavily modified and artificial water bodies, the classification of the ecological potential is defined in a similar way.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		SW4 b	Ecological status		See above	European code of SW body Ecological status: High, good, moderate, poor, bad	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	
		SW4 c	Ecological potential		Classification of the ecological potential for each body of water (artificial water bodies or heavily modified water).	European code of SW body Ecological potential: Good and above, moderate, poor, bad	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	
		SW4 d	Bad status or potential causes by (non-) synthetic pollutants.		annex V – 1.4.2-iii Those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants.	European code of SW body Non-compliant: true or false	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
8	**Chemical Status of Surface Water Bodies**			SW4 D1, D4, D8	annex V - 1.4.3 A map for each river basin district illustrating chemical status for each body of water, colour-coded in Good = Blue, Failing to achieve good = Red			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		SW4 e	Chemical status		See above	European code of SW body Chemical status: Good or 'Failing to achieve good'	n.a. (linked to layer SW2)		Table related to layer SW4 (Surface water bodies)	
9	**Groundwater Status**			GW1, SW1, SW3, D1, D4, (D2)	annex V – 2.5, VII – 4.2 Member States shall provide in the river basin management plan a map showing for each groundwater body or groups of groundwater bodies both the quantitative status and the chemical status of that body or group of bodies, colour-coded in accordance with the requirements of points 2.2.4 and 2.4.5. Member States may choose not to provide separate maps under points 2.2.4 and 2.4.5 but shall in that case also provide an indication in accordance with the requirements of point 2.4.5 on the map required under this point, of those bodies which are subject to a significant and sustained upward trend in the concentration of any pollutant or any reversal in such a trend.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		GW1 a	Quantitative status of groundwater bodies		annexes V - 2.2.4, V - 2.5, VII - 4.2 Quantitative status of groundwater bodies: Good: green Poor: red	European code of GW body Quantitative status: Good or Poor	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
		GW1 b	Chemical status of groundwater bodies		annex V – 2.4.5, V – 2.5, VII – 4.2 Chemical status of groundwater bodies: Good: green Poor: red	European code of GW body Chemical status: Good or Poor	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	
		GW1 c	Pollutant trend		Groundwater bodies which are subject to a significant and sustained upward trend in the concentrations of any pollutant resulting from the impact of human activity (black dot). Reversal of a trend (blue dot)	European code of GW body Pollutant trend: Upward or reversed Confidence level of the trend	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	
10	**Groundwater Monitoring Network**			GW1, SW1, SW3, D1, D4, (D2)	annex V – 2.2, V – 2.3, VII - 4 Groundwater level monitoring network; Surveillance monitoring network (chemical); Operational monitoring network (chemical).			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		GW2a	Groundwater level monitoring network		annex V - 2.2	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		GW2 b	Operational monitoring network chemical		annex V - 2.4	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		GW2 c	Surveillance monitoring network chemical		annex V - 2.4	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
11	**Protected Areas**				annexes IV, VII - 3 Maps including the following types of protected areas as described with the layers (below)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Possibly a different map necessary for each layer	2009
		PA1	Drinking water protection areas	GW1 D1, D4, SW1,SW3	(i) areas designated for the abstraction of water intended for human consumption under Article 7;	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
		PA2	Economically significant aquatic species protection areas (shellfish)	SW1, SW4, D1,	(ii) areas designated for the protection of economically significant aquatic species;	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
		PA3	Recreational waters	SW1, SW4, D1, D4	(iii) bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 76/160/EEC	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
		PA4	Nutrition-sensitive areas	SW1, SW4, D1,	(iv) nutrient-sensitive areas, including areas designated as vulnerable zones under Directive 91/676/EEC (Nitrates Directive) and areas designated as sensitive areas under Directive 91/271/EEC (Urban Waste Water Treatment Directive)	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres		Possibly 2 layers	
		PA5	Habitat protection areas (FFH)	SW1, SW4, D1,	(v) areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under Directive 92/43/EEC (habitats) and Directive 79/409/EEC (Birds).	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
		PA6	Bird protection areas	SW1, SW4, D1,	See above	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			

Map No.	Map Name	Layer Code	Layer	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
12	**Status of Protected Areas**			SW1, SW4, D1,	annexes VII - 4.3 Results of the monitoring programmes carried out for the status of protected areas.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		PA7	Status of protected areas			ID or Name of protected area Status	n.a. (linked to layers PA1 – PA6)		Table related to layers PA1 – PA6	
0	**"Background"**		Divers background layers							
		D1	International borders (NUTS 0)				Recommended: 125 metres Minimum: 1000 metres			
		D2	Corine Landcover							
		D3	Relief/Heights							
		D4	Settlements (selection of NUTS 4)		Only for reference, so bigger settlements					
		D5	Transport							
		D6	Ecoregions				Recommended: 125 metres Minimum: 1000 metres			
		D7	District of competent Authorities				Recommended: 125 metres Minimum: 1000 metres			
		D8	National borders (NUTS 1)							

(*) the date of reporting for maps No. 3 and 5 might change to 2004. See also footnote to Table 3.1.1 in Section 3.1.

Appendix III: Data Dictionary

The Data Dictionary provides a view of the data to be co-ordinated under the WFD as a generic (i.e. not dependent on any specific file format or database technology) representation as files / tables. For the attributes shown in the logical data model, a FieldName (shortened from the verbose description), a text description, a generic fieldtype and length, together with any restrictions (whether Mandatory or Optional, and any specific domains/codes to be used) are provided. Field names are shortened, primarily due to the physical restriction on field name length in commonly used data file formats (e.g. dBase – 10 characters). Fields relating to system B (WFD annex II) are shown in grey.

Classes and recommended file names are given in Table 1 below. File names are made up of a prefix (maximum 8 characters) and a suffix (3 characters). We recommend using a standard prefix for each class. The suffix will depend on the software used (see also Section 3.8).

The aim of the Data Dictionary is to provide a common understanding of the file / table structures that should be used for the WFD GIS data. The classes in the logical UML model which translate to tables are organised alphabetically as follows:

Table 1: Classes and Recommended File Names

Class	Recommended File Name Prefix
CoastalWaters	CWbody
CompetentAuthority	Compauth
EcoRegion	Ecoreg
FWEcologicalClassification	FWeccls
GroundwaterBody	GWbody
GroundwaterMonitoringStation	GWstn
GWStatus	GWstatus
LakeSegment	LWseg
LakeWaterBody	LWbody
MonitorGWBodies	GWmon
MonitorLWBodies	LWmon
MonitorRWBodies	RWmon
MonitorTWBodies	TWmon
PhysicoChemicalClassification	Pchemcls
ProtectedArea	Protarea
RiverSegment	RWseg
RiverWaterBody	RWbody
RiverBasin	Rivbasin
RiverBasinDistrict	RBD
SalineEcologicalClassification	Saleccls
SurfaceMonitoringStation	SWstn
SWStatus	SWstatus
TransitionalWaters	TWbody

CoastalWaters

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
SalinityTypology	SALINITY	Salinity category according to Annex II	String	1	Mandatory {F = Freshwater O = Oligohaline M = Mesohaline P = Polyhaline E = Euhaline}
DepthTypology	DEPTH_CAT	Depth category based on mean depth	String	1	Mandatory {S = Shallow <30m I = Intermediate 30-200m D = Deep >200m}
Latitude	LAT	Definition not	Number	8,5	Mandatory if Type = B.

Attribute	FieldName	Definition	Type	Length	Restrictions
		given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody			Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
TidalTypology	TIDAL	Not defined – assume same as Transitional Tidal range category according to Annex II	String	5	Mandatory if Type = B {MICRO, MESO,MACRO}
CurrentVelocity	VELOCITY	Not defined			Optional
WaveExposure	WAVE_EXPO	Not defined			Optional
MeanWaterTemp	AV_W_TEMP	Not defined			Optional
MixingCharac	MIXING	Not defined			Optional
Turbidity	TURBIDITY	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
RetentionTime	RET_TIME	Not defined			Optional
WaterTempRange	W_TEMP_RGE	Not defined			Optional

CompetentAuthority

Attribute	**FieldName**	**Definition**	**Type**	**Length**	**Restrictions**
Name	NAME	Locally used name	String	100	Mandatory
Address	ADDRESS	Correspondence Address	String	200	Mandatory
AuthorityCode	AUTH_CD	Unique code for the competent authority.	String	24	To be defined

EcoRegion

Delivered once by Commission

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		
Name	NAME	Locally used name	String	40	
EcoRegionCode	REGION_CD	Codes as specified by Annex XI	String	2	{1-25} {AT = Atlantic, NO = Norwegian, BR = Barents, NT = North Sea, BA = Baltic, ME = Mediterranean}

FWEcologicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYY MMDD	Mandatory
EuropeanCode	EU_CD	Unique code for freshwater body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake
OverallStatus	ECO_STAT	Overall ecological status for the water body	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Phytoplankton	PHYTO	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Macrophyto	MAC_PHYTO	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
BenthicInvertebrates	BEN_INV	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Fish	FISH	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate

Attribute	FieldName	Definition	Type	Length	Restrictions
					P = Poor B = Bad}
HydrologicalRegime	HYDRO_REG	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
RiverContinuity	RIV_CONT	Annex V 1.2.1 Rivers only	String	1	Mandatory if waterbody is River {H = High G = Good M = Moderate P = Poor B = Bad}
MorphologicalConditions	MORPH_COND	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

GroundwaterBody

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines.
Name	NAME	Locally used name	String	100	Optional
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	Mandatory. As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYY MMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
Horizon	HORIZON	Unique identifier for the horizon, where separate, overlying bodies exist	Number	2	Optional
StatusYear	STATUS_YR	Year of reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN

GroundwaterMonitoringStation

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (points)		
Name	NAME	Locally used name	String	100	Optional
EuropeanCode	EU_CD	Unique code for a station at EU level	String	24	Mandatory. See coding guidelines.
MSCode	MS_CD	Unique code for a station at MS level	String	22	Mandatory. See coding guidelines.
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
Level	LEVEL	Station Type	String	1	Mandatory {Y,N}
Operational	OPERAT	Station Type	String	1	Mandatory {Y,N}
Surveillance	SURVEIL	Station Type	String	1	Mandatory {Y,N}
Depth	DEPTH	Depth in metres	Number	4	Optional

GWStatus

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for SW body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in GroundwaterBody
QuantitativeStatus	QUANT_STAT	Annex V 2.2	String	1	Mandatory {G = Good P = Poor}
ChemicalStatus	CHEM_STAT	Annex V 2.3	String	1	Mandatory {G = Good P = Poor}
PollutantTrend	POLL_TREND	Annex V 2.4 Not defined	String	1	Assume : {U = Upward D = Downward S = Static}
ConfidenceLevel	CONF_LEVEL	Annex V 2.4 – not defined	String	1	Assume : {H = High M = Medium L = Low}

LakeSegment

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (polygons)		
LWBCode	LWB_CD	Unique code of LakeWater Body to which this segment belongs	String	24	Mandatory. Foreign Key to EU_CD in LakeWaterBody
SegmentCode	SEG_CD	Unique code for the segment	String	24	Mandatory.
Name	NAME	Locally used name	String	100	Optional

LakeWaterBody

Attribute	FieldName	Definition	FieldType	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterizatio n of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYY MMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of reporting of waterbody characterisatio n	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is	String	1	Mandatory {Y, N}

Attribute	FieldName	Definition	FieldType	Length	Restrictions
		heavily modified			
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
AltitudeTypology	ALT_CAT	Altitude category according to Annex II	String	4	{HIGH, MID, LOW}
GeologyTypology	GEOL_CAT	Geological category according to Annex II	String	1	{C = Calcareous, S = Siliceous, O = Organic}
SizeTypology	SIZE_CAT	Size based on catchment area according to Annex II	String	2	{S = Small 0.5-1km M = Medium 1-10km L = Large 10-100km XL = >100km}
DepthTypology	DEPTH_CAT	Depth category based on mean depth	String	1	Mandatory {V = Very Shallow <3m S = Shallow 3-15m D = Deep >15m}
Altitude	ALT	Not defined			Mandatory if Type = B.
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Depth	DEPTH	Not defined			Optional
Geology	GEOLOGY	Not defined			Optional
SizeMeasurement	SIZE	Not defined. Assume area in KM2			Optional
MeanDepth	AV_DEPTH	Not defined			Optional
LakeShape	LAKE_SHAPE	Not defined			Optional
ResidenceTime	RES_TIME	Not defined			Optional
MeanAirTemp	AV_A_TEMP	Not defined			Optional
AirTempRange	A_TEMP_RGE	Not defined			Optional
MixingCharac	MIXING	Not defined			Optional
AcidNeutCapacity	ACID_NEUT	Not defined			Optional
NutrientStatus	NUTRIENT	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
WaterLevelFluct	LEVEL_FLUC	Not defined			Optional

MonitorGWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
GWStationCode	GWSTN_CD	Code of the GW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in GroundWaterMonitoringStation
GWBodyCode	GWBODY_CD	Code of the GW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in GroundWaterBody

MonitorLWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
LWBodyCode	LWBODY_CD	Code of the LW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in LakeWaterBody

MonitorRWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
RWBodyCode	RWBODY_CD	Code of the RW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in RiverWaterBody

MonitorTWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
TWBodyCode	TWBODY_CD	Code of the TW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in TransitionalWaters

PhysicoChemicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for surfacewater body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters / CoastalWaters
GeneralConditions	GEN_COND	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
SyntheticPollutants	SYNTH	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
NonSyntheticPollutants	NON_SYNTH	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

ProtectedArea

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (polygons)		
Name	NAME	Locally used name	String	100	Optional
ProtectedAreaType	PROT_TYPE	Category of the protected area	String	1	Mandatory. {D = Drinking R = Recreational E = Economic Species N = Nutrient H = Habitat B = Bird}

RiverSegment

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (lines)		
RWBCode	RWB_CD	Unique code of RiverWaterBody to which this segment belongs	String	24	Mandatory. Foreign Key to EU_CD in RiverWaterBody
SegmentCode	SEG_CD	Unique code for the segment	String	24	Mandatory.
Name	NAME	Locally used name	String	100	Optional
Continua	CONTINUA	Whether river segment is an imaginary link segment to maintain network topology	String		Mandatory {Y, N}
FlowDirection	FLOWDIR	Flow direction with respect to digitized direction	String	1	{W = With, A = Against}

RiverWaterBody

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (lines)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of	String	4	Possibly can be

Attribute	FieldName	Definition	Type	Length	Restrictions
		reporting of waterbody characterisation			dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
AltitudeTypology	ALT_CAT	Altitude category according to Annex II	String	4	{HIGH, MID, LOW}
GeologyTypology	GEOL_CAT	Geological category according to Annex II	String	1	{C = Calcareous, S = Siliceous, O = Organic}
SizeTypology	SIZE_CAT	Size based on catchment area according to Annex II	String	2	{S,M,L,XL}
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Geology	GEOLOGY	Not defined			Mandatory if Type = B.
SizeMeasurement	SIZE	Not defined. Assume total length in KM			Mandatory if Type = B.
DistRiverSource	DIST_SOURCE	Not defined			Optional
FlowEnergy	ENERGY	Not defined			Optional
MeanWidth	AV_WIDTH	Not defined			Optional
MeanDepth	AV_DEPTH	Not defined			Optional
MeanSlope	AV_SLOPE	Not defined			Optional
RiverMorphology	RIV_MORPH	Not defined			Optional
DischargeCategory	DISCHARGE	Not defined			Optional
ValleyMorphology	VAL_MORPH	Not defined			Optional
SolidsTransport	SOLIDS	Not defined			Optional
AcidNeutCapacity	ACID_NEUT	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
Chloride	CHLORIDE	Not defined			Optional
AirTempRange	A_TEMP_RGE	Not defined			Optional
MeanAirTemp	AV_A_TEMP	Not defined			Optional
Precipitation	PPT	Not defined			Optional

RiverBasin

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a river basin within MS	String	22	As per coding guidelines
EuropeanCode	EU_CD	Unique code for a river basin at EU level	String	24	Mandatory. As per coding guidelines
DistrictCode	DIST_CD	Code for River Basin District the basin belongs to	String	24	Mandatory. Foreign Key to EU_CD in RiverBasinDistrict
AreaKM2	AREAKM2	Area in square kilometres	Number	6	Mandatory

RiverBasinDistrict

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a river basin district within MS	String	22	As per coding guidelines
EuropeanCode	EU_CD	Unique code for a river basin district at EU level	String	24	Mandatory. As per coding guidelines
CompetentAuth	AUTH_CD	Code of the competent authority for the RBD	String	24	Mandatory. Foreign Key to AUTH_CD in CompetentAuthority

SalineEcologicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYY MMDD	Mandatory
EuropeanCode	EU_CD	Unique	String	24	Mandatory. Foreign Key

Attribute	FieldName	Definition	Type	Length	Restrictions
		code for salinewater body to which this status refers			to EU_CD in TransitionalWaters / CoastalWaters
Phytoplankton	PHYTO	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Macroalgae	MAC_ALGAE	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad} If waterbody is coastal, refers to macroalgae AND angiosperms
Angiosperms	ANGIO	Annex V 1.2.3	String	1	Mandatory if waterbody is Transitional {H = High G = Good M = Moderate P = Poor B = Bad}
BenthicInvertebrates	BEN_INV	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Fish	FISH	Annex V 1.2.3 Transitional Waters only	String	1	Mandatory if waterbody is Transitional {H = High G = Good M = Moderate P = Poor B = Bad}
TidalRegime	TIDAL_REG	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
MorphologicalConditions	MORPH_COND	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

SurfaceMonitoringStation

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (points)		
Name	NAME	Locally used name	String	100	Optional
WaterBodyCode	BDY_CD	Unique code of parent waterbody	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters
EuropeanCode	EU_CD	Unique code for a station at EU level	String	24	Mandatory. See coding guidelines.
MSCode	MS_CD	Unique code for a station at MS level	String	22	Mandatory. See coding guidelines.
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
Depth	DEPTH	Depth in metres	Number	4	Optional
Drinking	DRINKING	Station Type	String	1	Mandatory {Y,N}
Investigative	INVEST	Station Type	String	1	Mandatory {Y,N}
Operational	OPERAT	Station Type	String	1	Mandatory {Y,N}
Habitat	HABITAT	Station Type	String	1	Mandatory {Y,N}
Surveillance	SURVEIL	Station Type	String	1	Mandatory {Y,N}
Reference	REFERENCE	Station Type	String	1	Mandatory {Y,N}

SWStatus

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for SW body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters / Coastal Waters
EcologicalStatus	ECO_STAT	According to Annex V		1	Mandatory {H = High G = Good P = Poor B = Bad}
EcologicalPotential		According to Annex V	String		Mandatory for artificial / modified {H = High

Attribute	FieldName	Definition	Type	Length	Restrictions
					G = Good M = Moderate P = Poor B = Bad}
NonCompliant		Annex V 1.4.2(iii) – whether the water body does not comply with environmental quality standards	String	1	N = Non-Compliant}
ChemicalStatus	CHEM_STAT	According to Annex V		1	{G = Good F = Failing}

TransitionalWaters

Attribute	FieldName	Definition	Type	Length	Restrictions
	SHAPE	Geometry (polygons)	Geometry		Mandatory
	EU_CD	Unique code for a waterbody at EU level	String		Mandatory. As per coding guidelines
	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS		22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String		Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy		Acronym of operator	String		Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String		Mandatory {Y,N}

Attribute	FieldName	Definition	Type	Length	Restrictions
SalinityTypology	SALINITY	Salinity category according to Annex II	String	1	Mandatory {F = Freshwater M = Mesohaline P = Polyhaline E = Euhaline}
	TIDAL	category according to Annex II	String		Mandatory {MICRO, MESO,MACRO}
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Can be calculated from supplied geometry
Depth	DEPTH				
CurrentVelocity	VELOCITY	Not defined			Optional
	WAV_EXPO	Not defined			Optional
ResidenceTime	RES_TIME	Not defined			Optional
MeanWaterTemp	AV_W_TEMP	Not defined			Optional
MixingCharac	MIXING				Optional
Turbidity		Not defined			
MeanSubstratComp		Not defined			Optional
ShapeCharacter		Not defined			
WaterTempRange	W_TEMP_RGE	Not defined			

Appendix IV: Unique Identification Coding Systems

1. Introduction

Many existing river coding systems were reviewed, these are documented at http://193.178.1.168/River_Coding_Review.htm. The historic attention to rivers was driven by the need to assign structure when identifying stream orders and nested sub-catchments. Other feature coding is more straightforward and has been largely ad-hoc.

Recommendations are going to upset established practices for most Member States. The benefits however necessitate that this task be undertaken. The Water Framework Directive demands that we manage and share environment data across national borders. At the core of this is the need to have a common approach to the way we reference components of the observed and managed environment.

The primary objective is to agree unique identification codes, which are harmonised internationally especially in the context of international river basins. The INSPIRE principles are considered with respect to the maintenance of codes by those who can do so most efficiently. Automated coding is also supported where appropriate with the objective of providing unique codes across numerous elements. Automation would in some instances also provide smart codes, which carry additional information about topological connectivity.

A common coding system will a) greatly facilitate the sharing of data across borders, b) form a framework for EU reporting and c) enable efficient electronic reporting at national and EU levels. Any other approach would merely put off the inevitable efficient structure that must evolve. Hopefully by acting now we can realise the benefits early at this crucial stage of implementation of the Water Framework Directive.

2. Required Coding Structure

2.1 Levels of unique identification coding

A. At the highest level, water bodies and river networks need to be identified;
B. These elements may need to be sub-divided. This cannot be fully predicted, as it may arise at a later date due to changes in ecological or physical boundaries. Thus, sub-division coding must not interfere with established primary coding;
C. Status monitoring, pressures and impacts are usually intrinsically linked to water bodies and thus may be developed as extensions of water body coding;
D. Diffused pressures are likely to be linked to many water bodies. Hence, they must be identified with their own codes and related back to water bodies through database links.

2.2 Coding Strategy

The proposed coding structure must adhere to the following:

1. Generation of unique European codes;
2. Establishment and maintenance of codes by those who can do so most efficiently.

It should also addresses the following important issues:

3. Generation of harmonised RBD and European codes where possible;
4. The use of codes that directly carry information, where possible and convenient, particularly where coding is automated. *(Such information can be used to a) directly determine hydrological connectivity, b) validate data and c) determine the organisations responsible for code maintenance.)*

Code maintenance is important and codes must be maintainable in a flexible way by a variety of independent organisations.

3. Local Spatial Features

These include pressures, status and impact monitoring and some water bodies. For example, municipal discharges, industrial discharges, agricultural pressures, groundwater abstraction points, coastal water bodies, etc. These features are generally identified and coded at a very local level and they lends themselves to the INSPIRE principle of data maintenance at one location and by those who can most efficiently do so. While feature codes are not strictly spatial data, but rather data tags, the same principle can be applied.

The recommended approach is:

1. Each Member States is uniquely identified by a 2-character code in accordance with ISO 3166-1-Alpha-2 codes;
2. Each MS, uniquely identifies the agencies or authorities, which manage or monitor local features. (For monitoring stations, the agencies of concern are those that establish them; other agencies may use these stations.
3. Local agencies or authorities assign, to features or monitoring stations, codes that are unique within local administrative areas;
4. Unique European codes are then generated by concatenating the above three elements.

Where there is only one organisation involved in the identification of particular features across the Member State, then step 2 above, identifying the coding agency, can be omitted.

In general a 4-digit code is recommended to identify coding authorities, features and monitoring stations. This can be split into a pair of 2 digit codes to represent local hierarchies and to enable infilling. However, Member States can use any feature coding structures required locally, provided:

- codes have a 2 character header attached prior to reporting at EU levels, which identifies the Member State, in accordance with ISO 3166-1-Alpha-2 country codes;
- the overall identification code does not exceed 24 characters (including the 2 character MS code);
- each identification codes generated is unique within the Member State.

4. Features with Hydrological Connectivity

Rivers are the primary example here, where gravity produces hydrological connectivity and flow direction. The extent of connectivity can reach across multiple Member States. Lakes, coastal waters and transitional waters are hydrologically connected through river networks. Hence it is wise to address rivers at the outset.

4.1 River Coding Approach

If rivers are already substantially identified, it may be pragmatic to extend existing coding. However, the number of additional rivers may amount to multiples of the number already coded. Also, codes may need to be reviewed for harmonisation with adjacent Member States.

River identification is likely to be computer-based. Coding could be as simple as sequential identifiers; however, structured hydrological codes are recommended. This enables rapid manual or automated analyses without the need to refer to GIS. The hierarchical nature of river structures lends itself to systematic nested coding. By using the same coding methodology at each tributary level, we can automatically determine codes and infer river connectivity.

A modified Pfafstetter system is recommended in the absence of alternative hydrological codes. The Pfafstetter system will need to be explored further to see if lakes can be better incorporated. Thus there may be further recommendations regarding its modification or replacement. For now, it is recommended on an interim basis and provides a mechanism to uniquely code river segments while also encapsulating river hydrological structures. Other hydrological coding or non-hydrological coding can be used, provided it uses unique identification codes, of lengths up to 22 characters. Codes of less than 22 characters should not be padded out with leading zeros ('0') for readability and to minimise data entry keying errors.

Both hydrological and non-hydrological identification codes should be preceded by two character codes to uniquely identify the Member State that assigned them.

4.2 River Coding

The main document explains the **MS MW N_1 N_2 N_3 N_4, …** code structure along with Modified Pfafstetter coding**.** Together the MW (Marine Waters) and N_1 N_2 N_3 N_4, … (river segment) components can provide unique hydrologically structured codes that integrate all surface water bodies. Alternatively these components can be replaced by any code not exceeding 22 characters.

4.3 River Coding - Practical Implementation Issues

4.3.1 Trans-boundary River Coding

Where Member States wish to co-operate in the generation of unique codes for trans-boundary rivers, the Pfafstetter system can be used. The highest level Pfafstetter code(s) could be established by the Member State with the coastal outlet. This will reserve the initial digit(s) for coding within each involved Member States, particularly along the main channel. More detailed coding can then be immediately undertaken in the border regions. Each Member State can then proceed with local detailed coding, at their own pace; yet when complete, the full catchment will be coded in a manner that enables hydrological connectivity to be ascertained.

The Pfafstetter approach can be used even where an adjacent Member State wishes to adopt a different coding practice. For example, downstream borders can be considered as marine borders. Catchment contributions from an upstream Member State can be assumed to come from a simplified catchment topology. Regardless of which approach is taken, there will always be a need to agree coding strategies along border regions.

4.3.2 Multiple Harmonisation Agreements

River identification coding may require independent harmonisation with different neighbouring Member States. Care is needed to ensure that multiple harmonisation agreements do not introduce the possibility of non-unique identifiers across different RBDs within the Member State. A number of options are available in this regard:

- A pan European or pan Member State river identifier coding system might be initially developed giving unique codes to all major rivers;
- Unique codes might be assured by the use of the MW code, a marine waters identifiers in accordance with the International Hydrographic Organisation delineation[1], with possible further local subdivisions per regional marine agreements;
- Where rivers drain into the same marine waters, the MS and MW header codes might be immediately followed by the coastal water outlet Member State code.

4.3.3 Impact of Lakes on River Codes

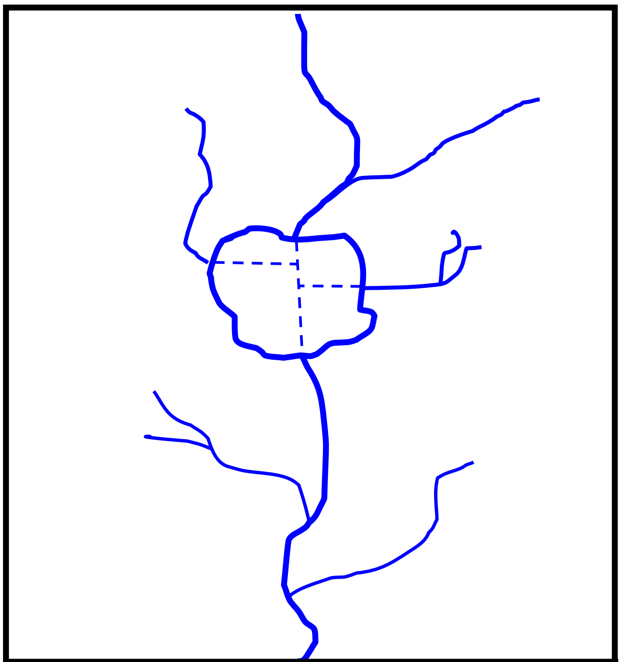


Fig.1. The network is connected manually through the lake. For simple lakes this could be straight lines joining the main channel to the lake tributaries.

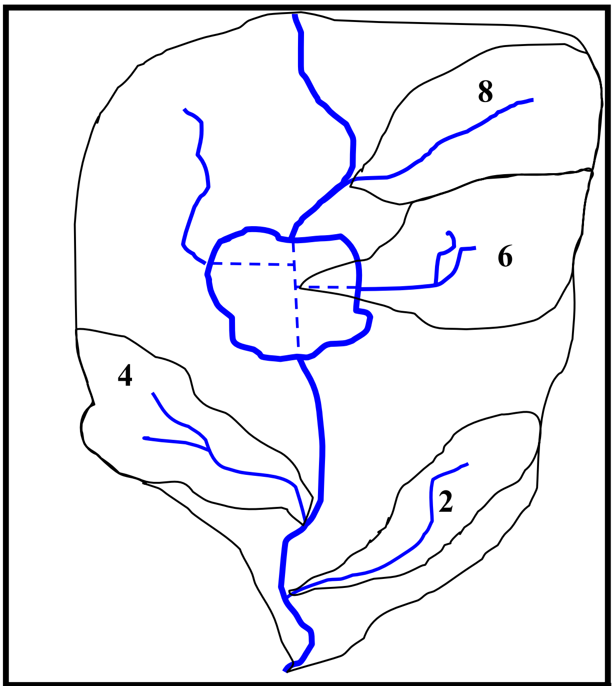


Fig. 2. The major tributaries are identified, while ignoring the presence of the lake.

The easiest way to code river reaches and their basins through lakes is to visualise lakes as wide river channels. This is presented in the Figures 1 and 2.

The river network is connected by simple line-work through the lake. For long curved lakes more extensive line-work is needed. The JRC and various Member States have achieved this with semi-manual procedures. The main tributaries of the resulting network are then coded.

By using a digital elevation model, and effectively ignoring the presence of the lake, we can determine how the sub basin boundaries cross the lake. Interpolation, between the elevation at the imaginary confluence and elevations outside of the lake, will generate a very slightly sloped surface, across the lake, draining towards the imaginary confluence. The lines of steepest gradient will then determine the imaginary watersheds across the lake.

The above method is reliant only on a digitised river network and on a digital elevation model to determine river coding. An undesirable result is that tributary catchments do not enter lakes at a point. This can be seen in Fig. 3 for tributary catchment '6'.

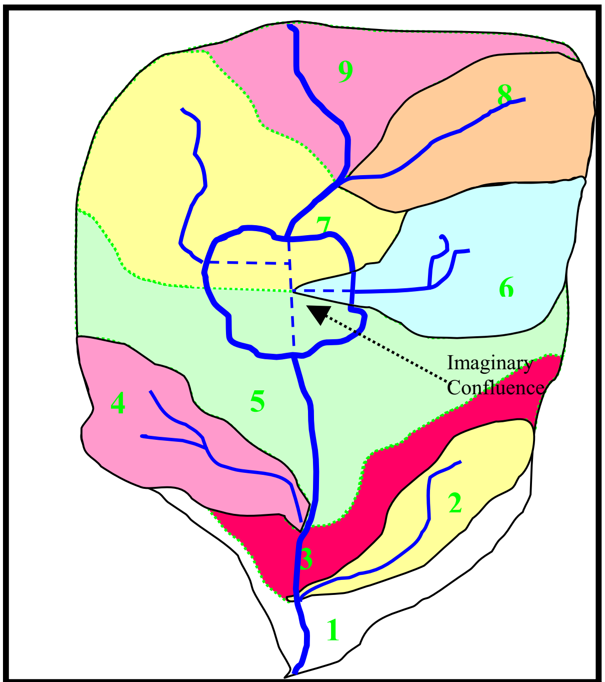


Fig. 3. The inter-basins are identified. Inter-basin boundaries meet, and cross, the lake at points determined by elevation model interpolation (e.g. basins 5 and 7)

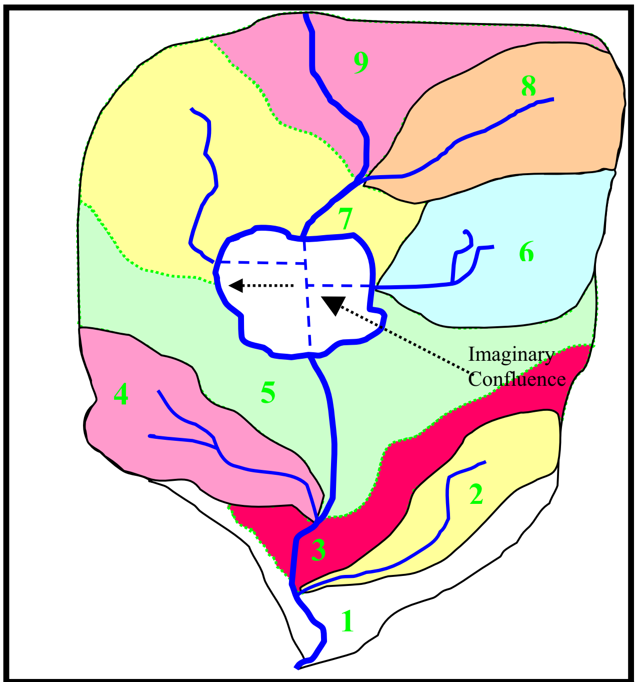
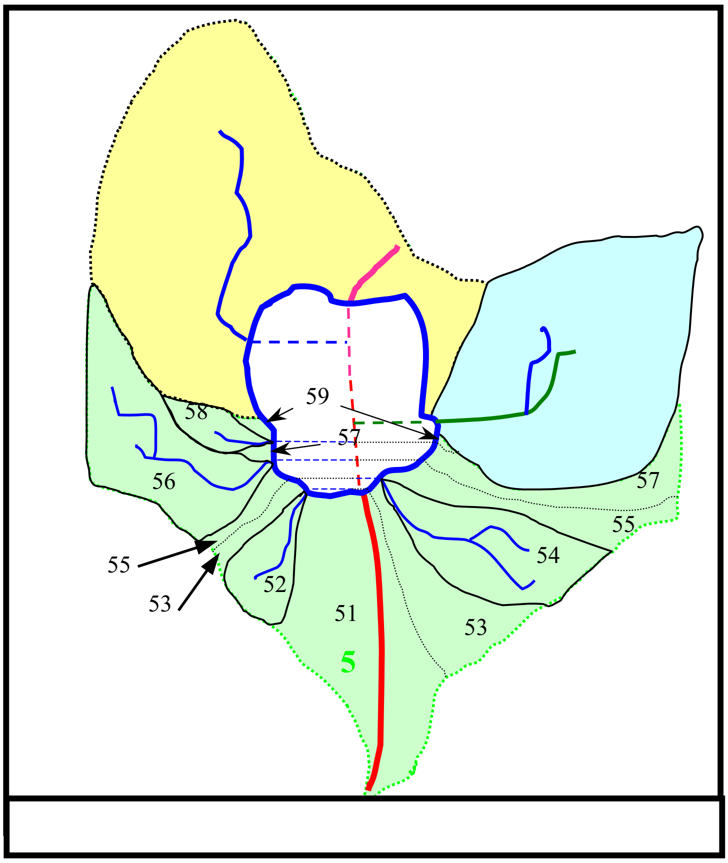


Fig. 4. Alternative approach to tributary catchment 06. Inter-basin boundaries meet the lake at a points determined by elevation model interpolation (e.g. basins 5 and 7).

An alternative approach, which takes lakes into account, is shown in Figure 4. This method determines tributary catchments from the tributary and lakeshore intersection. The inter-basin catchments are determined as before, but are truncated at the lakeshore. This approach lends itself better to subsequent further levels of coding of smaller tributaries along the lakeshore and provides a better hydrological breakdown. It is thus the recommended approach.

To proceed with further levels of river coding, the lakeshore can be treated as though it was the river bank of a rather wide main channel. Thus the major tributaries are identified in the inter-basins and a new level of sub-basins and sub-inter-basins is established.

As this process progresses, while tributaries will be neatly identified, inter-basin codes will refer to pairs of disjointed lake shorelines. See Fig. 5.



Hence the inter-basin codes are not suitable for identifying lakeshores, and an independent parallel coding system is needed for that purpose. The system also splits lake-inter-basins, odd numbered catchments in Fig. 5. Tributaries draining into the lake are however coded in a hydrologically sound manner, as can be seen in Fig. 5 for even numbered catchments. Along with the main river channel, these tributaries will generally be the main source of inputs to lakes.

4.3.4 General Anomalies in River Identification Coding

Rivers may disappear into underground systems. The larger flow at a confluence may not come from the upstream contributing catchment with the largest surface area. These and other anomalies will require some level of manual intervention to aid what would otherwise be a largely automated coding process.

4.3.5 Testing the Pfafstetter Coding System

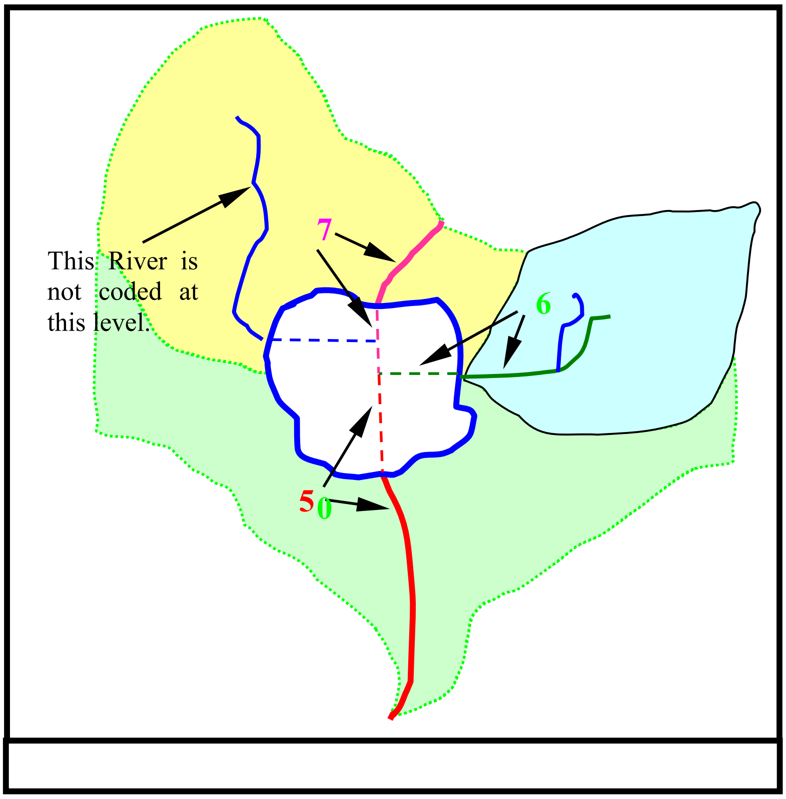
The JRC generated Pfafstetter codes across all of Europe in the prototype GIS. First river channels were identified from digital elevation models. Existing vector maps were used to automatically improve interpolation in flatter regions and to determine lake boundaries. River channels were connected through lakes. The codes generated were in general 6 digits long or less.

5. Lakes

5.1. Lake Coding

River reaches, or continua (imaginary reaches), within lakes, can be coded in the normal manner. A lake will typically be associated with many river reaches (real and imaginary). Fig. 6 demonstrates river codes generated around a lake. At this initial level of coding, there are 3 river reaches involved and the lake intersects each. As rivers and lakes will not usually meet at a drainage catchment boundary, we will not get neat inclusive relationships.

We need to select one code to uniquely represent the lake. The downstream reach code is a suitable candidate for this, as we already know that it is unique. In addition this reach is subject to all lake inputs. Thus, where hydrological river coding is deployed, the use of the downstream river reach code would also provide a degree of hydrological information to lake codes. Numeric upstream / downstream Pfafstetter tests could then be applied.



Shorelines could be identified by a further 2-digit code where even numbers identify the left bank and odd numbers identify the right bank. If additional subdivision is required, then an additional pair of digits can be added. These codes would be assigned manually, to identify administrative, hydrological, ecological and other boundaries. Intervals may be left to facilitate further subdivisions.

An alternative coding structure could be used for lakes and shorelines. Ideally the uniqueness of new lake or shoreline codes should be immediately visible to the person assigning them. Thus extensions of river network coding and the use of sequential identifies are desirable, with allowance for intervals within the sequence.

In summary then:

- Lake codes could use the same format as river inter-basin codes, e.g. '51' in the case of Pfafstetter coding in Fig. 6;
- Hydrological connectivity could be determined directly from lake codes if we use the downstream Pfafstetter or other hydrological river code;
- Lakeshores should use a sequential code format with allowance for later sub-division, such as 2 pairs of digits, e.g. 51-10/00;
- An objective should be to make uniqueness readily visible.

5.2. Dealing with Lake Anomalies

We may encounter:

1. Lakes which have no river outlet;
2. Lakes whose existence or extents are seasonal;
3. A number of small lakes of surface area >0.5 km^2 along a river of catchment size just greater than 10km^2;
4. Other special cases.

These exceptions will require manual intervention to assign reasonable unique codes. In the event that the anomalies are too numerous to achieve this, then use a simple system assigned code (e.g. a unique integer within a RBD or a hydrological area).

6. Transitional Water Bodies

The recommended river coding system will extend to marine waters and will maintain hydrological connectivity relationships. Those river reaches, which are wholly within the transitional waters area, can be assigned database attribute values to identify them as transitional. Around the transitional water body periphery, there will be river reaches, which are partially within transitional waters. Thus, we must rely on database attributes combined with GIS queries to identify the portions of river reaches that lie within transitional water bodies. And hence we can find no inclusive coding system that links directly with river coding.

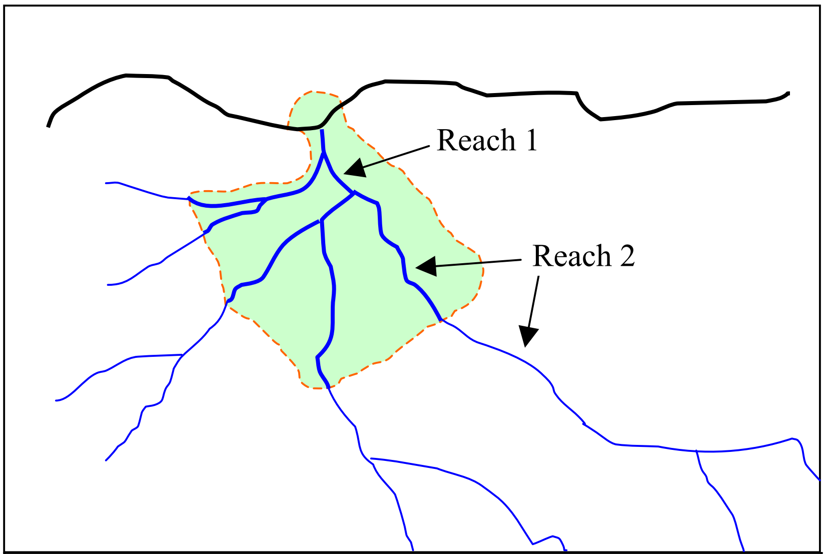


Figure 7. Rivers reaches wholly or partially in Transitional Waters

We can assign some hydrological intelligence to the transitional waters water body code if we use the down stream (outlet) river reach code as the code for the transitional water body. We can thus readily determine the upstream river catchments and lakes, which contribute to the freshwater inputs by referring to codes alone.

7. Coastal Water Bodies

As discussed under river coding sections, unique identifiers for marine waters can be provided internationally by using identifiers in accordance with the International Hydrographic Organisation delineation, with possible further local subdivisions per regional marine agreements. This area needs to be considered in conjunction with the findings of working groups concerned with the typology and classification of transitional and coastal waters.

8. Groundwater Bodies

The following code for **groundwater bodies** are recommended:

- a 2 character Member State Code (ISO 3166);
- an up to 22 character Groundwater Body code.

According to the WFD, groundwater bodies can be classified as single GW-bodies or as a group of GW-bodies. Furthermore GW-bodies can be classified as shallow or deep bodies, the definition of which is still under discussion.

GW-bodies might be divided into sub-bodies for several reasons. The WFD WG 2.8 "Guidance on tools for the assessment and classification of groundwater" has recommended the division of GW-bodies in sub-bodies for statistical purpose. Within the guidance paper, a criterion for monitoring networks is proposed and if the criterion is not fulfilled the monitoring network has to be adapted accordingly or the GW-body has to be sub-divided (http://www.wfdgw.net/).

WG 2.8 also developed a coding system for GW-bodies and sub-bodies. This system suits the statistical tool that was developed for the assessment and classification of groundwater. Within this tool GW-bodies and sub-bodies have different codes and can be addressed separately. Use of this system for GIS coding of GW-bodies would cause problems because the unique code for each polygon is made from two codes that are stored separately. A new unique code for each polygon would have to be introduced and as a consequence three codes would have to be maintained.

In future it might then be necessary to introduce a new code for trans-boundary GW-bodies to be able to assess the total body irrespective of Member State borders.

When assigning GW-bodies to river basins, the borders of river basins may not fit the borders of GW-bodies. The assignment of GW-bodies to river basins can only partly be done geographically. In many cases the assignment will be an administrative decision, handled within a database and will not be geographically reconstructable.

The above issues argue for a simple GW-body code as recommended and a more complex database solution with high flexibility.

9. Sub-Division of Primary Codes

9.1 Division of Rivers and Catchments

After identifying the river reaches that define the topology of the river, it will be necessary to subdivide these reaches for local management purposes. This subdivision will be necessary for river quality monitoring stations, industrial discharge points, ecological boundaries and physical boundaries such as those caused by weirs and changes in river channel geometry. This subdivision is going to be accomplished by manual means.

The need for common standards is determined by the needs for EU reporting but maybe more so by the needs of international RBDs. For example, we may want to divide a first order, and hence long, river reach into sections determined by water quality monitoring points or by sections upstream and downstream of major discharges or urban centres. As this is going to be largely a manual process, it is best to keep the coding simple and extendable.

The recommended approach is to use 2 pairs of digits. The first pair will enable up to 99 initial subdivisions of the reach. The second level would allow further break down of these at a later date. Intervals can be left to allow additional inputs. For example, the first upstream stretch on a reach might be numbered 10/00, the second 20/00. If necessary, the first section could be later subdivided at the top level by introducing 05/00. Lower level subdivision can be achieved by use of the second digit pair, e.g. 10/10, 10/20, 10/30, etc.

Thus if the river reach has a Pfafstetter code of 57, and a section on it is identified as 10/10, then the full section code is given by 57-10/10.

Practised variations on this approach include the use of upstream distance. This has the benefit of providing exact location. It has the disadvantage of requiring prior distance analyses and GIS can maintain location in any regard.

Which approach to take is a matter for individual Member States to decide upon. It is very dependent of the capabilities and structures of code management organisations. The primary objective must be to provide a mechanism for manual assignment of identification codes that allows immediate assurance of uniqueness by visual inspection.

When sharing GIS data, these sections should be provided as GIS line-work with this code attached to each element as its identifier.

9.2. Division of Lakes, Coastal, Ground & Transitional Waters

9.2.1. Division of Lakes

Subdivision of lakeshores has been discussed in Section 6.1. Lake regions, such as bays, etc, might be coded in a similar fashion, using initially 2 digits with a further 2 digits for subdivisions at a later date.

If '51' is a lake identifier, then:

- Lakeshores could use a format such as 2 pairs of digits, e.g. 51-10/00;
- Lake sub-regions could use a format such as 2 pairs of digits, e.g. 51-12/00.

Again, any unique coding mechanism can be adopted by Member States, but is strongly recommended that codes be easily reviewed visually.

When sharing GIS data, lakeshores and lake sub-regions should be provided as GIS line-work with this code attached to each element as its identifier.

9.2.2. Division of Coastal, Transitional & Groundwaters

Division of Coastal, Transitional and Ground Waters could take the same approach of assigning 2 pairs of digits, which allows for further sub-division. Any unique coding mechanism can be adopted by Member States, but is strongly recommended that codes be easily reviewed visually.

10. Pressures, Status and Impacts

10.1. Introduction

10.1.1. Coding Structure

This Section particularly lends itself to approach outlined in Section 3 'Local Spatial Features'. Hence unique European codes are generated by concatenating:

- a 2-character unique Member States code;
- a unique identifier for the local coding authority;
- a unique code for the feature administered by that coding authority.

10.1.2. The Impact of Laboratory Information Systems

All monitoring data is going to be processed through laboratory data management systems. Such databases are going to merge river monitoring samples with drinking water, bathing, landfill, lake, ground water, treatment plant, industrial discharge and other sample data. All samples taken are going to enter such databases in sequential order as they arrive at the laboratory. For feature codes to remain unique, within laboratory databases, it will be necessary to also identify the sample type.

The focus of such laboratory systems is on the laboratory process and not on the subsequent usage or ordering of the data. Sample type codes will also aid the subsequent separation of data into its GIS topics.

These additional sample type codes should be maintained within laboratory systems only, in an additional field alongside the feature coding field. To keep codes simple within GIS, it is not proposed that these laboratory tags be appended to proposed GIS codes.

For example, a river station would have a laboratory code such as 'RS'. This will be used to identify the type of sampling station at which the sample was taken. This will ease data displays, data reporting and data exports. But most of all, it will greatly assist electronic data transfer associated with the extensive pools of data that exist in laboratory systems.

It must be appreciated that such laboratory systems will be the data engines for much of the subsequent GIS thematics. Hence, we need to put in place practices that will ease the data flows to and from such systems. To do this, we need to identify the laboratory codes that will achieve this. Recommended laboratory codes are listed below.

10.1.3. Laboratory System Supplementary Codes

The following codes are suggested as possible identifiers within laboratory systems. These are database attributes, rather than identification codes, but they are required in combination with monitoring station codes for unique identification within laboratory system. They would thus provide a standard approach for direct access to such data from GIS.

'RS' for river stations.
'*LS*' for lake stations.
'CS' for coastal stations.
'TS' for transitional water stations.
'GW' for ground water stations.
'DW' for Drinking Water along with
- *'GWA'* to indicate Ground Water Abstraction, or
- *'SWA'* to indicate Surface Water Abstraction.

'BP' for bathing water stations.
'PI' for pollution incident samples.
'*DP*' refers to a sample taken at a Discharge Point (effluent). For monitoring of receiving waters at *Upstream* and *Downstream* locations, this should be replaced by '*DU*' and '*DD*' respectively. 'DP', 'DU' or 'DD' should be combined with
- '*IND*' to indicate an Industrial discharge, or
- '*COM*' for a Commercial discharge, or
- '*INS*' for a Institutional discharge, or
- 'AGR' for an Agricultural discharge, or
- 'PAV' for a Paved area discharge, or
- 'CSO' for a Combined Sewer Overflow, or
- 'WWT' for a Wastewater Treatment plant discharge, or
- 'WSP' for a Water Supply Plant discharge, or
- 'LFL' for Landfill Leachate.

10.2. Water Body Monitoring Stations

Transitional or Lake water body monitoring stations identification codes might be simple extensions to the overall water body code or the codes for the river segments that occupy the transitional water body. Either method will provide a mechanism for quick assignment of unique codes at a local level.

Thus if an Irish river stretch is identified as IE5441, and a station on that by 03/00, then the full station code is given by:

IE54410300.

In the example shown in Fig. 8., the transitional water body code would be '541'. Monitoring stations could be an extension of the water body code, '541'. Alternatively, as shown, they might be extensions of the river segment codes.

In laboratory databases, the code or attribute 'TS' (transitional station) might be associated with the code 'IE54410300' and 'RS' with 'IE5410450'.

Otherwise, monitoring stations might gain their unique identification codes as extensions of identification codes for local code assigning authorities. Other practical approaches to unique code maintenance may be possible. Visual confirmation of uniqueness and flexibility for all involved organisations should be incorporated into whatever approach is adopted.

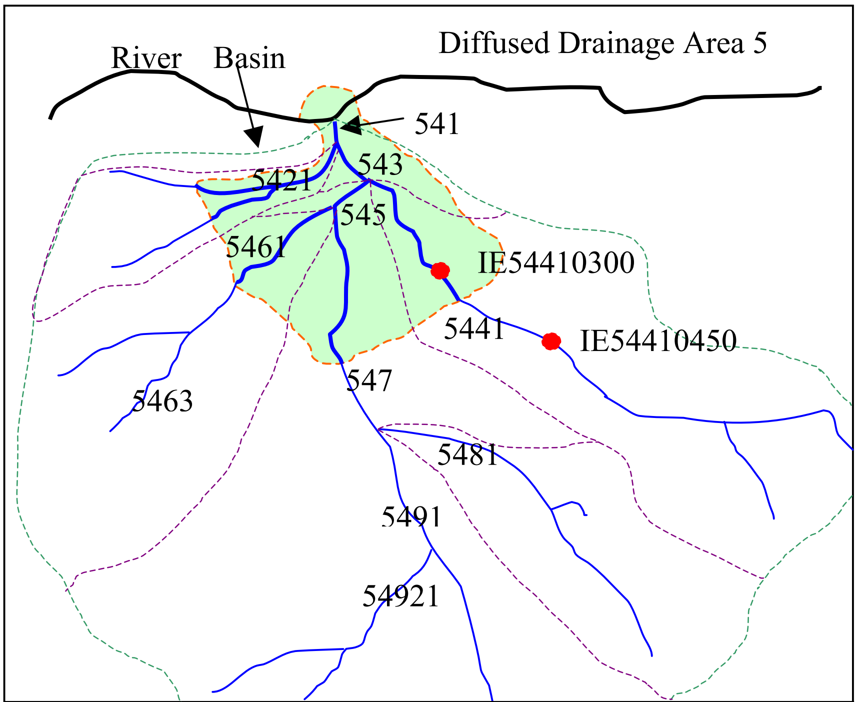


Figure 8. Rivers reaches wholly or partially in Transitional Waters

11. Introducing River Basin Districts

RBD competent authorities are not going to take on the regulatory functions of existing agencies. Thus other agencies are going to remain the primary source of feature identification. Hence it may cause confusion to try to introduce RBDs into the unique codes to be generated. It is suggested that the relevant RBD be identified through database fields and GIS.

12. Working within a Member State

Obviously the Member State component of codes, i.e. 'MS', can be dropped when using data at a local level, provided this information is added on to codes when required to be unique at a European level.

13. Additional Features

The chapter outlining recommended GIS layers identifies additional layers. These include administrative areas, background mapping and protected areas. These are covered by the general rule of supplying codes in the MS$\#_1\#_2\ldots\#_{22}$ format.

Protected areas layers are addressed by Natura 2000 which uses a two character Member State identification code followed by a 7-character code to identify SCI's (Sites of Community Importance) and SPA's (Special Protection Areas) within a Member State.

14. ISO 3166-1-Alpha-2 Country Names and Code Elements

The latest list can be acquired at:

http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1/en_listp1.html

Once feature codes are assigned, codes should not change. Hence, new country names and country codes should only impact on future feature coding. However, alternative arrangements may be agreed with adjacent Member States and the Commission.

Appendix V: Detailed Specifications for Data Validation

Form for data quality description

Data quality component	Short Name	Component Domain
Scope	DQ_Scope	Free text
Element	DQ_Element	Enumerated domain 1-Completeness 2-Logical consistency 3-Positional accuracy
Subelement	DQ_Subelement	Enumerated domain: Completeness 1-Commission 2-Omission Logical Consistency 1-Conceptual consistency 2-Domain consistency 3-Format consistency 4-Topological consistency Positional accuracy 1-Absolute accuracy
Measure[13]	DQ_Measure	
Measurement Description	DQ_MeasureDesc	Free text
Measurement ID	DQ_MeasureID	Enumerated domain
Evaluation Method	DQ_EvalMethod	
Type	DQ_EvalMethodType	Enumerated domain 1-internal (direct) 2-external (direct) 3-indirect
Description	DQ_EvalMethodDesc	Free text or citation
Quality Result	DQ_QualityResult	
Value Type	DQ_ValueType	Enumerated domain 1-Boolean variable 2-number 3-ratio 4-percentage 5-sample 6-table 7-binary image 8-matrix 9-citation 10-free text 11-other
Value	DQ_Value	Record
Value Unit	DQ_ValueUnit	(depends on data quality value type)
Date	DQ_Date	ISO conform
Conformance Level	DQ_ConformanceLevel	Value or set of values

[13] Abstract classes are indicated italic characters.

Topological rules for GIS layers

River basins

must not overlap
must not have gaps
must be covered by extent of river basin districts
must not overlap with coastal waters
must not overlap with transitional waters
boundary must be covered by river sub basins
must cover features of river sub basins
must contain at least one river
must touch the coastline

River sub-basins

must not overlap
must not have gaps
must be covered by extent of river basin districts
must not overlap with coastal waters
must not overlap with transitional waters
must contain at least one river

River basin districts

must not overlap
must not have gaps
must cover features of river basins, surface water bodies, groundwater bodies, monitoring stations

Districts of competent authority

must not overlap
must not have gaps
must cover features of basin districts

(Main) Rivers

must not have dangles (exceptions are sources and mouths)
must not overlap
must not intersect (nodes at intersections)
must not touch interior
must be covered by boundary of river basins
mouths must touch river basin boundaries
must not overlap with coastal waters, transitional waters
must not intersect with river (sub) basins (nodes at intersections)
outlet of each feature must touch coastline

Lakes

must not overlap
must not overlap with coastal waters, transitional waters
must be covered by districts of competent authority, river basin districts

Transitional waters

must not overlap
must not overlap with coastal waters, rivers, lakes, river basins
must be covered by districts of competent authority, river basin districts

Coastal waters

must not overlap
must not overlap with transitional waters, rivers, lakes
must be covered by districts of competent authority, river basin districts
must touch transitional waters, river basins

Groundwater bodies

must be covered by districts of competent authorities, river basin districts

Monitoring stations

must be covered by area of districts of competent authorities, river basin districts

National boundaries on land and coastlines

must cover features of national delivery of river basins
boundary must be covered by national delivery of river basins

Examples of reporting data quality according to ISO 19115

Quantitative quality information

	Data quality component	Value	Description
	dqSope[14]		
	scpLvl	009	feature
	scpExt		Info on geographical extent
	geoEle		
	exTypeCode	1	inclusion
	GeoDesc		
	geoid		
	code	France	
or	*GeoDesc*		
	BoundPoly		
	polygon	x0,y0,x1,y1,…,xN-1,yN-1,x0,y0	
or	*Geodesc*		
	GeoBndBox		
	westBL	-10	
	eastBL	7	
	southBL	38	
	northBL	55	
	scpLvlDesc		
	featSet	river confluences, mouths	
	dqReport		
	DQAbsExtPosAcc		Positional accuracy, absolute external
	measName	Positional Accuracy of nodes in river network	
	measDesc	Horizontal positional accuracy at 95% confidence level	
	evalMethType	2	directExternal
	evalMethDesc	Divide area into 4 segments. Draw a proportional sample of a total of 20 nodes. For each of the selected nodes, measure the error distance between absolute co-ordinate values of the node in the dataset and those in the IMAGE2000 dataset (universe of discourse). Compute the RMSE (Root Mean Square Error) and the horizontal positional accuracy from the RMSE. see: http://www.fgdc.gov/standards/status/sub1_3.html	
	evalProc	Federal Geographic Data Committee	
	measDateTime	2002-06-07	
	measResult		
	QuanResult		
	quanvalType	number	
	quanValUnit	metre	
	quanVal	30	

[14] Abstract classes are indicated italic characters.

Data quality information	Value	Description
dqScope		
scpLvl	005	dataset
scpExt		Info on geographical extent
geoEle		
exTypeCode	1	inclusion
GeoDesc		
geoid		
code	EU	
GeoDesc		
BoundPoly		
polygon	x0,y0,x1,y1,…,xN-1,yN-1,x0,y0	
Geodesc		
GeoBndBox		
westBL	-30	
eastBL	35	
southBL	32	
northBL	72	
scpLvlDesc		
featSet	dataset	
dqReport		
DQCompOm		Completeness, Omission
measName	Missing water bodies	
measDesc	Number of water bodies missing	
evalMethType	2	directExternal
evalMethDesc	Select all inland water bodies in CLC dataset > 0.5 km^2 (universe of discourse) and verify existence of each select water body in the dataset. Count those water bodies, that are not present in the data set.	
measDateTime	2002-06-07	
measResult		
QuanResult		
quanvalType	number	
quanValUnit	features	
quanVal	20	
or ***dqReport***		
DQCompOm		Completeness, Omission
measName	Missing water bodies	
measDesc	Pass – Fail	
evalMethType	2	directExternal
evalMethDesc	Select all inland water bodies in CLC dataset > 0.5 km^2 (universe of discourse) and verify existence of each select water body in the dataset. Count those water bodies, that are not present in the data set.	
measDateTime	2002-06-07	
Result		
ConResult		
conSpec	Draft GIS data model	Citation
conExpl	All features shall be in the dataset	
conPass	1	0 = fail, 1 = pass

Non-quantitative data quality information

Data quality component	ShortName	Value
Purpose	idPurp	The Communes dataset is a general purpose geographic database for supporting different GIS applications of the European Commission.
Usage	specUsage	**Usage #1** Mapping of population statistics An important reason of the creation of the GISCO commune boundaries database is the use of these data in combination with the SIRE data in a Geographic Information System. Typical usage is the presentation of SIRE statistics in all kinds of maps. An illustrative example is the presentation of population statistics. **Usage #2** Structural Funds Another important usage of the GISCO commune boundaries database is the definition, validation, storage and monitoring of regions eligible for structural funding. In general complete municipalities are eligible, but in some cases they are only partly eligible. In Sweden, for example, a differentiation is made between the 'mainland' part of a municipality and the islands. Mainland and islands are eligible for different funds. Because in Sweden the original dataset of administrative boundaries did not include the islands explicitly, it is not possible to store and present eligibility for structural funds in a proper way only on the basis of administrative boundaries. **Usage #3** Degree of urbanisation Within the framework of the Labour Force Survey, municipalities are classified according to their 'degree of urbanisation'. Three classes of degree of urbanisation are defined on the basis of the algorithm below: densely populated, thinly populated and an intermediate class.
Lineage	dataLineage	**Source**: As a basis for the 1997 data set of the Commune boundaries for the European Union the SABE database of MEGRIN is used. The SABE database is compiled from official NGI sources. The source data are of the best available semantic quality and of the application scale the closest to 1:50,000 for each country. For the 1:1,000,000 scale coverage the 200 m resolution data from MEGRIN have been used. **Process Step**: Acquisition of SABE data sets. **Process Step**: Coding the CMFTTP **Process Step**: Structuring of data coverage according to overall database design requirements. - Integration of coastlines for SE, NO, FI, NL, HR, PL: Overlay the commune cover with the Scole (coastline). - Integration of lakes through an overlay of the commune cover with the lakes. - Topological quality. Sliver polygons were removed manually. Most sliver polygons were detected in those countries where the coastlines and lakes were integrated. **Process Step**: Appending all country coverages to one coverage. **Process Step**: Conversion to standard GISCO projection system: Lambert Azimuthal projection. **Process Step**: To make a unique coding the SHN code was combined with the country code, SHN = 031003 and ICC = PT makes CMRGCD97 = PT031003. Process Step: The NUTS 3 codes were filled with information from the NUEC1MV7 coverage. This was carried out by taking the commune points and overlaying them with the NUTS coverage. All points that

did not have a match with the NUTS coverage were removed. Then the point coverage was linked to the polygon coverage and the NUTS field in the polygon cover could be filled. All communes that did not have a NUTS code were coded manually. Lakes have been coded with 'LAK', e.g. in Italy lakes are coded 'ITLAK' as NUTS 3 code.
The CMRGCD could only be coded with NUTS level 5 codes for countries that have a link to the SIRE database. These are: AT, BE, DE, DK, ES, FI, IE, IT, LU, PT, SE. For all other countries the CMRGCD was coded with the lowest available NUTS code plus a number of X to fill the complete field.
The Eastern European countries were coded with NURGCD = 'EUCON' and CMRGCD = 'EU00000CON'. Lakes are coded according to the same principal 'EULAK' and 'EU00000LAK'. Within the Italian borders there are two communes that have been coded in a special way, i.e. the Vatican City (CMRGCD = VA00000CON) and San Marino (CMRGCD = SM00000CON).
Process Step: For those countries where a link exists to the SIRE database the name field (CMRGNM) could be filled with names from SIRE. For all other countries the name field has been filled with data provided with the SABE boundaries. These names are delivered as lower case and they contain special characters. According to the GISCO naming conventions the names had to be converted to UPPER case and all special characters were replaced with their **replace characters???**

Appendix VI: Reference System

ETRS89 Ellipsoidal Co-ordinate Reference System (*ETRS89*)

The European Terrestrial Reference System 1989 (ETRS89) is the geodetic datum for pan-European spatial data collection, storage and analysis. It is based on the GRS80 ellipsoid and is the basis for a co-ordinate reference system using ellipsoidal co-ordinates. The ETRS89 Ellipsoidal Co-ordinate Reference System (ETRS89) is recommended to express and to store positions, as far as possible.

Table 1 gives a full description of the ETRS89 Ellipsoidal Co-ordinate Reference System (ETRS89), following ISO 19111 Spatial Referencing by Co-ordinates.

Relationship between ellipsoidal and Cartesian co-ordinates

The co-ordinate lines of the ellipsoidal co-ordinate system are curvilinear lines on the surface of the ellipsoid. They are called parallels for constant latitude *(φ)* and meridians for constant longitude *(λ)*. When the ellipsoid is related to the shape of the Earth, the ellipsoidal co-ordinates are named geodetic co-ordinates. In some cases the term geographic co-ordinate system implies a geodetic co-ordinate system.

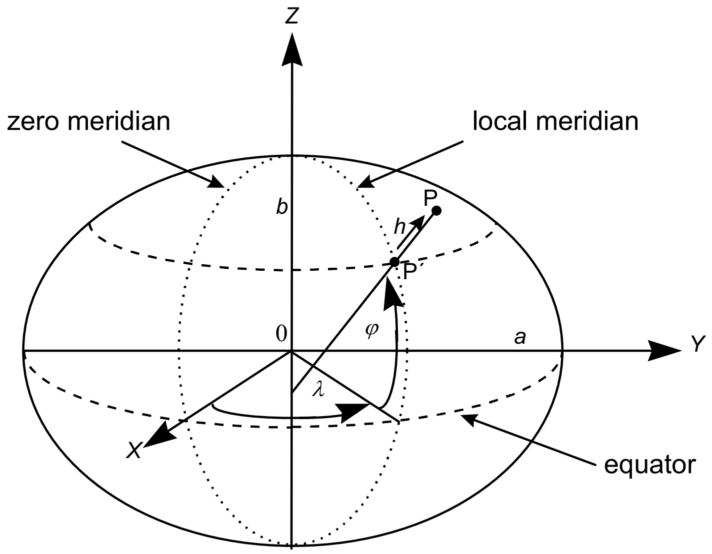


Figure 1 — Cartesian co-ordinates and ellipsoidal co-ordinates

If the origin of a right-handed Cartesian co-ordinate system coincides with the centre of the ellipsoid, the Cartesian *Z*-axis coincides with the axis of rotation of the ellipsoid and the positive *X*-axis passes through the point $\varphi = 0$, $\lambda = 0$.

Table 1 – ETRS89 Ellipsoidal Co-ordinate Reference System Description

Entity	Value
CRS ID	ETRS89
CRS alias	ETRS89 Ellipsoidal CRS
CRS valid area	Europe
CRS scope	Geodesy, Cartography, Geoinformation systems, Mapping
Datum ID	ETRS89
Datum alias	European Terrestrial Reference System 1989
Datum type	geodetic
Datum realization epoch	1989
Datum valid area	Europe / EUREF
Datum scope	European datum consistent with ITRS at the epoch 1989.0 and fixed to the stable part of the Eurasian continental plate for georeferencing of GIS and geokinematic tasks
Datum remarks	see Boucher, C., Altamimi, Z. (1992): The EUREF Terrestrial Reference System and its First Realizations. Veröffentlichungen der Bayerischen Kommission für die Internationale Erdmessung, Heft 52, München 1992, pages 205-213 or ftp://lareg.ensg.ign.fr/pub/euref/info/guidelines/
Prime meridian ID	Greenwich
Prime meridian Greenwich longitude	0°
Ellipsoid ID	GRS 80
Ellipsoid alias	New International
Ellipsoid semi-major axis	6 378 137 m
Ellipsoid shape	true
Ellipsoid inverse flattening	298.257222101
Ellipsoid remarks	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics
Co-ordinate system ID	Ellipsoidal Co-ordinate System
Co-ordinate system type	geodetic
Co-ordinate system dimension	3
Co-ordinate system axis name	geodetic latitude
Co-ordinate system axis direction	North
Co-ordinate system axis unit identifier	degree
Co-ordinate system axis name	geodetic longitude
Co-ordinate system axis direction	East
Co-ordinate system axis unit identifier	degree
Co-ordinate system axis name	ellipsoidal height
Co-ordinate system axis direction	up
Co-ordinate system axis unit identifier	metre

Appendix VII: Detailed Specifications for Metadata

1. Main metadata standardisation initiatives

Metadata is the information and documentation, which makes data understandable and shareable for users over time (ISO 11179, Annex B). We can distinguish different types of Metadata of increasing detail: Metadata for Inventory (i.e. internal to an organisation), Metadata for Discovery (i.e. that is necessary for external users to know who has what data, where to find it, and how to access it), and Metadata for Use (i.e. a fuller description of an information resource that enables users to make a judgement about the relevance and fitness-for-purpose of the resource before accessing it).

At the time of writing this report, no international standard on metadata is available. The European Committee on Standardisation (CEN) Technical Committee 287 developed a pre-standard on GI metadata in 1997, and the Federal Geographic Data Committee (FGDC) in the USA works at a national level on GI metadata standards.

Based on the experience of various standardisation bodies, the International Standardisation Organisation (ISO) is developing in its Technical Committee 211 a family of standards related to geo-spatial information, including one for metadata, ISO 19115. The resolution of the 14th plenary assembly of ISO TC 211 (Bangkok, 24-25 May 2002) has stated that the ISO standard No. 19115 Geographic Information – Metadata will be kept in the status FDIS and the date of publishing this document was postponed to December 2002.

In addition to the standardisation activities described above, other initiatives have emerged that gained wide support. One is the Dublin Core (DC) international initiative. It is not intended specifically for GI but focuses on the Discovery aspect of metadata related to multimedia in general. It helps discover information resources across disciplinary or sectoral domains.

Another relevant standard is ISO/IEC 11179, *Information technology — Specification and standardisation of data elements*. ISO/IEC 11179 is an international standard for formally expressing the semantics of data elements in a consistent manner, and is used as a base for many other standards, including DIS 19115.

Some organisations have already started to implement metadata, either in a proprietary "standard", or by adopting the recommendations of some national or international consensus process. Examples are the pre-standard of CEN/TC287, or the GISCO data dictionary. It is therefore desirable that appropriate migration mechanisms are set-out that allow to convert existing metadata into ISO 19115. Existing conversion, also called "mapping", exists between CEN/TC287 metadata elements and ISO 19115 and Dublin Core elements.

Recently the EC, EFTA and the European Committee for Standardisation (CEN) agreed to finance a project that will lead to an official mapping between Dublin Core elements and those of ISO 19115 (GI Metadata). The work, which takes form as a CEN Workshop Agreement (CWA), will result in three deliverables: the mapping (a draft of which is expected to be available by December 2002), a Guidance Document, and a spatial application profile. More information is available from http://www.cenorm.be/isss.

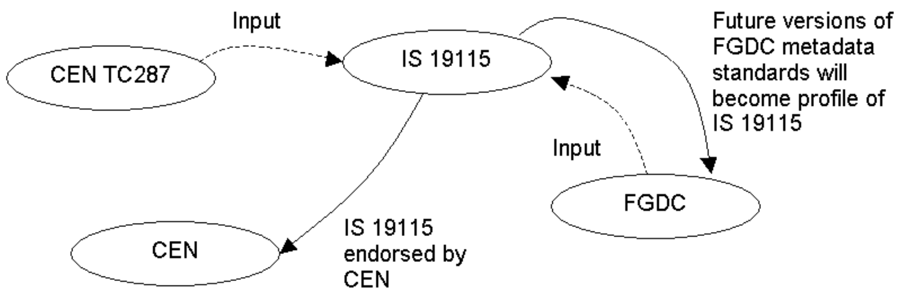


Figure 1: The CEN and FGDC (pre-)standards on metadata have given an important contribution to the creation of DIS 19115 (dashed lines).
No reference to Fig in text

2. ISO and the International Standard ISO 19115

ISO (the International Organisation for Standardisation) is a world-wide federation of national standards bodies (ISO member bodies). The International Standard ISO 19115 Geographic information - Metadata was prepared by Technical Committee ISO/TC 211: Geographic Information/Geomatics. ISO 19115, for example, highlights:

"*Digital geographic data is an attempt to model and describe the real world for use in computer analysis and graphic display of information. Any description of reality is always an abstraction, always partial, and always just one of many possible "views". This "view" or model of the real world is not an exact duplication; some things are approximated, others are simplified, and some things are ignored. There is seldom perfect, complete, and correct data. To ensure that data is not misused, the assumptions and limitations affecting the creation of data must be fully documented.*

Metadata allows a producer to describe a dataset fully so that users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use.

As geographic data producers and users handle more and more data, proper documentation will provide them with a keener knowledge of their holdings and will allow them to better manage data production, storage, updating, and reuse". (ISO 19115).

The creation of standard Metadata will:

- *"Provide data producers with appropriate information to characterise their geographic data properly.*
- *Facilitate the organisation and management of metadata for geographic data.*
- *Enable users to apply geographic data in the most efficient way by knowing its basic characteristics.*
- *Facilitate data discovery, retrieval and reuse. Users will be better able to locate, access, evaluate, purchase and utilise geographic data.*
- *Enable users to determine whether geographic data in a holding will be of use to them.*

This International Standard ISO 19115 defines general-purpose metadata, in the field of geographic information." (ISO 19115).

3. Scope of ISO 19115

The ISO 19115 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

This International Standard is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

This International Standard defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialised needs.

Though this International Standard is applicable to digital data, its principles can be extended to many other forms of geographic data such as maps, charts, and textual documents as well as non-geographic data.

4. Terms and definitions

data type	specification of the legal value domain and legal operations allowed on values in this domain *EXAMPLE:* Integer, Real, Boolean, String, Date, and SG_Point *NOTE:* A data type is identified by a term, e.g. Integer
dataset	identifiable collection of data *NOTE:* A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature or feature attribute contained within a larger dataset. A hardcopy map or chart may be considered a dataset.
dataset series	collection of datasets sharing the same product specification
metadata	data about data
metadata element	discrete unit of metadata *NOTE* 1: Equivalent to an attribute in UML terminology. *NOTE* 2: Metadata elements are unique within a metadata entity.
metadata entity	set of metadata elements describing the same aspect of data *NOTE* 1: May contain one or more metadata entities. *NOTE* 2: Equivalent to a class in UML terminology.
metadata section	subset of metadata which consists of a collection of related metadata entities and metadata elements

5. Metadata profile

The ISO 19115 for metadata comprises about 300 elements that exhaustively describe an information resource. Most of these elements are defined as being optional, i.e. they are not needed for compliance with the international standard but are defined for helping users to understand exactly the described data. Individual organisations may develop a profile of the standard according to their needs. A profile consists of the core metadata elements, an additional set of optional elements that are then declared as mandatory part of the profile. Additionally a profile may add elements, i.e. extensions that are not part of the international standard.

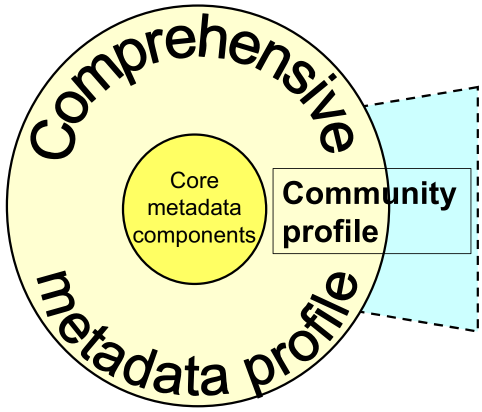


Figure 2: Metadata community profile
No reference to Fig in text

The ISO 19115 describes rules for defining community profiles and extensions. A profile must not change names, the definition or data types of metadata elements. A profile must include all core metadata elements of a digital geographic data set, all mandatory elements in mandatory sections as well as in conditional sections, if the data set meets the condition required by the metadata element. Relationships between the elements have to be identified. Finally, the profile has to be made available to any user of the metadata.

A profile has to follow the rules for defining extensions, too. Metadata extensions are used to impose more stringent obligations on existing metadata elements. In addition, an extension can limit or extend the use of domain values for describing metadata elements.

6. Core and mandatory elements of ISO 19115

The ISO 19115 consists of 22 core elements of which 12 are mandatory to comply with the international standard. The elements are described in Table 1. The mandatory elements focus on the discovery aspect of the metadata (catalogue purposes). Apart from?? information on the metadata itself, they provide information on the title, the category, the reference date, the geographic location, and a short description of the data and the data provider.

The core set expands the mandatory elements with additional information on the type, the scale, the format, the reference system and the data lineage. These elements give rough information on the potential usage of the data.

Table 1: Core metadata elements for geographic datasets (ISO/DIS 19115)

Information about the Metadata

1. Metadata language (C)	(MD_Metadata.language)
2. Metadata character set (C)	(MD_Metadata.characterSet)
3. Metadata file identifier (O)	(MD_Metadata.fileIdentifier)
4. Metadata standard name (O)	(MD_Metadata.metadataStandardName)
5. Metadata standard version (O)	(MD_Metadata.metadataStandardVersion)
6. Metadata point of contact (M)	(MD_Metadata.contact > CI_ResponsibleParty)
7. Metadata date stamp (M)	(MD_Metadata.dateStamp)

Information about the Dataset

8. Dataset title (M)	(MD_Metadata > MD_Identification.citation > CI_Citation.title)
9. **Dataset reference date (M)**	(MD_Metadata > MD_Identification.citation > CI_Citation > CI_Date.date and CI_Date.dateType)
10. Dataset responsible party (O)	(MD_Metadata > MD_Identification.pointOfContact > CI_ResponsibleParty)
11. Geographic location of the dataset (by four co-ordinates or by geographic identifier) (C)	(MD_Metadata > MD_DataIdentification.geographicBox or MD_DataIdentification.geographicIdentifier)
12. Dataset language (M)	(MD_Metadata > MD_DataIdentification.lauguage)
13. Dataset character set (C)	(MD_Metadata > MD_DataIdentification.characterSet)
14. Dataset topic category (M)	(MD_Metadata > MD_DataIdentification.topicCategory)
15. Spatial resolution of the dataset (O)	(MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance)
16. Abstract describing the dataset (M)	(MD_Metadata > MD_Identification.abstract)
17. Distribution format (O)	(MD_Metadata > MD_Distribution > MD_Distributor > MD_Format.name and MD_Format.version)
18. Additional extent information for the dataset (vertical and temporal) (O)	(MD_Metadata > MD_DataIdentification.extent > EX_Extent)
19. Spatial representation type (O)	(MD_Metadata > MD_DataIdentification.spatialRepresentationType)
20. Reference system (O)	(MD_Metadata > MD_ReferenceSystem)
21. Lineage statement (O)	(MD_Metadata > DQ_DataQuality > LI_Lineage.statement)
22. On-line resource (O)	(MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource)

- An “M” indicates that the element is mandatory.
- An “O” indicates that the element is optional.
- A “C” indicates that the element is mandatory under certain conditions.

Each of the ISO 19115 elements is further defined using a set of the following 7 attributes:

1. **Name.** A unique label assigned to a metadata entity or to a metadata element.
2. **Short name and domain code.** Short Name for each element.
3. **Definition.** The metadata element description.
4. **Obligation/Condition**. A descriptor indicating whether a metadata entity or metadata element shall always be documented or not. It may have values Mandatory, Conditional,

or Optional. Condition specifies an electronically manageable condition under which at least one metadata entity or a metadata element is mandatory.

5. **Maximum Occurrence.** Specifies the maximum number of instances the metadata entity or the metadata element may have.
6. **Data Type.** Specifies a set of distinct values for representing the metadata elements; for example, integer, real, string,
7. **Domain.** Specifies for each metadata element the values allowed or the use of free text.

7. Metadata information on data validation according to ISO 19115

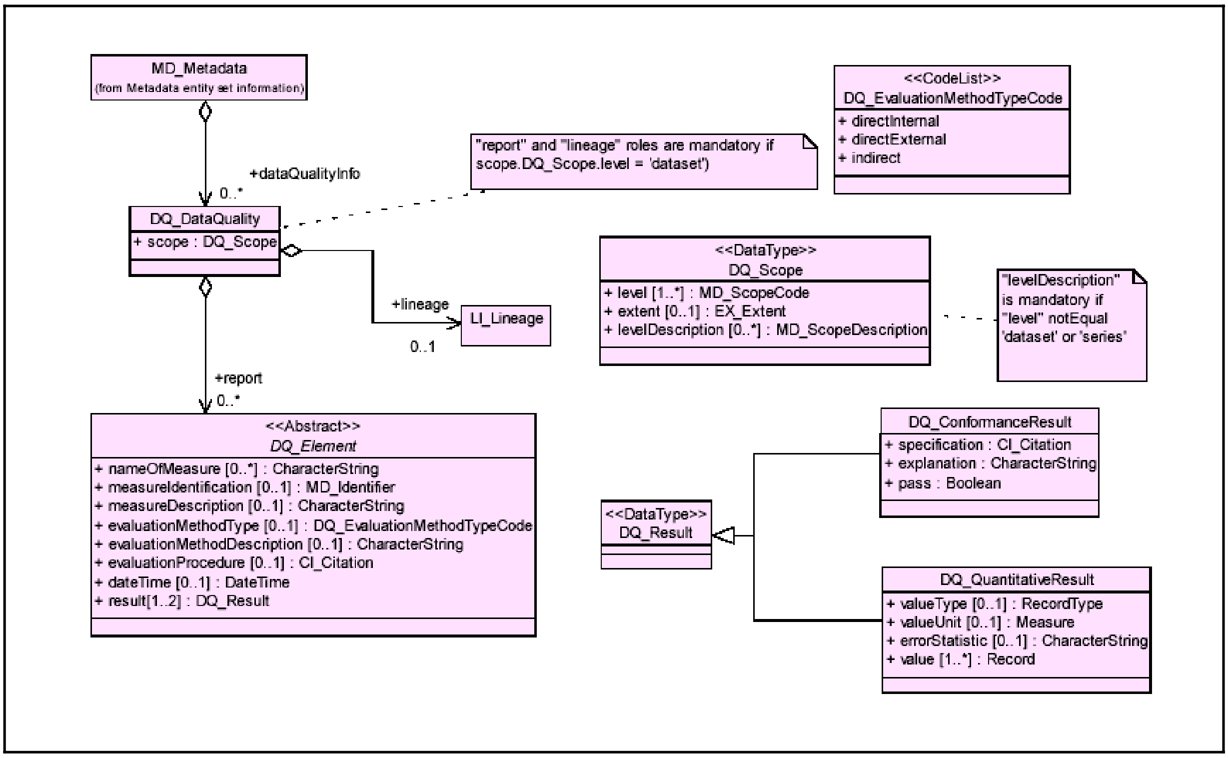


Figure 3: Conceptual model of metadata description on data quality

Bit difficult to read

Table 2: Elements to be integrated into the metadata profile

Name	**Description**	**ShortName**	**Obligation**	**Values**
MD_Identification		*Ident*		
Purpose	Rationale for creating a dataset and information on intended use; part of data quality overview elements	idPurp	O	
MD_USAGE		*Usage*		
SpecificUsage	Description of the application(s) for which the dataset has been used	SpecUsage	O	
DQ-DataQuality		DataQual	M	
Scope		dqScope	M	
Level	Hierarchical level of the data specified by the scope	scpLvl	M	
Extent	Information about the spatial extent, if test refers to spatial features	scpExt	C / scpLvl = dataset or series or feature or featureType	
EX_GeographicExtent		*GeoExtent*		
Ex_BoundingPolygon		*BoundPoly*	*C / if EX_GeographicBoundingBox and EX_GeographicDescription are empty*	
Polygon	Sets of points defining the bounding polygon	polygon	M	
EX_GeographicBoundingBox		*GeoBndBox*	*C / if EX_BoundingPolygon and EX_GeographicDescription are empty*	
westBoundLongitude	Western most co-ordinate, expressed in longitude in decimal degrees in ETRS89	westBL	M	
eastBoundLongitude	Eastern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	eastBL	M	
southBoundLatitude	Southern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	southBL	M	
northBoundLatitude	Northern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	northBL	M	
EX_GeographicDescription		*GeoDesc*	*C / if EX_BoundingPolygon and EX_GeographicBoundingBox are empty*	
geographicIdentifier		*geoID*		
code	Identifier used to represent a geographic area		M	
DQ_Scope		*DQScope*		
levelDescription		*scpLvlDesc*	*M*	*dataset,*

				series, ...
LI_LINEAGE		*Lineage*		
statement	General explanation of the data producer's knowledge about the lineage of the dataset	statement	C / DQ_Scope.level = "dataset" or "series" and source and processStep not provided	
processStep		*prcStep*	*C / statement and source are not provided*	
description	Description of an event in the creation process for the data specified by the scope, including related parameters or tolerances	stepDesc	M	
source			*C / statement and procStep are not provided*	
description	Detailed description of the level of the source data used in creating the data specified by the scope	srcDesc	M	
REPORT		*dqReport*		
DQ_Element	*The following information applies to one of the data quality elements or sub-elements.*	*DQElement*	*M / all tests specified in the handbook*	
nameOfMeasure	Name of the test applied to the data	measName	M	
measureIdentification	Code identifying a standard procedure as described in the handbook	measID	C / if measDesc, evalMethType, evalMethDesc not provided; ID according to Handbook	
measureDescription	Description of the measure being determined	measDesc	C / if measID not provided	
evaluationMethodType	Type of method used to evaluate quality of the dataset	evalMethType	C / if measID not provided	1=directInternal, 2=directExternal, 3=indirect
evaluationMethodDescription	Description of the evaluation method	evalMethDesc	C / if measID not provided	
dateTime	Date on which data quality measure was applied	measDateTime	M	
result	*Value (or set of values) obtained from applying a data quality measure (quantitative result) or the outcome of evaluating the obtained value against a specified acceptable conformance quality level (conformance result)*	*measResult*	*M*	
DQ_ConformanceResult		*ConResult*	*C / if DQ_QuantitativeResult not provided*	
specification	*Citation of product specification or user*	*ConSpec*	-	

	requirement against which the data is being evaluated			
title	Name by which the cited resource is known	ResTitle	M	
explanation	Explanation of the meaning of conformance for this result	conExpl	M	
pass	Indication of the conformance result	conPass	M	1 =pass, 0 = fail
DQ_QuantitativeResult		*QuanResult*	*C / if DQ_ConformanceResult not provided*	
valueType	Value type for reporting a data quality result	quanValType	M	
valueUnit	value unit for reporting a data quality result	quanValUnit	M	
Value	Quantitative value or values, content determined by the evaluation procedure used	quanVal	M	

Elements in **bold** are mandatory. Elements in *italics* are abstracts.

Explanation

The table (Table 2) describes the elements, that have to be integrated into the metadata profile for providing non quantitative quality information as well as information on applied data validation procedures as described in the part on data validation.

General information on the scope

The first part of the metadata documentation defines the scope to which the data quality information applies. The hierarchical level of the scope can be selected from a code list. If the information given is related to spatial features, then the geographic extent of the spatial features has to be specified. This can be done by means of a bounding polygon, a bounding rectangle or a geographic locator. All co-ordinates should be expressed in the ETRS89 co-ordinate reference system.

Lineage description

Non quantitative quality information is described as lineage of the dataset. For the description of lineage, there are three different alternatives. The first option is to include general information that summarises the knowledge of the data producer on the dataset. The second option is to give a detailed description on the data sources that were used to compile the dataset. The third option consists of an explanation of the processing steps that were applied to the dataset.

Quantitative quality information

Quantitative quality information is included in a report. The metadata profile distinguishes between reports on conformance testing and tests that yield a quantitative result. A quantitative result may be a value for the spatial accuracy of a dataset. A maximum acceptable error of distortion could be used as a threshold to determine whether the derived value is acceptable or not. The first information is related to a quantitative result, the second gives a conformance result.

The first item consists of information on the measurement that was applied to the data. Either there is an identifier that relates to the identifier in the handbook on data validation, or a description of the measurement has to be included. Depending on the type of test, conformance or quantitative result, either information on the conformance, i.e. title, explanation and result, or information on the measured values, i.e. type of value, unit and the value itself, have to be added to the metadata.

8. Metadata information on constraint information according to ISO 19115

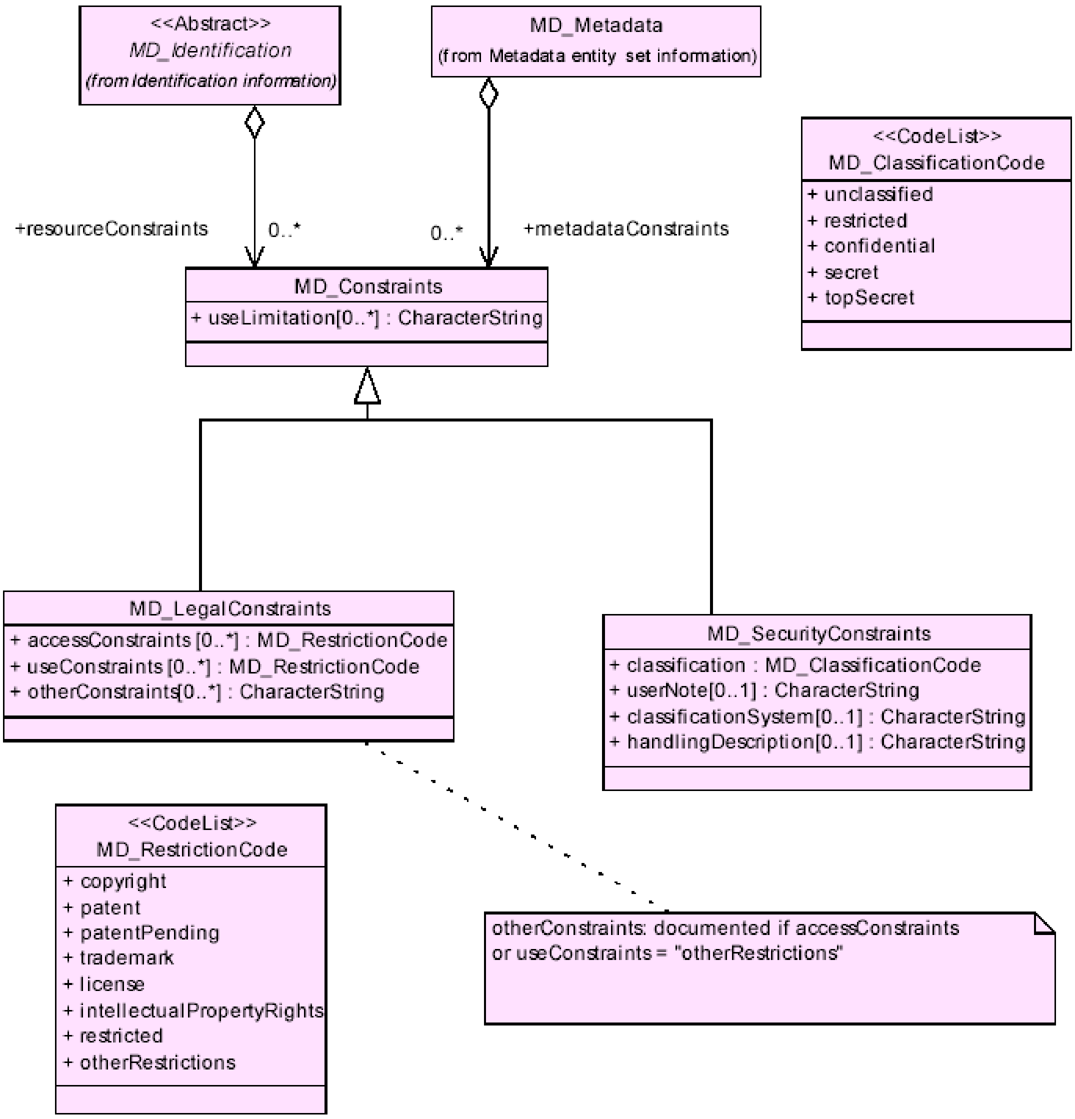


Figure 4: Constraint information

Table 3: Elements, to be integrated into the metadata profile for providing legal and security information.

Name	Description	ShortName	Obligation	Values
MD_Constraints	restrictions on the access and use of a resource or metadata	Consts	M Use obligation from referencing object	
UseLimitation	limitation affecting the fitness for use of the resource. Example, “not to be used for navigation”	useLimit	M	
MD_LegalConstraints	restrictions and legal prerequisites for accessing and using the resource	LegConsts	M	
AccessConstraints	access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource	accessConsts	M	
useConstraints	constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the resource	useConsts	M	
otherConstraints	other restrictions and legal prerequisites for accessing and using the resource	othConsts	C / accessConstraints or useConstraints equal “otherRestrictions”?	
MD_SecurityConstraints	handling restrictions imposed on the resource for national security or similar security concerns	SecConsts	M	
Classification	name of the handling restrictions on the resource	class	M	
UserNote	explanation of the application of the legal constraints or other restrictions and legal prerequisites for obtaining and using the resource	userNote	M	
HandlingDescription	additional information about the restrictions on handling the resource	handDesc	O	

Elements in bold are mandatory. Elements in italics are abstracts.

Explanation

The table (Table 3) describes the elements, that have to be integrated into the metadata profile for providing legal and security information.

Appendix VIII: Detailed Description of the GML Specification

Co-ordinates Element

A co-ordinate list is a simple list of co-ordinate tuples. The separators used to parse the co-ordinate list are encoded as attributes of the <co-ordinates> tag. In the example below, the co-ordinates in a tuple are separated by commas, and the successive tuples in the <co-ordinates> are separated by whitespace. A co-ordinate list is not a geometry in the Simple Features sense, merely the co-ordinate content. All tuples in the string must have the same dimension. A co-ordinate list is given by the following grammar.

```
<decimal>::='.'
<D>:=[0-9]
<cs>::=","
<ts>::=whitespace (see XML 1.0 [XML]
<co-ordinate>::='-'<D>+(<decimal><D>+)?
<ctuple>::=<ctuple>|<coordinate><cs><ctuple>
<coordinatelist>::=<coordinatelist>|<ctuple><ts><coordinatelist>
```

```
Note that the value of decimal, cs, and ts are determined by the GML
encoding of <co-ordinates>. The grammar is illustrated for default values
of decimal, cs and ts.
```

To find the co-ordinates of any Geometry class instance we introduce the co-ordinate property. We think of this as a function on the Geometry class instance that returns the co-ordinates as a co-ordinate list. The co-ordinate property has the associated DTD fragment:

```
<!ELEMENT co-ordinates (#PCDATA) >
<!ATTLIST co-ordinates
decimal CDATA #IMPLIED
cs CDATA #IMPLIED
ts CDATA #IMPLIED>
```

Note that the default for decimal is '.', for cs is ',' and for ts is whitespace.

<u>Example</u>

```
<co-ordinates decimal="." cs="," ts="whitespace">
1.03,2.167 4.167,2.34 4.87,3.0 1.06,2.3
</co-ordinates>
```

Point Element

The Point Element is used to encode instances of the Point geometry class. Each Point Element encloses a single co-ordinates element, the latter containing one and only one co-ordinate tuple. A Point geometry must specify a SRS in which its co-ordinates are measured. This is referenced by name. Thus the Point element has an srsName attribute. However this is defined to be optional. This is to allow the Point element to be contained in other elements which might have already specified a SRS. Similar considerations apply to the other geometry elements. The Point element also has an optional ID attribute. The DTD fragment for the Point element is as follows:

```
<!ELEMENT Point (co-ordinates) >
<!ATTLIST Point
ID CDATA #IMPLIED
srsName CDATA #IMPLIED>
```

LineString Element

A Line String is a piece-wise linear path. The path is defined by a list of co-ordinates that are then assumed to be connected by straight line segments. A closed path is indicated by having coincident first and last co-ordinates. At least two co-ordinates are required. The DTD fragment is as follows:

```
<!ELEMENT LineString (co-ordinates) >
<!ATTLIST LineString
ID CDATA #IMPLIED
srsName CDATA #IMPLIED >
```

LinearRing Element

A Linear Ring is a closed, simple piece-wise linear path. The path is defined by a list of co-ordinates that are then assumed to be connected by straight line segments. The last co-ordinate must be coincident with the first co-ordinate. At least four co-ordinates are required (the three to define a ring and the fourth duplicated one). Since a LinearRing is used in the construction of Polygons, which define their own SRS, it has no need to define a SRS. The DTD fragment is as follows:

```
<!ELEMENT LinearRing (co-ordinates) >
<!ATTLIST LinearRing
ID CDATA #IMPLIED >
```

Polygon Element

A Polygon is a connected surface. Any pair of points in the polygon can be connected to one another by a path. The boundary of the Polygon is a set of Linear Rings. We distinguish the outer (exterior) boundary and the inner (interior) boundaries. The Linear Rings of the interior boundary cannot cross one another and cannot be contained within one another. There must be at most one exterior boundary and zero or more interior boundary elements. The ordering of Linear Rings, whether they form clockwise or anti-clockwise paths, is not important. A Polygon is encoded via the DTD fragment:

```
<!ELEMENT Polygon (outerBoundaryIs, innerBoundaryIs*) >
<!ATTLIST Polygon
ID CDATA #IMPLIED
srsName CDATA #IMPLIED >
   <!ELEMENT outerBoundaryIs (LinearRing) >
   <!ELEMENT innerBoundaryIs (LinearRing) >
```

Appendix IX: Glossary of Terms

Term	Definition
Accuracy	Closeness of agreement between a test result and the accepted reference value (RDM)
Altitude	Elevation above or below a reference surface (RDM)
Architecture	The models, standards, technologies, specifications and procedures involved in using digital information
AST – INSPIRE	Standards and Architecture – INSPIRE Working group
Attribute	A defined characteristic of an entity type (e.g. composition) (RDM)
Attribute value	A specific quality or quantity assigned to an attribute
Background (Layer)	Display of an orthoimage in the background of other spatial data providing information on the context (RDM)
Bathing Directive	Directive 76/160/EEC
Birds Directive	Directive 79/409/EEC
Catalogue (1)	A mechanism for making third parties aware of available material. A clearinghouse directory. (ISF)
Catalogue (2)	Distributed service to locate geospatial data based on their characteristics expressed in metadata (ISF)
Catalogue services	Also called Clearinghouse. Cf. *Catalogue (2)* (AST - DERM)
CEN	REFCOND: European Committee for Standardization
Class	A set of objects that share the same attributes or characteristics
Clearinghouse (1)	A decentralised system of servers on the Internet which contain metadata (FGDC)
Clearinghouse (2)	A central agency for the collection, classification and distribution especially of information (RDM)
Completeness-attribute	The degree to which all relevant attributes of a features have been encoded (RDM)
Completeness - data	A measurable error of omission and commission observed between the database and the specification (RDM)
Completeness - model	The agreement between the database specification and the abstract universe (RDM)
Completeness - value	The degree to which values are present for all attributes
Concatenating	Combining two or more keys
Conformal projection	A projection on which all angles at each point are preserved. (RDM)
Conformance	Consistency with pre-stated capabilities and specifications
Conformance testing	Testing of a candidate product to determine the extent to which it satisfies the conformance requirements (RDM)
Consistency	Refers to the absence of apparent contradictions in a database. (RDM)

Co-ordinate(s)	Pairs of numbers (abscissa and ordinate) expressing horizontal distances along orthogonal axes (RDM)
Dangling node	Node connected to one line element only. Typically sources and outlets of river segments are dangling nodes.
Data	A formalised collection of facts, concepts or instructions for communication or processing by humans or by computer
Data dictionary	A catalogue of all data held in a database, or a list of items giving data names and structures
Data element	A logically primitive item of data
Data layer	Cf. *Layer*
Data model (1)	The result of the conceptual design process. A generalized, user-defined view of the data related to applications
Data model (2)	A formal method of describing the behaviour of the real-world entities. A fully developed data model specifies entity classes, relationships between entities, integrity rules and operations on the entities
Database	3.1 GIS: A collection of related data organised for efficient retrieval of information (RDM)
Dataset	3.1 GIS: A collection of data on a common theme or having similar attributes (RDM)
Dataset with geographic datatype	3.1 GIS: georeferenced digital dataset
Datum	A model of the earth's shape used for Geodetic calculations (RDM)
Delivery	The process of transferring possession from one individual or organisation to another
Digital Elevation Model (DEM)	A digital representation of a topographic surface (RDM)
Directive	Legal instrument binding as to the result to be achieved. Usually requires additional legislation at MS level
Dissemination	The publication of data to multiple users
Distribution	The process of moving products from supplier to consumer
Domain	Identifies valid values for a data element in the metadata standard definition (RDM)
Dublin Core	Metadata standard promoted by the Dublin Core Metadata Initiative (www.dublincore.org)
Elevation	Vertical height above a theoretical earth's surface base
Elevation	Cf. *Altitude*
Ellipsoid	The three-dimensional shape obtained by rotating an ellipse about its minor axis. (RDM)
Entity	A real world object that cannot be further subdivided into similar objects. (RDM)

Exclave	Polygon related to another polygon without having an explicit geometric relationship
Feature	A point, line or polygon in a spatial database that represents a real-world entity (RDM)
FGDC	Federal Geographic Data Committee (www.fgdc.gov)
Field	In database applications describes a space in which data of the same type is entered
Fish water Directive	Directive 78/659/EEC
Geographic Co-ordinates	A measurement of a location on the earth's surface expressed in degrees of latitude and longitude
Geographic data	The locations and descriptions of geographic features; the composite of spatial and descriptive data (RDM)
Geographic datatype	Category of geometric representation of geographic features (e.g. points, lines, polygons)
Geographic feature	Abstraction of a real world phenomenon associated with a location relative to the Earth (AST)
Geographic information	Information that is referenced to the earth's surface, whether by co-ordinates or by identifiers such as addresses
Geoid	The equipotential surface of the Earth's gravity field, which corresponds most closely with mean sea level and extends continuously through the continents.
Geometry	The scientific study of the properties of and relations between measures of points, lines and surfaces. In a GIS geometry is used to represent the spatial component of geographic features
Georeferencing	The process of determining the relation between the position of data in the co-ordinate system and its map location (RDM)
GIS	A system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth (UK Department of the Environment, 1987)
Grid	An array of equally sized square cells arranged in rows and columns referenced by geographic x,y location (RDM)
Habitats Directive	Directive 92/43/EEC
Harmonise/harmonisation	Be in line with, in accordance with, in conformity (AST)
Horizontal	Tangent to the geiod or parallel to a plane that is tangent to the geiod (RDM).
Horizontal/vertical	Horizontal means different user sectors; vertical means the global to local axis (ISF)
INSPIRE	Infrastructure for Spatial Information in Europe (http://egeols222.egeo.sai.jrc.it/inspire/)
ISF - INSPIRE	Implementing Structures and Funding - INSPIRE Working Group
Integration	The bringing together of previously segregated or separated units

Interoperability	The ability of two or more systems to operate in conjunction with each other (cf. RDM & IEEE 90). Semantic interoperability cf. Semantics
Lambert Azimuthal Equal Area	An azimuthal projection that sacrifices shape and distance but preserves area (RDM)
Lambert Conic Conformal	A projection of the earth's surface on a tangent cone normally based on two standard parallels (RDM)
Latitude	The angular distance along a meridian north or south of the equator expressed in degrees, minutes and seconds
Layer	A collection of similar features in a particular area referenced together for display on a map (RDM)
Level	The area over which unified specifications will apply, i.e. pan-European, national or local (RDM)
Line	A set of ordered co-ordinates that represent linear features with no area (RDM)
Location	Identifiable part (place) of the real world (RDM)
Long term	Usually held to be more than two years
Longitude	The angular distance east or west from a standard meridian such as Greenwich to the meridian of any place
Map	A graphical representation of a section of the earth's surface displayed on a planar surface
Map projection	Cf. Projection
Medium term	Usually held to be 6 months to 2 years
Member State (MS)	One of the (currently) fifteen members of the European Union
Metadata	Description of the characteristics of a set of data
Metadata element	One of the items that collectively form a metadata structure (OeE)
Metadata record	A full set of structured relevant metadata describing one information resource
Model	An abstraction of reality used to represent objects, processes or events. (RDM)
Nitrates Directive	Directive 91/676/EEC
Node	A zero-dimensional object that is the topological junction of two or more links or an end point of a link (RDM)
Object	The representation of a real-world entity with properties and relationships with other objects (RDM)
OpenGIS	Transparent access to heterogeneous geodata and geoprocessing resources in a networked environment (RDM)
Parse	Handling over of parameters from one transformation to another
Point	A zero-dimensional abstraction of an object represented by a single x,y co-ordinate (RDM)
Policy	A set of obligations, prohibition or permission rules that either constrain or enable action (AST)

Polygon	An irregular two-dimensional figure enclosing a pre -defined area or an area of common characteristics
Positional accuracy	The accuracy of the spatial component of a database. (RDM)
Precision	A measure of the statistical uncertainty equal to the half width of the C% confidence interval. For any one monitoring exercise, the estimation error is the discrepancy between the answer obtained from the samples and the true value. The precision is then the level of estimation error that is achieved or bettered on a specified (high) proportion C% of occasions.
Projection (1)	The technique used to convert the three-dimensional reality of the earth's surface into a two -dimensional image
Projection (2)	A mathematical model that transforms the reality of the earth's surface to a two-dimensional representation
Protocol	A conventional and accepted method of fulfilling a task
Prototype	A non-operational system for testing purposes
Quality	An essential or distinguishing characteristic necessary for cartographic data to be fit for use (RDM)
Quantitative status	Expression of the degree to which a body of groundwater is affected by direct and indirect abstraction *cf.* Art 2(28) 'good quantitative status'
RDM -INSPIRE	Reference data and metadata – Inspire working group
Reference data	Data necessary to identify the position of physical features in relation to other information in a geospatial context
Reference system	A method for identifying and relating different positions on the earth's surface
Scale	The relation between the dimensions of features on a map and the objects they represent on the earth (RDM)
Scale – large	> 1:25,000 with resolution range < 2.5m (RDM)
Scale – medium	1:25,000 to 1:250.000 with resolution range 10m
Scale – small	< 1:250.000 with resolution range > 100m (RDM)
Schema	Visual representation and simplification of complex relationships and dependencies.
Semantics	The meaning of words
Short term	Usually held to be up to six months
Spatial accuracy	Cf. *Positional accuracy*
Spatial data / information	Identifies the geographic location and characteristics of features and boundaries on the earth (RDM)
Spatial data set	Cf. data set with *geographic datatype*
Spatial Data Infrastructure	The relevant base of technologies, policies and institutional arrangements that facilitate data availability and access
Spatial resolution	The ground dimensions of the pixels making up the digital image (RDM)
Specification/s	A detailed description of construction and performance

Standard(s)	Includes the ISO 19100 series of standards, OGC, CEN and others
Symbology	Visual representation, simplification and classification of objects
Tabular	Data arranged in tables or lists
Topology	Properties of geometric forms remain invariant when the forms are deformed or transformed (RDM)
Transformation	Set of sequentially applied computer instructions yielding a change of one or more parameters.
Transverse Mercator	A projection resulting from projecting the sphere onto a cylinder tangent to a central meridian (RDM)
Type specific reference conditions.	2.3 REFCOND: Reference conditions (see separate definition) representative for a specific water body type.
Tuple	Unique set of parameters in a relational database.
Typology	The study and interpretation of types
Urban Waste Water Treatment Directive	Directive 91/271/EEC
Vector	Ordered list of co-ordinates used to represent linear features
Vertical	At right angles to the horizontal; includes altitude and depth (RDM)
Web mapping	The provision of map based information services on the Internet

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[1] *Country Codes follow ISO 3166-1-Alpha-2: Country names and code elements (http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1/en_listp1.html)*

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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 10

River and lakes – Typology, reference conditions and classification systems

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 10

Rivers and Lakes – Typology, Reference Conditions and Classification Systems

Produced by Working Group 2.3 – REFCOND

A great deal of additional information on the European Union is available on the Internet.
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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In the context of this strategy, the project "Development of a protocol for identification of reference conditions, and boundaries between high, good and moderate status in lakes and watercourses" was launched in December 2000 and named REFCOND. During 2001 the REFCOND project was widened to an informal working group included in the Common Implementation Strategy (working group 3.2). The final document to be produced was also changed from a more formal and binding protocol to a non-legally binding Guidance Document. Sweden is the lead country with responsibility of the co-ordination of the working group that is composed of ecologists and technical experts from governmental and non-governmental organisations. The Swedish Environmental Protection Agency (SEPA) has the responsibility for the administration and management and the Swedish University of Agricultural Sciences, as sub-contractor to SEPA, has the responsibility for the scientific project management.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the REFCOND group activities and discussions that have taken place since December 2000. It builds on the input and feedback from a wide range of experts and stakeholders from EU Member States and candidate countries that have been involved throughout the process of guidance development through meetings, workshops, conferences or electronic communication media, without binding them in any way to its content.

"*We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance through written procedure during April 2003. We would like to thank the participants and, in particular, the Swedish leaders of the Working Group, for preparing this high quality document.*

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive. This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work. Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation."

Table of contents

Introduction - A Guidance Document: What for?

To whom is this Guidance Document addressed?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the implementation of the Annexes II and V with special emphasis on inland surface waters and methods and principles for the establishment of reference conditions and class boundaries between high, good and moderate ecological status. If this is your task, we believe the Guidance will help you in doing the job, whether you are:

- *Establishing reference conditions and ecological status class boundaries for inland surface waters yourself or participating in the process as a stakeholder;*
- *Leading and managing experts undertaking the ecological status analysis;*
- *Using the results of the ecological status analysis for taking part to the policy making process; or*
- *Reporting on the ecological status analysis to the European Union as required by the Directive.*

What can you find in this Guidance Document?

Purposes and timing (Section 1)

- *What is the role of the key elements in the REFCOND Guidance Document within the implementation process of the Directive?*
- *The timetable of the Directive - When are Member States expected to deliver something that requires that reference conditions and class boundaries have been established?*

Common understanding of concepts and terms (Section 2)

- *What are the key elements of the Water Framework Directive relating to reference conditions and ecological status classes?*
- *Where in the Directive are these elements made explicit or referred to?*
- *Which is the common understanding of the concepts "reference conditions" and "high ecological status", "good" and "moderate ecological status", "surface water bodies, "wetlands", "water body types" and "classification of ecological status" incorporating the Directive's terminology and requirements?*

Principles and methods for establishing reference conditions and ecological status class boundaries (Section 3)

- *Which are the key steps in the suggested approach for establishing reference conditions and ecological quality class boundaries?*
- *Which infrastructure is needed for a successful implementation of the suggested approach?*
- *How can differentiation of water body types be done in order to support the establishment of reference conditions and the intercalibration exercise?*

- *How can ecological criteria and pressure criteria be used in site selection and for setting class boundaries?*
- *What benchmark should we use to determine very minor and slight disturbance in terms of pressure criteria?*
- *What methods can be used to establish reference condition values and what are the strengths and weaknesses of different methods?*
- *How can reference conditions and quality class boundaries be validated?*
- *How can " sufficient level of confidence about the values for the reference conditions" be dealt with?*
- *How can "adequate confidence and precision in the classification of the quality elements" be dealt with?*
- *Which are the circumstances for excluding quality element indicators when establishing reference conditions?*
- *How can the ecological quality class boundaries be set, and are there any alternative approaches?*

The Toolbox (Section 4)

- *Which specific tools are available for establishing reference conditions and ecological quality class boundaries?*
- *How can these tools be further developed and tested in order to be tailored for different water body types, different pressures-impacts and different quality elements?*

Good practice Examples (Section 5)

- *What examples are available of current good practice in respect of at least one aspect of the suggested approach for establishing reference conditions and ecological quality class boundaries?*

Adaptation to regional and national circumstances

The Guidance Document proposes an overall methodological approach. Because of the diversity of circumstances within the European Union, the way to deal with the logical approach and answer to questions will vary from one river basin to the next. The proposed methodology would therefore need to be tailored to specific circumstances.

What you will <u>not</u> find in this Guidance Document

The Guidance Document focuses on definitions, methods, principles and criteria to be used when establishing reference conditions and when setting the boundaries between high, good and moderate ecological status for inland surface waters. The document does not include guidance for specific quality elements and specific water body types but is restricted to general guidance that applies to most quality elements and most inland surface water body types. The Guidance does not focus on:

- *Groundwater, transitional water and coastal water (handled by CIS Working Group 2.8 (groundwater) and 2.4 (coastal and transitional water));*
- *Classification of poor and bad ecological status;*
- *Emission limit values and environmental quality standards for classification of chemical status (handled by Expert Advisory Forum on Priority Substances);*

- *Method standardisation and intercalibration (intercalibration is handled by CIS working group 2.7).*

Section 1. Introduction - Implementing the Directive

This Section introduces the overall context for the implementation of the Water Framework Directive and informs on the initiatives that led to the production of this Guidance Document.

1.1 December 2000: A Milestone for Water Policy

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force.

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the Water Framework Directive.

1.2 Purposes and timing

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- *Prevents further deterioration and protects and enhances the status of water resources;*
- *Promotes sustainable water use based on long-term protection of water resources;*
- *Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;*
- *Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and*
- *Contributes to mitigating the effects of floods and droughts.*

Overall, the Directive aims at preventing deterioration of the status of all bodies of surface water and achieving *good water status* for all waters by 2015. For surface waters, "good status" is determined by a "good ecological status" and a "good chemical status". Ecological status is determined by biological quality elements, supported by hydromorphological and physico-chemical quality elements. The point of reference is given by "undisturbed" conditions showing no or only "very minor" human impacts.

The various articles of the directive describe what shall be done and the sometimes rather elaborate annexes are to be seen as a way to help Member States in doing the job and achieving the overall purpose of the directive. Hence, although the text at a first reading may seem difficult to comprehend, the purpose that it is intended to result in is simple and easy to understand.

The present Guidance Document (REFCOND Guidance) will, together with the other Guidance Documents published by the Commission, help Member States achieve that purpose. It does so by advising on how member states may proceed to establish reference conditions and ecological status class boundaries for lakes and watercourses.

It should be pointed out here, that the REFCOND Guidance does not provide solutions in detail that may be copied and applied as such. Rather, it offers principles, ways of reasoning and suggestions on alternative pathways of action. It is up to Member States themselves to implement these principles and suggestions under their own circumstances and to be able to verify that the solutions meet the requirements of the directive. Harmonization between Member States will be achieved through intercalibration (which is described in WFD CIS Guidance Document No. 6) and participation in the work in Pilot River Basins and International River Basin Districts.

Guidance on the establishment of reference conditions and class boundaries are needed at several stages in the implementation of the directive (Figure 1). They will first be needed for the selection of sites for the draft register of intercalibration sites which should be completed in December 2003. More specifically, criteria for selecting minimally disturbed sites (on the high/good boundary) and slightly disturbed sites (on the good/moderate boundary) representative of different water body types will be needed. The present Guidance Document will also be needed for selection of complementary sites for the final register of intercalibration sites which should be completed in December 2004. The actual intercalibration exercise should be completed 18 months after the final register of sites has been established (described in WFD CIS Guidance Document No. 6 on intercalibration). As the intercalibration exercise will be completed before the monitoring programmes are fully operational (see Figure 1) pressure criteria for selection of sites will have to be used together with existing survey data on ecological status.

The analysis of characteristics of River Basin Districts and the assessment of the risk for individual water bodies of failing the environmental objectives in accordance with Article 5 and Annex II in the Directive will also require guidance on reference conditions and classification. This analysis should be completed at the latest in December 2004. As the monitoring programmes will not be fully operational this risk assessment will have to rely very much on pressure information.

According to Article 8 of the Directive monitoring programmes shall be operational at the latest in December 2006. The REFCOND Guidance will here be needed for the specification of the monitoring requirements of reference sites (high status sites) and assessing ecological status of all monitoring sites.

Finally, the REFCOND Guidance will be needed when producing the first River Basin Management Plans which should be published at the latest in December 2009. In these plans type-specific reference conditions shall be listed together with map presentations on ecological status classifications for surface waters.

The dates given in Figure 1 outline the time schedule for Member States to deliver documentation indicating that reference conditions and class boundaries have been established. In practice this means that work has to be done well in advance and should be started immediately. The time needed to do the job will vary with circumstances, such as the variability and complexity of the water bodies in Member States as well as the available expertise.

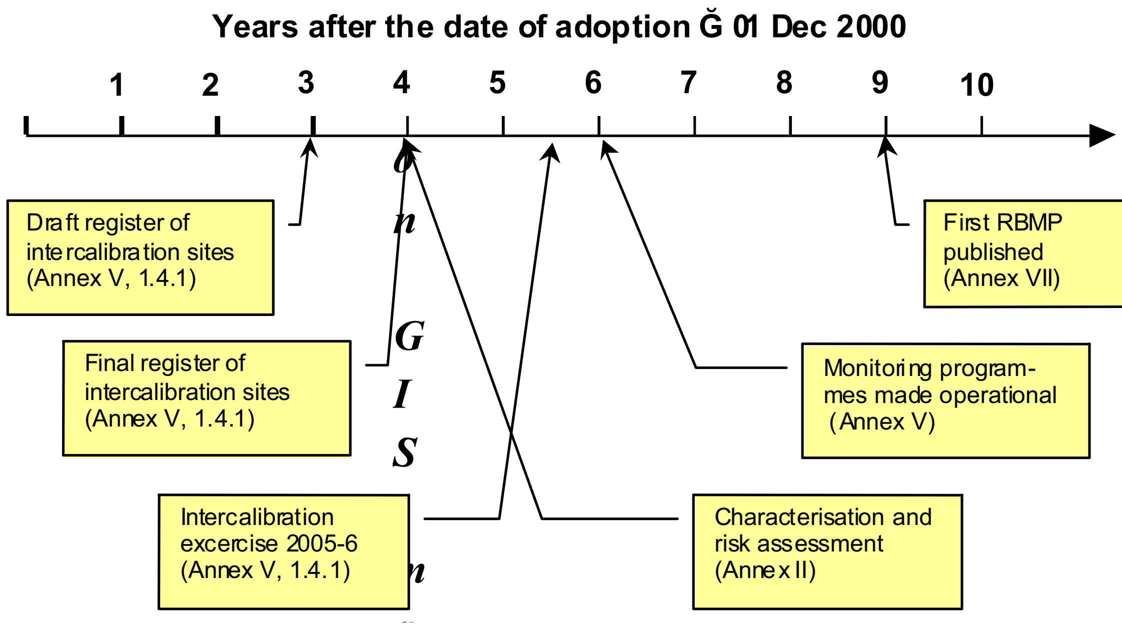

Figure 1. *Timetable for implementation of parts of the Water Framework Directive which are depending on Guidance from WG 2.3 (REFCOND).*

1.3 What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (Article 3, Article 24);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, establishing a register of protected areas lying within the river basin district and finally assessment of the risk for individual water bodies of failing the environmental objectives by 2004 (Article 5, Article 6, Annex II, Annex III);
- To make operational the monitoring networks by 2006 (Article 8);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (Article 11, Annex III);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- To make the measures of the programme operational by 2012 (Article 11);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (Article 4)

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water

Framework Directive offers the possibility to Member States to engage into two further six-year cycles of planning and implementation of measures.

1.4 Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

1.5 Integration: a key concept underlying the WFD

The central concept to the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- ➢ **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- ➢ **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- ➢ **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- ➢ **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- ➢ **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- ➢ **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- ➢ **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;

- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States, for river basins** shared by several countries, existing and/or future Member States of the European Union.1.6 What is being done to support implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support for the implementation of the Water Framework Directive by developing coherent and common understanding and Guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community (see Annex I for the overall structure of the Common Implementation Strategy).

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance Documents (see Table 1). A strategic co-ordination group (SCG) oversees these working groups and reports directly to the water directors of the European Union and the Commission that play the role of overall decision body for the Common Implementation Strategy.

Table 1. Working Groups in the "Common Implementation Strategy" with description of lead countries/organisations (see also Annex A).

Working group	**Lead**
2.1 Analysis of pressures and impacts (IMPRESS)	UK & Germany
2.2 Heavily modified water bodies (HMWB)	UK & Germany
2.3 Reference conditions and ecological status class boundaries for inland surface waters (REFCOND)	Sweden
2.4 Typology, classification of transitional & coastal waters	UK, Germany, France, Sweden & EEA
2.5 Intercalibration	Joint Research Centre
2.6 Economic analysis (WATECO)	France & Comm.
2.7 Monitoring	Italy & EEA (ETCw)
2.8 Tools on assessment & classification of groundwater	Austria

Working group	Lead
2.9 Best practices in river basin planning	Spain
3.1 Geographical Information Systems, GIS	Joint Research Centre
4.1 Integrated testing in Pilot River Basins	Comm., SCG

1.6 Working group 2.3 – REFCOND

A working group has been created to deal specifically with issues relating to the establishment of reference conditions and ecological status class boundaries for inland surface waters. The short-term objective of this working group, with the acronym REFCOND, was the development of a non-legally binding and practical guidance to support the implementation of the relevant parts of the Water Framework Directive, specifically the Annexes II and V.

The members of the REFCOND group are ecologists and technical experts from governmental and non-governmental organisations from each European Union Member States and from Norway. A number of candidate countries and stakeholders have also been involved in the working group. A list of REFCOND partners and other contacts is given in Annex B.

To ensure an adequate input and feedback during the Guidance development phase from a wider audience, the REFCOND group has organised three workshops. The first workshop, with focus on the review of techniques and principles used in Member States for identification of reference conditions and boundaries between quality classes, was held in Uppsala, Sweden, 14-15 May 2001. The second workshop, with focus on evaluation of techniques used for establishing reference conditions and quality class boundaries, was held in Ispra, Italy 5-6 December 2001. The third workshop, with focus on review and validation of the first draft Guidance Document, was held in Stockholm, Sweden, 5-6 September 2002. Full documentation of presentations, group discussions etc are currently available at the Circa System and at the REFCOND web site (http://www-nrciws.slu.se/REFCOND/).

A questionnaire has been used to collect information for the review of techniques and principles used in Member States for identification of reference conditions and boundaries between quality classes using the quality elements included in the WFD. The questionnaire and a summary of the questionnaire returns are available at the Circa System and the REFCOND web site (see above).

Based on the questionnaire returns and other available information four discussion papers have been produced by the REFCOND group to be used for the evaluation of techniques used in Member States (De Wilde & Knoben 2001, Johnson 2001, Owen et al. 2001 and Van de Bund 2001). These documents are concerned specifically with the processes involved in the definition and setting of reference conditions, the setting of class boundaries and typology. All papers are available at the Circa System and the REFCOND web site (see above).

The present Guidance Document is based on information from REFCOND workshops, questionnaire returns, discussion papers for evaluation of techniques and other available information, e.g. from on-going EU and national research projects, CEN (European Committee for Standardization), national strategy papers and from literature reviews.

Developing the Guidance Document: an interactive process

Within a very short time period, a large number of experts have been involved at varying degrees in the development of this Guidance Document. The process has included the following activities:

- Regular meetings with the REFCOND lead group;
- Regular meetings with the Strategic Co-ordination Group and meetings with the other work group leaders in Brussels;
- Organisation of three workshops to follow up the work programme and preliminary output of REFCOND;
- Regular interactions with experts from other working groups of the Common Implementation Strategy, mainly those dealing with typology and classification of transitional and coastal waters (WG 2.4) and intercalibration (WG 2.5);
- Regular interactions with experts from past and on-going EU-funded research projects, mainly AQEM, STAR, FAME and EUROLAKES;
- Participation in several meetings and workshops organised by Member States, European organisations or EU on the subject of reference conditions and ecological status classifications.

In Annex E of this document past and on-going EU-funded research projects relevant for REFCOND are listed with full names, acronyms and web sites if available.

Section 2. Common understanding of concepts and terms

2.1 Reference conditions and high ecological status

Excerpts from the Directive pertaining to reference conditions and high ecological status:

Annex II: 1.3 (i-vi) Establishment of type-specific reference conditions for surface water body types:

> *For each surface water body type….type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydro-morphological and physico-chemical quality elements specified….for that surface water body type at high ecological status….Type-specific biological reference conditions shall be established, representing the values of the biological quality elements…for that surface water body type at high ecological status….*
>
> *…. Type-specific biological reference conditions may be either spatially based or based on modelling, or may be derived using a combination of these methods. Where it is not possible to use these methods, Member States may use expert judgement to establish such conditions.*
>
> *Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods. The methods shall use historical, palaeological and other available data ….*

Annex V: 1.2 Normative definitions of ecological status classifications. Table 1.2. General definition of high ecological status:

> *There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.*
>
> *The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion.*

Annex V: 1.2.1-1.2.2 Definitions for high, good and moderate ecological status. Values of quality elements at high status:

Tables 1.2.1 (rivers) and 1.2.2 (lakes) provide normative definitions of high ecological status in rivers and lakes for each biological, physico-chemical and hydromorphological quality element. In every case, the definition includes the following clause in the status description of the biological quality elements:

> *The [specific quality element value] "corresponds totally, or nearly totally, to undisturbed conditions".*

In addition, more specific criteria are provided for specific pollutants:

> **Specific synthetic pollutants:** *"concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use".*
>
> **Specific non-synthetic pollutants:** *"concentrations remain within the range normally associated with undisturbed conditions (background levels)".*

Conclusions and recommendations

- Reference conditions (RC) do not equate necessarily to totally undisturbed, pristine conditions. They include very minor disturbance which means that human pressure is allowed as long as there are no or only very minor ecological effects;
- RC equal high ecological status, i.e. no or only very minor evidence of disturbance for each of the general physico-chemical, hydromorphological and biological quality elements;
- RC shall be represented by values of the relevant biological quality elements in classification of ecological status;
- RC can be a state in the present or in the past;
- RC shall be established for each water body type;
- RC require that specific synthetic pollutants have concentrations close to zero or at least below the limits of detection of the most advanced analytical techniques in general use[1];
- RC require that specific non-synthetic pollutants have concentrations remaining within the range normally associated with undisturbed conditions (background values)[2];

The last two bullet points above have been subject to a long debate (cf. OSPAR) and it is clear that no scientific specification can be given for terms like "close to zero". These issues are being examined by a sub group of the Expert Advisory Forum on Priority Substances dealing with Analysis and Monitoring (AMPS). It is recommended that the approach adopted by the EAF PS, AMPS group, be adopted for substances for which national detection limits and background concentrations are to be set.

2.2 Good and moderate ecological status

Excerpts from the Directive pertaining to good and moderate ecological status:

Annex V: 1.2 Normative definitions of ecological status classifications.. Table 1.2 General Definitions

> **Good ecological status:** *The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.*
>
> **Moderate ecological status:** *The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.*

[1] Examples on how to select the specific pollutants that are relevant to a particular water body are described in the Guidance Document from Working Group 2.1 (WFD CIS Guidance Document No. 3 - IMPRESS).
[2] See footnote 1.

Annex V: 1.2.1-1.2.2 Definitions for high, good and moderate ecological status. Values of quality elements at good and moderate status:

Table 1.2.1 (rivers) and 1.2.2 (lakes) provides normative definitions of good and moderate ecological status in rivers and lakes for each biological quality element. In every case, the definition includes the following clause in the status description:

> **Good ecological status:** *There are slight changes in the [specific biological quality element] compared to the type-specific communities.*
>
> **Moderate ecological status:** *The [specific biological quality element] differs moderately from the type specific communities. The values are significantly more disturbed than under conditions of good status.*

For general physico-chemical quality elements it is stated that the conditions for good ecological status should *"not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements"* (Annex V: 1.2).

In addition, more specific criteria are provided for good ecological status for synthetic pollutants:

> **Specific synthetic and non-synthetic pollutants***: "concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 (environmental quality standards - EQS)*[3]*".*

Conclusions and recommendations

For any surface water body type in **good ecological status** the following criteria should be met:

- The values of the biological quality elements show slight deviation from reference conditions (low levels of distortion resulting from human activity);
- The levels of the general physico-chemical quality elements do not exceed the range ensuring ecosystem functioning and the achievement of the values associated to biological quality elements at good status;
- Concentrations of specific synthetic and non-synthetic pollutants are not in excess of environmental quality standards (EQS) established in accordance with Annex V 1.2.6. or under relevant Community legislation.

For any surface water body type in **moderate ecological status** the following criteria should be met:

- The values of the biological quality elements show moderate deviation from reference conditions (moderate signs of distortion resulting from human activity);
- Conditions consistent with the achievement of values for the biological quality elements and significantly more disturbed than under conditions of good status.

[3] Detailed procedures for the establishment of EQS is under elaboration in the Expert Advisory Forum on Priority Sub-stances.

2.3 Surface water bodies

Excerpt from the Directive pertaining to surface water bodies:

Article 2, point 10:

> *"Body of surface water" means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water".*

The recommendations given below are mainly based on the WFD CIS Guidance Document No. 2 on the application of the term "water body" in the context of the WFD.

Most of the elements of the Directive's definition of surface water body are relatively clear and do not require further elaboration. The WFD CIS Guidance Document No. 2 provides guidance to two other points that do need to be elaborated, however, namely size and whether parts of lakes or watercourses may be regarded as water bodies.

Concerning the second point, the WFD CIS Guidance Document No. 2 explicitly says that significant changes in status (i.e. level of impact) should be used to delineate water bodies so that water bodies provide for an accurate description of water status. This means that rivers and lakes may be sub-divided into those parts that are impacted by human activities and those parts that are not or not much affected, e.g. a lake may be split into more than one "water body". Sub-divisions of surface waters into smaller and smaller water bodies that does not support a clear, consistent and effective application of its objectives should, however, be avoided.

The purpose of the Directive is to establish a framework for the protection of all waters including inland surface waters, transitional waters, coastal waters and groundwater[4]. Member States must ensure that the implementation of the Directive's provisions achieves this purpose. However, surface waters include a large number of very small waters for which the administrative burden for the management of these waters may be enormous.

The Directive does not include a threshold for very small "water bodies". However, the Directive sets out two systems for differentiating water bodies into types[5]. System A and System B. Only the System A typology specifies values for size descriptors for rivers and lakes. The smallest size range for a System A river type is 10 – 100 km^2 catchment area[6]. The smallest size range for a System A lake type is 0.5 – 1 km^2 surface area[7]. No sizes for small transitional and coastal waters are given. The application of system B must achieve, at least, the same level of differentiation as system A. It is therefore recommended to use the size of small rivers and lakes according to system A. However, it is recognised that in some regions where there are many small water bodies, this general approach will need to be adapted. Having said that, it may be appropriate to aggregate water bodies into groups for certain purposes as outlined in the WFD CIS Guidance Document No. 2 on water bodies in order to avoid unnecessary administrative burden.

[4] Article 1
[5] Annex II 1.2
[6] Annex II 1.2.1
[7] Annex II 1.2.2

However, there are still large numbers of discrete rivers and lakes that are smaller than these thresholds. A possible approach for the protection of these waters is outlined in the WFD CIS Guidance Document No. 2.

Conclusions and recommendations

- "Surface water bodies" must not overlap with each other;
- A surface water body must not cross the boundaries between surface water body types;
- Physical features (geographical or hydromorphological) that are likely to be significant in relation to the objectives of the Directive should be used to identify discrete elements of surface water;
- A lake or reservoir will normally be identified as one water body. However, where different reference conditions apply within a lake due to morphological complexity (e.g. sub-basins), the lake must be sub-divided into separate water bodies (see example in Figure 2). Furthermore, where there are significant differences in status in different parts of a lake, the lake must be sub-divided into separate water bodies to achieve the desired environmental outcome in the most cost effective way;
- A whole river, stream or canal can be a "water body". However, where different reference conditions apply within a river stream or canal, it must be sub-divided into separate water bodies. Furthermore, where there are significant differences in status in different parts of a river, stream or canal, it must be sub-divided into separate water bodies to achieve the desired environmental outcome in the most cost effective way;
- The lower size limit of surface water bodies may be set lower than the ones prescribed in typology system A (described in Annex II of the Directive) in certain cases, i.e. if Member States decide that certain smaller water bodies are significant and require separate identification. This is of specific ecological relevance for lakes.

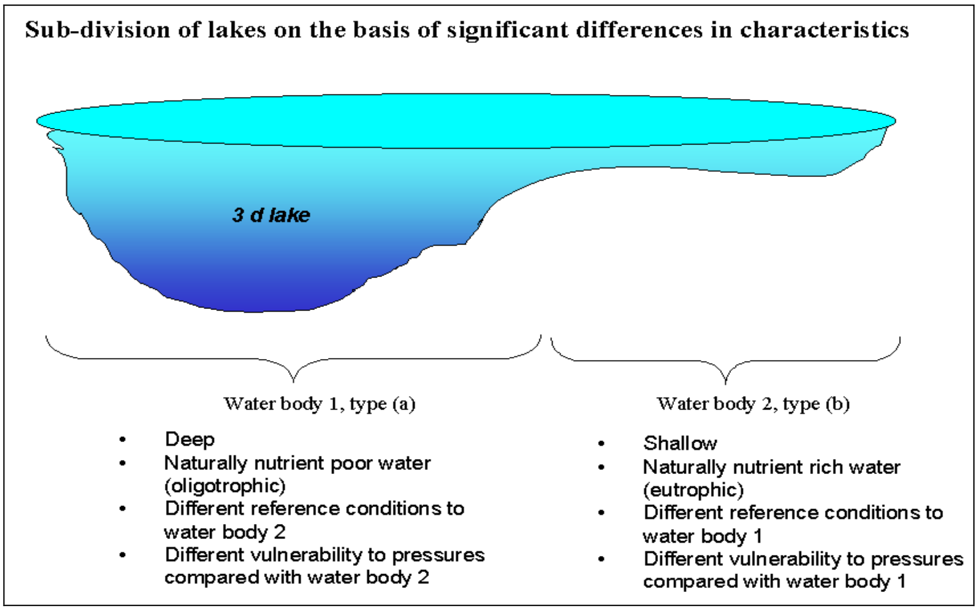

Figure 2. Sub-division of lakes on the basis of significant differences in characteristics (from the WFD CIS Guidance Document No. 2 on water bodies).

2.4 Wetlands

Excerpts from the Directive pertaining to wetlands:

Article 1

> *The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, which: prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems.*

Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in WFD CIS Guidance Document No. 2 on water bodies and further considered in Guidance on wetlands.

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate Guidance paper on wetlands (currently in preparation).

2.5 Water body types

Excerpts from the Directive pertaining to water body types:

Annex II: 1.1 (ii)

> *For each surface water category, the relevant surface water bodies within the river basin district shall be differentiated according to type. These types are those defined using either "system A" or "system B" identified in Section 1.2.*

Annex II: 1.1 (iv)

> *If System B is used, Member States must achieve at least the same degree of differentiation as would be achieved using System A. Accordingly, the surface water bodies within the river basin district shall be differentiated into types using the values for the obligatory descriptors and such optional descriptors, or combinations of descriptors, as are required to ensure that type specific biological reference conditions can be reliably derived.*

The Directive requires that Member States differentiate the relevant surface water bodies with respect to type and that Member States establish reference conditions for these types. The main purpose of typology is consequently to enable type specific reference conditions to be defined which in turn is used as the anchor of the classification system. The following guidance may be given relative to specific issues concerning types.

”System A” versus ”System B”
The two systems are about the same in that the same obligatory factors are to be used in both: geographic position, altitude, size, geology and, for lakes, depth. The difference is that System A prescribes how water bodies shall be characterised spatially (ecoregions) and with respect to specific altitude, size and depth intervals, and that System B, besides lacking this prescription, permits the use of additional factors. It is up to Member States to decide on what system to use, and most Member States have indicated that they prefer to use System B.

Degree of differentiation
The Directive requires that System B, if used, must achieve at least the same degree of differentiation as would System A. This is interpreted to mean that if System B is used, it should result in no greater degree of variability in type specific reference conditions than if System A had been used. Hence, if it can be demonstrated that the same or a lower degree of variability in reference condition values may be achieved with a lower number of types than would be derived using System A, this would be acceptable, since the purpose of typing is to establish reference conditions as precisely as possible. This comparison of “degree of differentiation” does not imply an obligation to compare one system with the other in great detail, but rather at a more general level based on existing data and expert judgement. What is important is that the established typology system assists in achieving an adequate confidence in reference conditions and the subsequent classifications.

Reducing variability
Member States must establish type-specific biological reference conditions for each quality element used for classification. Where the natural variability of a quality element in a type as a whole is much larger than the natural variability expected for it in any particular water body, Member States should be able to utilise a suitable reference value for the water body when interpreting monitoring results and calculating environmental quality ratios. The relevant reference value will be from within the range of values established for the type as a whole. The reference value arrived at in this way will be water body specific. The possibility to revise the typology system or to exclude a quality element indicator showing large natural variability in reference conditions should also be considered (Annex II: 1.3 (vi)).[8]

Use of optional factors
Concerning optional factors, the interpretation of the Directive is that these are factors that may be included according to the choice of the user, who may very well also decide to use others than those suggested in the Directive.

Catchment geology
An interpretation is also needed with respect to the Directive’s alternative descriptors of geology. The Directive is interpreted here to mean a relevant catchment area of the water body and to mean, in System A, the geology with the predominating influence of the water body. This is up to Member States to decide, depending on the circumstances.

[8] It should be stressed that the Directive only requires type specific reference conditions to be established and that water body specific reference conditions only should be regarded as a complementary approach.

Conclusions and recommendations

- Water body types may be differentiated using "System A" or "System B";
- The two systems are similar in that they contain the same obligatory factors: Geographic position, altitude, geology, size and (for lakes) depth;
- Optional factors of System B can be used as desired by Member States and can be complemented with factors other than those mentioned in the Directive;
- The Directive´s descriptors of geology (in System A) refer to the dominating character (calcareous, silicious, etc.), expected to have the strongest influence on ecological quality of the water body;
- The Directive´s requirement that Member State must achieve the same degree of differentiation with System B as with System A is interpreted to mean that if System B is used, it should result in no greater degree of variability in type specific reference conditions than if System A had been used. Hence, if a lower number of types, using System B, results in equally low or lower variability of reference conditions values as would be given by System A, this would be acceptable;
- Water body specific reference conditions, within a range of values for the type as a whole, may be used in order to cope with natural variability within types.[9]

2.6 Classification of ecological status

Excerpts from the Directive pertaining to ecological status:

Article 2(17):

> *"Surface water status" is the general expression of the status of a body of surface water, determined by the poorer of the ecological status and the chemical status.*

Article 2(21):

> *"Ecological status" is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V.*

The Directive requires surface water classification through the assessment of ecological status. Annex V, Table 1.1, explicitly defines the quality elements that must be used for the assessment of ecological status (see Table 2 below). Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used by Member States in the assessment of ecological status.

Annex V, Table 1.2, in the Directive provides a general definition of ecological quality in each of the five status classes. For each relevant quality element and a set of indicators, more specific definitions for ecological status at high, good and moderate status in rivers (Table 1.2.1) and lakes (Table 1.2.2) are given. These general and specific definitions are referred to as "normative definitions" (Table 1.2, 1.2.1 and 1.2.3 in the Directive and are listed in Annex C).

The specific hydromorphological quality elements are required for determination of high status. For other status classes the hydromorphological elements are required to have

[9] See footnote 4.

"conditions consistent with the achievement of the values specified [in Tables 1.2.1 and 1.2.2] for the biological quality elements."

The specific physico-chemical quality elements are required for determination of high and good status. For other status classes the physico-chemical elements are required to have "conditions consistent with the achievement of the values specified [in Tables 1.2.1 and 1.2.2] for the biological quality elements."

These relative roles of biological, hydromorphological and physico-chemical quality elements in status classification are presented in Figure 3.

Annex V, section 1.4.2. (i) Presentation of monitoring results and classification of ecological status and ecological potential

> *For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below.*

To classify ecological status, the Directive stipulates that the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements should be used (Annex V, 1.4.2. (i)). This implies, de facto, that Member States will need to establish methods/tools for assessing ecological status for both the biological and physico-chemical quality elements. Figure 3 illustrates that there are separate criteria in WFD Annex V, 1.2, for establishing appropriate ranges for physico-chemical elements at high and good status. It can also be concluded that classification of ecological status should be on the quality element level, i.e. not on parameter level (the quality elements are listed in Table 2).

There is a clear distinction between the role of general physico-chemical quality elements and specific pollutants in classification of ecological status. In good ecological status, general physico-chemical quality elements should not reach levels outside the range established to ensure ecosystem functioning and the achievement of the values specified for the biological quality elements ((a) in the middle box in Figure 3) and specific pollutants should meet the Environmental Quality Standards (EQS) set in accordance with Section 1.2.6 in the Directive ((b) in the middle box in Figure 3).

Once European EQS have been established, priority substances are not included in the ecological status, but are relevant for assessment of chemical status (Article 2, Annex X and Article 16(7) dealing with priority substances). For the purpose of assessing ecological status the quality elements for specific pollutants listed in Annex V, 1.1 and 1.2 ("specific synthetic pollutants" and "specific non-synthetic pollutants") must be considered and their national quality standards must be met[10]. Shifting of priority substances for which EU-wide quality standards have been set from ecological to chemical state assessment does not compromise the good status of a water body because for good status, both ecological and chemical status must be good.

The Expert Advisory Forum on Priority Substances will continue the discussion on these points in order to ensure a smooth transition from the current requirements to the upcoming proposals under Article 16 of the Water Framework Directive.

[10] Examples on how to select the specific pollutants that are relevant to a particular water body are described in the WFD CIS Guidance Document No. 3 from Working Group 2.1 (IMPRESS).

Annex V: 1.4.1 (ii). Comparability of biological monitoring results

> *In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.*

Classification of ecological status is to be based on ecological quality ratios, which are derived from biological quality values as illustrated in Figure 4. No EQR scheme or intercalibration exercise is envisaged in the Directive for classification of ecological status for the supporting physico-chemical quality elements. Member States need to develop their own methods/tools for assessing ecological status for these supporting elements (see above, and Figure 3).

The issue of how to use physico-chemical quality elements for classification of ecological status will be further developed within the work programme of the Common Implementation Strategy during 2003.

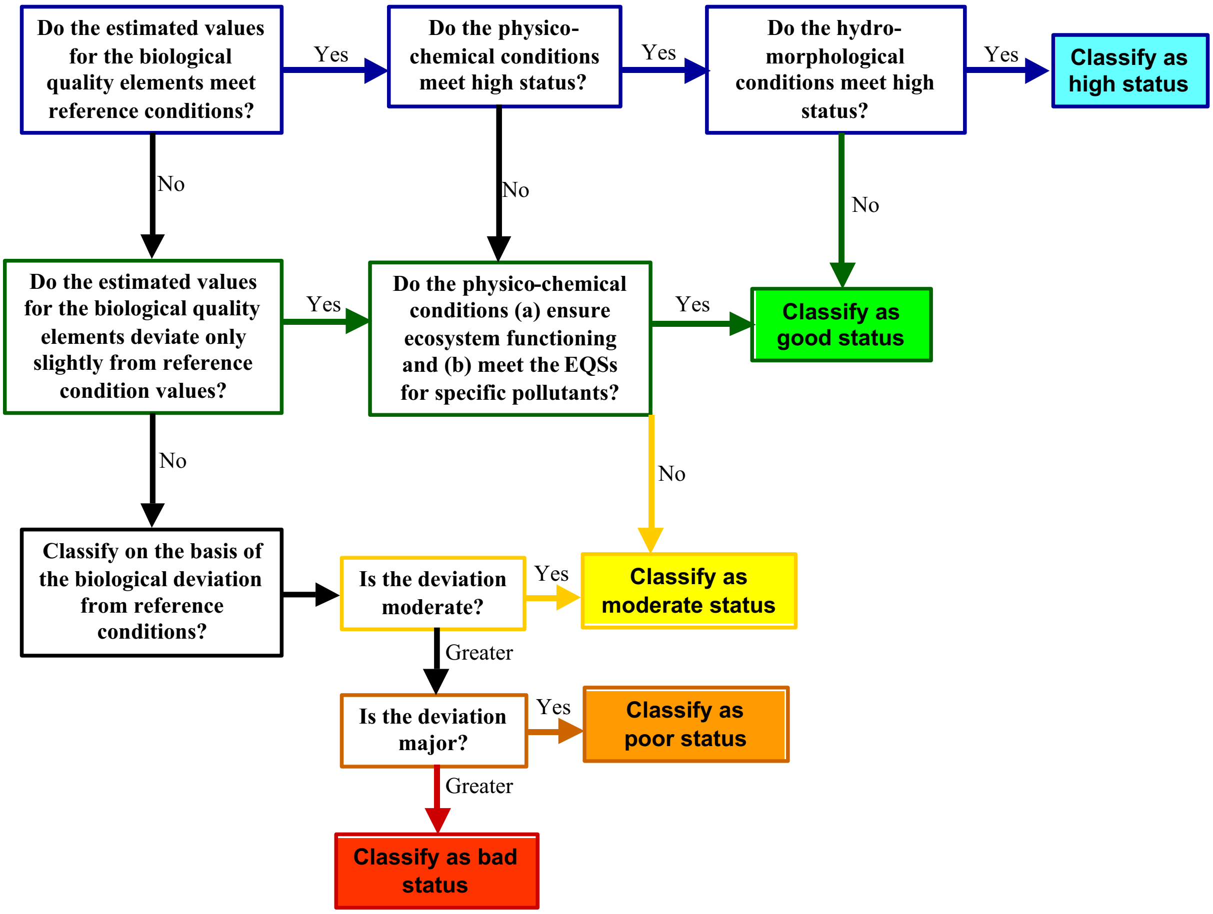

Figure 3. Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according the normative definitions in Annex V:1.2. A more detailed understanding of the role of physico-chemical parameters in the classification of ecological status will be developed in specific guidance on this issue during 2003.

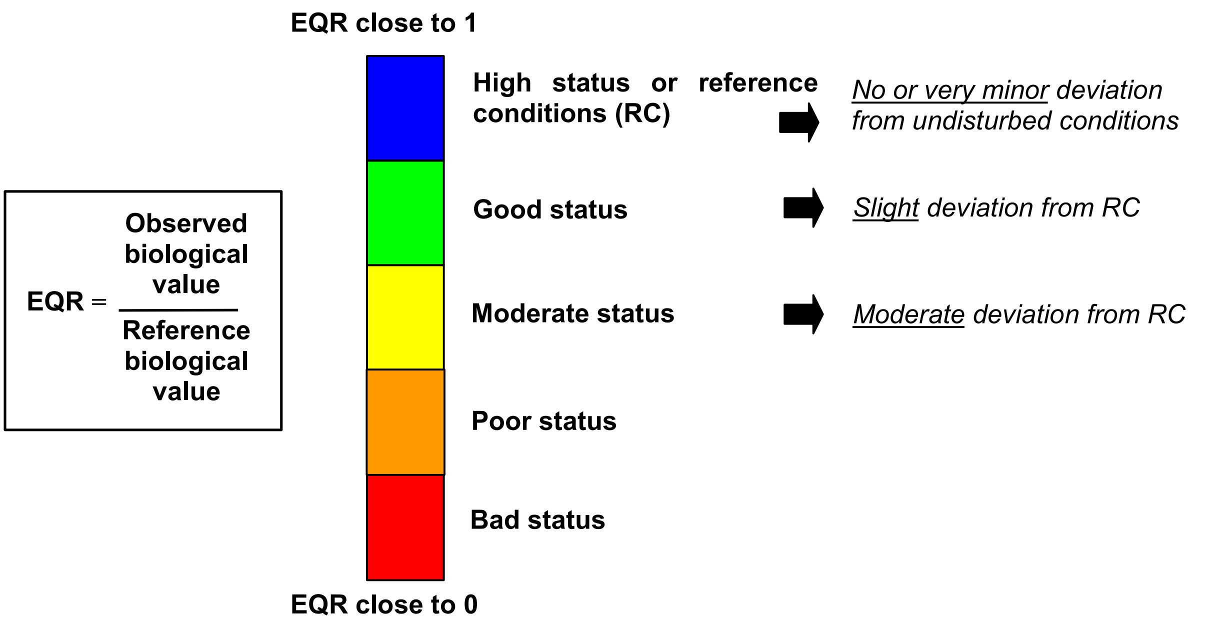

Figure 4. Basic principles for classification of ecological status based on Ecological Quality Ratios.

Table 2. Quality elements to be used for the assessment of ecological status based on the list in Annex V, 1.1, of the Directive.

Annex V 1.1.1. RIVERS	**Annex V 1.1.2. LAKES**
Biological elements	
• *Composition and abundance of aquatic flora*[11] • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*

Hydromorphological elements supporting the biological elements	
• *Quantity and dynamics of water flow* • *Connection to ground water bodies* • *River continuity* • *River depth and width variation* • *Structure and substrate of the river bed* • *Structure of the riparian zone*	• *Quantity and dynamics of water flow* • *Residence time* • *Connection to the ground water body* • *Lake depth variation* • *Quantity, structure and substrate of the lake bed* • *Structure of the lake shore*

Chemical and physicochemical elements supporting the biological elements	

• *Thermal conditions*
• *Oxygenation conditions*
• *Salinity*
• *Acidification status*
• *Nutrient conditions*
• *Specific pollutants*
    • *pollution by priority substances identified as being discharged into the body of water.*
    • *pollution by other substances identified as being discharged in significant quantities into the body of water.*
	• *Transparency*
	• *Thermal conditions*
	• *Oxygenation conditions*
	• *Salinity*
	• *Acidification status*
	• *Nutrient conditions*
	• *Specific pollutants*
	    • *pollution by priority substances identified as being discharged into the body of water.*
	    • *pollution by other substances identified as being discharged in significant quantities into the body of water.*

[11] Phytoplankton is not listed as a quality element in rivers in Annex V, 1.1.1., but is included as a quality element in Annex V, 1.2.1. It should therefore be possible to use phytoplankton as a separate quality element, if needed and appropriate especially in low land large rivers where phytoplankton may be important.

Conclusions and recommendations

- The normative definitions of the Directive (Annex V, Table 1.2) provide the basis for classifying surface waters according to their ecological status and each Member State must develop classification systems that conform to these status definitions;
- Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used by Member States in the assessment of ecological status (relative roles illustrated in Figure 3);
- Ecological status classifications should be made on the basis of the relevant biological and physico-chemical results, and classification should be made using quality elements and not parameters;
- The ecological status is represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements. The practical implementation is to be developed within the work programme of the Common Implementation Strategy during 2003;
- Classification of ecological status is to be based on ecological quality ratios, which are derived from biological quality values as illustrated in Figure 4, and on the Member States assessments of ecological quality for physico-chemical quality elements;
- No EQR scheme is envisaged in the Directive for classification of ecological status based on physico-chemical monitoring results. Member States will apply their own methods/tools for assessing ecological quality for these quality elements (see above);
- No definitions are given in the Directive for physico-chemical or hydromorphological quality elements in poor and bad status;
- All Issues relating to how to use physico-chemical quality elements for classification of ecological status will be further developed within the work programme of the Common Implementation Strategy during 2003.

Section 3. General guidance on principles and methods for establishing reference conditions and ecological status class boundaries

3.1 Overview – a stepwise approach

The establishment of reference conditions and the establishment of ecological quality class boundaries are closely interconnected. To establish the boundary between high and good ecological status it is necessary to identify conditions representing very minor anthropogenic disturbances. To establish the boundary between good and moderate ecological status it is necessary to identify conditions corresponding to slight anthropogenic disturbances. Both the establishment of reference conditions and the setting of class boundaries are dealt with in this chapter.

Figure 5 schematically shows a number of steps that may be taken to establish reference conditions and ecological class boundaries. Reference conditions and ecological class boundaries must be established by Member States for all surface water body types and all relevant quality elements. Member State's classification systems will also be compared in the intercalibration exercise (Annex V: 1.4.1), and the outcome of this intercalibration will be used to set the class-boundaries. This means that the process of intercalibration is closely interrelated with the process of establishing reference conditions and quality class boundaries. The process of intercalibration is described in a separate Guidance Document.

The different steps in the approach outlined in Figure 5 are described in the following sub-sections of Section 3.

The suggested approach for establishment of reference conditions and ecological quality class boundaries involves several technical considerations that might not be transparent to the public, water users and stakeholders. These considerations are, however, crucial for the judgement of the risk that individual water bodies will fail to reach the overall objective good water status by 2015. It is therefore important to involve the public, water users and stakeholders at an early stage in order to reach acceptance for the quality class boundaries finally set. It is also in line with Article 14 in the Directive to involve all interested parties in the implementation of the Directive.

The Guidance Document on "Public Participation", produced by a sub-group within Working Group 2.9 (Best practices in river basin management) will tell more about these forms of participation (WFD CIS Guidance Document No. 8). In short the Directive mentions the following:

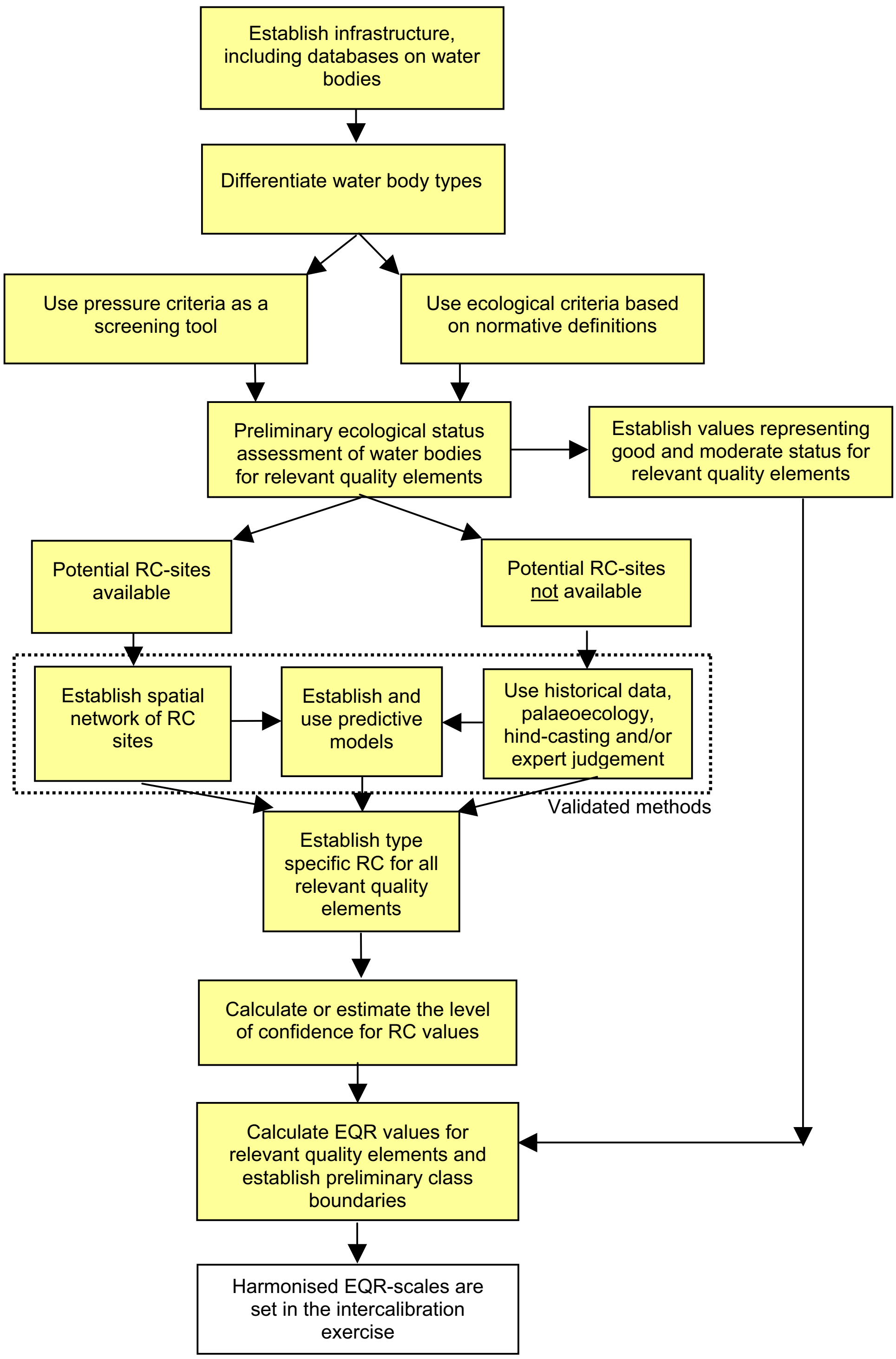

Figure 5. *Flow-chart of the suggested step-by-step approach for establishing reference conditions and boundaries between high, good and moderate ecological status classes (RC=reference conditions, EQR=Ecological Quality Ratio).*

Article 14 promotes the active participation of all interested parties in the development of River Basin Management Plans, and requires Member States to inform and consult the public. Stakeholder participation is important as it can fulfil many functions:

- Developing a process agreed by all will increase the legitimacy of its outcome;
- Stakeholders can be a useful source of information and have expertise of direct use for the reference condition analysis (see Table 1 in Annex G);
- Surveys of the public can be useful to understand how people value improvements in the environment and quality of our waters, and how far they are ready to pay for environmental improvements;
- Public involvement and the network of partners developed through participation can be useful to develop a sense of ownership over the River Basin Management Plans and may increase the effectiveness of measures taken to meet the Directive's objectives.

The Directive only specifies key dates for consultation, but rightly does not specify dates for the participation process, as this will depend on local institutions and socio-reference condition set-up. However, it will be important to start the participation process early (e.g. as part of the characterisation of the river basin before 2004) to improve its effectiveness.

See also Annex G at the back of this document showing who needs to get involved in carrying out and using the REFCOND Guidance.

3.2 Need for infrastructure

Paramount to the implementation of the directive is an infrastructure at the national as well as the water district level consisting of:

- Expertise;
- Databases;
- Assessment methods, models and other tools;
- Organisational structure.

If a robust infrastructure is not available, it would initially be important to set up a group of experts including, for matters relating to reference conditions and classification, ecological, chemical, hydrological, and statistical expertise as well as expertise on modelling, GIS and databases.

Databases are needed for the identification of relevant water bodies and characterisation of relevant pressures and ecological status, and subsequently for unconstrained implementation of the Directive. State variables would be those required in the Directive for characterisation and classification of water bodies (Annex II and V) plus optional variables suggested in the directive or other variables preferred by Member States (see Section 3.3). Pressure variables would include measures of land-use, point source discharges, hydromorphological alterations, etc (see Section 3.4).

Assessment methods, models and other tools should include (i) models for determining point-source and diffuse loadings of nutrients, metals and other substances, (ii) methods for determining biological state variables, and (iii) GIS applications.

The *organisational structure*, finally, will vary depending on the circumstances in Member States, and in many cases it will require a great effort of co-ordination among responsible authorities and stakeholders.

3.3 Differentiation of water body types

The Directive requires that Member States differentiate the relevant surface water bodies with respect to type (using either ”System A” or ”System B”.) and then establish reference conditions for these types. In the following Section guidance is given on the use of System A and B. Interpretations and clarifications regarding concepts and terms are given in Section 2.5.

Of the two systems prescribed in the Directive, System A is the most straightforward and simplest to implement. One clear disadvantage of System A is that the classes established may not adequately partition the variability of the quality elements used, resulting in poor detection of ecological change. Given the inflexibility of System A, most Member States are likely to use System B as a basis for characterising water body types.

System B provides, as indicated above, greater flexibility in defining water body typologies. Implementation of System B should contain both the obligatory factors given in Annex II:1.2 of the Directive and other relevant factors deemed useful by the Member State for minimising quality element variability.

Based on the data-availability, types may be delimited using various grouping procedures; these may be based on commonly used clustering techniques or more intuitive (expert opinion) methods. Statistical methods are also available for determining if “groups” differ from one another (e.g. using randomisation techniques) and if among-group variance can be adequately explained (e.g. using discriminant analysis). The objective of establishing typologies is to partition among-group variance to better detect ecological change.

Unlike the Guidance Document on transitional and coastal waters (WFD CIS Guidance Document No. 5) no common European typology system is proposed for inland surface waters. One reason for this difference is the apparent need for a common typology of coastal waters shared between countries. In contrast to coastal and transitional waters, a number of Member States presently use typology systems for inland surface waters.

Member States sharing the same (eco)region may, however, initiate activities to harmonise typology for inland surface waters on the most appropriate (eco)regional scale as soon as possible or latest in early 2003. This harmonisation should at least cover the types selected to be included in intercalibration and will help in the selection of sites to be included in the draft register for intercalibration network during 2003.

The suggested procedure and timetable for the development of (eco)region specific surface water body typologies to be used for selection of types and sites to be included in the intercalibration exercise is further outlined in Annex F.

Conclusions and recommendations

(Partly repeated, for the sake of clarity, from Section 2.5)

- Water body types may be differentiated using "System A" or "System B";
- The two systems are similar in that they contain the same obligatory factors: geographic position, altitude, size, depth (for lakes) and geology;
- Optional factors of System B can be used as desired by Member States and can be complemented with other factors;
- A data base including, at the least, values of the obligatory factors for relevant water bodies is a prerequisite for differentiation of water body types;
- System A is simple and easy to adopt but has the potential disadvantage of giving a lower level of precision of reference values;
- Using System B, types may be differentiated using various mathematical-statistical clustering methods, regional classifications or more intuitive methods, including expert opinion.

3.4 Use of pressure criteria and ecological criteria

It follows from the Directive that ecological criteria are the definitive test of high ecological status (Annex V:1.2). However, the use of both ecological and pressure criteria may be the most efficient way for screening of potential reference sites or values or needed to aid in at least a preliminary assessment of status of waters. Indeed, to establish reference conditions it could be most cost-effective to start with pressure criteria, because the reference community is defined as the biological community expected to occur where there is no or only very minor anthropogenic disturbance. In other words, to avoid circularity (see Section 3.6.1), pressure criteria may be used conveniently to screen for sites or values representing potential reference conditions. Once identified, biological elements should be used to corroborate this ecological high status.

Figure 6 shows how ecological and pressure criteria may be used (i) for determining potential reference sites or values and setting class boundaries between high and good ecological status, (ii) for determining potential sites for the intercalibration network, and (iii) for identifying bodies at risk of failing to achieve the Directive's objectives. Focus here is on how ecological and pressure criteria may be used for delineating potential reference sites or values and setting class boundaries. However, the approach outlined in Figure 6 may also be used to establish the class boundaries between good and moderate ecological status. Good status is defined in ecological terms as slight deviation from the expected biological reference condition. The setting of class boundaries should however explicitly incorporate the normative definitions for the ecological criteria as stipulated in the Directive (Annex V 2.1). In other words, while pressure criteria might be a proxy measure for assessing risk or screening for sites or values, their role in defining good status is secondary. Ultimately, as mentioned above, it is the biological data assessed against the normative definitions in Annex V 2.1, which will definitively assign water bodies to status classes.

For pressures and quality elements where critical loading models are established (i.e. phosphorus and phytoplankton, or acid rain and fish), pressure criteria can be used to estimate values for the related biological quality element. If the response of the biological quality element is in accordance with the normative definitions for good and moderate status, the values for the biological quality element corresponding to the critical load value can be used to set the border between good and moderate status for that element.

3.4.1 Setting a benchmark for very minor alterations

With regard to the definitions of high and good ecological status given in the Directive, it is necessary to come to a view on the spatial or temporal benchmark to set in respect of anthropogenic pressures so that appropriate comparison against the current condition of water bodies can be made across all Member States.

This allows a determination of whether current conditions in any water body equates to reference state or if a prediction of reference state will be required. The following benchmark for high ecological status or reference conditions is suggested:

- High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemistry, hydromorpology and biology.

This implies that there should be no fixed temporal and spatial benchmark but raises the problem of not knowing what we are accepting as the degree of change in an anthropogenic pressure that is incorporated into the concept of reference condition.

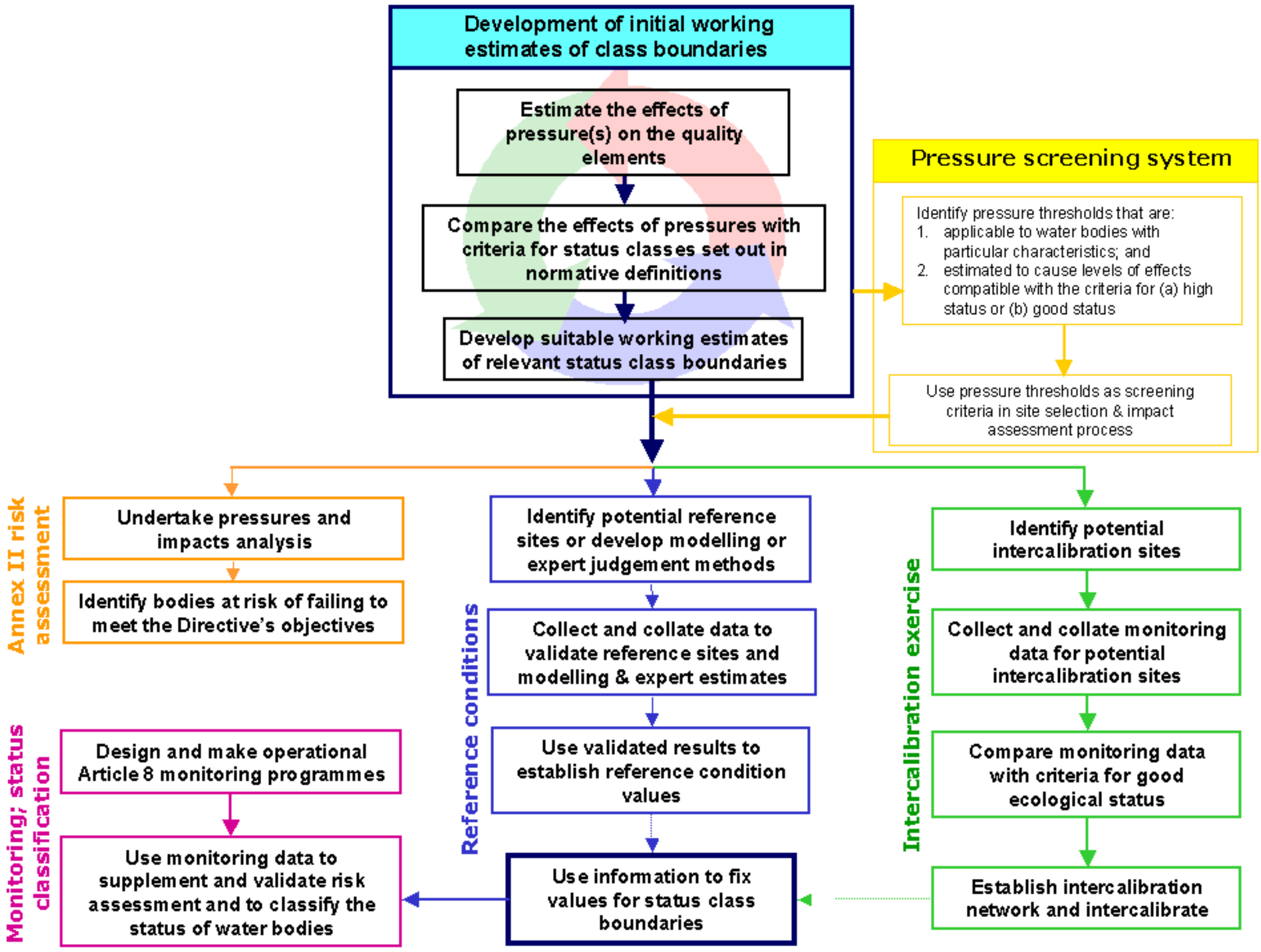

Figure 6. The respective roles of pressure criteria and ecological criteria in identifying status classes.

Bearing in mind the Directive's requirement that reference condition should represent totally, or nearly totally, undisturbed condition but also assuming that an absolutely pristine, post-glacial state is not realistic, then it is proposed that a flexible temporal benchmark as suggested above best fits the legislative intention. However, the temporal benchmark need not be coincidental for each pressure - merely chosen such that reference conditions can be adequately described.

If a water body was physically modified in the past the following recommendations are given:

- If the water body has changed category (e.g. a river impounded by a dam to form a lake) and can therefore be considered for designation as a heavily modified water body, it cannot be used as part of a network of sites for deriving spatially based type-specific reference conditions (e.g. as a reference site for lakes) under Annex II (1.3) of the Directive (see Guidance on heavily modified and artificial water bodies);

- If a water body has changed neither category nor type and the biology shows no or only minor changes, the water body can be considered as a reference site (e.g. kettle hole lakes in Northern Europe which have been artificially increased in size);

For current uses, for example water abstraction, guidance is provided on the degree of acceptable change (i.e. with negligible effect on ecological structure and functioning) within the reference condition. This should be qualified in each case by the over-riding requirement to demonstrate no or only very minor ecological change (see tool 1 in the Toolbox Section).

3.4.2 Pressure criteria as a screening tool

To facilitate the assessments of status classes, the basic process outlined in Figure 6 can be used to identify generic pressure thresholds (or criteria), which, for any water bodies with a specified set of characteristics, would be expected to result in effects that are compatible with a particular status class. These thresholds can then be used to help screen water bodies in order to identify potential reference sites or values, intercalibration sites or bodies that can be confidently identified as not at risk or at risk of failing to achieve their objectives. Critical loads for acid deposition are an example of such thresholds, although the ecological effects they reflect need to be validated with the criteria relevant to the boundary between good and moderate ecological status.

Tool no 1 in the Toolbox Section suggests a set of criteria which elaborate on the degree of acceptable change in an anthropogenic pressure, that would provide the limits of reference condition sites or values and, hence, be used as a screening tool. However, if no or only very few reference sites are available, it would be advisable to consider use of reference state sites in unaltered parts of water bodies elsewhere slightly altered, or use of sites that are altered only regarding certain biological elements. The existence of only minor alteration for all biological elements (relevant for the type) is, however, a prerequisite for the definition of reference sites. Such sites can, accordingly, not be treated as "true" reference sites even if data for a specific quality element is used for establishing reference conditions.

Different water body types will respond differently to one and the same pressure. The proposed pressure screening criteria should therefore be regarded as illustrating concepts and principles to be used for developing water body type specific pressure screening criteria. A prerequisite for the use of pressure screening criteria is that the relationship between pressure-state-impact is established and that the state corresponds to the normative definitions in the Directive (Annex V: 1.2).

3.4.3. Use of ecological criteria

Although the ecological status definitions must be used as the firm basis for establishment of classification systems by Member States (Annex V: 1.2), it might be considered useful to provide some further practical guidance on how such definitions can be developed into more quality element specific descriptions of expected ecological conditions at high, good and moderate status.

The development of robust ecological criteria requires further work beyond this Guidance Document and it is recommended that this should be given high priority. An indicative approach has been provided for the biological quality elements as interim guidance (Tool 2 in the Toolbox Section) but it should be noted that this approach may not be suitable for all types and all pressures. Certain pressures may induce specific needs for ecological status assessment and the choice of parameters may need adjustment according to type and also to prevailing monitoring systems.

With the exception of fish[12] no specific guidance is given in the directive as to the level of taxonomic resolution that is required for the purpose of the characterisation of the biological communities at reference condition and for the derivation of the interpretations of the status of these communities at the various quality classes. Depending on type of water body and pressure, different levels of taxonomic resolution might be necessary to achieve a sufficient level of confidence in classification. Even if it is not required by the Directive, a consensus on the level of taxonomic resolution will be beneficial between Member States sharing similar water body types in the intercalibration exercise, at least concerning data provided for intercalibration.

3.5 Methods for establishing reference conditions

According to the Directive reference conditions need to be established for water body types and quality elements which in turn are represented by parameters indicative of the status of the quality elements. Quality elements may however be excluded from the assessment procedure, and hence establishment of reference conditions is not necessary, if they display high degrees of natural variability (see Section 3.7). In addition, it may be difficult to establish type-specific reference communities for all quality elements with acceptable precision. However, certain biological quality element indicators, such as taxa richness or the presence of sensitive taxa, may be less variable than others (e.g. community composition) and hence more reliably inferred (e.g. if few reference sites are available). Furthermore, it should be emphasised that the reference conditions should be established for the same quality element indicators that will be used for the classification of ecological status.

The basis for the identification of reference conditions is given in Annex II, 1.3 in the Directive. Without any specific ranking of the methods the main options for establishing reference conditions are:

- Spatially based reference conditions using data from monitoring sites;

[12] For fish quality elements the Directive (Annex V 1.2.1 – 1.2.2) specifically referes to species.

- Reference conditions based on predictive modelling;
- Temporally based reference conditions using either historical data or paleoreconstruction or a combination of both;
- A combination of the above approaches.

And where it is not possible to use these methods, reference conditions can be established with expert judgement.

A short description of a number of methods commonly used to ascertain reference conditions is given below. It should be noted that establishing reference conditions for many quality elements may involve using more than one of the methods described below.

3.5.1 Spatially based reference conditions

If undisturbed or minimally disturbed sites are available and numbers are adequate for determining a reliable measure of mean, median or mode and distribution of values (percentiles, confidence limits), then the use of survey data is one of the most straightforward methods available for establishing reference conditions. This is done a priori by collection of data from reference sites only, by using inclusion/exclusion criteria for delineating a reference population. One of the reasons that spatially based or survey approaches are commonly used is that they can be designed to include natural (both spatial and temporal) variability. For example, in establishing reference communities using field surveys, water body and site stratification (e.g. by size, altitude, substratum, etc) should insure adequate representation and precision of distinctive ecosystem types. In addition, the importance of temporal variability can be dealt with directly if among-year variability is measured. A disadvantage of this approach is that spatially extensive data sets are needed to cover the inherent variability within all water body types.

3.5.2 Reference conditions based on predictive modelling

When adequate numbers of representative reference sites are not available in a region/type, predictive modelling, using the data available within a region/type or “borrowing” data from other similar regions/types, can be used in model construction and calibration.

One of the advantages of using predictive approaches is that the number of sites needed for reliable estimates of mean or median and error are usually lower than those needed if spatial approaches are used. This usually results in fewer sites that need to be sampled, and lower implementation costs. A second advantage of using predictive approaches is that the models can often be “inverted” to examine the likely effects of mitigation measures. It must be stressed that predictive models only are valid for the ecoregion and water body type they are created for.

3.5.3 Temporally based reference conditions

Temporally based reference conditions may be based on either historical data or paleoreconstruction, or a combination of both approaches. Both of these approaches are commonly used in areas where human-induced stress is widespread and unperturbed references are few or lacking entirely. For example, paleoreconstruction of past conditions may be determined either (i) directly, based on species presence/absence from fossil remains or (ii) indirectly, using relationships between fossil remains and inference to determine other values such as the reference pH situation. One of the strengths of a paleo-approach is that it can often be used to validate the efficacy of other approaches if the conditions are stable.

Another advantage is that recent step-changes in ecological status are more easily determined. A third strength of palaeoreconstruction is that if strong relationships exist between land use and ecosystem composition and function, a predictive approach (hindcasting or extrapolating dose-response relationships) may be used to predict quality elements prior to major alterations in land use (e.g. pre-intensive agriculture).

Both of these approaches share, however, some of the same weakness. They are usually site- and organism-specific, and hence may be of limited value for establishing type-specific values. Regarding palaeoreconstruction, caution should also be exercised in unequivocal reliance on this method as providing the definitive value, as choice of the calibration dataset used to infer ecological status may result in different values. Regarding the widespread use of historical data, it may be limited by its availability and unknown quality.

3.5.4 Establishing reference conditions using expert judgement

Expert judgement usually consists of a narrative statement of expected reference condition. Although an expert´s opinion may be expressed semi-quantitatively, qualitative articulation is probably most common. Use of expert judgement may by warranted in areas where reference sites are lacking or few. However, one of the strengths of this approach is that it may also be used in combination with other methods. For example, expert judgement may be used to extrapolate findings from one quality element to another (i.e. paleoreconstruction using fossil diatom remains may be used to infer invertebrate community composition) or to extrapolate dose-response relationships to those expected in unperturbed sites. Another strength of this approach is that both empirical data and opinion can be amalgamated with present-day concepts of ecosystem structure and function.

However, as a number of weaknesses are inherently associated with this approach, caution should be exercised when using this approach as the sole means of establishing reference condition. For example, subjectivity (e.g. the common perception that it was always better in the past) and bias (e.g. even sites with low diversity can be representative) may limit its usefulness. Other drawbacks include the lack of clarity or low degree of transparency in assumptions used to establish reference and the lack of quantitative measures (e.g. mean or median values) for validation. A further weakness of this (and many other approaches) is that the measure obtained is often static, and hence does not include the dynamic, inherent variability often associated with natural ecosystems.

3.5.5 Concluding remarks

Many of the above approaches may be used either singly or in concert for establishing and/or cross-validating reference condition. Knowledge of the inherent strengths and weaknesses of the various approaches or the potential problems associated with using different methods is, unfortunately, weak and fragmentary. A summary of the strengths and weaknesses with different methods is presented in Table 3. Regardless of the approach(es) used to establish reference condition, the variability (or errors) associated with the method(s) should be estimated.

In areas where human-generated disturbances are low or not widespread (e.g. in the Nordic countries), spatial approaches may be used either singly or in concert with predictive modelling to establish potential reference conditions for the quality elements. In contrast, in areas that are/have been strongly affected by single or multiple pressures, identification of potential reference conditions may require a suit of methods and substantial validation.

Table 3. Strengths and weaknesses of a few approaches commonly used to determine reference condition.

Approach	Strengths	Weaknesses
Spatially based using survey data	Region specific	Expensive to initiate
Predictive modelling	Site-specific	Requires data, calibration and validation
Historical data	Often inexpensive to obtain	Variable data, few parameters and data quality may be poor or unknown, static measure
Palaeoreconstruction	Incorporates both physico-chemical and biological data	Basically limited to lakes, high initial costs
-Direct	Site-specific	Few parameters
-Indirect	Calibration models currently available for modelling a number of stressor variables; pH, total phosphorus and temperature reconstructions	
Expert opinion or best judgement	May incorporate both historical data/opinion and present day concepts	Bias may be present

3.6 Validation of reference conditions and ecological class boundaries

Knowledge of the variability or uncertainty associated with establishing reference conditions and setting ecological class boundaries is a crucial step in the process of determining the ecological status of water bodies. Clearly, estimating the errors associated with ecological banding schemes and validation of reference conditions are important steps. An intercalibration exercise will be facilitated by the Commission in accordance with Annex V, Section 1.4.1, in the Directive. This exercise will calibrate the class boundaries established by the Member States. As there is a Guidance Document available on intercalibration (WFD CIS Guidance Document No. 6) this Section will focus more on validation of reference conditions.

3.6.1 Minimise risk of circularity

To minimise risk of circularity in establishing reference conditions, ideally mainly physico-chemical, hydromorphological and pressure criteria (i.e. community driving forces) should be used in a first step. Inclusion of biological quality elements in this first step of screening for potential reference sites or values may introduce bias (e.g. different persons/experts may have different perceptions of what reference conditions represents) and circularity (i.e. use of the same variable to delineate and validate reference condition). There will also be a risk that naturally occurring rare water body types (e.g. naturally nutrient poor, low diversity water bodies) will not be detected. In practice, however, it is likely that Member States may have to resort to using all data currently available (including biological data), to initially identify potential reference sites or values. If biological quality elements are used in this initial stage, it is important that additional biological data (e.g. for other quality elements) is collected to verify the final identification of a site as a reference.

If a water body fulfils the requirements for reference conditions in this first step, biological reference conditions can then be established in the next step. The suggested procedure can be described as follows:

- Find sites at which on the basis of all the identified pressures, the physico-chemical, hydromorphological and biological quality elements are believed to be subject to no more than minor disturbance. Use Tool 1-2 in the Toolbox Section for this initial risk assessment;

- Sample the biological quality elements to see if they appear to be only affected, if at all, by minor alterations to the physico-chemical and hydromorphological quality elements. If sampling shows that a biological value is more disturbed than predicted by the risk assessment, further investigation of possible pressures and their effects should be undertaken (i.e. refinement of the risk assessment);

- If sites deviate from what is expected to occur under reference conditions, but no known human-generated pressures are evident, removal of these sites should be considered. Care should, however, be exercised as these sites may indicate the true, natural, variability expected to occur.

3.6.2 Secure documentation

As part of the decision-making process, it is important to document how the values representing reference conditions and ecological quality class boundaries have been established. Likewise, the steps taken to validate reference and class boundaries need to be documented in detail.

3.6.3 Validation of methods

Since different methods used to establish reference conditions most likely have different inherent errors, some form of validation procedure needs to be performed. Clearly the main issue is to determine whether the reference values obtained can be used to achieve robust classifications of ecological status (see Section 3.7). When several methods have been used for establishing reference conditions, they should be compared, if possible, using the same quality element(s). If the outcome of this comparison is that there is a significant difference between the different methods there has to be an expert judgement on how to set the value.

3.7 Assessing variability in reference conditions

The Directive requires a "sufficient level of confidence about the values for the reference conditions" regardless of which method is used for establishing reference conditions (Annex II, 1.3). Adequate confidence and precision in the classification of the quality elements is another statistical requirement mentioned in the Directive (Annex V, 1.3).

Neither "sufficient level of confidence about the values for the reference conditions" nor "adequate confidence and precision in the classification" is specified in statistical terms in the Directive. It is, consequently, up to the Member States to decide about this definition, taking into account the natural spatial and temporal variability for different quality elements together with errors associated with sampling and analysis.

The Directive´s requirements about confidence levels require relevant databases including data of several years for a good temporal variations appraisal. Such databases will, however, not be necessarily available for the first River Basin Management Plan publication in 2009. So, the databases have to be improved during the first RBMP implementation and at the latest 3 years after the first RBMP publication to be able to consider in 2015 if the WFD targets have been failed or fulfilled on sufficient statistical basis.

Methods for establishing reference condition and setting class boundaries must include an estimate of error. This information is needed to determine the confidence and precision in status classification. For example, estimates of a biological reference condition will incorporate the natural (i.e. real) variability of the quality element in time and space and the errors in the method of estimation.

3.7.1 Sources of errors

A multitude of factors can affect measurement uncertainty and confound interpretations using biological parameters. The most common errors are related to measurement and include errors associated with sampling effort and sample processing. The importance of natural variability can also vary among organism groups. For example, small organisms such as those making up the phytobenthos community may change markedly over a period of weeks, whereas macrophyte and fish communities may have much longer response scales (e.g. years). An understanding of how uncertainty is related to different methods is needed to better interpret human-induced deviations from those naturally expected to occur.

Regardless of the method used to establish reference condition, it is important to estimate the errors that are inherently associated with the method used and how levels of uncertainty relate to specific quality elements. Errors can be intrinsically related to different quality elements, and different methods used to establish reference conditions can vary in accuracy and precision. For example, paleoreconstruction is probably more precise than spatially based approaches in reconstructing reference conditions of specific sites. This approach may, however, be less accurate than methods that provide estimates of mean or median values. For example, if the site measured is not representative of the type-specific population, and if an adequate number of sites are not measured to obtain reliable measures of mean or median (e.g. for regional patterns), this method can be less accurate than other methods.

The sources of uncertainty in the observed biological quality fall roughly into the following categories:

- **Sampling errors (natural spatial variation).** Within each site/water body there will be spatial heterogeneity in the microhabitats. This means e.g. that taxonomic richness and composition will vary between samples taken during the same period;
- **Sample process errors.** When e.g. sorting the material in a new macroinvertebrate sample and identifying the taxa, some taxa may be missed or misidentified. This may lead to underestimation of the EQR-value for number of taxa at the site;
- **Analytical errors.** For chemical quality elements the errors associated with different analytical techniques may vary for the same substance;
- **Natural temporal variation**. The taxa present at a site will vary naturally over time.

3.7.2 Choice of quality element indicators

The indicators used in establishing reference conditions and the subsequent classification must enable significant impacts to be reliably detected and recorded through the assignment of an ecological status class. Indicators that do not do this will be unsuitable.

The selection of indicators will be an iterative process, requiring consideration of the factors described below.

- **Relevance**. An indicator should indicate the condition of the quality element. It should be capable of indicating the effects of pressures, and thus represent the response of the quality element to pressures;
- **Responsiveness**. Different indicators may be sensitive to different pressures. The use of different indicators for the same quality element may be appropriate depending on which pressures are affecting a water body;
- **Range of sensitivity**. Indicators may detect effects over a range of pressures but reach their maximum response at a low level of pressure (e.g. a sensitive species may disappear). It may be necessary to use one set of indicators for the lower classes and another for higher classes;
- **Ability of Member States to estimate reference values**. Values for some indicators may be more easily estimated than others. For example, where there are no sites at reference condition, other options may be to borrow sites from neighbour regions or states, use historical data, modelling or expert judgement to estimate reference conditions for some indicators;
- **Variability**. Indicators whose natural variability is high and poorly understood are likely to be unsuitable. Indicators measured by methods that produce large sampling and analysis errors, or for which the size of the sampling and analysis errors has not been quantified, are also likely to be inappropriate;
- **Confidence**. Indicators should be selected so that there is good and demonstrable confidence and precision in classification of ecological status. If confidence is low, the range of uncertainty in the value of the quality element may span the boundaries of several or all the classes. This will result in random allocations of status class and false indications that class has changed.

If the risk of misclassification is too large, more than one indicator may be used to estimate the value of the quality element. In such cases, the number of indicators, and the means by which the data for these are combined, should be such as to achieve the required degree of confidence in the estimate for the quality element.

3.7.3 Exclusion of indicators and quality elements

The reference value for each indicator should be identified, including an estimate of the variance associated with it. The variance should be estimated so that a decision can be taken as to whether the indicator can be used to achieve reliable classification. If the variance is too high, reliable classification will not be possible and the indicator should not be used. One reason for excluding a specific quality element from assessment of ecological status is that the natural variability is too large. This would mean that the natural variability is too high for all relevant quality element indicators. This exclusion principle is described in the Directive in the following way:

<u>Annex II 1.3 (vi) Establishment of type-specific reference conditions for surface water body types:</u>

> *Where it is not possible to establish reliable type-specific reference conditions for a quality element in a surface water body type due to high degrees of natural variability in*

that element, not just as a result of seasonal variations, then that element may be excluded from the assessment of ecological status for that surface water type. In such circumstances Member States shall state the reasons for this exclusion in the River Basin Management Plan.

3.8 Setting EQR-based class boundaries

Excerpts from the Directive pertaining to setting quality class boundaries is given in the following Sections of the Directive:

Annex V: 1.4.1 (ii). Comparability of biological monitoring results

In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.

Annex V: 1.4.1 (iii)

Each Member State shall divide the ecological quality ratio scale for their monitoring system for each surface water category into five classes ranging from high to bad ecological status, as defined in Section 1.2, by assigning a numerical value to each of the boundaries between the classes. The value for the boundary between the classes of high and good status, and the value for the boundary between good and moderate status shall be established through the intercalibration exercise described below.

Annex V: 1.4.1 (iv)

The Commission shall facilitate this intercalibration exercise in order to ensure that these class boundaries are established consistent with the normative definitions in Section 1.2 and are comparable between Member States.

Annex V: 1.4.1 (vi)

Each Member State monitoring system shall be applied to those sites in the intercalibration network which are both in the ecoregion and of a surface water body type to which the system will be applied pursuant to the requirements of this Directive. The results of this application shall be used to set the numerical values for the relevant class boundaries in each Member State monitoring system.

3.8.1. Options for setting class boundaries

Based on theoretical considerations and the experience from EQR-based classification systems currently used in Member States, the following guidance may be given on alternative options for setting class boundaries. These alternatives are further elaborated in tool 3 in the Toolbox Section. It should be noted, that whereas Member States may set their own class boundaries, harmonisation within a European scale will be achieved through the intercalibration procedure.

The suggested options for setting class boundaries need to be further developed and tested in Pilot River Basins and future work of the Common Implementation Strategy during 2003-4.

Within each of the alternative options A, B and C below, several alternative methods may apply (e.g. different statistical measures). It is recommended to use the method considered most relevant for the available data set.

A. With access to sufficient data from sites or historical records, derived as described in Sections 3.4-3.7, class boundaries may be set as follows for an individual quality element indicator[13]:

1. Establish a suitable summary statistic (e.g. median value or arithmetic mean) of the values pertaining to reference conditions or high status – the reference value[14].

2. Divide the values pertaining to reference conditions (or high status) by the reference value, thus creating a set of normalised values pertaining to reference conditions (or high status). These values are ratios between observed values and the reference value, and as such potential EQR values for the borderline between high and good status.

3. Invert the normalised values if the nominal values increase toward the "bad end" of the scale. This is necessary in order to achieve a final scale that descends from 1 to 0, as required by the Directive.

4. Select a suitable statistic among the normalised values to represent the class boundary between high and good status, e.g. the 10^{th} percentile.

5. Repeat step 2 (and if necessary 3) for values pertaining to good status, i.e. divide by the reference value and (if necessary) invert.

6. Select a suitable statistic among the normalised values arrived at in the preceding step to represent the class boundary between good and moderate. If the 10^{th} percentile were selected in step 4, the same statistic (of the values representing good status) would be selected here.

The same procedure as described above may be used to set the remaining class boundaries if nominal values representing these quality classes are available.

B. With scarce access to data from sites or historical records corresponding to ecological quality criteria, class boundaries may be set as follows for an individual quality element indicator[15]:

1. Establish a tentative scale of ecological quality ratios based on expert judgement of what may be considered to represent appropriate intervals from high to bad quality.

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[13] Note: Class boundaries will have to be developed for each quality element indicator

[14] The mean or median value from the distrubution of reference site values are considered the most rubust values to be used as the reference value in classification of ecological status (relatively few data/sites needed for sufficient confidence in RC). One disadvantage with using the mean or median value as the reference value is that many reference sites will fall outside the range 0-1 (>1). However, if sufficient amount of data from the reference population exist a high percentile (eg. the 75th, 90th or 95th percentile) may be used as the reference value. This would reduce the problem of many reference sites lying outside the range 0-1. On the other hand, reference values established this way will be very much influenced by extreme values. The conclusion is that the mean or median values from the reference site/data population is considered the best staring point when establishing the classification schemes for ecological status.

[15] Note: Class boundaries will have to be developed for each quality element indicator

2. Apply the scale on a number of real or virtual data sets and compare, by expert judgement, the resulting classification with the ecological quality criteria given by the normative definitions and, if available, further developments of these such as those described in Tool 2 in the Toolbox Section.

3. If necessary adjust the scale and repeat the procedure described in Step 3 above until a scale of class boundaries has been established that results in a classification corresponding to the ecological quality criteria.

C. A statistical distribution approach may be used as an alternative to the above one based on expert judgement if the ecological quality criteria represented by the normative definitions and the developments thereof are deemed too weak to support any judgement of where the borderlines between quality classes should be:

1. Establish a suitable summary statistic (e.g. mean value or percentile) of the reference values.

2. Calculate EQR ratios by normalising all values of the reference dataset (i.e. divide all values by the selected reference value).

3. Determine the "upper anchor" and in doing so the width of the high or reference band by selecting an appropriate statistic (e.g. the 10^{th} percentile) using the distribution of the reference values. The width of this class is determined by the natural variation associated with undisturbed or least impaired reference sites. The upper anchor is also the class boundary between high and good ecological status.

4. Determine the width of the four remaining classes by dividing the interval between the upper and lower anchors equally. The lower anchor used in setting classification band widths can be a zero value. However, some thought should be given to using the minimum value measured or expected to occur in nature. Setting the lower anchor to a value > 0 might be more ecologically relevant and should result in lower probabilities of committing type 2 errors.

3.8.2 Errors associated with classification schemes

Once a classification scheme has been established, the error associated with the individual classes (i.e. misbanding errors) needs to be determined. Determination of the error or uncertainty associated with a classification scheme can be done using a number of randomisation tests. In brief, uncertainties in classification need to explicitly address the question of "what is the probability that a site is assigned to the wrong class?" If a site is incorrectly placed in a class denoting poorer ecological status than the actual condition this is considered as a type 1 or false positive error. If a site is incorrectly placed in a class denoting higher ecological status than the actual condition this would be classified as a type 2 or false negative error. False negative errors (i.e. wrongly assigned to a higher class) mean that ecological degradation may proceed undetected, while false positive errors may cause hugely wasted effort and investment in monitoring and measures. Consequently, both kinds of errors have serious associated problems.

Furthermore, attempts at lowering false negative error frequencies are in line with the European Councils precautionary principle. Article 7 of this resolution states that the Council "considers that use should be made of the precautionary principle where the possibility of harmful effects on health or the environment has been identified and preliminary scientific evaluation, based on the available data, proves inconclusive for assessing the level of risk" (European Council Resolution on the Use of the Precautionary Principle, 14328/00, 5 December 2000).

The errors associated with classification schemes can be alarmingly high. Therefore, an understanding of the errors associated with misclassification is needed so as to design and implement cost-effective monitoring and assessment programmes.

Section 4. The Toolbox

The toolbox includes the following elements and instruments which can be seen as examples illustrating possible ways of implementing the different steps in the REFCOND Guidance. All tools need to be further developed and tested by Member States for specific water body types and pressures The Pilot River Basin testing during 2003-4 will also contribute in the development of the REFCOND tools and tools from other Guidance Documents.

List on tools included in the toolbox:

1. Pressure screening criteria for high status sites or values;
2. Ecological criteria or interpretations of normative definitions for the biological quality elements;
3. Examples on setting class boundaries according to alternative A, B and C in Section 3.8.

Tool 1. Proposed pressure screening criteria for selecting potential reference condition sites or values.

In the table below a set of criteria is suggested which elaborate the degree of acceptable change in an anthropogenic pressure that would provide the limits of high status sites or values. The table may be used as a screening tool alongside with ecological criteria for selection of potential reference sites or values. A prerequisite for the use of pressure screening criteria is that the relationship between pressure and ecological impact is well established and that the impact corresponds to the normative definitions in the Directive (Annex V: 1.2). The screening criteria is suggested to be further developed into water body type specific criteria and tested in Pilot River Basins and future work of the Common Implementation Strategy during 2003-42004.

	High ecological status
General statement	• High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemistry, hydromorpology and biology.
Diffuse source pollution	
Land-use intensification: Agriculture, forestry	• Pre-intensive agriculture or impacts compatible with pressures pre-dating any recent land-use intensification.
	• Pressures pre-dating any recent intensification in airborne inputs that could lead to water acidification.
Point source pollution	
Specific synthetic pollutants	• Pressures resulting in concentrations close to zero or at least below the limits of detection of the most advanced analytical techniques in general use (A Selection process for relevant pollutants in a river basin is presented as an example of best practice in Section 6 of the WFD CIS Guidance Document No. 3 from Working Group 2.1, IMPRESS).
Spec. non-synthetic pollutants	• Natural background level/load (see reference above)
Other effluents/discharges	• No or very local discharges with only very minor ecological effects.
Morphological alterations	
River morphology	• Level of direct morphological alteration, e.g. artificial instream and bank structures, river profiles, and lateral connectivity compatible with ecosystem adaptation and recovery to a level of biodiversity and ecological functioning equivalent to unmodified, natural water bodies
Lake morphology	• Level of direct morphological alteration, e.g. structural modifications that hinder fluctuations of the water surface, compatible with ecosystem adaptation and recovery to a level of biodiversity and ecological functioning equivalent to unmodified, natural water bodies
Water abstraction	
River and lake water abstraction	• Levels of abstraction resulting in only very minor reductions in flow levels or lake level changes having no more than very minor effects on the quality elements.

Flow regulation	
River flow regulation	• Levels of regulation resulting in only very minor reductions in flow levels or lake level changes having no more than very minor effects on the quality elements.
Riparian zone vegetation	
	• Having adjacent natural vegetation appropriate to the type and geographical location of the river.
Biological pressures	
Introductions of alien species	• Introductions compatible with very minor impairment of the indigenous biota by introduction of fish, crustacea, mussels or any other kind of plants and animals. • No impairment by invasive plant or animal species.
Fisheries and aquaculture	• Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends • Stocking of non indigenous fish should not significantly affect the structure and functioning of the ecosystem. • No impact from fish farming.
Biomanipulation	• No biomanipulation.
Other pressures	
Recreation uses	• No intensive use of reference sites for recreation purposes (no intensive camping, swimming, boating, etc.)

Tool 2. Interpretations of normative definitions for the biological quality elements

The table may not be suitable for all types and all pressures. Choice of indicators may need adjustment according to prevailing monitoring. The table suggested is to be further developed and tested in Pilot River Basins and future work of the ECOSTAT cluster. Interpretations of the normative definitions will also be needed for physico-chemical and hydromorphological quality elements.

Rivers	High Status	Good Status	Moderate Status
Phytoplankton	**Taxonomic composition** – the phytoplankton community will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will reflect the type specific phytoplankton community. Any taxa present that are not from the type specific reference phytoplankton community list are likely either to be at very low abundance or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. Size structure of the phytoplankton community is indistinguishable from the type specific reference conditions. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Biomass** – The biomass of the phytoplankton community will be within the range of values expected at reference conditions. **Transparency**- The average transparency will not be significantly changed from that expected at type specific reference conditions as a result of phytoplankton. **Planktonic blooms** – The frequency and intensity of planktonic blooms will be within the range found at reference conditions. **Note:-** *taxonomic composition and abundance are relevant to all pressures; biomass, transparency and planktonic blooms are relevant primarily to eutrophication.*	**Taxonomic composition** – the phytoplankton community may be slightly changed from the type specific reference conditions. The community may contain a minority of taxa which indicate changes from the type specific reference community. Taxa which reflect the type specific reference phytoplankton community are likely still to be dominant. Size structure of the phytoplankton community is near or just outside the type specific reference conditions. **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Biomass** – The biomass of the phytoplankton community will be higher than the range of values at reference conditions. The overall increase in abundance of algae will not be sufficient to significantly alter the light climate or alter the physico-chemical quality of the water or the sediment and thus change the composition of other biota from their expected condition. **Planktonic blooms** – blooms may occur more frequently than expected, but will not be sufficiently frequent or intense so as to cause any significant damage to other quality elements.	**Taxonomic composition** – the phytoplankton community may be significantly changed from the type specific reference conditions. The community may contain taxa which indicate a significant change from the type specific reference community. Size structure of the phytoplankton community is significantly outside the type specific reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Biomass** – The biomass of the phytoplankton community will be significantly higher than the range of values at reference conditions. Other quality elements, such as macrophytes and benthic invertebrates, may be altered by the increased algal abundance. (e.g. depth of colonisation of macrophytes may be demonstrably affected and significant areas of channel vegetation may have been lost. The benthic invertebrate fauna may be significantly altered as a result of the increased biomass) **Planktonic blooms** – persistent blooms will occur regularly. Even in types where plankton blooms are common at reference condition, these will be considerably more intense than expected at reference conditions and will frequently consist of taxa that do not usually dominate at reference conditions.
Macrophytes and phytobenthos	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list. The number of taxa present will usually be within the range of	**Taxonomic composition** – this will differ slightly from the type specific reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition may constitute a significant part of the flora.	**Taxonomic composition**-– this will differ significantly from the type specific reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list (particularly pollution tolerant taxa) may dominate the flora.

[16] Applies only to organic matter pollution.
[17] Applies only to organic matter pollution.

	values expected at reference conditions. Any taxa present that are not from the type specific list, will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. The total vegetated area will be within the range expected at reference conditions. **Bacterial tufts and coats**[16] - No bacterial films due to human activity present. (Bacterial tufts and coats should also be considered to include other decomposers such as fungi and microscopic animals)	The number of taxa present will be near or just outside the distribution of values at reference conditions. Dominant taxa at reference condition are likely still to be dominant **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Bacterial tufts and coats**[17] **-** Bacterial films due to human activity may be present underneath stones etc., but not above.	The number of taxa present will be significantly outside the range expected at reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions and taxa from outside the type specific list may dominate the flora. **Bacterial tufts and coats**[18] - Bacterial tufts and coats visible to the naked eye may be present on the upper surfaces of stones and other substrate, but are likely to cover less than a moderate proportion (for example, 25%) of the available substrate.
Benthic Invertebrate Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list and the number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Taxa known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Diversity** – The balance of the number of taxa present and their individual abundances is within the range expected at reference conditions. Major Taxonomic Groups –Taxonomic groups which are usually found at reference conditions are present in their expected proportion.	**Taxonomic composition** - the number of taxa present will be near or just outside the distribution of values at reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition are likely to be present. Dominant taxa at reference condition are likely still to be dominant **Abundance** – Some of the taxa present will be outside their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Some taxa known to be sensitive to the pressures to which the waterbody is subject may be absent. **Diversity** – The balance of the number of taxa present and their individual abundances may be outside the range expected at reference conditions. Major Taxonomic Groups – Most taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and occasionally major groups are absent.	**Taxonomic composition** – the number of taxa present will be significantly outside the range expected at reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of taxa will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the taxa known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Diversity** – The balance of the number of taxa present and their individual abundances will usually be outside range expected at reference conditions. This may be due, for example, to large increases in the relative abundance of a few insensitive taxa, combined with the loss of sensitive taxa. Major Taxonomic Groups – Some of the taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and some of the major groups are absent.

[18] Applies only to organic matter pollution.

Fish Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. Any species present that are not from the type specific list will be naturally uncommon or rare species or their presence will be attributable to the chance occurrence of species outside their normal distribution range. In either case, their presence will not be indicative of disturbance. The number of species present will usually be within the range of values expected at reference conditions. **Abundance** - Nearly all the species present will be within their expected abundance values at reference conditions. The overall fish abundance will be within the range expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Age classes** - All expected age classes of the type specific species must be present.	**Taxonomic composition** - the number of species present will usually be just within or just outside the distribution of values expected at reference conditions. The majority of species present will be in the type specific species list, but species that are not commonly found at reference condition may be present. Dominant species at reference condition will still be dominant **Abundance** - Some of the species present may be outside their expected abundance values at reference conditions. The overall fish abundance will usually be near or just outside the range of values expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels near or just outside the lower end of the range of values expected at reference conditions. **Age classes** - All expected age classes of the type specific dominant species must be present. Age classes of minor species may be absent.	**Taxonomic composition** – the number of species present will be significantly outside the range expected at reference conditions. As few as half of the species present may be regularly found in the type specific species list. Species from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of species will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the species known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Age classes** - The type specific dominant species is still present, although expected age classes may be missing. Minor species may be completely absent or represented only at abundances significantly outside the expected range of values for reference condition sites.

Lakes	High Status	Good Status	Moderate Status
Phytoplankton	**Taxonomic composition** – the phytoplankton community will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will reflect the type specific phytoplankton community. Any taxa present that are not from the type specific reference phytoplankton community list are likely either to be at very low abundance or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. Size structure of the phytoplankton community is indistinguishable from the type specific reference conditions. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Biomass** – The biomass of the phytoplankton community will be within the range of values expected at reference conditions. **Transparency**- The average transparency will not be significantly changed from that expected at type specific reference conditions as a result of phytoplankton. **Planktonic blooms** – The frequency and intensity of planktonic blooms will be within the range found at reference conditions. **Note:-** *taxonomic composition and abundance are relevant to all pressures; biomass, transparency and planktonic blooms are relevant primarily to eutrophication.*	**Taxonomic composition** – the phytoplankton community may be slightly changed from the type specific reference conditions. The community may contain a minority of taxa which indicate changes from the type specific reference community. Taxa which reflect the type specific reference phytoplankton community are likely still to be dominant. Size structure of the phytoplankton community is near or just outside the type specific reference conditions. **Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Biomass** – The biomass of the phytoplankton community will be higher than the range of values at reference conditions. The overall increase in abundance of algae will not be sufficient to significantly alter the light climate or alter the physico-chemical quality of the water or the sediment and thus change the composition of other biota from their expected condition. **Planktonic blooms** – blooms may occur more frequently than expected, but will not be sufficiently frequent or intense so as to cause any significant damage to other quality elements.	**Taxonomic composition** – the phytoplankton community may be significantly changed from the type specific reference conditions. The community may contain taxa which indicate a significant change from the type specific reference community. Size structure of the phytoplankton community is significantly outside the type specific reference conditions. **Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Biomass** – The biomass of the phytoplankton community will be significantly higher than the range of values at reference conditions. Other quality elements, such as macrophytes and benthic invertebrates, may be altered by the increased algal abundance. (e.g. depth of colonisation of macrophytes may be demonstrably affected and significant areas of vegetation may have been lost. The benthic invertebrate fauna may be significantly altered as a result of the increased biomass) **Planktonic blooms** – persistent blooms will occur regularly. Even in types where plankton blooms are common at reference condition, these will be considerably more intense than expected and will frequently consist of taxa that do not usually dominate at reference condition.
Macrophytes and phytobenthos	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list. The number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance.	**Taxonomic composition** – this will differ slightly from the type specific reference condition. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition may constitute a significant part of the flora. The number of taxa present will be near or just outside the distribution of values at reference conditions. Dominant taxa at reference conditions are likely still to be dominant	**Taxonomic composition**-– this will differ significantly from the type specific reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list (particularly pollution tolerant taxa) may dominate the flora. The number of taxa present will be significantly outside the range expected at reference conditions.

	Abundance – Nearly all the taxa present will be within their expected abundance values at reference conditions. The total vegetated area will be within the range expected at reference conditions. **Bacterial tufts and coats** - No bacterial films due to human activity present. (Bacterial tufts and coats should also be considered to include other decomposers such as fungi and microscopic animals)	**Abundance** – The majority of the taxa present will be within their expected abundance values at reference conditions, but some may deviate significantly from expected. **Bacterial tufts and coats** - Bacterial films due to human activity may be present underneath stones etc., but not above.	**Abundance** – Many taxa will be outside their expected abundance at reference conditions. **Bacterial tufts and coats** - Bacterial tufts and coats visible to the naked eye may be present on the upper surfaces of stones and other substrate, but are likely to cover less than a moderate proportion (for example, 25%) of the available substrate..
Benthic Invertebrate Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. All or nearly all of the taxa present will be contained in the type specific taxa list and the number of taxa present will usually be within the range of values expected at reference conditions. Any taxa present that are not from the type specific list will be naturally uncommon or rare taxa or their presence will be attributable to the chance occurrence of taxa outside their normal distribution range. In either case, their presence will not be indicative of disturbance. **Abundance** – Nearly all the taxa present will be within their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Taxa known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Diversity** – The balance of the number of taxa present and their individual abundances is within the range expected at reference conditions. **Major Taxonomic Groups** –Taxonomic groups which are usually found at reference conditions are present in their expected proportion.	**Taxonomic composition** - the number of taxa present will be near or just outside the distribution of values at reference conditions. The majority of taxa present will be in the type specific taxa list, but taxa that are not commonly found at reference condition are likely to be present. Dominant taxa at reference condition are likely still to be dominant **Abundance** – Some of the taxa present will be outside their expected abundance values at reference conditions. **Disturbance sensitive taxa** –Some taxa known to be sensitive to the pressures to which the waterbody is subject may be absent. **Diversity** – The balance of the number of taxa present and their individual abundances may be outside the range expected at reference conditions. **Major Taxonomic Groups** – Most taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and occasionally major groups are absent.	**Taxonomic composition** – the number of taxa present will be significantly outside the range expected at reference conditions. As few as half of the taxa present may be regularly found in the type specific taxa list. Taxa from outside the type specific list may dominate the fauna. **Abundance** – Many or even the majority of taxa will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the taxa known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Diversity** – The balance of the number of taxa present and their individual abundances will usually be outside range expected at reference conditions. This may be due, for example, to large increases in the relative abundance of a few insensitive taxa, combined with the loss of sensitive taxa. **Major Taxonomic Groups –** Some of the taxonomic groups that are usually found at reference conditions are present but numbers of individuals of some of these may be low and some of the major groups are absent.
Fish Fauna	**Taxonomic composition** – this will be indistinguishable from the type specific reference conditions. Any species present that are not from the type specific list will be naturally uncommon or rare species or their presence will be attributable to the chance occurrence of species outside their normal distribution range. In either case, their presence will not be indicative of disturbance.	**Taxonomic composition** - the number of species present will usually be just within or just outside the distribution of values expected at reference conditions. The majority of species present will be in the type specific species list, but species, that are not commonly found at reference condition, may be present. Dominant species at reference condition will still be dominant	**Taxonomic composition** – the number of species present will be significantly outside the range expected at reference conditions. As few as half of the species present may be regularly found in the type specific species list. Species from outside the type specific list may dominate the fauna.

	The number of species present will usually be within the range of values expected at reference conditions. **Abundance** - Nearly all the species present will be within their expected abundance values at reference conditions. The overall fish abundance will be within the range expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels within the expected values at reference conditions. **Age classes** - All expected age classes of the type specific species must be present.	**Abundance** - Some of the species present may be outside their expected abundance values at reference conditions. The overall fish abundance will usually be near or just outside the range of values expected at reference conditions. **Disturbance sensitive taxa** –Species known to be sensitive to the pressures to which the waterbody is subject will be present at levels near or just outside the lower end of the range of values expected at reference conditions. **Age classes** - All expected age classes of the type specific dominant species must be present. Age classes of minor species may be absent.	**Abundance** – Many or even the majority of species will be outside their expected abundance at reference conditions. **Disturbance sensitive taxa** –Many of the species known to be sensitive to the pressures to which the waterbody is subject will probably be absent. **Age classes** - The type specific dominant species is still present, although expected age classes may be missing. Minor species may be completely absent or represented only at abundances significantly outside the expected range of values for reference condition sites.

Tool 3. Numerical examples on setting class boundaries according to alternative A, B and C in Section 3.8.

The setting of class boundaries is illustrated below, using imaginary data on a particular quality element indicator – species richness of benthic macroinvertebrates. The description follows the steps outlined in Section 3.8.1.

A. Sufficient data from sites (or historical records) are available

1. Observations at reference condition sites representative of rivers of type XX gave the following set of data (numbers of species per unit area or per effort): 35, 28, 29, 43, 45, 31, 37, 29, 33, 34, 39, 35, 32.

The median value – 34 – was selected to represent the reference value.

2. The data set was divided by the reference value, thus creating a set of normalised values: 1.03, 0.82, 0.85, 1.26, 1.32, 0.91, 1.09, 0.85, 0.97, 1.00, 1,15, 1.03, 0.94.

3. Species richness does not increase toward the ”bad” end of the scale. Hence, there was no need to invert the values arrived at in the previous step in order to achieve a scale that descends from 1 to 0.

4. A lower percentile of the normalised data set arrived at in step 2 above, in this case the 10th percentile, was selected to represent the class boundary between high and good status: 0.83.

5. Observations at sites of river type XX considered to be representative of good ecological status gave the following data set: 30, 27, 28, 31, 27, 29, 28, 23, 27, 24.

6. Division by the reference value (34) gave the following set of normalised values: 0.88, 0.79, 0.82, 0.91, 0.79, 0.85, 0.82, 0.68, 0.79, 0.71.

7. The 10th percentile was, again, selected to represent the class boundary: 0.68.

In summary, the following class boundaries were thus established in terms of EQR values:

High status: ≥ 1.00 – 0.83
Good status: 0.83 – 0.68.

The remaining class boundaries might have been established in the same way, had nominal values representing these quality classes been available.

Finally, one would have to decide weather the scale developed for a particular type of river would be applicable to all types. If not, separate scales would have to be developed.

B. Few data from sites (or historical records) available

1. The following tentative scale of EQR values was established by a group of experts, based on their judgement of what would be appropriate intervals from high to bad in terms of species richness of benthic macroinvertebrates:

High status: ≥1.00 – 0.80
Good status: 0.80 – 0.60
Moderate status: 0.60 – 0.40
Poor status: 0.40 – 0.20
Bad status: <0.20

2. Application of the tentative scale on a number of real and virtual data sets and consideration of whether the scale is compatible with the normative definitions of ecological status in Appendix V, 1.2, of the Directive, and the interpretations of the normative definitions given in Tool 2 of the toolbox of this Guidance Document, caused the group of experts to adjust the class boundaries upwards into the following scale:

High status: ≥1.00 – 0.85
Good status: 0.85 –0.70
Moderate status: 0.70 – 0.55
Poor status: 0.55 – 0.40
Bad status: <0.40.

3. No further iterations were considered necessary. It was recommended that the scale be subject to re-evaluation as more data become available from monitoring and intercalibration procedures.

It was decided to apply the scale on all types of rivers, pending re-evaluation with more data.

C. A statistical approach (alternatives A and B deemed not applicable)

1. Same as A1 above.

2. Same as A2 above.

3. The 10th percentile was selected as the ”upper anchor” and the class boundary between high and good (same as A4 above): 0.83.

4. The width of the four remaining classes was evenly spaced over the remaining interval (the ”lower anchor” was set to 0 as there was considered to be no need to set a higher value). This resulted in the following class boundaries:

High status: ≥1.00 – 0.83
Good status: 0.83 – 0.62
Moderate status: 0.62 – 0.41
Poor status: 0.41 – 0.20
Bad status: <0.20.

The scale would presumably have been levelled off to more even figures, since there was no quantitative basis for a two decimal accuracy.

General comment to tool 3:
When establishing the class boundaries it will be obvious that some sites/data that was pre-selected for a specific quality class will fall in another class in the classification scheme (sites/data close to the boundaries). This means that the first preliminary classification have to be reassessed for these sites/data in the final status classification.

Section 5. Examples on Good Practice

Example 1. Development of a risk based prioritisation protocol for standing waters in Great Britain, based on a georeferenced inventory, as an aid to defining reference conditions.

Principle

Standing waters respond to catchment pressures (including development, land use, changes in land management, and atmospheric deposition) by displaying changes in their physicochemical environment. This in turn leads to changes in the condition of the biological elements supported, and in WFD terms, may lead to movement away from reference condition. The rationale is developed therefore that a measure of catchment pressures will give an indirect estimate of proximity to reference condition. This approach can, therefore, be regarded as a preliminary screening tool or risk assessment method to identify potential reference sites which can then be tested against the ecological criteria of the WFD for reference condition. The crux of this approach is the definition of the WFD high status class boundary based on pressure criteria for "no or only very minor" disturbance, this has not yet been achieved.

Method

Implementation of the WFD requires a procedure to identify lakes at risk of a deterioration in water quality as a result of the presence of a hazard(s) in their catchment. A protocol using a three-tiered hierarchical prioritisation system was developed to assess environmental harm using nutrients and acid deposition as example hazards. In order to carry out these prioritisations, basic information was required on the location, number and size of lakes, in association with ecological and water quality data and target (reference) conditions. Since no single comprehensive inventory of lakes and reservoirs in Great Britain existed, prior to this study, the development of a georeferenced inventory of standing waters in Great Britain and their physical, chemical and ecological properties was an integral part of the project.

In Great Britain there are some 46000 standing waters identified on the 1:50,000 OS maps, and some 14000 waters of >1ha surface area. The regulatory agencies have little data on most of these waters, including many of the larger waters which have been assumed to be in good condition. The only realistic approach to collating information on the bulk of these waters to assist in implementing the WFD was seen as using macro scale datasets covering most of the land surface of GB, together with some simple models to derive estimates of various pressures. The focus of the project to date has been the identification of waters at risk of failing to meet the requirements of the WFD, and this work is described below.

The inventory itself contains basic physical characteristics for all standing waters in Great Britain derived from the 1:50 000 ordnance survey panorama digital dataset. For those water bodies >1 hectare, catchment boundaries were generated and associated attribute data were derived, to allow implementation of the risk based prioritisation protocol. The inventory was linked to external databases using a metadata system and summary water chemistry data were collated from some of these databases for over 400 water bodies. It is hoped that further meta-data and summary data can be added in the future as and when data become available.

Project outline

The project was comprised of two phases, Phase 1, completed in 2001, was a scoping study to identify the content and structure of the inventory and to design the risk based prioritisation protocol. During Phase 2, the inventory has been populated and the risk based prioritisation protocol further developed, tested and refined. The approach used to develop the risk based prioritisation protocol largely follows the framework for environmental risk assessment and management detailed by the DETR (2000). The scheme is based on the three properties, importance, hazard and sensitivity, and appropriate measures of each were determined. A three-tiered approach was adopted whereby an initial rapid assessment is made at Risk Tier 1 for all standing waters in Great Britain (approximately 14,000 greater than 1ha), based on the minimum of information gained from already available data sources. This assessment is then used to guide the acquisition of further data for more detailed evaluation of a subset of standing waters at Risk Tier 2 (a few hundred to a few thousand) and, in even finer detail at Risk Tier 3 on a very small subset of waters (a few tens) for which remedial action is likely to be taken.

Phosphorus as an indication of nutrient enrichment

The anthropogenic phosphorus load (human sewage, run-off from land and domestic farm animal waste – the latter data were not available for Scotland) was used as a measure of the eutrophication hazard. The loads were converted into in-lake concentrations using relevant OECD equations, and lakes were given a rank on the basis of the standard Vollenweider classifications of lake trophic status. Retention time was used to identify lakes where the algae would remain in the lake long enough to utilise the phosphorus in the water. Depth data were unavailable for most lakes so that modelled depths were used in calculations.

Acidification from atmospheric deposition

The Risk Tier 1 estimation of hazard and sensitivity to acidification was much simpler since the appropriate data sets had already been compiled for other purposes. Total acid deposition load was used to identify the level of hazard. Five classes were defined and only those in class 1 (<0.5 keq/ha/y) were not passed through to the sensitivity assessment. Data were already available on the sensitivity of lakes to acidification. The data are available at 1 km square grid scale and relate to the buffering capacity of the dominant soil type and baseline geology within each square. Five sensitivity classes were defined. Only classes 1 and 2 (High and medium-high, respectively) were passed on to the final tier 1 risk assessment. The acid deposition class and freshwater sensitivity class for each lake was assessed jointly and lakes with specified combinations of deposition class and sensitivity class were passed through to the Risk Tier 2 assessment.

Identification of potential reference sites

Eutrophication and acidification have been identified as the two major causes of downgrading of water quality in standing waters across Europe (Ref: Dobris Assessment). The method described here permits National screening of all standing waters greater than 1 ha in size for exposure to the risk of damage from these two hazards. The sub-set of standing waters identified as having minimal exposure to catchment pressures in the Tier 1 assessment form the basis for a Tier 2 more detailed assessment at the site level, both to validate the assessment of the principle pressures of enrichment and acidification and to assess other pressures and impacts of relevance to reference condition such as impoundment, shoreline development etc.

Testing of the protocol outputs

Application of the protocol to 30 test lakes across Great Britain indicates that the schemes for both eutrophication and acidification produce reliable risk assessments. These 30 lakes were sites which are well studied by direct survey and sampling of both their physicochemical and ecological quality. Additionally some sites had undergone palaeolimnological investigation.

It is recommended that this method of identifying potential reference lakes is employed as a first screening step offering a method of dealing with a large number of standing waters for which no direct evidence of condition exists. It could be used in conjunction with the method outlined in Example 2 in this section of this Guidance, the use of palaeolimnology and species turnover measures to select potential reference lakes, to provide a two-way assessment of sites for further evaluation.

Example 2. The use of palaeolimnology and species turnover measures to select potential reference lakes

Principle

The Water Framework Directive requires lakes to be classified according to the assemblage of biological elements they currently support. The system specified for this classification is a state-changed system, comparing any lake's current condition with its condition at a reference state (where: There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions). The identification of a suite of lakes at an undisturbed condition is difficult in Western Europe, and presupposes that all possible causes of disturbance are known and quantified. An alternative method exists for lakes – the use of palaeolimnology. This permits a direct comparison of sub-fossil elements of the biological assemblage representing conditions at some previous undisturbed state with the same biological element in its current state.

Method

In Great Britain most palaeolimnological investigations have worked with diatoms, and for this reason diatoms are the most practical choice for the identification of potential reference lakes across all lake types. Additionally, diatoms have been shown to be amongst the most sensitive of biological elements and responsive to the two most significant pressures in Western European lakes, eutrophication and acidification (Ref: Dobris Assessment). Sediment cores from the deepest part of lakes may be dated and the diatom assemblages characterised and their development traced over long periods of time. For the purposes of the WFD, undisturbed conditions may be interpreted as being those pertaining before the intensification of agriculture and before any gross disturbance by industrialisation. For Great Britain this broadly indicates a period circa 1850. Classification of diatom assemblages existing around this date allows a provisional "diatom based typology" of lakes to be made and comparison of sediment strata at this date with current diatom assemblages permits an assessment of the proximity of each lake to reference condition.

Project outline

Analysed sediment cores exist for 166 lakes across the United Kingdom (England, Scotland, Wales and Northern Ireland) and the strata for circa 1850 or earlier were examined and their diatom assemblages described. Analysis by Ward's minimum variance clustering produced an optimal number of 6 end groups of diatom assemblage. The 166 lakes in the diatom dataset appear to represent a broad range of UK lake types and cover a wide geographical distribution, their diatom assemblages from circa 1850 may be taken then, in the first instance, as representing the major reference assemblages for UK lakes.

Comparison of these bottom core strata with diatom assemblages in the most recent strata allows a direct comparison of previous and current diatom assemblages. The degree of floristic change (diatom species turnover) between the core bottom and surface sample for each of the 166 lakes was assessed using a simple chord distance dissimilarity measure. The scores range from 0 to 2 whereby 0 indicates that two samples are exactly the same and 2 indicates that they are completely different. Any score <0.39 can be judged to have insignificant species turnover at the 2.5th percentile, a score <0.48 at the 5th percentile, and a score <0.58 can be judged to have insignificant species turnover at the 10th percentile.

Within each of the six diatom end groups, the lakes are ranked according to the degree of floristic change between the base and surface core sample.

In Group 1 there are very few lakes with low species turnover, with only two having a chord distance of <0.48. This indicates that there are currently few examples of potential reference lakes for this group in the diatom dataset. Similarly for Group 2, where only 4 lakes have a chord distance <0.48. Both Groups 1 and 2 are largely lowland sites in relatively productive catchments and hence many are impacted by eutrophication. It may be difficult, therefore, to find good examples of potential reference lakes for these lake types.

In Group 3 there are many examples of lakes with low species turnover (c. 50% of lakes in this group have a chord distance of <0.48). Therefore, good examples of reference lakes are available for this lake type. Note, however, that there are very few lakes in this group in England and Wales.

In Group 4, only 7 lakes have a species turnover of < 0.48. Given that this group includes most of the large (deep) lakes, more examples of potential reference lakes in this group may need to be found.

In Group 5, 11 lakes have a species turnover of < 0.48. Many lakes in this group have acidified.

In Group 6, 15 lakes have a species turnover of < 0.48. Whilst there are a number of potential reference lakes, many lakes in this group have been impacted and the pressures appear to include both eutrophication and acidification.

Testing of the project outputs

Sites selected as potential reference sites will be cross checked using pressure criteria from Example 1 in this section of the Guidance “Development of a risk based prioritisation protocol for standing waters in Great Britain, based on a georeferenced inventory, as an aid to defining reference conditions”.

Representative sites having a chord distance of <0.4 from each of the 6 diatom based types have been selected for survey and sampling to determine their current biological assemblages. These data should prove useful for classification tool development and for intercalibration purposes.

At each stage, assessment will be made of compliance with reference state criteria as described in the WFD.

Example output from analysis: Type 4 lochs (highlighted potential reference lochs).

SITE code	Site name	grid ref	country	WBID	Wardcluster	chord distance
MARE	Loch Maree	NG 985675	S	14057	4	0.12908
LOMO	Loch Lomond North Basin	NS 365945	S	24447	4	0.2199
RANN	Loch Rannoch	NN 610580	S	22782	4	0.25262
CRAI	Loch of Craiglush	NO 042444	S	23557	4	0.32084
ECK	Loch Eck	NS 141939	S	24996	4	0.41377
WAST	Wast Water	NY 165060	E	29183	4	0.43559
EINI	Loch Einich	NN 913990	S	21191	4	0.47976
LOWS	Loweswater	NY 126217	E	28986	4	0.52396
AWE	Loch Awe North Basin	NM 930 065	S	24025	4	0.65754
BUTT	Loch of Butterstone	NO 058449	S	23531	4	0.67202
CLUN	Loch of Clunie	NO 115442	S	23561	4	0.71851
AWE	Loch Awe South Basin	NM 930 065	S	24025	4	0.73948
LDE	Loch Dee	NX 470790	S	27948	4	0.74503
BALA	Lake Bala or Llyn Tegid	SH 905347	W	34987	4	0.76477
CWEL	Llyn Cwellyn	SH 560549	W	34002	4	0.80267
MARL	Marlee Loch	NO 145443	S	23553	4	0.87704
MENT	Lake of Menteith	NN 580005	S	24919	4	0.94378
BASS	Bassenthwaite Lake	NY 214296	E	28847	4	0.97801
LOWE	Loch of Lowes	NO 049439	S	23559	4	1.17712
DOON	Loch Doon	NX 495985	S	27604	4	1.21363
ESTH	Esthwaite Water	SD 358969	E	29328	4	1.33895
EARN	Loch Earn	NN 640235	S	24132	4	1.62814

Example 3. The establishment and validation of reference conditions for lakes and large rivers in German parts of the Central European Lowland, ecoregion 14, using paleolimnology

Introduction

The member states of the European Community shall finish the establishment of type-specific reference conditions for surface water body types by 2004. Spatially based reference conditions cannot be derived for all types of lakes and rivers in ecoregion 14. Methods based on modelling are therefore required, especially for shallow and flushed lakes. Type-specific biological and physico-chemical reference conditions based on modelling may be derived using hindcasting methods. One valid opportunity to obtain quantitative data about the natural biota and physico-chemical conditions is to analyse fossil diatom communities in sediment cores and to reconstruct nutrient concentrations based on diatom-environment-transfer functions. These quantitative paleolimnological approaches make use of multivariate statistics and regional calibrated data sets.

Situation in the ecoregion 14

In northern Germany there are approximately 500 lakes each greater than 50 ha. Trophic status ranges from oligotrophic to hypereutrophic. The water bodies are 1 to 68 m deep and fully imbedded in the loamy sand of the Weichselian ice age moraines. Groundwater is rich in hydrogen carbonate and phosphorus, coming from Interglacial lake deposits. The lake internal phosphorus concentration strongly depends on residence time (<0.1 to >30 years) and the latter on lake volume and catchment size (1 to 20,000 km²). All the lake catchments were clear cut during the 12^{th} to 13^{th} centuries and no one lake can be classified undisturbed. After 1750 approximately 30% of the landscapes have been afforested. An assemblage of approximately 30 lakes with small catchment areas were kept from agriculture during the last 200 years and have been quasi renaturalized. These lakes form the web of ecological reference sites of the oligotrophic and slightly mesotrophic stratified lake types. The higher mesotrophic and eutrophic reference conditions for lakes with larger catchments and inflow of surface water by rivers are not available from present-day conditions. Therefore three cooperating REFCOND-relevant paleolimnological projects are in progress or starting in October 2002:

- Paleolimnological reconstruction of reference conditions for flushed lakes in the catchment area of the lowland river Havel (Brandenburg Office for the Environment, funded by Federal Ministry of Education and Research, 2002-2004);
- Biotic reference conditions for shallow lakes: Paleolimnological studies on diatoms, algal pigments, chironomids and macrophytes in the catchment area of the lowland river Spree (Brandenburg University of Technology Cottbus, funded by Ministry of Agriculture, Environment and Structural Development Brandenburg, 2001-2002);
- Reconstruction of natural biotic reference conditions in combination with hydromorphological, hydraulic and hydrochemical conditions on rivers in the northeastern German lowland (Leibniz-Institute of Freshwater Ecology and Inland

Fisheries Berlin, funded by the Senate Department of Urban Development Berlin, 2002-2004).

Type specific reference conditions for lakes using diatoms – principles and first results

The paleolimnological approach is used to reveal undisturbed diatom communities (benthic and planktonic) and to quantify the relationship between catchment size and undisturbed water chemistry with respect to the assumed strong influence of lake morphology.

Weighted-averaging regression and calibration of 304 indicator taxa with tolerance down-weighting and classical deshrinking was used to develop transfer functions between littoral diatoms and TP, TN, DIC, pH, chloride and the DOC:TP ratio in 84 German lakes and river sites (Schönfelder *et al.* 2002). Transfer functions based on littoral diatoms have been used successfully for the reconstruction of past water chemistry in flushed and shallow lakes, for example in the lake Großer Treppelsee, (see Figure 1). For deep lakes a diatom data set based on profundal samples from >100 sites is in progress. Twelve lakes have been selected to drill long sediment cores. They can be grouped into four lake types in respect of their water residence times. Diatom based inferences of TP and TN will be used to establish a model to predict in-lake TP and TN as a bivariate function of lake catchment size and lake volume for undisturbed conditions. The model will be validated using data from the most renaturalized lakes in the region. Recent studies on flushed lakes with a great catchment area such as Großer Treppelsee have shown that the anthropogenic influence on water quality has been evident since AD 1250. In other lakes with smaller catchment areas anthropogenic pressures from settling and intensifying agriculture were not indicated by fossil diatoms before the end of the 18th century.

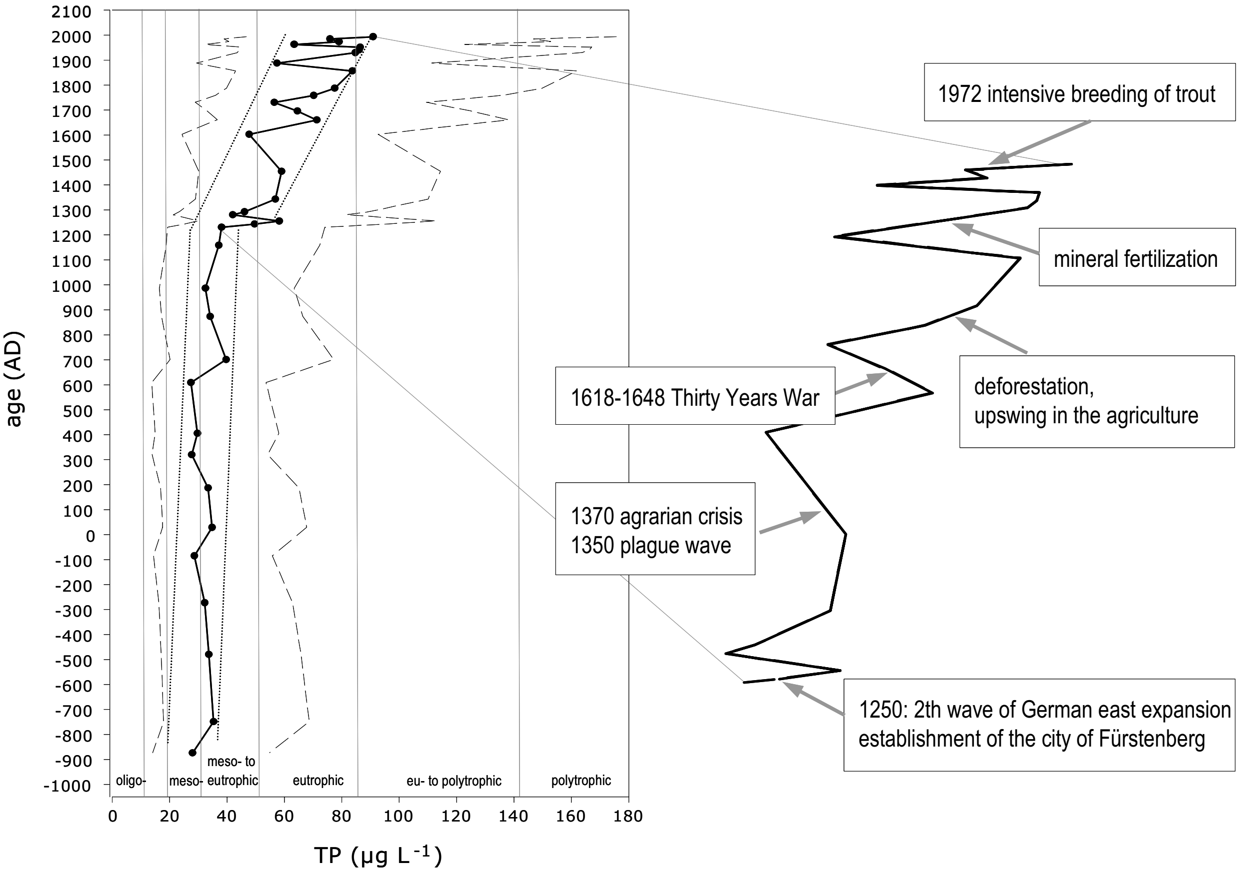

Figure 1. Long term changes of TP concentration of the lake Großer Treppelsees based on diatoms and the main historical events in the catchment which led to higher or lower TP concentrations. The strong anthropogenic impact in this flushed lake started in 1250. To reconstruct undisturbed conditions in such lake types with a large catchment area the water authorities require a quantitative look on past centuries.

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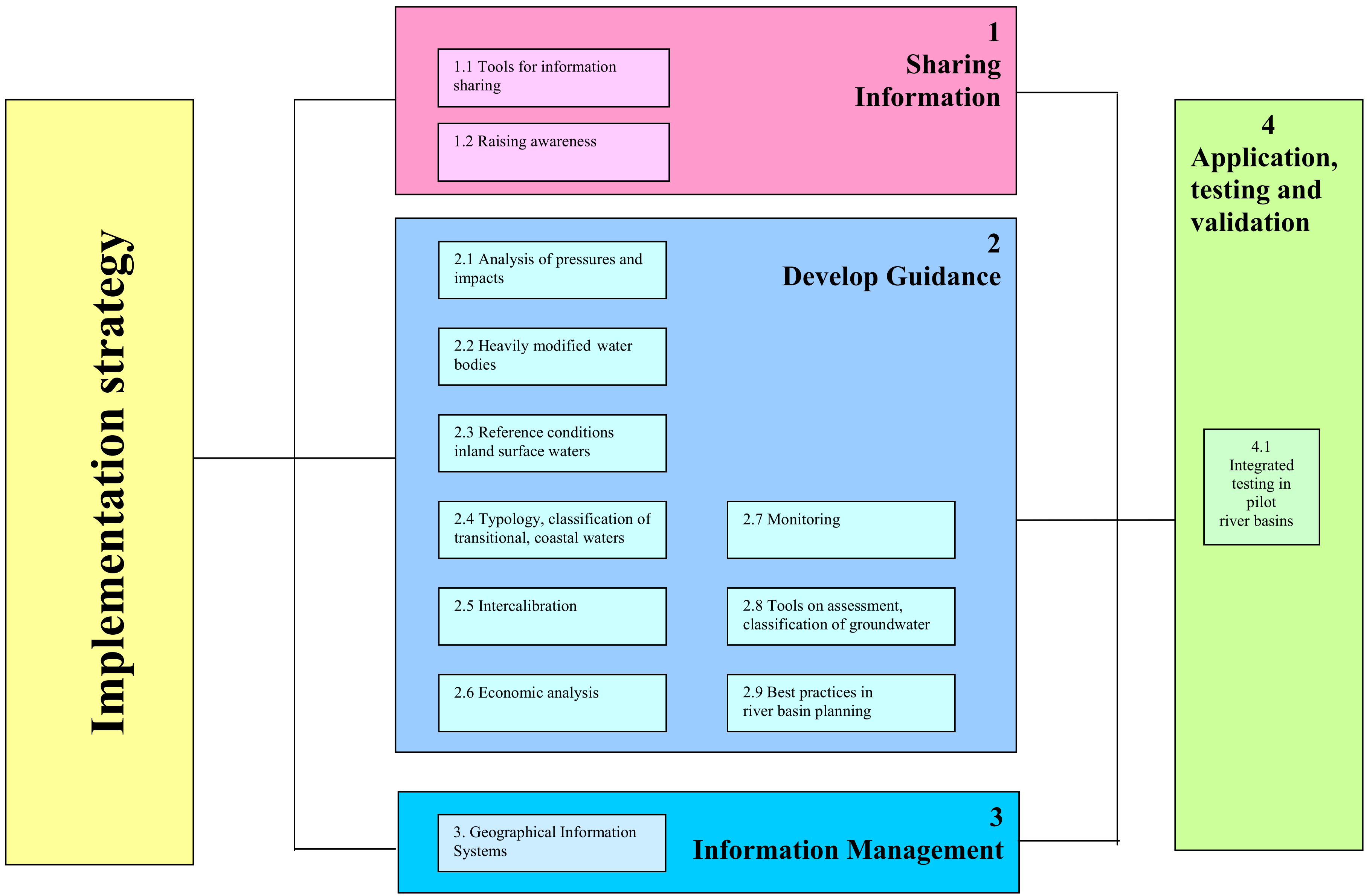
Annex A. Overall structure of the Common Implementation Strategy



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Annex C. Normative definitions in WFD of ecological status classifications for rivers and lakes.

1.2 Normative definitions of ecological status classifications

Table 1.2 General definition for rivers, lakes, transitional waters and coastal waters

The following text provides a general definition of ecological quality. For the purposes of classification the values for the quality elements of ecological status for each surface water category are those given in tables 1.2.1 - 1.2.4 below.

	High status	**Good status**	**Moderate status**
General	There are no, or only very minor, anthropogenic alterations to the values of the physicochemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions. The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion. These are the type specific conditions and communities.	The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

Waters achieving a status below moderate shall be classified as poor or bad.

Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad.

1.2.1 Definitions for high, good and moderate ecological status in RIVERS

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition of phytoplankton corresponds totally or nearly totally to undisturbed conditions. The average phytoplankton abundance is wholly consistent with the type-specific physicochemical conditions and is not such as to significantly alter the type specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.	The composition of planktonic taxa differs moderately from the type specific communities. Abundance is moderately disturbed and may be such as to produce a significant undesirable disturbance in the values of other biological and physico-chemical quality elements. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differs moderately from the type-specific community and is significantly more distorted than at good status. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels.	There are slight changes in the composition and abundance of invertebrate taxa from the type-specific communities The ratio of disturbance sensitive taxa to insensitive taxa shows slight alteration from type specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific communities. Major taxonomic groups of the type-specific community are absent. The ratio of disturbance sensitive taxa to insensitive taxa, and the level of diversity, are substantially lower than the type specific level and significantly lower than for good status.

Element	**High status**	**Good status**	**Moderate status**
Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type specific disturbance sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of any particular species.	There are slight changes in species composition and abundance from the type specific communities attributable to anthropogenic impacts on physicochemical and hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of anthropogenic disturbance, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	**High status**	**Good status**	**Moderate status**
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements [19]

Element	High status	Good status	Moderate status
General conditions	The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 [20] without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

19 The following abbreviations are used: bgl = background level, eqs = environmental quality standard
20 Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels: (eqs>bgl)

1.2.2 Definitions for high, good and moderate ecological status in LAKES

Biological quality elements

Element	High status	Good status	Moderate status
Phytoplankton	The taxonomic composition and abundance of phytoplankton correspond totally or nearly totally to undisturbed conditions. The average phytoplankton biomass is consistent with the type-specific physicochemical conditions and is not such as to significantly alter the type specific transparency conditions. Planktonic blooms occur at a frequency and intensity which is consistent with the type specific physicochemical conditions.	There are slight changes in the composition and abundance of planktonic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment. A slight increase in the frequency and intensity of the type specific planktonic blooms may occur.	The composition and abundance of planktonic taxa differ moderately from the type specific communities. Biomass is moderately disturbed and may be such as to produce a significant undesirable disturbance in the condition of other biological quality elements and the physico-chemical quality of the water or sediment. A moderate increase in the frequency and intensity of planktonic blooms may occur. Persistent blooms may occur during summer months.
Macrophytes and phytobenthos	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic and the average phytobenthic abundance.	There are slight changes in the composition and abundance of macrophytic and phytobenthic taxa compared to the type-specific communities. Such changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbance to the balance of organisms present in the water body or to the physicochemical quality of the water. The phytobenthic community is not adversely affected by bacterial tufts and coats present due to anthropogenic activity.	The composition of macrophytic and phytobenthic taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic and the average phytobenthic abundance are evident. The phytobenthic community may be interfered with, and, in some areas, displaced by bacterial tufts and coats present as a result of anthropogenic activities.
Benthic invertebrate fauna	The taxonomic composition and abundance correspond totally or nearly totally to the undisturbed conditions. The ratio of disturbance sensitive taxa to insensitive taxa shows no signs of alteration from undisturbed levels The level of diversity of invertebrate taxa shows no sign of alteration from undisturbed levels	There are slight changes in the composition and abundance of invertebrate taxa compared to the type-specific communities. The ratio of disturbance sensitive taxa to insensitive taxa shows slight signs of alteration from type specific levels. The level of diversity of invertebrate taxa shows slight signs of alteration from type specific levels.	The composition and abundance of invertebrate taxa differ moderately from the type-specific conditions Major taxonomic groups of the type-specific community are absent. The ratio of disturbance sensitive to insensitive taxa, and the level of diversity, are substantially lower than the type specific level and significantly lower than for good status

Element	High status	Good status	Moderate status
Fish fauna	Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type specific sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.	There are slight changes in species composition and abundance from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	The composition and abundance of fish species differ moderately from the type specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, level, residence time, and the resultant connection to groundwaters, reflect totally or nearly totally undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Lake depth variation, quantity and structure of the substrate, and both the structure and condition of the lake shore zone correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Physico-chemical quality elements [21]

Element	High status	Good status	Moderate status
General conditions	The values of physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity, transparency and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity, transparency and salinity do not reach levels outside the range established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels = bgl).	Concentrations not in excess of the standards set in accordance with the procedure detailed in Section 1.2.6 [22] without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<eqs)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

[21] The following abbreviations are used: bgl = background level, eqs = environmental quality standard

[22] Application of the standards derived under this protocol shall not require reduction of pollutant concentrations below background levels

Annex D. Glossary

Complementary to Article 2 in the Directive:

Term	Definition
Anthropogenic	Caused or produced by human influence.
Baseline scenario	Projection of the development of a chosen set of factors in the absence of policy interventions.
Benthic Invertebrate Fauna	Invertebrate animals living at least for part of their lifecycles on or in the benthic substrates of rivers, lakes, transitional waters or coastal waters.
BEQUALM	Biological Effects Quality Assurance in Monitoring Programmes.
Birds Directive	Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.
Catchment	Refer to definition of 'River Basin' in Article 2 of the WFD (2000/60/EC).
CEN	European Committee for Standardization.
Common Implementation Strategy	The Common Implementation Strategy for the Water Framework Directive (known as the CIS) was agreed by the European Commission, Member States and Norway in May 2001. The main aim of the CIS is to provide support in the implementation of the WFD, by developing a common understanding and guidance on key elements of this Directive. Experts from the above countries and candidate countries as well as stakeholders from the water community are all involved in the CIS to: Raise awareness an exchange information; Develop Guidance Documents on various technical issues; and, Carry out integrated testing in pilot river basins. A series of working groups and joint activities has been developed to help carry out the activities listed above. A Strategic Co-ordination Group (or SCG) oversees these working groups and reports directly to the Water Directors of the European Union, Norway, Switzerland, the Candidate Countries and Commission, the engine of the CIS. For more information refer to the following website: http://europa.eu.int/comm/environment/water/water-framework/index_en.html.
Confidence	The long-run probability (expressed as a percentage) that the true value of a statistical parameter (e.g. the population mean) does in fact lie within calculated and quoted limits placed around the answer actually obtained from the monitoring programme (e.g. the sample mean).
Critical Load	A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified elements of the environment do not occur, according to present knowledge (UNECE 1994).

Term	Definition
Deterioration	A reduction in quality of one or more of the quality elements.
Diffuse Source Pollution[23]	Pollution which originates from various activities, and which cannot be traced to a single source and originates from a spatially extensive land use (e.g. agriculture, settlements, transport, industry). Examples for diffuse source pollution are atmospheric deposition, run-off from agriculture, erosion, drainage and groundwater flow.
Discharge[24]	The release of polluting substances from individual or diffuse sources in the installation through effluent directly or indirectly into water bodies as defined under Article 2 (1) of Directive 2000/60/EC.
Disturbance	Interference with the normal functioning of the ecosystem.
Ecological Quality Ratio	Ratio representing the relationship between the values of the biological parameters observed for a given body of surface water and values for these parameters in the reference conditions applicable to that body. The ratio shall be represented as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero (Annex V 1.4(ii)).
Eco-region	The geographical areas illustrated in Annex XI Maps A (rivers and lakes) and B (transitional waters and coastal waters).
Emissions[25]	The direct or indirect release of polluting substances from individual or diffuse sources in the installations into air, water or land including "discharges" as defined below.
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
Hydromorphology	The physical characteristics of the shape, the boundaries and the content of a water body. The hydromorphological quality elements for classification of ecological status are listed in Annex V.1.1 and are further defined in Annex V.1.2 of the Water Framework Directive.
Impact	The environmental effect of a pressure (e.g. fish killed, ecosystem modified).
Intercalibration	An exercise facilitated by the Commission to ensure that the high/good and good/moderate class boundaries are consistent with the normative definitions in Annex V Section 1.2 of the Directive and are comparable between Member States (see Guidance produced by WG 2.5) (Annex V 1.4. (iv)).
Losses[26]	Any intentional or unintentional release or transfer of polluting substances, other than discharges, emissions or the result of accidents, directly or indirectly into water bodies as defined under Article 2 (1) of Directive 2000/60/EC.
Macrophyte[27]	All aquatic higher plants, mosses and characean algae, but excluding single celled phytoplankton or diatoms.

[23] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[24] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[25] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[26] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[27] Interim working definition. Discussions in the context of the WFD implementation are ongoing.

Term	Definition
Parameter	Parameters indicative of the quality elements listed in Annex V, Table 1.1 in the Directive that will be used in monitoring and classification of ecological status. Examples on parameters relevant for the biological quality element composition and abundance of benthic invertebrate fauna are.: number of species or groups of species, presence of sensitive species or groups of species and proportion of tolerant/intolerant species.
Phytobenthos[28]	Vascular plants, heterotrophic organisms and photosynthetic algae (including cyanobacteria) living on or attached to substrate or other organisms in surface waters.
Phytoplankton	Unicellular algae and cyanobacteria, both solitary and colonial, that live, at least for part of their lifecycle, in the water column of surface water bodies.
Point source pollution	Pollution arising from a discrete source , e.g. the discharge from a sewage treatment works.
Precision	A measure of the statistical uncertainty equal to the half width of the C% confidence interval. For any one monitoring exercise, the estimation error is the discrepancy between the estimated sample statistic (e.g. mean) calculated from the sampling result and the true value. The precision is then the level of estimation error that is achieved or bettered on a specified (high) proportion C% of occasions.
Pressure[29]	The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry of surface and groundwater bodies.
Quality Element	Annex V, Table 1.1 in the Directive, explicitly defines the quality elements that must be used for the assessment of ecological status (eg. composition and abundance of benthic invertebrate fauna). Quality elements include biological elements and elements supporting the biological elements. These supporting elements are in two categories: 'hydromorphological' and 'chemical and physicochemical'.
Reference conditions	For any surface water body type reference conditions or high ecological status is a state in the present or in the past where there are no, or only very minor, changes to the values of the hydromorphological, physico-chemical, and biological quality elements which would be found in the absence of anthropogenic disturbance. Reference conditions should be represented by values of the biological quality elements in calculation of ecological quality ratios and the subsequent classification of ecological status.
Register of Protected Areas	A register of areas lying within the river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater, or for the conservation of habitats and species directly depending on water (see Annex IV). This register must be completed by December 2004 (Art 6, 7 and Annex IV).
Risk	Chance of an undesirable event happening. It has to aspects: the chance and the event that it might happen. These are conventionally called the probability and the confidence.

[28] Interim working definition. Discussions in the context of the WFD implementation are ongoing.
[29] Interim working definition. Discussions in the context of the WFD implementation are ongoing.

Term	Definition
River Basin Management Plan	A plan that must be produced for each River Basin District within a Member State in accordance with Article 13. The plan shall include the information detailed in Annex VIII.
Specific Pollutants	Pollution by all priority substances defined as being discharged into the body of water; and pollution by other substances identified as being discharged in significant quantities into the body of water (Annex V, 1.1).
Specific Non-Synthetic Pollutants	Naturally occurring priority substances identified as being discharged into the body of water and other substances identified as being discharged in significant quantities into the body of water (Annex V 1.1).
Specific Synthetic Pollutants	Man-made priority substances identified as being discharged into the body of water and other substances identified as being discharged in significant quantities into the body of water (Annex V 1.1).
State	2.1 IMPRESS: the condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics).
Strategic Co-ordination Group	A group led by the Commission with participants from all Member States which was established to co-ordinate the work of the different working groups of the Common Implementation Strategy.
Taxa	Taxonomic groups of any rank.
Type specific reference conditions	Reference conditions (see separate definition) representative for a specific water body type.
Wetland	Refer to Guidance on wetlands currently under preparation.
WFD, The Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy.

Annex E. List of Relevant EU-funded research projects

EU-funded projects can provide a strong support as far as the classification of inland surface water status is concerned, but very little has been and is being done as far as the definition and identification of reference conditions is concerned. Most of the past or on-going EU-funded projects have also been directed towards streams and rivers. This means that limited support for classification of ecological status of lakes can be gained from these projects.

For the first aspect, at least five main projects, among the others in the list in Annex E, have to be cited, because they represent today the main effort carried out at European level with the objective of development and standardisation of assessment methodologies. One of these projects, the AQEM project, was recently concluded with the production of all the expected deliverables. The AQEM web site (www.aqem.de/) contains in a downloadable format all the main results of AQEM:

- assessment software
- manual how to apply the AQEM system
- taxa list (>7700 European macroinvertebrate taxa)
- several reports, tools and interesting software products

AQEM (http://www.aqem.de/)
Development and testing of an integrated assessment system for the ecological quality of streams and rivers throughout Europe using benthic macroinvertebrates.
The aim of the project is to develop and test an assessment procedure for streams and rivers which meets the demands of the EU Water Framework Directive using benthic macroinvertebrats. The assessment system will be based on a European stream typology and on near-natural reference conditions. The method will be adapted to regional conditions in order to allow comparable use in all EU member states. It will be combined with methods for stream assessment and indication currently used in the EU member states. If these methods supply additional information for certain regions they will be included in the assessment system as additional modules. Data bases on European macroinvertebrate taxa used for the assessment system will be generated. Finally, the method will be transferred into water management application via a manual and a PC program.

PAEQANN (http://www-cesac.ecolog.cnrs.fr/~paeqann/)
Predicting Aquatic Ecosystem Quality using Artificial Neural Networks: Impact of Environmental characteristics on the Structure of Aquatic Communities (Algae, Benthic and Fish Fauna).
The goal of the project is to develop general methodologies, based on advanced modelling techniques, for predicting structure and diversity of key aquatic communities (diatoms, micro-invertebrates and fish), under natural (i.e. undisturbed by human activities) and under man-made disturbance (i.e. submitted to various pollutions, discharge regulation, ...). Such an approach to the analysis of aquatic communities will make it possible to: i) set up robust and sensitive ecosystem evaluation procedures that will work across a large range of running water ecosystems throughout European countries; ii) predict biocenosis structure in disturbed

ecosystems, taking into account all relevant ecological variables; iii) test for ecosystem sensitivity to disturbance; iv) explore specific actions to be taken for restoration of ecosystem integrity. Among the available modelling techniques, artificial neural networks are particularly appropriate for establishing relationships among variables in the natural processes that shape ecosystems, as these relationships are frequently non-linear.

STAR (http://www.eu-star.at/)
Standardisation of river classifications: Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive.
The ecological status of rivers will be determined in the STAR project from a range of taxonomic groups and a variety of methods. Most Member States will have their own assessment procedures, but a common European standard is still missing. Through field sampling and desk studies the project aims to: 1) cross-calibrate and integrate assessments using different methods and taxonomic groups 2) recommend which procedures to use in which situations 3) define the precision and reliability of each method and 4) assist the EU in defining the boundaries of classes of ecological status. A decision support system will be developed for applying the project findings. The research will be used to assist in the establishment of a European standard for assigning the ecological status of rivers on the basis of multiple sources of ecological data. The STAR project builds upon the results of the previously funded AQEM project and will be clustered with the complementary FAME project.

FAME (http://fame.boku.ac.at/)
Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers: A Contribution to the Water Framework Directive.
The objective of the project is to develop, evaluate and implement a standardised Fish-based Assessment Method for the ecological status of European rivers (FAME), a method identified as priority requirement for the implementation of the Water Framework Directive. FAME will follow a pan-European approach in developing models to characterise reference and degraded conditions based on existing fish data of 17000 sites (5200 rivers) in 16 of the 25 eco-regions of Europe. An integrated system to assess the ecological status will be developed in close co-operation with end-users integrated into the project as "Applied partners". The new method will be evaluated by field tests within ongoing national monitoring programmes. A manual and PC-software will be produced and made available to the public via a project web site. FAME will be clustered with the complementary STAR project.

ECOFRAME
Ecological quality and functioning of shallow lake ecosystems with respect to the needs of the European Water Framework Directive.
Contact address: Prof. Brian Moss, School of Biological Sciences, Derby Building, University of Liverpool, Liverpool L69 3GS, UK (brmoss@liverpool.ac.uk). The ECOFRAME project was recently concluded and a draft summary final report is available. Using expert workshops and subsequent field testing a practical pan-European typology and classification system have been developed for shallow lakes, which can be expanded to all lakes. It is minimal, based on current limnological understanding and as cost-effective as possible given the provisions of the Directive.

The typology is a core typology that can be expanded easily in particular States to met local conditions. The core includes 48 ecotypes across the entire European climate gradient and incorporates climate, lake area, geology of the catchment and conductivity. The classification system is founded on a liberal interpretation of Annexes of the Directive and uses variables that are inexpensive to measure and ecologically relevant. Taxonomic expertise is minimised. The scheme has been through eight iterations, two of which were tested in the field on tranches of 66 lakes. The final version, Version 8, is offered for operational testing and further refinement by statutory authorities.

Full list on relevant EU-funded research projects

- **AASER** - ARCTIC AND ALPINE STREAM ECOSYSTEM RESEARCH - ENV4-CT95-0164

- **AQEM** - DEVELOPMENT AND TESTING OF AN INTEGRATED ASSESSMENT SYSTEM FOR THE ECOLOGICAL QUALITY OF STREAMS AND RIVERS THROUGHOUT EUROPE USING BENTHIC MACROINVERTEBRATES - EVK1-CT-1999-00027 - http://www.aqem.de/

- **BIOMASS** - BIODIVERSITY OF MICROORGANISMS IN AQUATIC SYSTEMS - ENV4-CT95-0026

- **ECOFRAME** - ECOLOGICAL QUALITY AND FUNCTIONING OF SHALLOW LAKE ECOSYSTEMS WITH RESPECT TO THE NEEDS OF THE EUROPEAN WATER FRAMEWORK DIRECTIVE - EVK1-CT-1999-00039 –

- **EMERGE** - EUROPEAN MOUNTAIN LAKE ECOSYSTEMS: REGIONALISATION, DIAGNOSTICS & SOCIO-ECONOMIC EVALUATION - EVK1-CT-1999-00032 – http://www.mountain-lakes.org/index.html

- **ERMAS** - EUROPEAN RIVER MARGINS: ROLE OF BIODIVERSITY IN THE FUNCTIONING OF RIPARIAN SYSTEMS - ENV4-CT95-0061

- FLOBAR-1 – FLOODPLAIN BIODIVERSITY AND RESTORATION PART 1: HYDROLOGICALAND GEOMORPHOLOGICAL MECHANISMSINFLUENCING FLOODPLAIN BIODIVERSITY AND THEIR APPLICATION TO THE RESTORATION OF FLOODPLAINS – ENV4-CT96-0317

- MOLAR – MEASURING AND MODELLING THE DYNAMIC RESONSE OF REMOTE MOUNTAIN LAKE ECOSYSTEMS TO ENVIRONMENTAL CHANGE: A PROGRAMME OF MOUNTAIN LAKE RESEARCH- ENV4-CT95-0007 – http://www.mountain-lakes.org/molar/index.html

- **PAEQANN** - PREDICTING AQUATIC ECOSYSTEM QUALITY USING ARTIFICIAL NEURAL NETWORKS: IMPACT OF ENVIRONMENTAL CHARACTERISTICS ON THE STRUCTURE OF AQUATIC COMMUNITIES (ALGAE, BENTHIC AND FISH FAUNA). - EVK1-CT-1999-00026 - http://www-cesac.ecolog.cnrs.fr/~paeqann/

- **STAR** - STANDARDISATION OF RIVER CLASSIFICATIONS: FRAMEWORK METHOD FOR CALIBRATING DIFFERENT BIOLOGICAL SURVEY RESULTS AGAINST ECOLOGICAL QUALITY CLASSIFICATIONS TO BE DEVELOPED FOR THE WATER FRAMEWORK DIRECTIVE - EVK1-CT-2001-00089 - http://www.eu-star.at/

- **SWALE** - SHALLOW WETLAND LAKE FUNCTIONING AND RESTORATION IN A CHANGING EUROPEAN ENVIRONMENT - ENV4-CT97-0420 - http://swale.sbs.liv.ac.uk/index.html

- **TARGET** - INTEGRATED ASSESSMENT TOOLS TO GAUGE LOCAL FUNCTIONAL STATUS WITHIN FRESHWATER ECOSYSTEMS - EVK1-CT-1999-00005 - http://bscw.bio.ua.pt:3000/

- EUROLAKES - INTEGRATED WATER RESOURCE MANAGEMENT FOR IMPORTANT DEEP EUROPEAN LAKES AND THEIR CATCHMENT AREAS - EVK1-

- FAME - DEVELOPMENT, EVALUATION AND IMPLEMENTATION OF A STANDARDISED FISH-BASED ASSESSMENT METHOD FOR THE ECOLOGICAL STATUS OF EUROPEAN RIVERS: A CONTRIBUTION TO THE WATER FRAMEWORK DIRECTIVE – EVK1-CT-2001-00094 – http://fame.boku.ac.at/

Annex F. (Eco)region specific typology

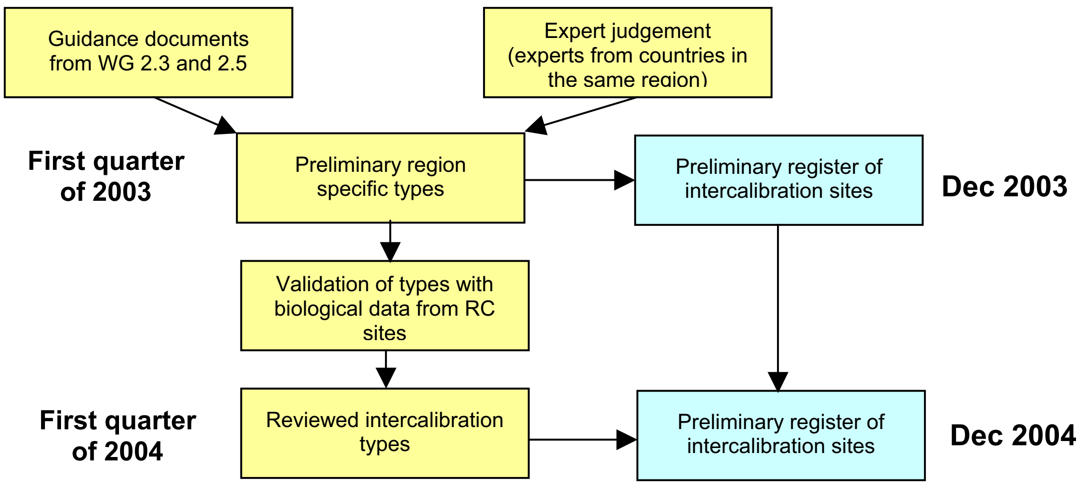
One important use of typology systems is for the selection of types and sites to be included in the intercalibration exercise (see separate WFD CIS Guidance Document No. 6 on intercalibration). Ideally, the chosen typology system should be validated using biological data from reference condition sites. Monitoring programmes will, however, not be fully operational until 2007 and the availability of biological data for validation purposes will be scarce before that. Below a stepwise approach is suggested for establishing inland surface water body types for the purpose of selecting sites for the intercalibration network.

Based on the information in the Guidance Documents from workgroup 2.3 (REFCOND) and 2.5 (Intercalibration) together with expert judgement preliminary (eco)region specific typology system is suggested to be developed in co-operation between Member States sharing the same (eco)region. Based on the preliminary (eco)region specific typology, types are selected for the preliminary selection of intercalibration sites.

Hydromorpological, physico-chemical and biological data is collected from the selected sites together with data on different human pressures. Data from potential high status sites are used for validating the preliminary types (only reference sites can be used for testing and validation to avoid impact from human pressure on the typology). The minimum requirement on the validation result is that the variability in reference conditions within types is smaller than the variability between types.

Depending of the outcome of the validation procedure the types may be revised and complementary types and sites are selected for the final register of intercalibration sites. The typology system may be revised once again when monitoring data from all water bodies at risk and other selected water bodies will be available.

The suggested procedure and timetable for the development of (eco)region specific surface water body types to be used for selection of intercalibration sites is described in the figure below.



Assessing "who needs to get involved" in the reference condition and class boundary analysis requires addressing some of the following questions:

- Who will be responsible for the analysis?
- Who will undertake the analysis?
- Who will provide input into the analysis?
- Who will control the quality of the analysis?
- Who will use the results of analysis?
- Who will pay for the analysis?

Answers to these "Who" questions are likely to include a wide range of organisations, stakeholders and individuals according to questions. For example, experts from the Ministry of Environment or other ministries (land planning, nature protection units, GIS units, agriculture, etc), experts from river basin agencies or regional authorities, managers in charge of developing river basin management plans, ministry heads of water departments, researchers and consultants, historians, the public and a wide range of stakeholders that have developed expertise in specific fields (see table 1) and are involved in water management.

Developing a stakeholder analysis with possible involvement of key stakeholders can be an appropriate step for finding answers to these questions. It also helps in identifying key steps in the analytical process when involvement or input from specific stakeholders is required (different "Who" for different steps).

Annex G. Who needs to get involved in carrying out and using the reference condition analysis?

Table G1. Key Stakeholders can be a Very Important Source of Information and expertise

Key Stakeholders	Where they can help with information and expertise
Water Service Suppliers	➢ Characterising water services and their relations to the river system condition, e.g. impact on groundwater levels ➢ Knowledge about previous water quality situation ➢ Developing trends in water services and their impact on river system conditions
Experts from Ministries (agriculture, transport, planning, finance…) -	➢ Characterising water uses and their impact of the anticipated reference condition ➢ Assessing changes in key national and regional policies and drivers for the trend analysis, e.g. drainage of wetlands ➢ Defining coherent methodologies for assessing key variables at Member State level
Environmental NGOs	➢ Identifying key environmental issues ➢ Providing information about previous stage of the river system ➢ Developing methodologies for estimating impacts on anticipated reference condition ➢ Assessing political complications related to choosing between various reference condition alternatives ➢ Providing social acceptance of agreed reference condition
Economic sectors (farmers, industrialists, etc)	➢ Assessing trends in economic sectors and their previous impact on the river system ➢ Identifying possible measures needed for achieving a certain water quality status based on an anticipated reference condition, and their costs
Researchers/Experts	➢ Assessing key policies/drivers for the trend analysis ➢ Assessing impact of such policies on pressures ➢ Assessing impact of climate change on water quality ➢ Assessing the impact of previous impacts and pressures on water status (e.g. via modelling)
Stakeholders/civil society/public	➢ Assessing changes in key policies/drivers for the trend analysis ➢ Assessing (local, regional, national) priorities *vis-à-vis* water quality improvements, ➢ Providing input into the assessment of disproportionate costs and analysis aimed at explaining derogation, when taking into account various reference condition alternatives ➢ Providing input into the assessments of socio-economic impacts and costs ➢ Providing historic knowledge about the river system in previous decades / centuries

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Environment themes

General

Water

Land

Air

Industry

Waste

Nature

Urban

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European Commission

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 11

Planning process

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 11

Planning Processes

Produced by Working Group 2.9 – Planning Processes

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of this strategy, an informal working group dedicated to best practices in river basin planning issues of the Directive has been set up. The main objective of this working group, launched in July 2001, is the development of a non-legally binding and practical Guidance Documents on four elements of the Water Framework Directive: Identification of river basin districts, planning process, public participation and integrated river basin management planning. Spain and the Commission have the responsibility of the secretariat and animation of the working group that is composed of technical experts from governmental and non-governmental organisations (NGOs).

The present document is the final version of the Guidance on planning process. It presents a general overview of the whole planning cycle and provides some recommendations for its successful implementation. It builds on the input and feedback from a wide range of experts and stakeholders from both EU Member States and candidate countries.

We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union have examined and endorsed this Guidance by means of a written procedure in March 2003. We would like to thank the participants of the Working Group and, in particular, the leaders for preparing this high quality document

We strongly believe this and other Guidance Documents developed under the common implementation strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a *living document* that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond, We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the Guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

Table of contents

Section 1. Introduction - A Guidance Document: What For?

This document aims at guiding the competent authorities entrusted with the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "WFD"). The document focuses on the interactions and scheduling activities and tasks to accomplish WFD requirements. This Guidance claim to be a management tool to WFD implementation at national level.

To whom is this Guidance Document addressed?

It addresses in particular the competent authorities responsible for implementing the Directive at the level of River Basin Districts although it also includes information at other planning scales: sub-basin, national and international.

The document may also help governments in taking decisions concerning the allocation of responsibilities and resources to the implementing authorities. It can further be interesting for stakeholders and non-governmental organisations (NGOs) with a view to a better understanding of the planning process.

What are the objectives of this Guidance Document?

The objective of this Guidance Document is to inform practitioners on the issues and activities to be organised and co-ordinated during the planning process and to provide procedural guidance on the production and development of River Basin Management Plans. This will ensure consistency in approach and efficiency in their preparation. These guidelines are not intended to be overly prescriptive and detailed, but to provide for a conceptional framework which can and has to be tailored to the character and needs of individual river basins.

The Guidance Document is trying:

- To create a common understanding with regard to planning process in the Directive;
- To provide guidelines by explaining the requirements of the Directive with regard to the implementation steps and stages of river basin management planning and by analysing the possibilities the Directive offers;
- To provide recommendations and experiences of how to make the planning process operational;
- To explain how to organise the planning process, providing information on what, who and when.

The Guidance Document is not about:

- Providing Guidance on the specific technical elements of the planning process. Other Working Groups have produced this (See Annex 3 of this Guidance).

What can you find in this Guidance Document?

This Guidance is mainly divided into four sections:

- Section 3 that introduces the ***concept*** of Water Planning;
- Section 4 that proposes ***good practices*** in Water Planning;
- Section 5 that describes the ***requirements of the Directive*** on the Planning Process; and
- Section 6 that provides flowcharts that summarise the ***main tasks to be done*** in the process.

Therefore, the Guidance is answering the following questions:

The concept of planning process

- *What does planning mean?*
- *Which are the main types of planning processes?*
- *Relation to other planning concepts and links to other planning processes*
- *What is the spatial scope of the planning process?*

Good practices on water planning

- *What are the key elements for a sound planning process?*
- *How do these elements fit with the Directive's overall river basin planning process?*
- *Recommendations for a successful planning.*

Requirements of the Directive and main tasks to be done

- *Which are the main activities and when do they have to be developed in the planning process?*
- *Where in the Directive are these activities made explicit or referred to?*
- *Which are the links between main activities?*
- *Which are the main preparatory constraints and bottlenecks?*
- *Which are the objectives and functions of the river basin management plan?*
- *From planning to plan; What has to be taken into consideration during the planning process to meet the requirements set by the Directive for the River Basin Plan?*
- *How should the different results of the planning process be reported through the Plan?*

... and Where are the main contents of the Guidance?

The concept of planning process

***Section 3**: Principles relevant for the water planning and needs for the decision making process – 3.1 Introduction – 3.2 General scope, functions and types of planning processes – 3.3 Planning of water management and links with other planning processes*

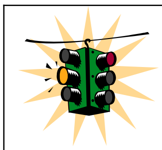
Good practices in water planning

***Section 4: Some considerations for a sound planning process - 4**.1 Long-term vision for the RBD –4.2 Knowledge and information management. The need of building capacity – 4.3 Integration at the operational level. Links with other planning policies – 4.4 The right timing– 4.5 The appropriate toolbox*

Requirements of the Directive and main tasks to be done

***Section 5**: Specific requirements in the WFD with regards to the planning process – 5.1 General considerations - 5.2 to 5.9 Main components in the planning process*

***Section 6**: General overview and overall flowchart of the planning process – 6.1 Introduction: Why and how to use flowcharts in the planning process? – 6.2 The legally binding timetable of the WFD– 6.3 The planning levels and the planning cycle – 6.4 Overall flowchart for the planning process – 6.5 Main bottlenecks in the planning process – 6.6 Recommendations for the preparation and use of flowcharts.*



Look out! The methodology from this Guidance Document needs to be adapted to regional and national circumstances within the frame of the Directive.

The Guidance Document proposes an overall methodological approach. It describes principles and the processes in the management cycle. Because of the diversity of circumstances within the European Union, the logical approach and answers to questions will vary from one river basin to the other. This proposed methodology will therefore need to be tailored to specific circumstances.

What you will not find in this Guidance Document?

The Guidance does not focus on:

- Specific methodologies for the planning process: hydrologic modelling, decision support systems, etc.;
- The establishment of the programmes of measures. There will be a specific Guidance Document.

Section 2. Implementing the Directive: Setting the Scene

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

December 2000: A Milestone for Water Policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water management that form today the foundation of the Water Framework Directive.

The Water Framework Directive: new challenges in EU water policy

What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

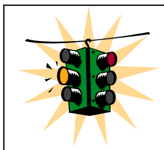
- Prevents further deterioration of, protect and enhance the status of water resources;
- Promotes sustainable water use based on long-term protection of water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

…and what is the key objective?

Overall, the Directive aims at achieving good water status for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (Article 3, Article 24);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (Article 5, Article 6, Annex II, Annex III);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (Article 2 (22), Annex V);
- To make operational the monitoring networks by 2006 (Article 8);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (Article 11, Annex III);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- To make the measures of the programme operational by 2012 (Article 11);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (Article 4).



Look out!
Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular about:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept to the Water Framework Directive is the concept of integration that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise**, combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making**, by promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status**, be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States**, for river basins shared by several countries, existing and/or future Member States of the European Union.

WHAT IS BEING DONE TO SUPPORT IMPLEMENTATION?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national Guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance. A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall decision body for the Common Implementation Strategy.

The Working Group on Best Practices in River Basin Planning

A working group has been created under the common strategy for the implementation of the Water Framework Directive for dealing specifically with river basin planning issues. The main short-term objective of this working group is the development of a legally non-binding and practical guidance for supporting the implementation of the planning process as it is foreseen in the Water Framework Directive. The members of the group are experts and stakeholders from European Union Member States and from a limited number of candidate countries to the European Union (see Annex 4).

The main work packages involved in the group are as follows:

Work Package 1. Guidance on the identification of river basin districts;
Work Package 2. Guidance on the planning process;
Work Package 3. Guidance on public participation;
Work Package 4. Manual on how to produce an integrated river basin management plan and a program of measures.

This document is the final version of the Work Package 2, "Guidance on the planning process".

The Working Group and Drafting Group meetings held and the timetable followed for the completion of Work Package 2, "Guidance on planning process" were as follows:

Date	***Activity***
16 April 2002	*First meeting of the drafting group of the so-called Work Package 2 (WP 2), "Guidance on planning process" in Madrid.*
25 June 2002	*Terms of reference and draft of document on preliminary steps available.*
4-5 July 2002	*Working Group Meeting. Discussion of terms of reference and draft on preliminary steps. Re-elaboration of the table of contents and timetable of WP 2.*
14-15 October 2002	*Drafting group and working group meeting in Brussels.*
25 October	*Version of the Guidance in CIRCA, considering conclusions from working group meeting and new comments.*
7-8 November 2002	*Presentation of first version of "Guidance on planning process" and new work programme to Strategic Co-ordination Group.*
21-22 November 2002	*Presentation of first version of "Guidance on planning process" and new work programme to Water Directors' meeting in Copenhagen.*
2 December 2002	*Drafting groups meeting (text).*
9 December 2002	*Drafting groups meeting (flowcharts).*
20 December 2002	*Revised version in CIRCA.*
20-21 January 2003	*Workshop with other Working Groups and water planners in Madrid.*
21 February 2003	*Final version of the Guidance on planning process to be presented to Strategic and Co-ordination Group.*
March 2003	*Final version of the Guidance to be endorsed by Water Directors by means of a written procedure.*

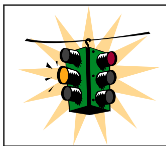
At the Meeting of Water Directors held in Copenhagen (21-22 November 2002) four themes in the follow-up of the Common Implementation Strategy were identified. Among them, the so called in the conclusions of the meeting WG 2B "Integrated River Basin Management" will continue the work already carried out by the former WG 2.9. A detailed mandate for the new WG is in preparation but it is expected to include as key working areas the development of the pilot river basin exercise and the elaboration of new Guidance Documents as "Preparation of river basin management plans and programmes of measures including the integration of different river basin management plans".

Section 3. Principles relevant for the water planning and needs for the decision making process.

3.1 Introduction

This Section discusses some backgrounds of planning processes. It does not deal with the details of the Directive (this is done in the following Sections), but gives insights into the theories of planning itself. The system of planning introduced with the Directive is not the only possible one, yet the deadlines and objectives from the Directive are compulsory. In planning, decisions are made on who is doing what and when. There is no a single best approach to make this decision. This has led to the development of different types of planning process. A flexible use of different planning styles can be useful for competent authorities in order to achieve the requirements from the Directive. This Section provides the information to make that flexibility possible. It presents general principles of planning processes, and the different aspects that must be taken into account when making a choice for a certain type of planning during the implementation of the Directive in a Member or Accession State.

The primary purpose of planning is to provide a Plan as an instrument for making decisions in order to influence the future. Planning is a systematic, integrative and iterative process that is comprised of a number of steps executed over a specified time schedule.



Look out! Water planning is a means to improve and support a sound management of water resources. In this sense, water planning has to be regarded as a process and not as an objective of the Directive in itself.

Planning culminates when all the relevant information has been considered and a course of action has been selected. The plan is then produced and implemented in order to achieve the goals and objectives.

The Directive introduces environmental objectives for water bodies in the river basins. The planning process adopted in the Directive is best characterised by the term 'end result planning'; from the start of the process it is clear what the final outcome will be, in this case 'good water status' (or ´good potential´).

There are certain factors that have to be taken into account in the planning process, so they do not prevent the achievement of the objectives of the Directive:

- In the river basins concerned, not only is the planning process of the Directive is ongoing, but also other initiatives exist, e.g. the development of regional industrial zones, the building of houses, extension of infrastructure, restructuring the agriculture, construction of recreational areas, etc., from which conflicts with the objectives of the WFD can arise. The planning process has to be flexible, dynamic, cyclic and prospective, so it can anticipate and take into account events such as flooding or droughts;

- The different Member States have their own planning traditions, which means they all have their own long-established manners of adjusting developments in society, with corresponding division of roles and allocation of tasks between public and private sectors. In order to implement the Directive in a socially acceptable manner, every Member State should be able to inform, capacitate and promote the active involvement of stakeholders and the public which may mean that the current planning can be improved and revised.

The Directive provides a framework; the actual operational implementation must take place at Member State level. Within this framework there are opportunities to act in different scales: per Member State, per (sub-)basin or per water theme, as long as the prospect of 'good status' stays the leading principle, and the different prescribed steps of the Directive are followed.

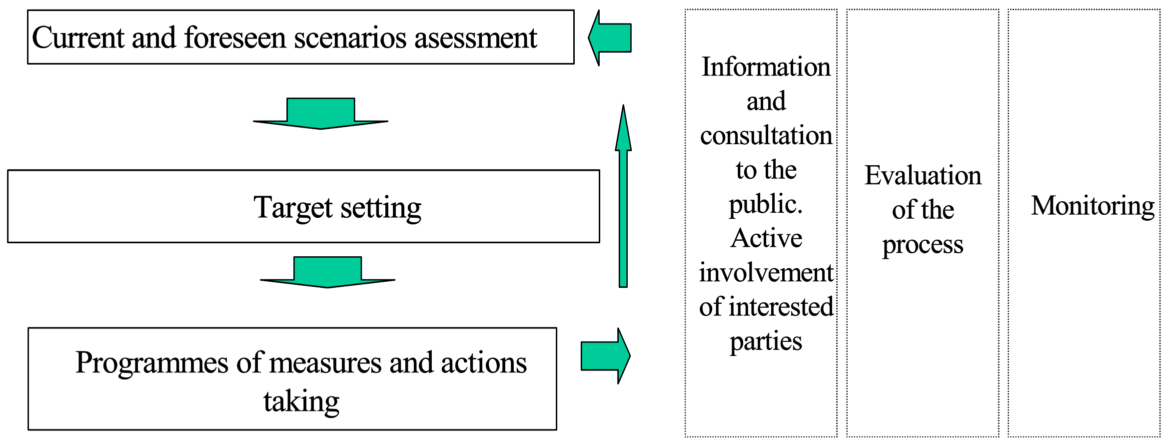
Look out! Needs for the decision making process.

Examples of questions relevant for decision making (and therefore for planning process):

- *When to make the particular decision?*
- *Who will be in response of it?*
- *How "independently" is it possible to make the particular decision in the member states? What kind of co-ordination is needed in a Community level?*
- *Is it a decision, which will be specified later? (iterative process)*
- *What kind of consequences does the decision have?*
- *In which way will the decision limit range of choices in the further steps of implementation of the WFD?*

3.2 General scope, functions and types of planning processes

The classical approach for planning usually includes three main stages: current and foreseen scenarios assessment, target setting and development of alternative programmes of measures including action taking. These stages are part of a cyclical and iterative process in which it is possible to define three additional elements (public participation, monitoring and evaluation of the process) that will be developed in a continuous way in parallel, serving as a link between the others. The process is shown in the figure below.



As it will be described in Sections 5.1 and 6.3, the planning process to be followed in accordance with the WFD comprises ten main components that can be identified with the stages shown in the above figure as follows:

Main Stage	***Components according to WFD***
Current and foreseen scenarios assessment	▪ Setting the scene ▪ Assessment of the current status and analysis of preliminary gaps
Target setting	▪ Gap analysis ▪ Setting up of the environmental objectives
Alternative programmes of measures and actions taking	▪ Setting up of the programme of measures ▪ Development of river basin management plans ▪ Implementation of the programme of measures and preparation of the interim report.
Linking stages	▪ Establishment of monitoring programmes ▪ Evaluation of the first and second period ▪ Information and consultation of the public, active involvement of interested parties

Effective water planning will provide a way of anticipating a water issue, analysing the alternatives management options and proposing policies and specific measures while making the optimum use of resources.

However, water planning provides not only a strategic approach. Although the role of the water planning in the Directive is aimed at the implementation of programmes of measures to improve and to maintain the current water status, other additional functions can be identified[1]:

To provide a framework for developing institutional arrangements and co-ordination with other planning schemes (See next Section).

[1] Note that some of these functions are Directive requirements indeed.

To increase the legitimacy and transparency for water management

Planning has the capacity to increase the legitimacy of decisions to be taken by enabling open and wide dialogue between the public, interest groups and authorities. It's crucial for the legitimacy of a planning process to start dialogue as early as the phases of problem defining and setting the agenda. Better understanding of the interests of those involved arising during the planning process and so the chance to influence planning will increase their willingness to co-operate in problem solving.

To facilitate the interaction and discussion among managers and stakeholders providing tools for conflicts resolution

Some issues can create conflicts in water resources planning that are not necessarily the result of wrong or illicit approaches. As different people have different goals, perspectives, and values, water resources planning should take into account multiple users, multiple purposes, and multiple objectives. Planning for maximum net economic benefits is not sufficient. Issues of equity, risk, redistribution of national wealth, environmental quality, and social welfare can be as important as economic efficiency. It is clearly impossible to develop a single objective that satisfies all interests and all political and social viewpoints.

In consequence, the water planning process should develop a number of reasonable alternatives to consider; evaluating from each one its economic, environmental, political, and social impacts.

However, achieving environmental, social and economic goals simultaneously can be impossible. Therefore, it will be necessary to develop a balance between environmental functioning and users with conflicting aims. Planning can help practitioners to approach complex problems, to organise thinking, and to form the understanding necessary to strike that appropriate balance. Only in that way, crucial issues can be identified and sometimes difficult choices made on the basis of adequate information and a full review of the options.

To report on water management policy

The Directive explicitly requires Member and Accession States to produce a management plan for each RBD. The River Basin Management Plan (RBMP) is intended to record the current status of water bodies within the RBD, set out, in summary, what measures are planned to meet the objectives, and act as the main reporting mechanism to the Commission and the public.

There are a number of outputs of this process, in the form of reports, that Member and Accession States are required to submit to the Commission by prescribed deadlines in order to confirm progress. The river basin planning process is followed by the implementation of the management plan.

The actual planning process may vary significantly because of different traditions in policy making and implementing of policy. Distinguishing factors that characterise the different planning types are:

- the way (public and private) stakeholders are involved;
- the way the objectives are set; and
- the types of operational plans that form the outcome of the process.

The variation in these factors reflects the vision on planning of the initiating authority. Among the different types of planning, the table below describes four visions on planning that are internationally distinguished.

Vision on planning	**Policy making means:**	**Participants**	**Type of plans**
1a. plain rational-instrumental	achieving targets with certain means within a certain time.	the problem is defined by the initiating authority; public actors are responsible for the preparation of the plans, private actors can participate during implementation.	spatial-technical imagination of the desired state; implementation following target-means-rationality.
1b. rational-instrumental with an open eye for the complexity of the political, administrative and social context	identifying of sets of related targets and measures, on the basis of an analysis of the actions possible.	the problem is defined by the initiating authority; the analysis of the situation and the preparation of the plans is done in co-operation with several public actors; private actors can participate during implementation.	framework of agreements (who will do what when, what has when to be geared to each other, in which cases must the plan be adjusted); the plan may be incremental (= periodically review of targets and measures, in the light of the target).
2a. plain interactive	policies are the outcome of a process (of learning and negotiating) between interdependent public actors (among themselves) and private actors, each using their own resources.	the definition of the problem is stable if the network of participants is stable; public and private actors both contribute to preparation and implementation of the plans.	picture of the agreed desired target status, in which public as well as private targets are achieved; programme with in any case everybody's tasks and financial inputs.
2b. interactive with an open eye for the power of fundamental debate	on the basis of a powerful discourse, regrouping of actors and means with the aim of achieving certain targets (e.g. 'water service').	the problem is defined by a coalition of public and private actors; a broader audience (public and private) is invited to preparation and implementation of the plans.	review of the activities of public and private actors, in the setting of the discourse; plan with sub-plans for the adjustment of everybody's activities, tasks, responsibilities and financial consequences.

1a In the *rational-instrumental* type of planning (top-down), the initiating authority defines the problem, the solution to the problem, and the means and time schedule for achieving that solution. Other stakeholders are not involved during this process, although they might be informed once the solution is set. Private actors may be involved in the implementation of the plans.

E.g. the planning of the (re)construction of dikes, after the authorities decided that the problem of flooding has to be solved by enlarging the hydraulic capacity of the river. The actual work on the dikes can be carried out by private actors.

1b In the *rational-instrumental planning 'with an open eye'*, the authority recognises the complexity of the social structure in which policy making takes place. Yet the problem is defined by the initiating authority. In the phase of problem analysis and preparation of solutions, other public stakeholders (= other authorities) can co-operate. As in the first type, private actors may be involved in the implementation of the plans.

E.g. the drafting of a programme, initiated by a water authority, of several upstream measures in municipalities a region, in order to reduce risks of flooding downstream by decreasing the peak flow in a certain river.

2a In the *interactive* planning form, the initiating authority starts a process of learning and negotiation between interdependent public actors and private actors, each with their own resources. The definition of the problem is an outcome of that process, and stays stable as long as the network of participants is stable. Public and private actors both contribute to the preparation and implementation of the plans. In short, the initiating authority sets the objectives, while other stakeholders have a say in the means employed.

E.g. an overall plan against flooding in a certain district, with measures agreed on by all different actors involved, concerning the hydraulic capacity of the river, the rainwater sewer system in municipalities, reduction of rainwater runoff from roofs, fields and car parks of private persons, and the retention of water in agriculture and nature grounds.

2b In the *interactive planning 'with an open eye'*, the initiative may come from the authority, but also from other actors. Nevertheless, the authority facilitates the process of problem definition. The discussion in this type of planning is structured by new viewpoints on a problem that are recognised by several actors. On the basis of these viewpoints, strong coalitions can be formed, pursued by the adjustment of ongoing activities.

E.g. the understanding that the available space for water cannot be tightened endlessly without consequences, and that in spatial planning the water flow must be taken into consideration. This brings a reversal in the thinking on planning, from water management rendering services to spatial planning, to water management being prescriptive on the possibilities for spatial planning.

In the order of the four visions on planning, the uncertainties present in planning processes are judged of an increasing importance. Although an historical development is recognisable in the planning types, all forms are applicable at present. More than that, the different planning types can occur at the same time in a certain region!

For example, in several countries as in the Netherlands and in policies on certain forms of non-point sources of water pollution, the interactive planning style is predominant. At the same time, after large flooding, in some cases, the tackling of high water levels became so urgent, that for that particular issue, the rational-instrumental planning style was used. At present, since the memories of the impressive water masses have fainted, the call for more participation is growing louder, which results in a shift in planning style to a more interactive one.

This example shows that the predominant planning style can vary, not only in a geographical scale, but also in a time scale.

As has been substantiated in other Guidance Documents (e.g. WFD CIS Guidance Documents No. 1 – WATECO and No. 8 - Public Participation), for the competent authority it is a matter of the utmost importance to know the social context of an issue, starting with a stakeholder analysis. By knowing the positions of stakeholders – by this is meant public and private stakeholders – a competent authority can choose which type of planning best suits the given situation. It brings the opportunity to flexible shift between the different planning styles, resulting in the best results.

3.3 Planning of water management and links with other planning processes

One of the most significant characteristics of planning is that it is a dynamic process and therefore can be characterised in terms of a set of activities that take place over time and that interact through the transmission and feedback of information. It is the function of these activities to convert that information into forms from which a set of decisions (i.e., plans) can be produced. At all stages of this process, co-ordination with other relevant planning processes should be ensured. In fact, water resources must be planned and managed in an integrated and holistic way. This is likely to involve the co-ordination of river basin planning with the planning processes of other relevant sectors in order to ensure that the objectives of the Directive are met.

For example, many land use activities depend on water. Therefore, a sound water management is crucial to avoid undesirable side effects. Vice versa, land use also affects determinants of water flow and can alter its characteristics, for example, by introducing pollutants along water pathways. Land use regulations can be needed for water protection purposes.

Although WFD contains no explicit provisions in relation to land-use planning, the arrangements for implementation will need to ensure that bodies responsible for land use planning take account of the objectives which it creates. Therefore, it will be advisable to ensure that the land use and water planning processes support one each other as far as possible. Regarding this issue, the requirements of the Directive on Strategic Environmental Assessment (2001/42/EC) will also need to be taken into account.

Although, as it has been stressed above, there are a lot of links with other planning processes, water management planning has some characteristics that cause significantly differences from other planning fields (as for example spatial or economic planning).

In the first place water – on the one hand – is something we use, so that in water management those functions are planned and facilitated (e.g. shipping, water for industry and drinking, etc.). Yet at the same time – on the other hand – policies are carried out to preserve water from deterioration, in order to guarantee the preconditions for those functions. The Directive especially deals with the care for the functioning of water systems, and only in a derived manner with the interests associated with it (e.g. via the concept of water services).

Another characteristic that makes water a special good to manage, are the two types of functions existing at the same time: first the territorial functions; water being the imperative basis for other activities that highly depend on the water system (e.g. agriculture, shipping, spatial planning), and second the utility functions; water being materially used in processes (e.g. drinking water, industrial water).

These characteristics make water planning pre-conditional for other types of planning. Yet it is not an easy precondition to deal with, since the natural dynamics of water systems bring permanent uncertainty. If, for example, the spatial planning is neglected for a certain period, the landscape won't suddenly change by itself. If the same is done with the planning of water systems, dangerous situations can occur with respect to risks of flooding, droughts and health.

Planning is not 100% accurate
Uncertainty can be defined as the occurrence of events that are beyond our control. Uncertainty is always an element in the planning process. It arises because the complexity of the many factors involved. In fact, meteorological, demographic, social, technical, and political conditions which will determine the planning process have behaviour patterns not always known with sufficient accuracy. Uncertainty arises mainly due to the stochastic nature of some key elements affecting these processes.

The programme of measures can be a tool to deal with this uncertainty since it can be revised according to the circumstances (article 11(5) and Annex VII.B)

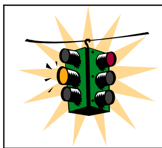
Finally water is not stationary, but a flowing substance, not constrained by administrative or political boundaries, but following physical and hydromorphological limits. This spatial context is commonly known as the catchment.

The Directive – in reflection of the natural water cycle – prescribes the management activities to take place within geographical areas called River Basin Districts (RBDs). These are based largely on surface water catchments, together with the boundaries of associated groundwater and coastal water bodies. In the case of small river basins, adjacent to larger ones, or of several neighbouring small basins, the Directive allows the competent authority to combine or join them in order to make water management in the River Basin District more efficient.

For coastal waters the planning process should consider the influence of other plans that may affect the coastal water beyond the Water Framework Directive controlled one nautical mile coastal strip. Water exchange with more offshore waters may influence the coastal, or even transitional waters, and to not account for this could lead to incorrect assumptions about quality downgrades and the programme of measures required to improve the situation

By creating a spatial unit for water management, based on river basins, it is likely that spatial conflicts will occur with other policy sectors that have a significant impact on water, but are structured along administrative and political boundaries.

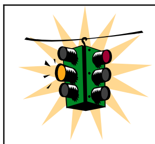
This point also brings the scale-issue into the picture. The complexity of the planning process of water management depends for a great deal on the characteristics of the catchment of the water system considered; in a small scale water system, the planning is more easily carried out than in very large scale systems, such as the Danube or the Rhine, with many countries involved. The Directive requires co-ordination across administrative and political borders.



Look out!
Directive requires that spatial context for integrated and co-ordinated water management has to be the river basin district level.

Section 4. Some considerations for a sound planning process

Planning is a tool or working methodology for preparing decision making with the objective of improving the use of resources available to achieve certain goals. It requires knowledge of the reality on which it operates and capacity to evaluate both the expected outcome and the process through which it can be attained.



Look out! Think globally, act locally.
As a matter of "good practice", river basin planners and managers need to build some cross-cutting principles into all components of their work, to ensure that co-ordination and coherence required for effective results is actually achieved.

The following preconditions for a sound planning process according to the relevant aspects of the WFD can be underlined:

- Long-term vision for the RBD;
- Knowledge and information management. The need of building capacity;
- Integration on the operational level. Links with other planning policies;
- The right timing;
- Appropriate toolbox.

4.1 Long-term vision for the RBD

Having a vision of what the RBD will be in the future can help to determine what measures have to be taken in the perspective of a sustainable development and thus to leave water resources in sufficient quantity and quality for the future generations. Article 1 of the Directive stresses on the necessity to promote sustainable water use based on a long-term protection of available water resources.

Working on a long-term vision for the RBD is an essential tool :

- to reach an agreement between authorities and stakeholders on objectives;
- and then, to plan the necessary actions to reach progressively these objectives.

A stable long-term planning is also important to have a reference during the whole implementation process. At the end of the period covered, the progress made can be compared with the initial vision so to revise the measures if necessary.

Long-term vision for the river basin district is mentioned several times in the Water Framework Directive:

- Baseline scenario.
  Annex III asks the Member States to take account of long term forecasts of supply and demand for water in the River Basin District. The WFD CIS Guidance Document No. 1 on water economics (WATECO) explains why and how the establishment of a baseline scenario for the district is necessary;

- Surveillance monitoring.
  According to Annex V, surveillance monitoring programmes must provide information for the assessment of long term changes in natural conditions and the assessment of long term changes resulting from widespread anthropogenic activity;

- Taking into account the natural time-lag for the pollution transfers and renewal of resources.
  Such time-lag should be taken into account in timetables when establishing measures for the achievement of good status of groundwater and reversing any significant and sustained upward trend in the concentration of any pollutant in groundwater.

4.2 Knowledge and information management. The need of building capacity

The foundation for effective management is good scientific information. In particular, an understanding of freshwater ecosystems and key hydrological and ecological processes is essential and should be used to decide on all aspects of integrated river basin management."Good practice" means that for any river basin management process, the ecological components should be based on a freshwater ecoregional assessment to establish a scientifically based, shared vision on how to conserve the freshwater plants and animals in each river basin.

Similarly, socio-economic analyses are key to understanding the drivers behind water uses. Information databases must be regularly updated through effective programmes. This does not mean measuring everything all the time, but rather carrying out a strategic, targeted and integrated programme, the results of which can be used to inform and adjust management decisions. In many cases, socio economic data is mainly collected at other than river basin spatial scale by central statistical offices. In that case, the implementation of co-ordination mechanisms between them and RBDs may be needed.

Sound information management and analysis needs capacity. Capacity is generally defined as the availability of instruments to take actions. Given the complex and challenging nature of the WFD, it is vitally important that capacity for actual implementation is maximised among all relevant actors. General elements of a capacity-building programme might include raising public awareness (e.g. to help secure broad support for the river basin management objectives), informal transfer of "know how" (e.g. through the exchange of experience between river basin managers), and formal training (e.g. in specialised monitoring techniques), both internal and external. However, the exact needs will vary from country to country and from river basin to river basin, *inter alia* according to different socio-economic conditions, or the concrete water management issues identified. The relevant aspects are:

- The need to build capacity (starting with awareness raising) among economic sectors and NGOs, as well as among officials, planners and administrators;
- The need to enhance sharing of information and experience between countries and regions sharing river basins, with the internet providing valuable new opportunities;
- The need to allocate adequate human and financial resources for capacity building activities in each RBD as part of overall WFD implementation.

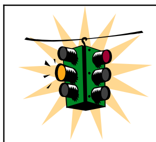
4.3 Integration at the operational level. Links with other planning policies

The WFD sets out a coherent framework for the sustainable management of the water environment (article 1, recitals 3, 5 and 16). This sustainable view is more integrative and places water within the fabric of a larger environmental system.
For example, the management of the water environment is directly and indirectly influenced by many different activities. These activities can be attributed to sectors other than water e.g. transport, agriculture and land-use planning etc.

Clearly, for effective water management, it is essential for activities that impact the water environment, but that fall within the competence of other sectors, to be co-ordinated with the objectives of water management and protection. Failure to take such a holistic approach to water management is recognised as one of the main deficiencies of the existing aquatic legislative framework and has contributed to its inadequate implementation across Europe.

The approach taken by the WFD recognises the need for co-ordination across sectors and proposes a system of planning and management to accommodate it. The river basin planning process will be the central tool for the co-ordination of policies for the purpose of water management.

This does not necessarily mean that the policy objectives of other sectors will be constrained by those of water management. However, it will mean achieving economic and social goals in ways that safeguard, and wherever enhance, the status of the water environment.



Look out! The WFD can only contribute to environmental sustainability if it co-ordinates policy in other relevant sectors for the purposes of water management.

MS will need to establish a planning framework with a clear and explicit purpose and clear national policies, including a set of objectives for protecting and improving the environment in relation to other sectors.
Better overall co-ordination at the river basin level is a pre-requisite for implementing the WFD effectively. This, in turn, needs more integration at the operational level, especially:

- Among bodies involved directly with water management (e.g. those responsible for water storage and supply, flood management and treatment of waste water);
- Between water managers and other sectors, such as land-use planning, agriculture, forestry, flood management, industry and tourism/recreation;
- Integration of surface- and ground-water management (at present often dealt with separately);
- Integration of "inland" and coastal waters, for example by applying the approach and principles of Integrated Coastal Zone Management (ICZM);
- In the case of international river basins, establishing co-operation (where not already in place) between countries and seeking consistency between WFD implementation and any existing bilateral or multilateral agreements that affect water management.

The scale is a very relevant aspect for a good integration. In this sense, sometimes integration needs to happen at the river basin scale, e.g. between flood management, water supply and environmental protection measures; sometimes at the national scale, e.g. between water resource legislation and environmental protection legislation; and some other times at the European scale, e.g. between WFD, Common Agricultural Policy (CAP) and Structural Funds. In this sense, it is important to recognise that the great variation in the size of river basins within and between countries means that approaches suitable for one location are not automatically transferable elsewhere. Good integration on the planning scale implies also the need to co-ordinate "top–down" and "bottom–up" approaches (i.e. to ensure that many physically separate actions at local scale are sufficiently co-ordinated to reach, in combination, the objective of "good status" at the river basin scale). As a matter of "good practice", river basin planners and managers need to build some cross-cutting principles into all components of their work, to ensure that the co-ordination and coherence required for effective results is actually achieved.

Therefore, the planning process in general and the drafting of a RBMP in particular, will depend on contributions from various administrations and institutions. In larger basins and in particular in international basins, the input for the draft RBMP will most probably have to pass different levels of co-ordination and decision-making.

In order to make the drafting of the RBMP easier and to ensure coherence and compatibility of the contributions, it is necessary to define as early as possible the overall structure of the RBMP. Furthermore, the requirements in terms of scale, level of detail, etc. should be clarified at an early stage to set the framework for all involved in the production of the RBMP. It might be a good idea to test the basic structure with the preparation of the report on the analysis required by article 5 of the WFD.

4.4 The right timing

The deadlines for achieving the objectives of the WFD are extremely challenging. It is therefore better to begin implementation "early and imperfectly" than to wait for "perfect conditions" (e.g. when all possible data have been collected and analysed). Consequently, the deadlines in the WFD text must not be seen as a step-by-step timetable for implementation. Result-oriented "good practice" will require many elements to be run simultaneously. Furthermore:

- Timing of preparatory work by Member States should recognise that achievement of WFD deadlines and "good practice" approaches will require immediate action. Primary or secondary legislative changes may be necessary though the appropriate organisational arrangements may not be in place and the required skills and resources may not be available or adequately developed;
- Time can be saved by using existing structures, processes and tools wherever possible. However, this should be subject to the outcomes of a review, checking the suitability and capacity of these structures for delivering WFD requirements. In many cases, a certain degree of adaptation will be needed;
- Monitoring and planning are tools to facilitate management actions in the WFD context. However, management action should not be delayed until all possible planning and monitoring has been completed. For example, if

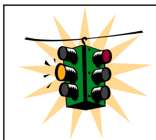
monitoring is not operational until the final deadline of 2006, there will be a severe "bottleneck" in preparing an effective programme of measures by the corresponding final deadline of 2009;

- It is especially important that strategies for public participation and stakeholder involvement are developed and implemented from the beginning, though recognising that different groups will need to be engaged at different stages of the process (see also Work Package 3 of Working Group 2.9, Guidance on public participation);
- Timing of initiatives in related policy areas (e.g. land-use planning policy, capital investment in infrastructure) may impact significantly on the timetable for achieving WFD objectives if the links are not considered at an early stage.

4.5 The appropriate toolbox

Knowledge and information management, capacity building and integration on the operational level needs appropriate tools. Tools are needed for e.g.

- collecting appropriate data (data bases, GIS);
- picking up relevant data and information on data bases;
- analysing and describing the content and planning process of the WFD (flowcharts and GIS-based maps directed to the authorities and the public);
- facilitating administrative requirements;
- public participation (actor analysis, workshops, logical framework etc.)**;**
- decision support tools able to make right priorities concerning the program of measures.



Look out! Under the Common Implementation Strategy a specific Guidance Document (WFD CIS Guidance Document No. 9) has been developed on the GIS elements of the WFD (WG 3.1)

However, those who are involved in the development of water resources systems methodology know that the use of the appropriate tools cannot guarantee by itself the development of optimal plans for water resources and management. In fact, given the competing and changing objectives and priorities of different interest groups, it is unclear how useful the concept of an "optimal plan" really is. What system methodology can do, however, is to help define and evaluate, in a rather detailed manner, numerous alternatives that represent various possible compromises among conflicting groups, values, and management objectives. In particular, a rigorous and objective analyses should help to identify the possible trade-offs between quantifiable objectives so that further debate and analysis can be more informed. The art of systems analysis is to identify those issues and concerns which are important and significant and to structure the analysis to shed light on these issues.

Although the systems approach to water resources planning is not restricted to mathematical modelling, models do exemplify the approach. They can represent in a fairly structured and ordered manner the important interdependencies and interactions among the various control structures and users of a water resources system. Models permit an evaluation of the economic and physical consequences of alternative engineering structures, of various operating and allocating policies, and of different assumptions regarding future flows, technology, costs, and social and legal requirements. Although this systems methodology cannot define the best objectives or assumptions, it can identify good decisions, given those objectives and assumptions.

To engage in a successful water resource systems study, the systems analyst must possess not only the requisite mathematical and systems methodology skills, but also an understanding of the environmental engineering, economic, political, cultural, and social aspects of water resources planning problems.

Thus, the role models may be viewed as that of tools from which to derive answers to well-posed questions about the performance or behaviour of the system that is being planned. However, because of the dynamics of the planning process, it may happen that the answers derived from the models will suggest that the original questions were not well conceived and need to be reformulated. Hence, the role of models is iterative. They are used to produce information that may be fed forward to aid in decision-making (i.e., plan formulation). With equal value, they may produce information that is fed back to aid in redefining the problem.

Section 5. Specific requirements in the Water Framework Directive with regards to the planning process

5.1 General considerations

The publishing of the Water Framework Directive forms a legal obligation for the competent authorities to organise the management of water within River Basin Districts. Understanding the planning and management requirements of the Directive is the basis on which these guidelines on the planning process are considered and established. The planning process is aimed to improve the establishment of river basin management plans and the programmes of measures and hence contribute to the establishment of the overall environmental goals of the Directive: that of achieving "good water status"(recital 25), prevent "further deterioration", "promote sustainable water use" and enhance protection and improvement of the aquatic environment through measures "for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances"(Article 1).

Common understanding

There are a number of different planning concepts related to the WFD that are often used interchangeably and require some clarification – these relate to river basin planning, river basin management, river basin management plan, programme of measures and the appraisal process.

The River Basin Management Plan

The WFD requires MS to produce a management plan for each river basin district. This requirement is described in Article 13 and 15. The RBMP will act as the central focal point for the outcome of river basin planning. It will record the current status of water bodies within the River Basin District, set out, in summary, what measures are planned to meet the objectives, and act as the main reporting mechanism to the Commission and the public. The full contents of the plan are specified in Annex VII.

River basin planning and river basin management

River basin planning is the process of collecting and analysing river basin data and evaluating management measures in order to achieve the objectives of the WFD within prescribed timescales.

The river basin planning process is followed by implementation of the programme of measures. The planning process together with the implementation of the programme of measures is often referred to as river basin management.

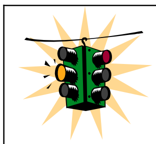
As the name implies, the WFD establishes an outline framework for the planning and management of the water environment. The framework includes a series of key tasks to be completed by prescribed deadlines. In order to confirm progress against these tasks, MS are required to submit a number of outputs from this process, in the form of reports, to the Commission.

Although the key tasks represent milestones in a planning process, the WFD does not specify the procedural detail necessary to support the development of the river basin management plans. The specific nature of river basin planning process is at the discretion of MS.

In the Directive there is no specific article on the planning process. The preambles of the Directive deal with the planning process in an explicit way only to stress the needs of considering different solutions for different conditions and to note that water planning is a long term process (Preambles 13 and 28, see Annex 2).

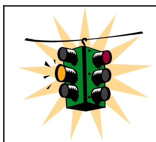
However, several articles deal with tasks that are linked with the planning process as has been summarised in Section 3 and it is shown in more detail in Section 6 of this Guidance. In fact, according the Directive, the general approach for water planning can be seen as based in the following main components:

- Setting the scene;
- Assessment of the current status and analyse preliminary gaps;
- Setting up of the environmental objectives;
- Establishment of monitoring programmes;
- Gap analysis;
- Setting up of the programme of measures;
- Development river basin management plans;
- Implementation of the programmes of measures and prepare the interim report on the implementation;
- Evaluation the first and the second period;
- Information and consultation of the public, active involvement of interested parties.



Look out!
The Directive includes specific requirements for non deterioration and the implementation of extra measures to comply with previously existing water related community legislation. The Commission is leading the production of a horizontal paper that will shed light on the requirement to "prevent deterioration".

There is a tendency to view the planning process based in the above mentioned components as a clearly defined linear sequence. In reality these components are unlikely to be followed in rigid succession, but involve non-linear iterative processes.



Look out! River basin planning process will not run in a linear sequence
The planning includes a number of components that depend on each other, and ideally should be developed as soon as possible. The planning flowchart in Section 6 gives a clear image of work plans that overlap on the time scale.

Each component in the process will consist of numerous activities. Detail on these activities is given later in this Section and in Section 6. Additional technical detail is provided in the other Guidance Documents.

Look out! This Guidance on planning is focused specifically in the general approach of the process.
The technical aspects and tools to be used in planning will be dealt with in a comprehensive Manual on integrated river basin management planning to be prepared at a later stage. On the other hand, specific and detailed information of every step of the planning process mentioned in this Guidance can be found in the Guidance Documents developed by the working groups involved in the Common Implementation Strategy.

5.2 First component: Assessment of current status and preliminary gap analysis

The initial stage in the process of implementing the Water Framework Directive can be called as "Setting the scene" and includes the identification of the River Basin Districts, establishment of the appropriate administrative arrangements for co-ordination of activities, and designation of competent authorities.

Following this, the **first component of the planning process** is to describe the characteristics of each River Basin District. This requirement is outlined in Article 5 (see Annex 2).

Hence, the assessment on current water status is based in the four following tasks:
- General description of the river basin district that should include the establishment of reference conditions for surface waters;
- Register of protected areas;
- Identification of significant pressures and assessment of their impacts;
- Economic analysis of water uses.

These tasks should be completed by 22 December 2004, and reported to the Commission by the 22 March 2005.

Look out! *The general description of the RBDs is important because it will serve as the foundation of the subsequent process*

The general description of the RBD includes assigning coastal water bodies to districts. Article 2(7) of WFD defines coastal waters as extending for a nautical mile from the territorial baseline.

Shared groundwaters must only be assigned to one RBD. This is an outstanding difference with respect to coastal waters, where the Directive allows them to be assigned to more than one RBD.

Look out! Under the Common Implementation Strategy the following specific documents have been developed on:

- ***Guidance document on the Definition of water bodies (WFD CIS Guidance Document No. 2);***
- ***Information document on the Identification of River Basin Districts (WG 2.9);***
- ***Establishing reference conditions and ecological status class boundaries for inland surface waters (WFD CIS Guidance Document No. 10 from WG 2.3);***
- ***Typology, reference conditions and classification systems for transitional and coastal waters (WFD CIS Guidance Document No. 5 from WG 2.4).***

Moreover a specific Guidance Document in Wetlands is in preparation and expected to be finished in 2003.

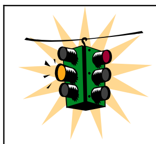
For all water bodies, good status must be achieved unless a derogation is applied. Each water body has to be characterised according to ecoregion types (System A) or to the differentiation of water bodies into types using the different obligatory and optional factors (System B). This work will provide the foundation for further activities to establish what "good status" will mean for each "type".

According to the Directive, it is necessary to identify what the relevant aspects of a waterbody's characteristics would be like if there were "no or only very minor alterations" to the body resulting from human activities. In the Directive these nearly undisturbed conditions are called as reference conditions.

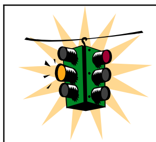
Reference conditions also have to be included in the general description of the RBD and they should be selected according to chemical and hydro-morphological characteristics and evaluated more specifically in quantitative terms on the basis of biological parameters. Reference conditions must be defined for each quality element and each water body type in order to allow an ecological quality ratio to be calculated and a class determined for each surface water body. They also have to be included in the general description of the RBD and they should be selected according to chemical and hydro-morphological characteristics and evaluated more specifically in quantitative terms on the basis of biological parameters. The characterisation of surface waters requires that Member States develop a reference network for each surface water body type. If no reference waters are available, reference conditions could be based on modelling or on expert judgement.

Sometimes it will not be possible to achieve a "nearly undisturbed condition" of a water body because of substantial physical alterations made to it to permit activities as irrigation, drinking water supply, power generation, navigation and so on. The Directive recognises that in some cases the benefits of such uses need to be retained and if a series of criteria are fulfilled, allows their designation as artificial or heavily modified water bodies.

The reference conditions for artificial or heavily modified water bodies of surface water is the "maximum ecological potential", that has to be derived from the water body type that is most similar to the uninfluenced body of surface water.



Look out! First characterisation of water bodies may also include a provisional identification of artificial and heavily modified water bodies.
The designation of artificial or heavily modified water bodies can be also considered as an exemption from the "good ecological status objective" but this task is required in the river basin management plan in which the final designation shall be made before December 2009. In any case, a provisional identification of artificial and heavily modified water bodies may be undertaken by 2004 and the formal designation by 2009.



Look out! Under the Common Implementation Strategy a specific Guidance Document has been developed on the identification and designation of heavily modified and artificial water bodies (WFD CIS Guidance Document No.4 from WG 2.2)

The Directive provides protection to higher standards through the *designation and registration of protected areas*. Protected areas are those that have been designated as requiring special protection under EU legislation, either to protect their surface water or groundwater or to conserve habitats and species that directly depend on those waters. A register of protected areas within the district shall also be published by the end of 2004 (article 6 and Annex IV).

Under Article 4 of the Directive, for individual protected areas, any standards and objectives that have been set for them must be complied with within 15 years of the Directive entering into force unless otherwise specified in the Community legislation under which they have been designated.

The register of protected areas required under article 6 must include the following types of protected areas:

- areas designated for the abstraction of water intended for human consumption;
- areas designated for the protection of economically significant aquatic species;
- bodies of water designated as recreational waters;
- nutrient sensitive areas; and,
- areas indicated for the protection of habitats or species where the maintenance or improvement or the status of water is an important factor in their protection.

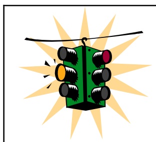
The following table shows the Community legislation more relevant for each type.

Protected areas	***Community legislation***
Abstraction of water intended for human consumption.	Surface Water Abstraction Directive (75/440/EEC)
Protection of economically significant aquatic species	Shellfish waters designated under the Shellfish Waters Directive (79/923/EEC)
Recreational waters	Bathing waters designated under the Bathing Waters Directive (76/160/ECC)
Nutrient sensitive areas	NVZs designated under the Nitrates Directive (91/676/EEC) and sensitive areas designated under the Urban Waste Water Treatment Directive (91/272/EEC)
Protection of habitats or species	Natura 2000 sites designated under the Habitats D

Generally, protected areas derive their status from the specific Community legislation under which those areas are identified or defined. Consequently, it is considered that no specific power to "designate" new categories of protected areas will be needed, although a power is needed to specify the protected areas to which the article 6 (and then article 4) obligations will apply.

An exception to this general rule concerns article 7 (water used for the abstraction of drinking water), which provides a new obligation to identify all bodies of water used for the abstraction of drinking water and those bodies intended for such future use.

The identification of significant anthropogenic current and foreseen pressures and the assessment of their impacts are based on Annex II (1.4) of the WFD. Once the main pressures have been identified, an assessment shall be made to predict how they can impact on the water bodies, i.e. how they influence the achievement of the environmental quality objectives. The susceptibility of the surface water bodies status to the pressures can be obtained using both monitoring data and modelling techniques.

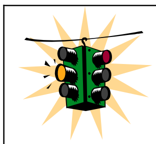


Look out! Under the Common Implementation Strategy a specific Guidance Document has been developed on the analysis of pressures and impacts in accordance with the WFD (WFD CIS Guidance Document No. 3 from WG 2.1)

For both surface and groundwaters, although the requirements are phrased slightly differently, the approach is essentially the same. That is, to gather available information about pressures on water bodies, and to assess the impact of those pressures on water bodies and the risk of them failing to meet the environmental status objectives set for the water bodies.

In fact, what the Directive requires from the identification is an assessment of which water bodies are at risk of failing to meet the environmental objectives. This information will be used to define the programmes of measures and the design of monitoring programmes.

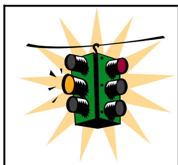
The risk assessment for groundwater considers that groundwater can take a long time to recover once it is polluted. If achieving good status by 2015 is technically unfeasible or disproportionately expensive, lower objectives can be established. Groundwater bodies which will have these lower objectives have to be identified and require an evaluation of the feasibility of natural or artificially assisted restoration. The use of derogations is subject to a number of tests that must be reported to the Commission in the RBMPs.



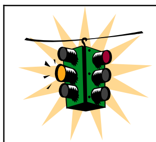
Look out! Under the Common Implementation Strategy a specific Guidance Document has been developed on the Statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results (WG 2.8). A so-called daughter directive on Groundwater is expected to be finished during 2003.

For 2004, a provisional identification of HMWB is needed on the basis of significant hydromorphological alterations. The risk assessment for surface water bodies will determine whether the effects of hydromorphological alterations to a surface body are likely to prevent the achievement of good ecological status.

If the achievement of good ecological status is considered as uncertain, a further assessment will be required after 2004 to determine what improvements to the hydromorphological conditions would be needed to achieve good ecological status and whether such improvements would have significant adverse effects on the activity related to the alteration (derogation on the basis of disproportionate costs). The result of this assessment of the risk to fail to meet the objectives is the identification of HMWB. At this stage, a third assessment will be required to determine the risk of the HMWB to fail to achieve the good ecological potential.



Look out! For 2004, only a first assessment of risk of failing to meet the objectives is required.
Results of monitoring will precise this risk in 2005-2006 (confirmation of the risk or not). Monitoring is a task that is greatly related to the risk assessment. Specific requirements for monitoring can be found in Article 8 (see Annex 2 of this document). Results of monitoring are necessary in order to decide if it is necessary to make further assessment.



Look out! Risk assessment is one of the main tool of the river basin planning process.
If every pressure could be reliably identified and its effects accurately predicted, monitoring would be redundant. However, risk assessments can never be perfect. They always need to be tested. The risk assessments completed by the end of 2004 will provide an estimate of which water bodies could be at risk of failing to achieve environmental objectives. The monitoring programmes must provide the information needed to supplement and validate these assessments and to establish the status of the bodies confirmed at risk.

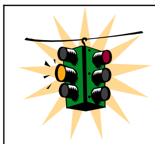
Wetland ecosystems are ecologically and functionally significant parts elements of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in WFD CIS Guidance Document No. 2

on water bodies and further considered in Guidance on wetlands (currently under preparation).

Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

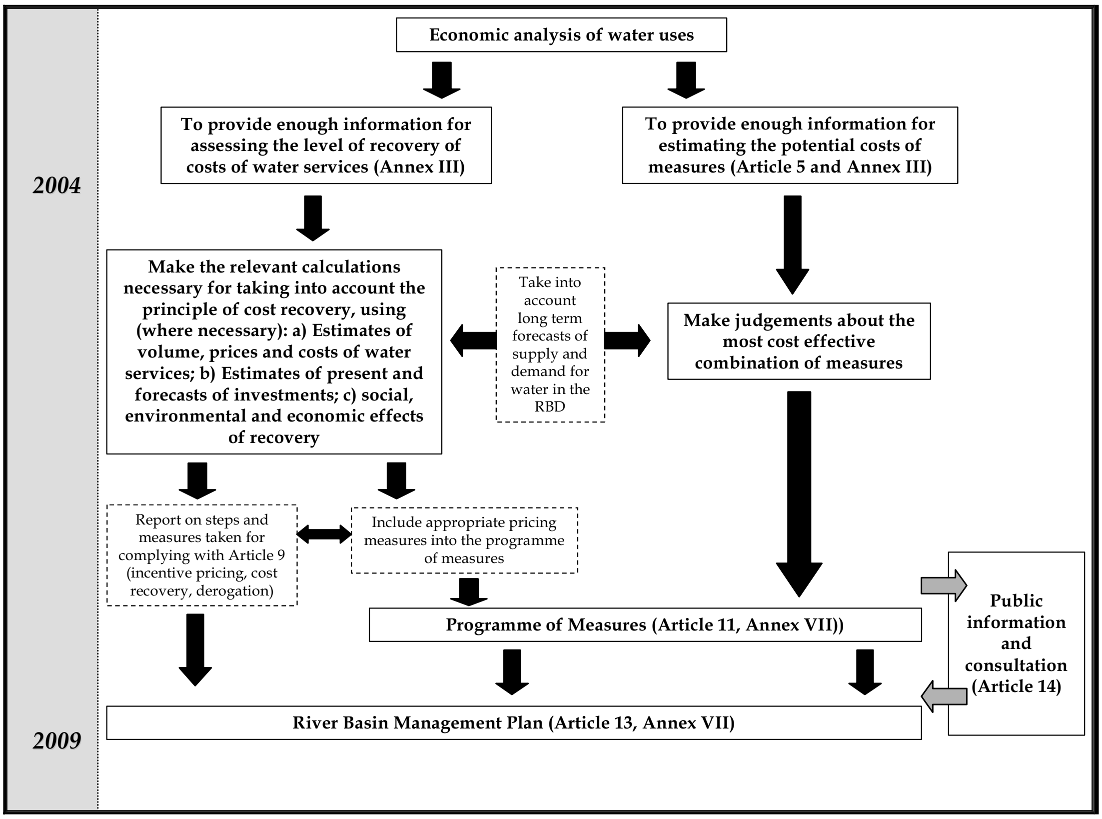
Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal Guidance paper on wetlands (currently in preparation).

The economic analysis of water uses is mainly described in the Article 9 and Annex III of the WFD (see Annex 2).

	***Look out! Under the Common Implementation Strategy a specific Guidance Document (WFD CIS Guidance Document No. 1) has been developed on "Economics and the environment - The implementation challenges of the WFD" (WG 2.6).***

The comparison between the economic elements of the Directive reviewed and the content of Annex III of the WFD shows that not all components of the economic analysis required to support the implementation of the economic elements of the Directive are specifically spelt out in Annex III.

A difference is made between the explicit and implicit functions of the economic analysis, the term explicit referring to the economic components that are specifically outlined in Article 5 and Annex III (see Figure 5.1), and the term 'implicit' referring to references made to economic issues in other parts of the text of the Directive that will also require some economic analysis which has not been mentioned in Article 5 and Annex III (see following figures).



Source: WFD CIS Guidance Document No. 1 - WATECO.

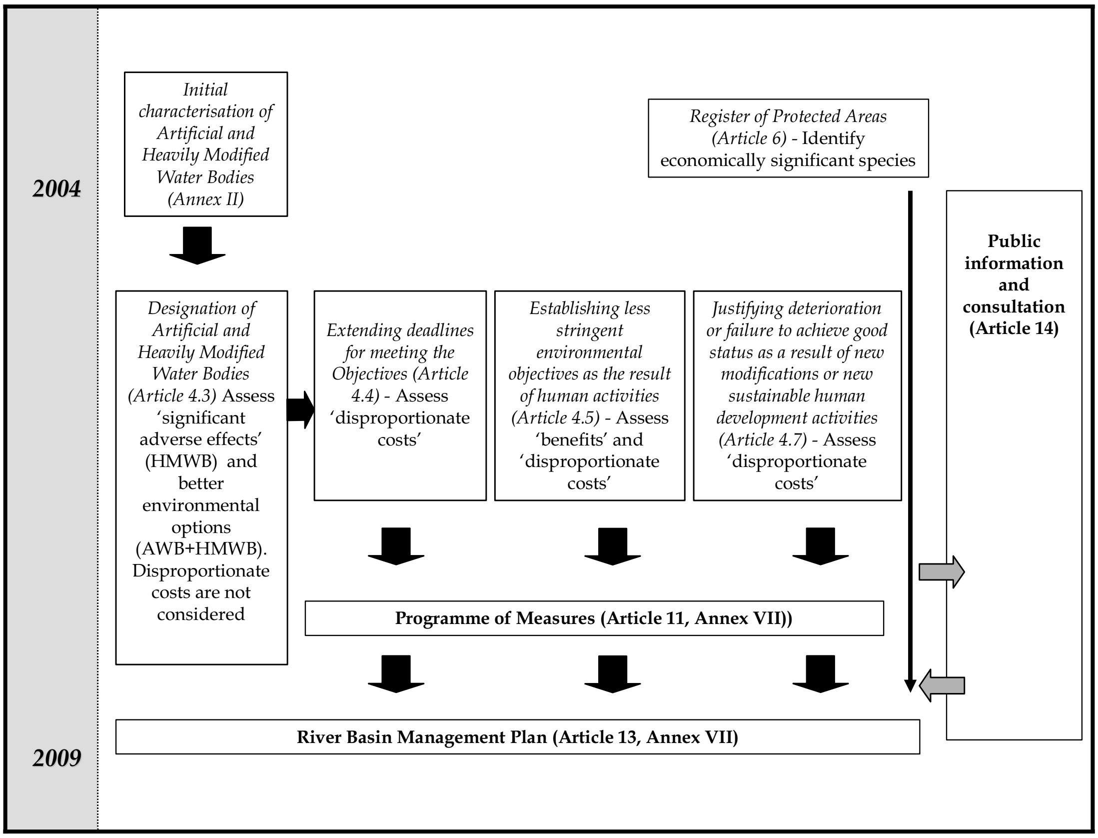
Figure 5.1 **The *explicit* economic functions of the economic analysis.**

Look out! The economic analysis undertaken by 2004.

2004 is the first major deadline aimed at characterising river basin districts as referred to primarily in Article 5 and relevant annexes of the Directive. Therefore, 2004 is also the first milestone for the economic analysis that requires for each river basin district to:

- *Undertake **the economic analysis of water uses** – the main objective is to assess how important water is for the economy and socio-economic development of the river basin district. The analysis needs to pave the way for the identification of significant water issues to be reported to the public by 2007;*
- *Investigate the dynamics of the river basin and providing economic input into the **development of a baseline scenario** – The economic analysis will assess forecasts in key economic drivers likely to influence pressures and thus water status;*
- *Assess **current levels of recovery of the costs of water services**, in accordance to Article 9 of the Water Framework Directive – The main elements to be investigated include the status of water services, the extent of the recovery of the costs (financial, environmental and resource costs) of these services, the institutional set-up for cost-recovery and the contribution of key water uses to the costs of water services;*
- *Prepare for the **cost-effectiveness analysis** – It is suggested that data are collated on costs for the key measures that will be considered, after 2004, in the development of the river basin management plans.*

	➢ *Propose activities* ***for enhancing the information and knowledge base*** *- Practical steps and measures will be identified for filling key economic-related information and knowledge gaps, both identified during the characterisation of the river basin and likely to arise when undertaking the cost-effectiveness analysis.*



Source: WFD CIS Guidance Document No. 1 - WATECO.

Figure 5.2 The *implicit* economic functions of the economic analysis.

5.1 Second component: Setting up of the environmental objectives

The second component in the implementation of the planning process includes the setting up of the **environmental objectives** mainly based in Article 4 of the WFD (see Annex 2).

The Directive specifies the following principal environmental objectives for surface water bodies:

- ➢ to prevent deterioration in their status ;
- ➢ to restore to good surface water status (or good ecological potential for heavily modified and artificial water bodies) by 2015; and
- ➢ to implement the necessary measures with the aim on progressively reducing pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous substances.

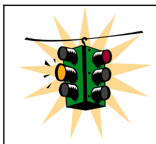
For groundwater:

- to implement the measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater;
- to protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status on December 2015 at the latest; and
- to implement the measures necessary to reserve any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to reduce pollution of groundwater progressively.

For protected areas:

- to achieve compliance, by December 2015 at the latest, with specific standards and objectives specified in the Community legislation under which the individual protected areas have been established;

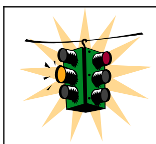
- to achieve compliance with good status objectives by December 2015, unless delay or less stringent objective if all the necessary improvements in the water status cannot reasonably be achieved within 2015.



Look out! Classification schemes.
Ultimate aim of the WFD is the achievement of "good water status".
*The status of **surface water bodies** will be determined by the poorer of its chemical or ecological status.*
Chemical status describes whether or not the concentration of any pollutant exceeds standards that have been set at the European level
Ecological status is principally a measure of the effects of human activities to water.
*The status of **groundwater bodies** will be determined by the poorer of its chemical and quantitative status.*
Quantitative status is an expression of the degree to which a body of groundwater is affected by direct and indirect abstractions.

The main aim of the definition of environmental objectives is to set goals and targets which then serve as the foundation of the decision on programmes of measures. Goals and targets should fix into a long-term vision for the RBD, and be seen as steps to achieve the vision via a concrete planning process.

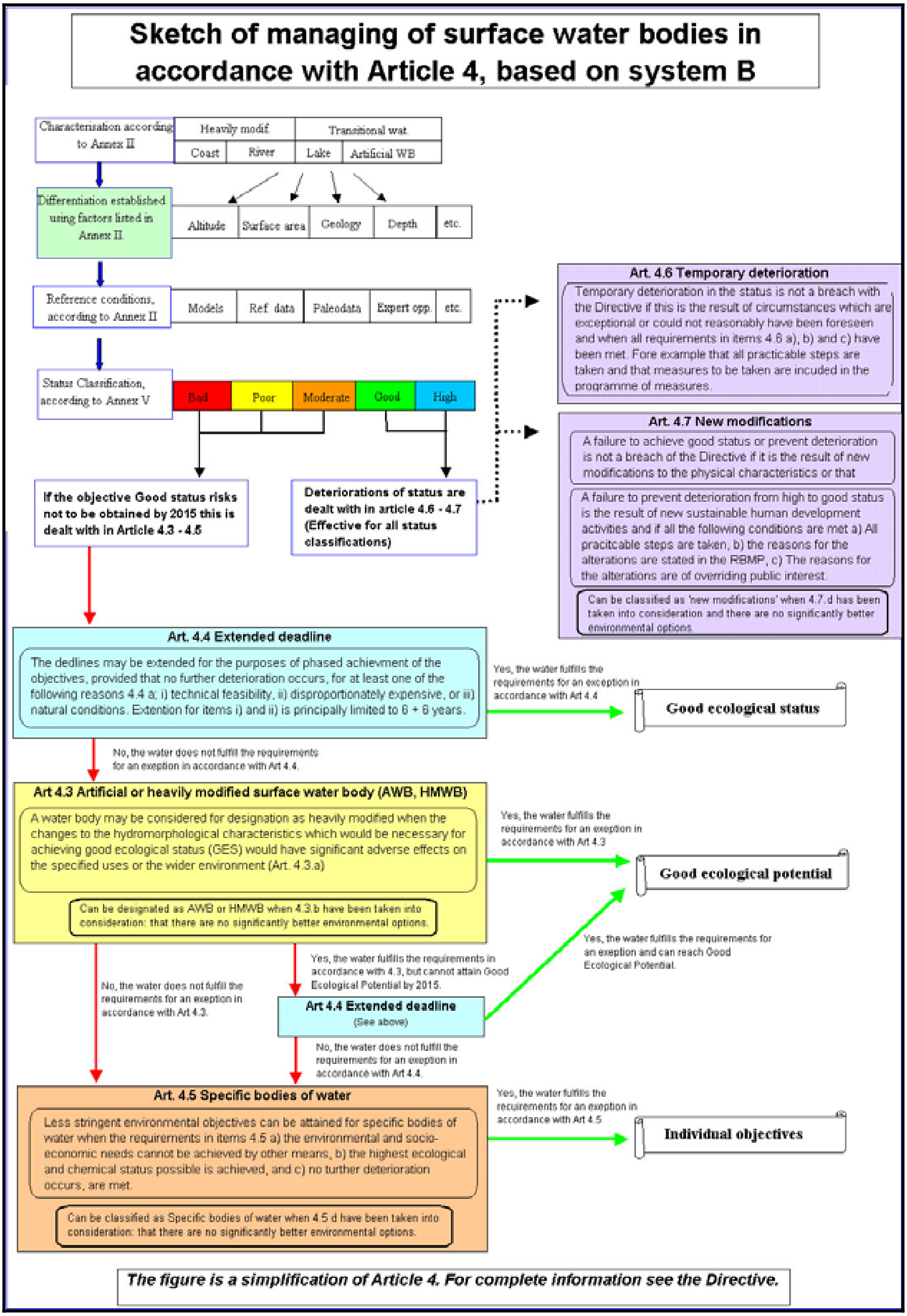
In certain circumstances, different objectives may be specified through the river basin planning process, e.g. for water bodies for which the restoration of good status would be technically unfeasible or disproportionately expensive. For surface waters designated as heavily modified or artificial, the status objectives that must be achieved by 2015 are good ecological potential and good surface water chemical status.



Look out! Boundaries have to be defined for every ecological region.
The intercalibration process developed by the European Commission will be the key element to define high ecological status and boundaries between high and good, as well as good and moderate. There is a specific Guidance Document on this basis to create the intercalibration network developed by WG 2.5 (WFD CIS Guidance Document No. 6).

Look out! Classification for heavily modified and artificial surface water bodies.
Despite being designated as heavily modified, water bodies still have to achieve good chemical status and good ecological potential.
Maximum Ecological potential defines the reference conditions considering all mitigation measures which do not have a significant adverse effect on specified uses or the wider environment.
Good ecological potential is defined as a "slight" shortfall from the maximum ecological potential these bodies can achieve.

The setting of the environmental objectives can be considered as one of the core components of the implementation of the WFD and also of its planning process. As explained before, setting the objectives in the context of the WFD means taking decisions on using the different options of Article 4. The definition of environmental objectives is not only a question of what exactly the status of a certain water body (and not that of an entire basin) should be but also a question of when this status should be achieved. Thus, the expression of setting of objectives is used in order to make a distinction between what is defined as objectives in the WFD itself and what is at the discretion of the river basin authorities. As the process required by Article 4 is very complex, it was felt useful to provide in this Guidance a more detailed explanation of the implementation tasks to be carried out and the steps to be taken in the form of a sketch included below.

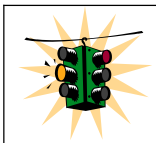

Sketch of managing of surface water bodies in accordance with Article 4, based on system B
Characterisation according to Annex II
Heavily modif.
Transitional wat.
Coast
River
Lake
Artificial WB
Differentiation established using factors listed in Annex II
Altitude
Surface area
Geology
Depth
etc.
Reference conditions, according to Annex II
Models
Ref. data
Paleodata
Expert opp.
etc.
Status Classification, according to Annex V
Bad
Poor
Moderate
Good
High
If the objective Good status risks not to be obtained by 2015 this is dealt with in Article 4.3 - 4.5
Deteriorations of status are dealt with in article 4.6 - 4.7 (Effective for all status classifications)
Art. 4.6 Temporary deterioration
Temporary deterioration in the status is not a breach with the Directive if this is the result of circumstances which are exceptional or could not reasonably have been foreseen and when all requirements in items 4.6 a), b) and c) have been met. Fore example that all practicable steps are taken and that measures to be taken are incuded in the programme of measures.
Art. 4.7 New modifications
A failure to achieve good status or prevent deterioration is not a breach of the Directive if it is the result of new modifications to the physical characteristics or that
A failure to prevent deterioration from high to good status is the result of new sustainable human development activities and if all the following conditions are met a) All pracitcable steps are taken, b) the reasons for the alterations are stated in the RBMP, c) The reasons for the alterations are of overriding public interest.
Can be classified as 'new modifications' when 4.7.d has been taken into consideration and there are no significantly better environmental options.
Art. 4.4 Extended deadline
The dedlines may be extended for the purposes of phased achievment of the objectives, provided that no further deterioration occurs, for at least one of the following reasons 4.4 a; i) technical feasibility, ii) disproportionately expensive, or iii) natural conditions. Extention for items i) and ii) is principally limited to 6 + 6 years.
Yes, the water fulfils the requirements for an exception in accordance with Art 4.4
Good ecological status
No, the water does not fulfil the requirements for an exeption in accordance with Art 4.4.
Art 4.3 Artificial or heavily modified surface water body (AWB, HMWB)
A water body may be considered for designation as heavily modified when the changes to the hydromorphological characteristics which would be necessary for achieving good ecological status (GES) would have significant adverse effects on the specified uses or the wider environment (Art. 4.3.a)
Can be designated as AWB or HMWB when 4.3.b have been taken into consideration: that there are no significantly better environmental options.
Yes, the water fulfils the requirements for an exception in accordance with Art 4.3
Good ecological potential
Yes, the water fulfils the requirements for an exeption and can reach Good Ecological Potential.
Yes, the water fulfils the requirements in accordance with 4.3, but cannot attain Good Ecological Potential by 2015.
No, the water does not fulfil the requirements for an exeption in accordance with Art 4.3.
Art 4.4 Extended deadline
(See above)
No, the water does not fulfil the requirements for an exeption in accordance with Art 4.4.
Art. 4.5 Specific bodies of water
Less stringent environmental objectives can be attained for specific bodies of water when the requirements in items 4.5 a) the environmental and socio-economic needs cannot be achieved by other means, b) the highest ecological and chemical status possible is achieved, and c) no further deterioration occurs, are met.
Can be classified as Specific bodies of water when 4.5 d have been taken into consideration: that there are no significantly better environmental options.
Yes, the water fulfils the requirements for an exception in accordance with Art 4.5
Individual objectives
The figure is a simplification of Article 4. For complete information see the Directive.

5.3 Third component: Establishment of monitoring programmes

Monitoring is a task that is greatly related to the risk assessment and to the evaluation of the effectiveness of the measures taken to achieve the environmental objectives in the planning process. Specific requirements for monitoring can be found in Article 8 (see Annex 2).

The Directive, in its Annex V, describes three types of monitoring programmes with different information purposes:

- ***Surveillance monitoring*** that is mainly devoted to improve the assessment of which bodies are at risk of failing to meet the Directive's objectives and which are not. It includes monitoring of surface water bodies and the chemical status and pollutant trends of groundwater bodies;
- ***Operational monitoring*** that is exclusively focused on those water bodies that, on the basis of the risk assessments and the surveillance monitoring programmes, are at risk of failing to meet the Directive's environmental objectives. Operational monitoring has to be based on indicators that are sensitive to the identified pressures. This program should also include monitoring of groundwater levels to assess groundwater at risk according to their quantitative status;
- ***Investigative monitoring*** is to be used to ascertain the response why a water body is at risk and it should help to design the appropriate management measures.

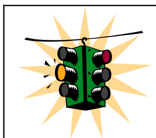


Look out! Under the Common Implementation Strategy a specific Guidance Document (WFD CIS Guidance Document No. 7) has been developed on monitoring for the WFD (WG 2.7)

By the end of 2006, the Directive requires the implementation of the monitoring programme (article 8) for surface and groundwater. The monitoring of the water status is to be operational in 2006. It particularly includes the definition of reference sites and water status evaluation grids and the performance of comparative analyses on the European level (intercalibration). The monitoring systems shall be made to comply with the requirements of the Directive and the monitoring programme shall be operational by 2006.

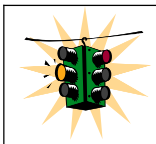
5.4 Fourth component: Gap analysis

Gap analysis has to take account of the results carried out in the assessment of the current status (first step) comparing them with the environmental objectives (defined in the second step).



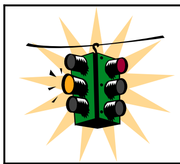
Look out! Gap analysis must be developed having in mind that the Directive is broader and more ambitious than the former European water legislation.
Previous European water legislation set objectives to protect particular uses of the water environment from the effects of pollution and to protect water environment from specially dangerous substances. The Directive introduces broader ecological objectives, designed to protect and where necessary, restore the aquatic ecosystems.

Effective gap analysis requires sound data, information and knowledge. To increase the effectiveness of the activity this information usually has to be aggregated for example in the form of indicators and systems for benchmarking. In fact, existing information is often sufficient to get started, but difficult to assemble and integrate. One key element is to assess what is available versus what information is really needed.



Look out! RBD characterisation is mainly to support gap analysis
Gap analysis tools should be considered at early stage to design the current status assessment Tools as GIS, expert systems, mathematical models, etc are useless for gap analysis if accurate data is not available.

Different analytical tools can support the analysis but it must not be forgotten that gap analysis can not rely on quantitative information only. Moreover, these methods should be transparent and flexible, promoting public participation and facilitating negotiation processes.



Look out! The results from gap analysis will give elements to elaborate the overview of main significant issues for water management in the district (required by Article 14(1)).

5.5 Fifth component: Setting up of the programme of measures

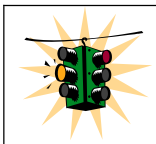
The fifth component in the implementation of the planning process is the establishment and implementation of the programmes of measures. The Directive requirements are in Article 11 (See Annex 2 of this Guidance Document).

WFD requires river basin plans to integrate the management of water quality and water resources and surface and groundwater management in order to meet the environmental objectives.

The programme of measures to be established by the end of 2009 will consist of defining, for each district, the regulatory provisions or *basic measures* to be implemented in order to achieve the objectives defined for 2015 by the management plan in accordance with Community and/or national laws (e.g. extension of sensitive or vulnerable areas, reporting and authorisation system, definition of resource protection areas, discharge control etc.). These measures also include pricing measures taken to provide users with incentives to manage water more efficiently. Measures may be decided on the national level.

If the aforementioned provisions do not suffice to achieve the set objectives, *supplementary measures* shall be taken. The Directive provides a non-exclusive list of such measures, which are aimed at either reinforcing the previous provisions or setting up new provisions such as good practices codes, voluntary agreements, economic and tax instruments etc. *Additional measures* have also been defined. They particularly relate to the implementation of international agreements.

In international RBDs the implementation of the programmes of measures should be co-ordinated for the whole of the river basin district for the significant water management issues identified. For river basins extending beyond the boundaries of the Community, Member States should endeavour to ensure the appropriate co-ordination with the relevant non-member states.



Look out! Co-ordination must be ensured from the very beginning of the planning process.
It is not possible to co-ordinate programmes of measures of river basin management plans without a co-ordinated analysis and review of the status, co-ordinated monitoring programmes, co-ordinated assessment and co-ordinated approaches for the involvement of the public. Therefore, co-ordination must be ensured from the very beginning of the planning process. One possible approach that competent authorities could take is to develop a co-ordination network, work plan and a timetable indicating the various co-ordination steps within the planning process.

Basic measures include the so-called combined approach (Article 10). This means that water policy should be based on using control of pollution at source through the setting of emission limit values and of environmental quality standards. For example, for point source discharges liable to cause pollution, basic measures can be a requirement for prior regulation (i.e. a prohibition on the entry of pollutants) or a requirement of authorisation or registration laying down emission controls for the pollutants concerned. For diffuse sources liable to cause pollution, basic measures are to prevent or control the input of pollutants or prior regulation, authorisation or registration in a similar way to point source discharges. Prohibition of direct discharges of pollutants into groundwater is a basic measure subject to some provisions – use for geothermal purposes, injection for mining activities, construction, civil engineering and so on – that are listed in Article 11 (j).

Article 10(1) (combined approach for point and diffuse sources) refer to a range of directives such as Integrated Pollution Prevention and Control (IPPC) (96/61/EC), Cadmium Discharges (85/513/EEC), Mercury Discharges (82/176/EEC) and nitrates, and any future relevant directives. Controls required by these directives must be established by 2012 at the latest (the same date that programmes of measures must be operational), unless otherwise specified in the legislation concerned. These parts of article 10 therefore have no additional effect to what is required by the directives to which they refer.

Article 10(3) specifies that where different quality objectives or quality standards have been established according to the different directives referred to in article 10, and they require stricter conditions than those which result from the application or article 10, the emission controls must be tightened. Therefore, if the application of the environmental quality standard approach required tighter controls on emissions than would otherwise be the case, those controls would need to be tightened.

The use of economic instruments is part of the basic measures. As it is mentioned in preamble 38, the principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter-pays principle. An economic analysis of water services based on long-term forecast of supply and demand for water in the river basin district will be necessary for this purpose.

The Directive aims to ensure that pricing policies improve the sustainability of water resources. Within this broad framework, water charging policy already meets the water charging provisions in WFD, which require water pricing policies to perform the following functions by Dec 2010:

- take account of the principle of the recovery of costs or water services, including environmental and resource costs;
- embody the "polluter pays" principle;
- provide adequate incentives to use water resources efficiently;
- ensure that water use groups (separated into at least industry, households and agriculture) make an adequate contribution to the recovery of the cost of water services.

WFD requires the "principle of recovery of the costs of water services" to be taken into account. It also requires that an adequate contribution of the different water uses be made to the recovery of the costs of water services.

Very often, water users, as customers of the companies who supply water and sewerage services, already in aggregate meet the financial costs of their services. The industry not subsidised, and all costs placed on the water and sewerage companies have to be recovered from the customers.

As well as meeting in full the aggregate costs of water services, the breakdown of the aggregate costs among water customers broadly reflects both a division between sectors of water users and the polluter pays principle.

Basic measures must ensure good water quality in the supply for the population including the identification of waters used for the abstraction of drinking water.
Drinking water quality must be safeguarded in order to reduce the level of purification treatment.

The obligation in the Directive requires the adoption of a programme of measures to meet the requirements of article 7 and additionally to safeguard water quality in order to reduce the level of water treatment required for the production of drinking water.

The general requirement of article 7 is the identification, within the river basin districts proposed, of water bodies that are used or are intended to be used for human consumption. The requirement applies to both surface waters and groundwaters where the rate of abstraction exceeds 10 m^3/d and will therefore apply to public water sources and some private water sources. Article 7 also requires monitoring of water sources where the rate of abstraction exceeds 100 m^3/d.

Article 7 also requires that all waters intended for human consumption meet the objectives of article 4 for surface waters and groundwaters. In addition surface waters must meet additional quality standards prescribed in article 16. Member States are required to ensure that under the treatment regimes applied, drinking water produced meets the requirements of the Directive on the Quality of Water Intended for Human Consumption (80/778/EEC) as amended (98/83/EC).

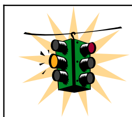
The final provision of article 7 is the requirement to ensure that the necessary protection for the water bodies identified is provided, with the aim of avoiding deterioration in their water quality, in order to reduce the level of water treatment required. Article 11 requires that the measures to be taken for the protection of each river basin district are specified within a programme.

Basic measures must deal also with controls over relevant abstractions of fresh surface water or groundwater and impoundment of fresh surface water and artificial recharge or augmentation of groundwater bodies. For water quantity, overall principles should be laid down for control on abstraction and impoundment in order to ensure the environmental sustainability of the affected water systems.

The obligation in WFD in respect of the abstraction of fresh surface water and groundwater has four parts to it:

- there must be controls over abstraction of fresh surface water and groundwater;
- a register of abstractions (but not impoundments) must be maintained;
- abstraction must have prior authorisation;
- controls must be periodically reviewed and, where necessary, updated.

The philosophy of the approach in WFD to regulating abstraction is "risk-based".
Consequently, in the case of abstraction, the Directive does not provide for generic exemptions from controls on the basis of purpose, location, source or size of the abstraction. Rather, following the "risk-based" principle and according Article 11(3)(e), abstractions that have no significant impact of water status can be exempted from control.



Look out! The programme of measures can be phased in order to spread the costs of implementation.

The Directive includes a number of provisions that allow for derogation from the environmental objectives for legitimate economic and technical reasons. This will help Member States to strike a balance between environmental, economic and social goals. Justification for the use the derogation must, in all cases, be included with the RBMP.

5.6 Sixth component: Development of the River Basin Management Plans

A management plan must be produced for each river basin district. The milestone of the river basin planning process (analysis, monitoring, objective setting, consideration of measures to maintain or improve water status) is the RBMP which will summarise the relevant planning information for its river basin district.

Indeed the outcome of the planning process is not the RBMP: the planning process continues after the elaboration of the RBMP. After the publication of the RBMP the planning process enters in a concrete phase in which the RBMP is followed and the programme of measures is applied. In this phase, the role of the planning process is to guide the implementation of measures in an appropriate way so to reach the objectives. Besides the first RBMP will be followed by updated RBMP in the next management cycles.

One way of thinking about the first generation RBMPs is to regard them as representing the transition between initial analysis and implementation, i.e. they are to be adopted after having worked out what the current situation is (both terms of the state of the environment and the pressures on it), and having determined where the Member States is aiming to get to (what the objectives should be for specific water bodies) and having decided how the Member State is going to get to there (a summary of the programme of measures).

The plans are not the principal mechanism for implementing measures to achieve the environmental obligations imposed by the Directive. Those measures are to be set out in the programme of measures required by article 11 that is to be adopted for each river basin district. Programmes of measures will then be summarised in the relevant RBMP. The role of RBMPs is rather broader than this. For example, they are to be the primary vehicle for consulting the public and stakeholders on plans for managing the water environment within the river basin district.

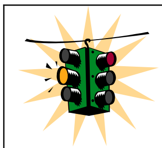
The plans will also be, ultimately, the main reporting mechanism to the Commission and to the public. The plan will be a summary of how the objectives set for the river basin (ecological status, quantitative status, chemical status and protected area objectives) are to be reached within the timescale required.

The plan will include a summary of the results of the analyses; the characteristics of the river basin; a review of the impact of human activity on the status of waters in the basin; estimation of the effect of existing measures and the remaining “gap” to meeting those objectives; and, what more is required.

The plans must include the information detailed in annex VII of WFD. This is split into 12 parts, which are summarised in the box below.

Contents of the RBMP

- General description of the characteristics of the river basin district, including a map showing the location and boundaries of surface water bodies and groundwater bodies and a map showing the different surface water body types within the river basin.
- Summary of significant pressures and impact of human activity on the status of surface water and groundwater, including estimations of point source pollution, diffuse source pollution (including a summary of land-use) and pressures on the quantitative status of water including abstractions, and an analysis of other impacts of human activity on the status of water.
- Map identifying protected areas.
- Map or the monitoring network.
- Presentation in map of the results of the monitoring programmes showing the ecological and chemical status of surface water, the chemical and quantitative status of groundwater and the status of protected areas.
- List of the environmental objectives established for surface waters, groundwaters and protected areas, including where use has been made of the derogations.
- Summary of the economic analysis of water use.
- Summary of the programme or programmes of measures.
- Register of any more detailed programmes and management plans and a summary of their contents.
- Summary or the public information and consultation measures taken, their results and the changes to the plan as a consequence.
- List of competent authorities.
- Contact points and procedures for obtaining background documentation and information, including actual monitoring data.



Look out! The River Basin Management Plan summarises the results of the planning process.

A RBMP is a strategic planning document and an operational guide to implement programmes of measures that will form the basis for integrated, technically, environmentally and economically sound and sustainable water management within a River Basin District for a period of six years. It will be developed in consultation with the public.

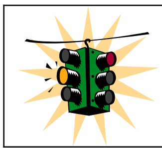
In conclusion, the plan has a number of functions, but primarily it is intended to record the current status of water bodies within the river basin district and to set out, in broad terms, what measures are planned to meet environmental objectives.

The functions of the plan are to:

- serve as a fundamental inventory and documentation mechanism for information gathered according to the directive including, e.g.:
  - environmental objectives for surface waters and ground waters;
  - information on quality and quantity of waters;
  - information on main impact of human activity on the status of surface water and ground water bodies.
- co-ordinate programmes of measures and other relevant programs concerning the area of river basin district;
- serve as main reporting mechanism of river basin district authorities to EC.

The plan, to be published by 22 December 2009, shall finalise the quality and quantity objectives to be achieved by 2015. The objective of good water status being the rule, the management plan must justify any derogation from that objective, particularly on the basis of an economic analysis. Derogations shall first be studied from the viewpoint of postponing the deadline, followed by a change in the objective if necessary. The plan shall define the provisions and action priorities (or measures in the terminology of the Directive) to be implemented in order to achieve the set objectives.

With regards to the preparation of the management plan, the Directive provides for consultation with the public at three stages – the first time before the end of 2006, as regards the planned work programme, the second time before the end of 2007, as regards the significant issues and the third before the end of 2008, as regards the draft management plan.



***Look out!** The Directive only requires a summary of programmes of measures to be included in RBMPs.*

Article 13 paragraphs 1 to 3 of the WFD require one RBMP for each river basin district. Annex VII lists the information to be included in the RBMP. According to Article 13 paragraph 5, the RBMP can be supplemented by producing more detailed programmes or management plans for sub-basins, sectors, issues, or water types.

Planning levels

Member States need to set out how river basin planning can be effectively co-ordinated at all levels (sub basin, basin, District and international District) to ensure that the plans are

- coherent and consistent at each level; and
- compatible between levels.

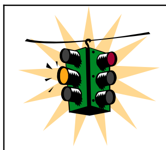
Although river basin planning should be organised (and reported) at a River Basin District level, the detail required for management decisions will mean that planning will need to be carried out at a lower spatial scale. For example, it may be necessary to collate and review data at a basin/sub-basin level in order to make planning decisions. The data, information and decision making should be capable of aggregation and disaggregation. This will facilitate the straightforward production of the Characterisation Report and River Basin Plan at District level. It will also help to ensure transparency. For example, users of the River Basin Plan – government, industry, public etc - may want to examine and compare plans at the same level and between levels.

The Directive contains a definition for "sub-basin" (article 2(14)). These are distinct parts of a basin (sometimes referred to as "sub-catchments"). WFD does not require sub-basins to be identified and plans to be produced for them, but where they are identified and plans are produced for the purposes of the Directive, then their existence has to be recorded on a register (as required in annex VII, paragraph 8), together with a summary of their contents.

In consequence, plans can be made for individual basins where a river basin district comprise more than one river basin. Article 13(5) or WFD is not absolutely clear on this point, but it would be impossible to prepare a district plan where more than one basin is involved, without building up the district plan based on basins.

But what does it mean to produce one RBMP? In fact, there are various options and the choice among these options will to a large extent be influenced by the size and characteristics of the basin, the number of political entities (states, provinces, regions etc) involved, the way co-ordination and the involvement of the public is organised in the River Basin District. For large River Basin Districts, but probably also for medium sized River Basin Districts with a decentralised administrative and political structure, sub-dividing the River Basin District into manageable sub-units could be necessary.

Regarding other planning instruments it is too soon to say what additional plans would be necessary, but they could have a valuable role in overall plan preparation, including consultative processes. On the other hand, they could come to represent an unwelcome administrative burden.

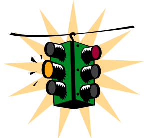


Look out! The target is a single River Basin Management Plan for international RBDs.
The directive requires the Member States to ensure co-ordination with the aim of producing a single international river basin management plan, with support from existing structures stemming from international agreements.

The Directive does not explicitly require or specify the process of developing the management plans. The nature of the river basin planning process is something that is at the discretion of Member and Accession States. This brings the opportunity to the Member and Accession States, to apply the appropriate planning type for the physical and social circumstances in River Basin District concerned, as long as the outcome of the process stays in line with the objective of the Directive (to achieve good water status).

5.7 Seventh and eighth components: Implementation of the programmes of measures and evaluation

The implementation of the programmes of measures has to be linked with a continuous process of evaluation. This evaluation has quite often been seen as a last - more or less additional - box in a planning process. However, evaluation has usually been done after the planning process to get feedback about what has actually been planned or even carried through already. This means that evaluation has not been used as a tool of continuous development and making choices or in other words as an ordinary part of a planning process.



Look out!
After implementing the programme of measures, the evaluation of the first planning period (to be made from 2012 to 2015) is the key element for the preparation of the second period.

The planning process according to WFD is iterative by nature and offers various steps and decisions which need to be evaluated: e.g. identification of water bodies, discrimination into types, analysis of the impact on the status of waters, setting environmental objectives etc.

5.8 Ninth component: Information and consultation of the public, active involvement of interested parties

Public Participation is not only another step in the process. Best practices in the implementation of the WFD can be only reached if public participation is taken in mind in every component. A more detailed Guidance on public participation (WFD CIS Guidance Document No. 8) has been produced as the so called "Work package 3" under the same working group that has developed this Guidance on planning process.

That Guidance Document on Public Participation (WFD CIS Guidance Document No. 8):

- explains why stakeholders should engage in river basin management planning and what can be expected by them and the general public: to voice opinions and concerns about future decisions and to ensure that relevant locally-held knowledge finds its way to the right decision platform;
- outlines practical opportunities and approaches for engaging at different levels and at different stages of planning;
- clarifies, that this is a new process and a new form of partnership which requires patience and mutual trust.

Public consultation and involvement are crucial for successful planning, and must therefore be highlighted in this Section. The potential benefits of greater stakeholder can be summarised as follows:

- RBMPs are likely to be more successful through achievement of "buy-in" to their objectives and delivery by promoting "ownership", acceptability and the co-operation of relevant stakeholders;

- Decision making is likely to be more efficient through earlier identification and, where possible, resolution of conflicts;
- Solutions are likely to be more sustainable and equitable through the input of a wider range of knowledge and perspectives;
- In the longer term, relationships between competent authorities and stakeholders are likely to be strengthened.

In order to achieve best practice in the planning process, high priority must be given to establishing effective mechanisms for public participation (consultation and active involvement) in planning and decision-making, right from the start of the IRBM process.

Provision of genuine opportunities for participation means far more than simply distributing information or setting up a consultation exercise, and needs to be carefully adapted to the appropriate scale, target group(s) and issue(s). Participation initiatives must be managed carefully to ensure that they are transparent and accessible, that all opinions are respected and that expectations from all sides are clear at the beginning.

Co-ordination and public participation

It is necessary to distinguish between administrative co-ordination and public participation. Administrative co-ordination should be treated as a managerial process, and public participation as an integral part of the planning process.

Effective river basin planning will require the Competent Authority to establish the appropriate management structures with other relevant authorities and organisations. These relationships will help to provide the Competent Authority with information for characterisation, input to planning and delivery of the Programme of Measures with organisations responsible for other sectors that have an impact on water status e.g. agriculture and land-use development. Administrative co-ordination should be organised between the Competent Authority and relevant bodies at the appropriate scale (sub-basin, basin, district and international district).

Section 6. General overview and overall flowchart on the planning process

6.1 Introduction: Why and how to use flowcharts in the planning process?

The role of flowcharts in the definition of a planning process for the WFD implementation

Defining a precise planning process with flowcharts for the implementation of the WFD is necessary on account of:

- the complexity of the WFD and its implementation;
- the necessity to anticipate the obligatory deadlines and determine the deadlines which are necessary in practice to meet the obligatory deadlines;
- numerous interdependent tasks;
- urgency regarding the first deadlines (2004);
- involvement of numerous working groups, numerous institutions, numerous stakeholders;
- integration of several levels : European , national and districts working groups;
- the necessity to have a common reference among stakeholders, among institutions;
- the necessity to check during the process if we are late or not according to the deadlines which were defined.

Objectives of the flowcharts

The purpose of the definition of flowcharts describing the planning process is to:

- identify the different tasks, their duration and links between them;
- identify the different key products and key steps;
- identify the actions or sub-tasks required to meet the requirements for the obligatory deadlines;
- assess the organisational level at which they should be carried out;
- build up a sequencing plan of these tasks and stages, compatible with both the technical preparatory constraints & the requirements of the directive;
- identify the critical path for project scheduling and resources allocation.

Recommendations for the preparation and use of flowcharts

The overall flowchart presented in Section 6.4 below can be used as a starting point for developing a more detailed management project for the implementation of the Water Framework Directive in the River Basin Districts or part of them. It is ***strongly recommended*** to set up such a management project and to establish a controlling of its implementation. Such a management project can help to check the coherence between River Basin Districts at national level and re-adjust the process if there is a gap between the forecast timing and the practical state of play.

At River Basin District level a more detailed breakdown of the level III task will be necessary taking into account the recommendations of the respective WFD CIS

Guidance Documents. Each single task has to be assigned to a responsible organisational entity or more than one organisational entity with a strong co-ordination between them. Deadlines have to be set for delivering the expected results taking into account the time needed for aggregation and co-ordination.

Example: The district review (Art. 5 and 6) has to be completed for December 2004 according to the deadline defined by the Water Framework Directive. In practice the draft district review has to be finished several months before to take into account the time needed for potential consultation and validation procedures.

Be aware that according to the reporting deadlines as defined by the Water Framework Directive information on the results of accomplishing certain tasks is required rather late in the process, mainly as part of the River Basin Management Plan. However, in most cases the task itself has to be implemented earlier in the process because the results are necessary for further steps.

Example: A first report on the results of the monitoring programmes has to be delivered as part of the River Basin Management Plan only in 2009. However, at River Basin level monitoring results will *inter alia* be necessary for the identification of the water bodies at risk of failing to meet the objectives which has to be done before defining the programme of measures by the end of 2004.

Be aware that implementing certain tasks will at a starting point require decisions on the approach to be followed by all organisations involved. To prepare such decisions will take time and resources. Furthermore these decisions usually will be taken at another organisational level than the operational one. This is a particular problem for international River Basin Districts where a co-ordination or even harmonisation of national approaches will have to be achieved.

Be aware that, although theoretically some activities cannot begin until others are finished, it will be necessary to begin these activities as early as possible and in parallel to meet the obligatory deadlines. As a consequence, an **iterative process** has to be put in place between such interlinked activities.

In other terms, in some cases, a "parallel" scheduling of tasks will have to be implemented rather than a sequential one.

Examples : Evaluation of the risk of failure to meet the environmental objectives (defined in terms of good status) and definition of what good status is: the first evaluation of the risk of failing to meet the objectives (line 33 of the flowchart) has to be made by using provisional classifications before the reference conditions and the class boundaries of the classification schemes are established; then the results of the first evaluation of water bodies can have an influence on refining the classification scheme.

Iterative elaboration of management plans and programmes of measures: the management plan should set the guidelines and priorities for the programme of measures; the measures will be detailed in the programmes of measures themselves which have to be developed in parallel with the preparation of the management plan.

The flowcharts can also be used as a starting point for developing national or River Basin District specific guidelines for implementing the tasks. For each of the listed tasks such guidelines could contain:

- a reference to the respective provisions in the Water Framework Directive and the national legislation;
- a description of the approach taken at national/district level to address the task, including recommendations concerning methods and tools to be used and reference to the WFD CIS Guidance Documents;
- a list and description of materials and data already available and accessible (for example GIS-data sets, maps, monitoring data) and information on how to get access to the material and data;
- a description of the specific activities to be carried out by the respective responsible organisational entity;
- requirements concerning the documentation and presentation of results (text, spread sheets, maps, data format).

Such guidelines should provide all actors involved with the information necessary to understand the overall organisational setting (who is responsible for what?) and their specific role in the process.

The advantage of developing such guidelines are *inter alia*:

- It requires stock taking of what is already available;
- It helps to make the available information accessible to all actors involved;
- It helps to ensure coherence;
- It helps to assign responsibilities and to avoid double or parallel work.

Ensure a general coherence between tasks and between scales and levels

It is essential to ensure a general coherence of the general process, beyond the own objective of the specific tasks. The right succession of the tasks must be found in order to succeed in the elaboration of the final products. It is also necessary to ensure consistency of timetables between district, national and international levels.

Set up an iterative process

In theory, some activities cannot begin until others are finished. However, to meet the obligatory deadlines, it will be necessary to begin these activities as early as possible. As a consequence, an iterative process has to be put in place between both activities. In other terms, in some cases, a "parallel" scheduling of subtasks will be implemented rather than a sequential basis.

Examples:

- Evaluation of the risk of failure to meet the environmental objectives (defined in terms of good status) and definition of what good status is;
- The evaluation of the risk to fail to the objectives has to be made with draft evaluation grids of the good water status ; then these grids can be precised according to the results of the first evaluation of water bodies at risk;
- Iterative elaboration of management plans and programmes of measures;
- The management plan should set the guidelines and priorities of the programme of measures. The measures will be detailed in the programmes of measures itself.

Ensure follow up and co-ordination

The flowcharts need to be followed and updated all along the process and a co-ordination must be ensured:

- between the national districts;
- between the national and international districts;
- between the national parts of international districts.

In the particular case of international districts, a specific co-ordination between the national parts of international districts must be ensured concerning timetables and succession of tasks, taking into account the time needed for the exchange of information and the consultation between the competent authorities of the national parts of international districts.

6.2 The legally binding timetable of the Water Framework Directive

As explained above, one of the main interests for defining a precise planning process with flowcharts for the implementation of the WFD is the necessity to anticipate the obligatory deadlines and determine the deadlines which are necessary in practice to meet the obligatory deadlines. In principle, deviation from this timetable is not allowed and deadlines cannot be postponed, except for the derogations mentioned in Article 4.

As the WFD and its implementation are very complex, it was felt necessary to include in this Guidance a readily understandable and exhaustive enumeration of all deadlines and dates mentioned in the WFD.

This is done in a schematic and graphical form as follows:

- In the first place, an exhaustive chart for Member States, which contains all deadlines and dates mentioned in the WFD regarding obligations for Member States. The flow-chart contains a reference to the specific WFD article in which the date is mentioned. Reporting dates are also explicitly indicated;
- Secondly, an exhaustive chart for the European Commission, which contains all deadlines and dates mentioned in the WFD regarding obligations for the European Commission.

Legally binding deadlines for Member States

Action/ Member States	Article	2002	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
The laws, regulations and administrative provisions necessary into force	24.1																										
Identification of competent authority by MS	3.7																										
MS provide EC with a list of competent authorities and of competent authorities of all international bodies in which they participate *(updates of this list should be reported to EC within 3 months)*	3.8, 24.1				* 22.06.2004																						
Analyses and reviews mentioned in Art 5.1: - Establishment of characteristics of the River Basin District, - Review of the environmental impact of human activity, - Economic Analysis of water use	5.1																										
Establishment of register of Protected Areas	6.1																										
Submission of summary reports of analyses according to Art.5 (RBD characteristics, human activity, economics) undertaken for the purposes of the *first* RBMP	15.2					* 22.03.2005																					
In absence of EC agreement MS shall establish appropriate criteria for strategies to prevent and control groundwater pollution	17.4																										
The EC and MS shall complete the intercalibration exercise.	Annex V 1.4.1 (viii)																										
Programmes for monitoring of surface water status, groundwater status and protected areas shall be operational. *Unless otherwise specified in the legislation concerned.*	8.2																										
For Public information and consultation about the RBMP, MS make available for comments a timetable and work programme for the production of the RBMP *(three years before the beginning of the period to which the plan refers. MS shall allow at least six months to comment on those documents)*	14.1a																										
Review of the designation of HMWB	4.3																										
In absence of EC agreement: *MS* establish environmental quality standards for priority substances and controls on the principal sources.	16.8																										
Submission of summary reports of monitoring programmes according to Art.8 (surface water status, groundwater status and protected areas) undertaken for the purposes of the *first* RBMP	15.2							* 22.03.2007																			
For Public information and consultation about the RBMP, MS make available for comments an overview of significant water management issues *(two years before the beginning of the period to which the plan refers. MS shall allow at least six months to comment on those documents)*	14.1b																										
For Public information and consultation about the RBMP, MS make available for comments a draft copy of RBMP *(one year before the beginning of the period to which the plan refers. MS shall allow at least six months to comment on those documents)*	14.1c																										
Establishment of programme of measures for River Basin District	11.7																										
Publication of River Basin Management Plans (detailed information in annex VII of the WFD)	13.6																										
In absence of EC agreement: For substances subsequently included on the PS-list, MS take such action (establishment of environmental quality standards for priority substances and controls on the principal sources)	16.8																										
Sending of copies of RBMP to EC and other MS concerned	15.1										* 22.03.2010																
MS shall ensure that: - water pricing policies provide adequate incentives for users to use water resources efficiently - adequate contribution of the different water uses to the recovery of the costs of water services	9.1																										

LEGEND

Deadline in the WFD

Reporting to the EC and date * 22.06.2006

Legally binding deadlines for Member States (2)

Action/ Member States	Article	2002	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Establishment and/or implementation of emission controls (BAT, BEP) and limit values for the combined approach for point and diffuse sources	10.2																										
Programme of measures for RBD shall be made operational	11.7																										
Submission of interim report describing progress in implementation of the planned programme of measures under Art.13	15.3											* 22.12.2012															
Review and update of analyses and reviews mentioned in Art 5.1: - Establishment of characteristics of the River Basin District - Review of the environmental impact of human activity - Economic Analysis of water use	5.2												* 22.12.2013														
Environmental objectives to be achieved; good surface water status good ecological potential and good surface water chemical status for heavily modified waters (HMWB and AWB) good groundwater status compliance with any standards and objectives for Protected Areas (Less stringent environmental objectives under certain conditions)	4.1																										
Review and update of programme of measures for RBD	11.8																										
Review and update of the RBMP	13.7														* 22.12.2015												
Revised measures established under an updated programme of measures shall be made operational.	11.8																										
Submission of interim report describing progress in implementation of the planned programme of measures under Art.13	15.3																	* 22.12.2018									
Review and update of analyses and reviews mentioned in Art 5.1: - Establishment of characteristics of the River Basin District - Review of the environmental impact of human activity - Economic Analysis of water use	5.2																		* 22.12.2019								
Cessation or phasing out of priority hazardous substances	16.6																							See footnote			
Environmental objectives to be achieved; (first extended deadline) good surface water status good ecological potential and good surface water chemical status for heavily modified waters (HMWB/AWB) good groundwater status compliance with any standards and objectives for Protected Areas	4.1																										
Review and update of programme of measures for RBD.	11.8																										
Review and update of the RBMP	13.7																				* 22.12.2021						
Revised measures established under an updated programme of measures shall be made operational.	11.8																										
Review and update of analyses and reviews mentioned in Art 5.1: - Establishment of characteristics of the River Basin District - Review of the environmental impact of human activity - Economic Analysis of water use	16.6																								22.12.2025 *		
Environmental objectives to be achieved; (second extended deadline) good surface water status good ecological potential and good surface water chemical status for heavily modified waters (HMWB/AWB) good groundwater status compliance with any standards and objectives for Protected Areas	4.1																										22.12.2027 *

Note: For priority substances and according to Article 16.6, the Comission shall submit proposals of controls for the cessation or phasing out of discharges, emissions and losses. Tentatively, the Commission is going to do that at the end of 2003, so, the European Parliament and the Council could adopt them in 2004 or 2005 that will be the starting date for operational purposes. The Directive establishes that from that date, the timetable shall not exceed the duration of 20 years.

Legally binding deadlines for the European Commission

Action/ European Comission	Article	2002	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
For issues which can not be dealt with at MS-level, the MS may report and make recommendations to the EC. The EC shall respond within 6 months.	12.2																										
Presentation of a proposal for strategies to prevent and control groundwater pollution.	17.1																										
Submission of proposals by the EC for emission controls for point sources and environmental quality standards.	16.8																										
Presentation to the Committee (Art. 21) of an indicative plan of measures having an impact on water legislation which it intends to propose in the near future. *(once a year after 2002)*	19.1																										
Preparation of a draft register of sites to form the intercalibration network which may be adapted in accordance with the procedures laid down in article 21.	Annex V 1.4.1 (vii)																										
Review of adopted list of priority substances	16.4																										
The final register of sites (for intercalibration) shall be established and published by the EC.	Annex V 1.4.1 (vii)																										
Completing the intercalibration exercise together with the MS.	Annex V 1.4.1 (viii)				*			22.06.2006																			
Publication of the results of the intercalibration exercise and the values established for the MS monitoring system classifications.	Annex V 1.4.1 (ix)																										
Submission of proposals by the EC for emission controls for point sources and environmental quality standards.	16.8																										
Publication of a report on progress in implementation of analyses according to Art.5 based on summary reports of MS under Art. 15.2:	18.3																										
Repeal of certain existing directives	22.1																										
Review of adopted list of priority substances	16.4																										
Publication of a report on progress in implementation of monitoring programmes according to Art.8 based on summary reports of MS under Art. 15.2	18.3																										
Submission of proposals by the EC for emission controls for point sources and environmental quality standards. (if necessary)	16.8																										
Submission of an interim report describing progress in the implementation of the planned programme of measures.	15.3																										
Review of adopted list of priority substances	16.4																										
Publication of a report on the implementation of the WFD	18.1																										
Repeal of certain existing directives	22.2																										
Submission of proposals by the EC for emission controls for point sources and environmental quality standards. (if necessary)	16.8																										
Publication of an interim report describing progress in implementation on basis of the interim reports of MS mentioned in Art. 15.3	18.4																										
Review of adopted list of priority substances	16.4																										
Publication of a report on the implementation of the WFD	18.1																										
Review of Water Framework Directive, proposal of amendments	19.2																										
Review of adopted list of priority substances	16.4																										

LEGEND

Deadline in the WFD

Reporting and date * 22.06.2006

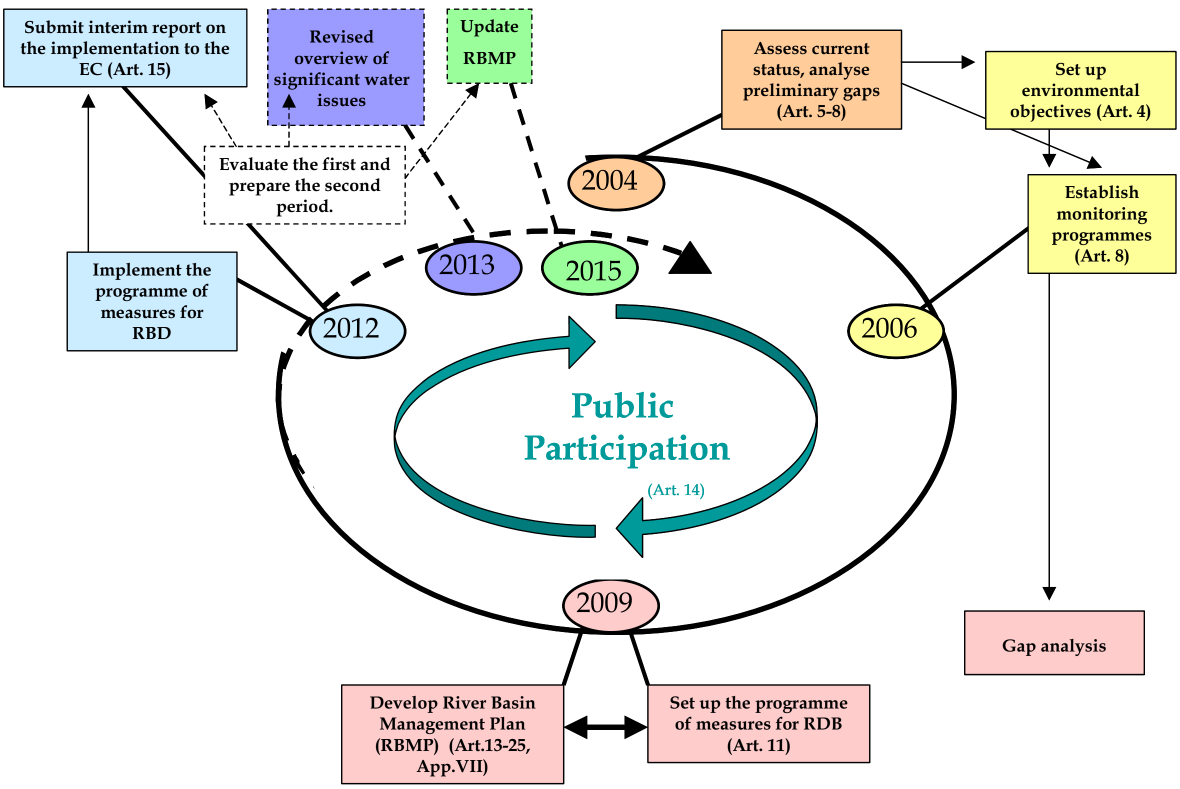
6.3 The planning cycle

The overall flowchart of the planning process presented in the following Section 6.4 includes the first so-called planning cycle required in the WFD to be finalised in 2015. Accordingly, the flowcharts apply to the first period (2002-2015) and the preparation of the second one (2015-2027), this second period being managed as the first one (same tasks and time schedule). It should be also noted that the second planning cycle until 2027 needs to be developed on the basis of the experience of the first cycle outlined below.

In order to develop the flowchart the following ten components of the planning process were considered:

1. Setting the scene;
2. Assessment of the current status and analyse preliminary gaps;
3. Setting up of the environmental objectives;
4. Establishment of monitoring programmes;
5. Gap analysis;
6. Setting up of the programme of measures;
7. Development river basin management plans;
8. Implementation of the programmes of measures and prepare the interim report on the implementation;
9. Evaluation the first and the second period;
10. Information and consultation of the public, active involvement of interested parties.

The following figure shows the sequence of and the relations between these activities as well as the main deadlines and milestones of the first planning cycle.



The previous chart is the most aggregated level information on the planning process: it indicates the 10 main components which are distinguished and developed in the following flowcharts (sub-Section 6.4).

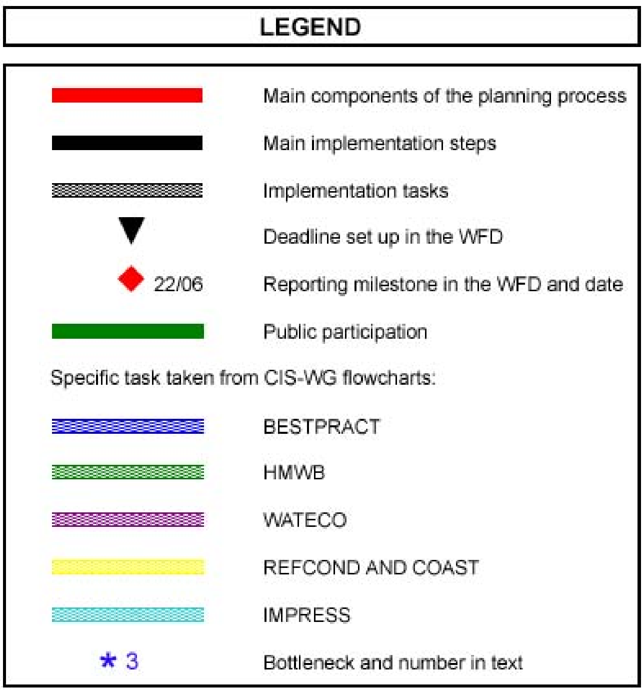
For every component, the main "steps" for the implementation of the WFD were identified and within each step, different implementation tasks could be again identified. Starting from the most aggregated level of information, three levels of details can finally be identified through components, steps and tasks.

At the scale at which these flowcharts were established, it was not possible to go into more details. However, river basin districts should develop their own flowcharts with a level of detail more adapted to the scale at which they work.

6.4 Overall flowchart for the planning process

The following overall flowchart for the WFD planning process lists the major steps to implement the Water Framework Directive, indicates linkages between the tasks, shows milestones and deadlines and includes recommendations on the overall timing for accomplishing the tasks. The chart is structured into three different levels. The first level mirrors the overall planning cycle and its main components as described in the previous Section, the second level represents the main implementation steps whereas the third level indicates the specific tasks to be performed within the respective steps. The third level tasks are taken from the specific WFD CIS Guidance Documents but not as detailed as the information provided by them. These specific tasks related to Guidance Documents are distinguished by different colours as shown in the legend below.

The following legend is used throughout the flowchart:

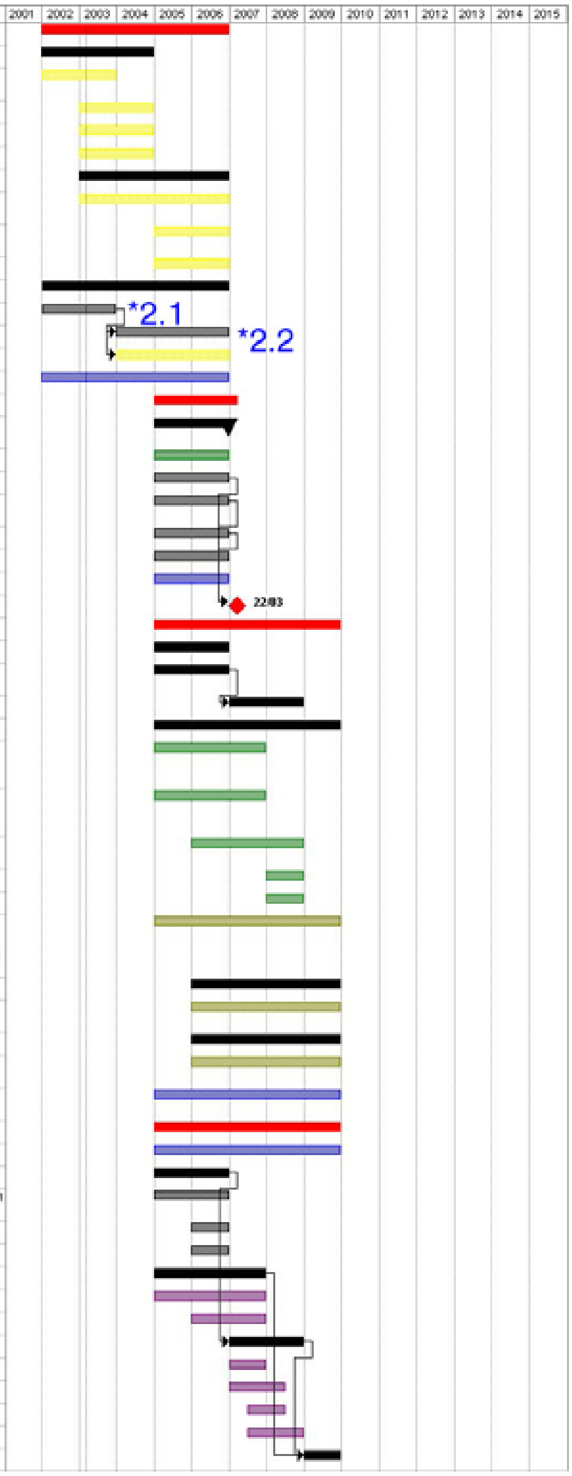


Flowchart for the first cycle of the planning process

No.	Key activities for the first planning cycle	WFD articles	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	**Set the scene**																
2	**Identify river basin districts and assign coastal water and groundwater**	**3.1**															
3	Identify and delimitate river basins																
4	Identify and delimitate coastal and transitional waters																
5	Identify and delimitate groundwaters																
6	Designate river basin districts																
7	Assign coastal and transitional waters to nearest or most appropriate river basin districts																
8	Assign groundwaters to nearest or most appropriate river basin district																
9	**Identify stakeholders and design public participation procedures**																
10	Provide information on the WFD and the planning process via existing structures																
11	Develop strategy for stakeholder identification																
12	Design public participation procedures																
13	**Establish necessary GIS infrastructure and take necessary steps for harmonisation**	**3.8, Annex I (ii)**															
14	Produce map/GIS-layers on RBD boundaries, main rivers, subbasins, etc.	Annex I (ii)															
15	**Bring into force laws, regulations and adminitrative provisions necessary to comply with the WFD**	**24.1**															
16	Bring into force laws, regulations and administrative provisions necessary to comply with the WFD																
17	**Inform the EC of the legislative provisions adopted**	24.2			22/12												
18	**Identify competent RBD authority**	**3.7**															
20	Produce map/GIS-layers on competent RBD authorities	Annex I															
21	**Provide the EC with a list of competent authorities including the relevant information of Annex 1**	3.8, Annex I				22/06											
22	**Assess the current status and analyse preliminary gaps**																
23	**Analyse the characteristics of RBDs**	**5.1**															
24	Establish typology	Annex II															
25	Identify the boundaries of water bodies	Annex II															
26	Produce map on surface water body types	Annex II, Annex VII A.1.1															
27	Active involvement of stakeholders (e.g. information supply)																
28	**Review the pressures and impacts of human activity on the status of waters**	**5.1**															
29	Collect available information and data on human activities and pressures	Annex II															
30	Evaluate existing monitoring data and assess gap with respect to objectives																
31	Set up databases of information on human activities and existing monitoring data for the whole river basin district and at the level of water bodies when available																
32	Identify pressures caused by human activities, in particular those listed in Annex II	Annex II															
33	Assess the impacts of these pressures	Annex II															
34	Active involvement of stakeholders (e.g. inventory of knowledge and perceptions)																
35	**Provisional identification of AWB and HMWB**	**4.3**															
36	Screening for hydromorfological changes in water bodies	Annex II 1.4															
37	Describe significant changes in hydromorphology in water bodies that have not been "screened out"	5.1, Annex II.1.4-5															
38	Identify water bodies likely to fail good ecological potential due to changes in hydromorphology	Annex II.1.5															
39	Select water bodies substantially changed in character due to physical alterations by human activity and identify them provisionally as HMWB	5.1, Annex II.1.1															
40	Active involvement of stakeholders (e.g. transparent designation via formal consultative mechanisms)																
41	**Evaluate the gap between current status and objectives**	**Annex V.1.4.2**					*1										
42	Define and apply the baseline scenario and evaluate the gap between trend status and objectives																
43	Define the provisional identification of water bodies at risk of failing to reach the WFD objectives in 2015	Annex II															
44	Active involvement of stakeholders (e.g. information flow)																
45	**Provide an economic analysis of water use**	**5.1, Annex III**															
46	Identify water uses and services by economic sector																
47	Conduct an economic analysis of water use																
48	Assess current pricing policies																
49	Project trends in key indicators and drivers up to 2015 by constructing a business as usual (BAU) scenario for pressures (refine beyond 2004)																
50	Active involvement of stakeholders (e.g. information flow, evaluate current levels of costs)																
51	**Register protected areas**	**6.1, Annex IV.2, Annex VII.3**															
52	Register protected areas																
53	Active involvement of stakeholders (e.g. information flow)																
54	**Inform the public on the results of the analysis**																
56	**Submit summary reports to EC on the analyses of the current status**	15.2					22/03										

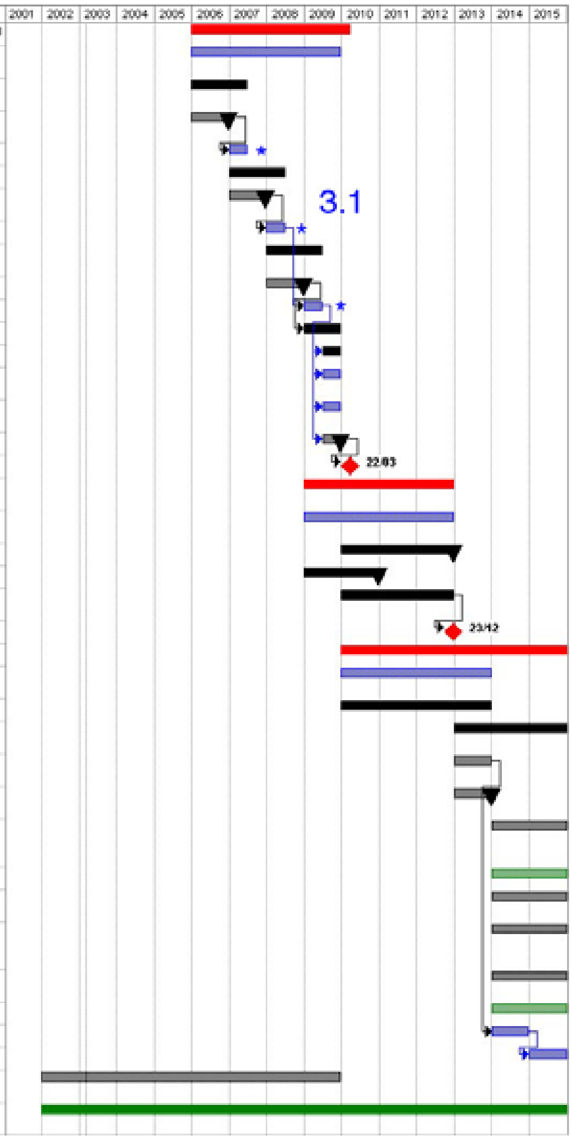
Flowchart for the first cycle of the planning process (2)

No.	Key activities for the first planning cycle	WFD articles
57	**Set up environmental objectives**	Annex II/V
58	**Establish provisional reference conditions**	
59	Establish necessary infrastructure (authorities, expert groups, databases, models, etc.) at national and water district level	5.1
60	Assign body types for assisting in establishing reference conditions	Annex II.1.3
61	Establish criteria for high and good status	
62	Select potential high and good status sites	
63	**Establish reference conditions and ecological quality class boundaries**	
64	Choose quality elements and methods for establishing reference conditions (RC) and ecological quality class boundaries	5.1
65	Establish type specific RC and calculate ecological quality ratio (EQR) values for all relevant quality elements	Annex V.1.4
66	Propose ecological quality class boundaries	
67	**Carry out intercalibration**	
68	Select intercalibration sites	
69	Conduct the intercalibration exercise	
70	Establish ecological class boundaries	
71	Active involvement of stakeholders (e.g. information flow)	
72	**Establish monitoring programmes**	8, Annex V
73	**Establish the monitoring programmes taking into account the identification of water bodies at risk of failing the objectives**	
74	Select the most sensitive indicators for operational monitoring of HMWB and AWB	
75	Design surveillance monitoring networks	
76	Design operational monitoring networks for water bodies at risk and transboundary groundwater bodies	
77	Design investigative monitoring if necessary	
78	Design additional monitoring for protected areas	
79	Active involvement of stakeholders (e.g. information flow)	
80	**Submit summary reports of the monitoring programmes according to Art. 8**	
81	**Gap analysis**	
82	**Verify and refine the preliminary gap analysis**	
84	**Evaluate whether cost for closing the gap are disproportionate and justify potential derogations**	**4.4, 4.5**
86	**Decide on deadline extensions and application of less stringent objectives**	**4.3-4.7**
88	**Designate HMWB and AWB**	**4.3**
89	Designation test (a): Identify restoration measures necessary to achieve GES and check whether these measures have significant adverse effects on the wider environment or the "specified uses"	4.3.a
90	Designation test (b): Check whether the beneficial objectives served by the AWB or the modifications of the HMWB can be achieved by other means which are a significantly better environmental option, technically feasible and not disproportionately costly	4.3.b
91	Designate the water bodies not meeting the designation test (b) as HMWB or AWB	
92	Establish environmental objectives: Maximum Ecological Potential (MEP)	
93	Establish environmental objectives: Good Ecological Potential (GEP)	
94	Mapping/GIS-layer of monitoring networks (operational,surveillance, investigative and reference monitoring sites and sites for monitoring of drinking water abstraction points)	Annex V.1.3.1-1.3.3, 1.3.5, 2.2, 2.4, Annex II.1.3
95	**Apply ecological status/potential classification to surface water bodies**	
96	Produce maps/GIS-layers on classification (ecological status, ecological potential, bad status/potential caused by (non-)synthetic pollutants, chemical status	Annex V.1.4.2.
97	**Apply status classification to groundwater bodies**	
98	Produce maps/GIS-layers on quantitative and chemical status of groundwater bodies or groups of groundwater bodies	
99	Active involvement of stakeholders (e.g. building-in of knowledge and perceptions, reality-test)	
100	**Set up the programme of measures**	
101	Active involvement of stakeholders (e.g. information flow)	
102	**Define potential measures**	
103	Assess the status of implementation of basic measures according to Art. 11.3 and Annex VI	11.3, Annex VI
104	Select additional basic measures if necessary	
105	Select potential supplementary measures (Annex VI, Part B)	Annex VI/B
106	**Analyse the cost-effectiveness of potential measures**	
107	Develop database on costs and effectiveness on measures	
108	Estimate costs and effectiveness of measures in river basin	
109	**Set up a cost-effective programme of measures**	
110	Assess and rank cost effectiveness	
111	Construct programme of measures and estimate total costs	
112	Assess whether total costs are disproportionate	
113	Assess the financial implementation of the programmes of measures	
114	**Finalise the detailed programme of measures**	**11.7**



Flowchart for the first cycle of the planning process (3)

No.	Key activities for the first planning cycle	WFD articles
116	**Develop river basin management plans**	**13, Annex VII**
117	Active involvement of stakeholders (e.g. workshops, inventory of key issues, expert sessions and field observations)	
118	**Prepare and consult the timetable and work programme for the production of the RBMP**	
119	Publish and make available to the public a timetable and a work programme for the production of the RBMP	14.1.a
120	Allow a period of at least six months for comments by the public	
121	**Provide an interim overview of significant water management issues**	**14.1.b**
122	Publish and make available for comments to the public an interim overview of the significant water management issues identified in the RBs	
123	Allow a period of at least six months for comments by the public	
124	**Complete the draft river basin management plans and make it available for comments to the public**	**14.1.c**
125	Complete the draft river basin plans	
126	Allow a period of at least six months for comments by the public	
127	**Produce a summary of the programme of measures**	
129	**Finalise and publish river basin management plans**	**13.6**
130	Summary of public information and consultation measures taken, results and changes to the plan made as a consequence	
131	Active involvement of stakeholders to ensure a continuation of PP after the normal consultation period	
132	Finalise and publish river basin management plans	
133	**Send copies of the river basin management plans to the EC**	**15**
134	**Implement the programmes of measures and prepare the interim report on the implementation**	
135	Active involvement of stakeholders (e.g. workshops, inventory of key issues, expert sessions and field observations)	
136	**Make the measures of the programme of measures operational**	**11.7**
138	**Establish incentive water pricing policies**	**9**
140	**Prepare an interim report describing progress in the implementation of the planned programme of measures**	**15.3**
142	**Submit the interim report to the EC**	
143	**Evaluate the first and prepare the second period**	
144	Active involvement of stakeholders (e.g. collecting information and knowledge and assessment)	
145	**Update the RBD status**	**5**
147	**Review the programme of measures and the RBMP**	**13.7, 11.8, Annex VII**
148	Prepare a new timetable, work programme and make it available for public consultation	
149	Review and update of analyses and reviews of significant water management issues mentioned in Art. 5.1	5.2
150	Prepare a summary of changes or updates since the publication of the previous version of the RBMP including a summary of the reviews to be carried out under Art. 4, 5, 6 and 7	
151	Review of MEP and GEP values for AWB and HMWB	
152	Prepare a summary of and explanation for any measures foreseen in the earlier version of the RBMP which have not been undertaken	
153	Assess the progress made towards the achievement of the environmental objectives including a presentation of the monitoring results for the period of the previous plan in map form and an explanation of the unachieved environmental objectives	
154	Prepare a summary of any additional interim measures adopted under Art. 10 since the publication of the previous version of the RBMP	
155	Review of MEP and GEP values for AWB and HMWB	
156	New draft river basin management plan and public consultation	
157	Publish the updated river basin management plan	
158	**Interim measures to prevent further deterioration of the status of aquatic ecosystems**	**1, 4.3-4.9**
159	**Information and consultation of the public, active involvement of interested parties in accordance with the Public Participation Guidance document**	**14**



Notes:

- The reporting deadline for tasks no. 22, 67, 86 and 88 is 22 March 2010, as part of the River Basin Management Plan.

- Tasks no. 59 and 60 are co-ordinated by the Working Group on Ecological Status and Intercalibration.

- Task no. 158 is related to the array of measures necessary to meet one of the main objectives of the WFD, which is to prevent further deterioration of the status of aquatic ecosystems (Article 1). Articles 4.3 to 4.7 have to be taken into account for the application of this principle and to define the deadlines. For the moment, an ongoing task is proposed throughout the whole first assessment and planning period until December 2009 although, in any case, details of the time schedule of this issue will be dealt with in a specific document.

- Task nº 159. A specific Guidance Document has been produced on Public Participation as one of the outputs of Working Group 2.9, (WFD CIS Guidance Document No. 8) explaining in detail activities and deadlines.

6.5 Bottlenecks in the planning process

The analysis of the flowchart has allowed the identification of the so-called "bottlenecks" of the implementation of the Directive, i.e. the incongruities in planning that occur when comparing the official deadline requirements of the Directive with a pragmatic approach regarding the implementation. As a result of the scrutiny of the Directive by the Working Groups for preparing the Guidances under the Common Implementation Strategy, several incongruities have been made explicit. This Guidance on planning has intended to bring together the activities and bottlenecks that have been identified by the different Working Groups of the Common Implementation Strategy.

All Working Groups have been confronted with the ambitious and legally binding timetable of the Directive. In principle deviation from this timetable is not allowed and deadlines cannot be postponed, except for the derogations as mentioned in Article 4. Several Working Groups experienced on the one hand that the timetable is tight and leaves little time to go through the matter in to great depth and on the other hand that the chronological order of the deadlines is not always logical when dealing with the practical implementation. This combination often results in bottlenecks. The scope of this document is on the bottlenecks that primarily identify *timing-related* implementation problems. These are common for all Member States dealing with the implementation. Bottlenecks that occur due to lacking financial or technical means or institutional arrangements are often specific for a Member State or river basin due to priority-setting, habits and traditions and not covered explicitly by this document. However it is recognised that these "local" bottlenecks can be of interest to a wider public and can be added to this document at a later stage. During the preparation of the Guidances so called "open issues" were identified by the Working Groups. Not all of these issues are related to planning and therefore not always mentioned here.

Some of the bottlenecks are indicated in the flowchart and are identified for the period until the first River Basin Management Plan in 2009. For each bottleneck identified an information sheet has been prepared which clarifies the bottleneck. For the moment the list is not exhaustive or finalised and will be completed later on in the Manual for Integrated River Basin Management to be developed by the "cluster group" as well as during the testing of Pilot River Basins which will be a part of the manual.

As a result of the above-mentioned preliminary analyses, the following bottlenecks have been identified:

- The lack of data for the first district review: need for existing information and data on pressures and impacts, need for a definition for the significant pressures, need for a translation between pressures and impacts, need for the baseline scenario before estimating the forecasted impacts, need to know the 2015 objectives to assess the risk to fail;
- Data on RC prerequisite for assigning ecologically relevant typology;
- Need to start monitoring potential RC sites before monitoring programmes are operational;
- Need for monitoring data from intercalibration sites for calculating EQRs;
- Evaluation of the testing and review of Guidances is too late for the reporting on the status in 2005;

- Typology, reference conditions and class boundaries not available. Draft register based on expert judgement and (little available data);
- Finishing intercalibration exercise before monitoring programmes are operational;
- Pressed time schedule for assessing comments and reviewing document concerning the draft management plan;
- Simultaneously elaboration of the programme of measures and the management plan, with a summary of the programme within the plan;
- The 2004 review of the districts should be done with data and tools currently available, but these have to be used in a pragmatic manner in order to meet the requirements of the directive. Making the 2004 review is an opportunity to assess the lacking data and shortcomings to be resolved.

It can be observed that most bottlenecks can be reduced to a few basic issues or deadlines within the Directive:

1. Objectives to be achieved in 2015 are unclear. The Directive refers to the achievement of "good water status" in 2015 which can be defined by the help of Annex II and V. Still this information is general and needs to be elaborated and made operational for the several water types and/or water bodies which takes time and is planned to finish by 2004. This has as a consequence that it is hard to tell if a water body is at risk of failing the environmental quality objectives before 2004 (gap analysis) and which measures need to be taken.

2. Data availability: the monitoring programme does not have to be in place until 2006. This means that recent and complete information (measured values) on parameters that are of importance to the pressure and impact analysis, reference conditions, ecological class boundaries, intercalibration sites, and indirectly to the designation of heavily modified water bodies, will be available earliest in 2007. In combination with a low monitoring frequency the availability of this data is not optimal. As a consequence assumptions will be made about missing data which increases the uncertainties in the analyses and affects the validity of the assessments.

3. The publication of the *draft* River Basin Management Plan (RBMP) in 2008 in order to allow for comments of the public. This means that the RBMP (which officially has to be published in 2009) should be ready in quite an advanced state by the end of 2008 in order to give a realistic and truthful impression of the RBMP as it will be in 2009. Consequently it implies that activities for producing the contents of the plan should be wrapped up by 2008 which shortens the available time.

Some solutions for the bottlenecks are recommended in this document and can be divided into 3 principal types of solutions:

a. Anticipated deadlines

It is recommended to adopt a pragmatic approach for the setting up of intermediary and informal or anticipated deadlines for certain tasks if necessary so as to be able to meet in practice the obligatory deadlines required in the WFD. The advancing of activities might help to meet the deadlines but also confronts the actors with an even tighter planning scheme. Member States might have different priorities and can shift or delete the informal deadlines accordingly. However for the international level good co-ordination on informal deadlines is recommended.

b. Use of existing information.
As existing information can be considered a range is available from expert judgement to existing monitoring data resulting from existing legislation. Also when using existing data, the collection and collation of data will require good co-ordination and a good deal of time. The information is usually neither readily available in one place nor in the right format.
In this context, a consultation to stakeholders and the scientific community can improve the existing data and/or help advance where gaps have been identified.

c. Preliminary exercises
It is recommended to perform preliminary exercises that are checked, refined and finalised later when more information will be available.
The combination of unclear objectives, missing data and the first major deadline in 2004 (Article 5) makes it nearly impossible to give a very exact assessment of the current water status and the risk of failing to meet the objectives. Therefore several Working Groups already considered the process being iterative and to do *preliminary* analyses and assessments, based on available data (if necessary assumptions) by 2004 and to check these assessments at a later stage when monitoring data become available. It is important to estimate the uncertainty of these preliminary exercises.

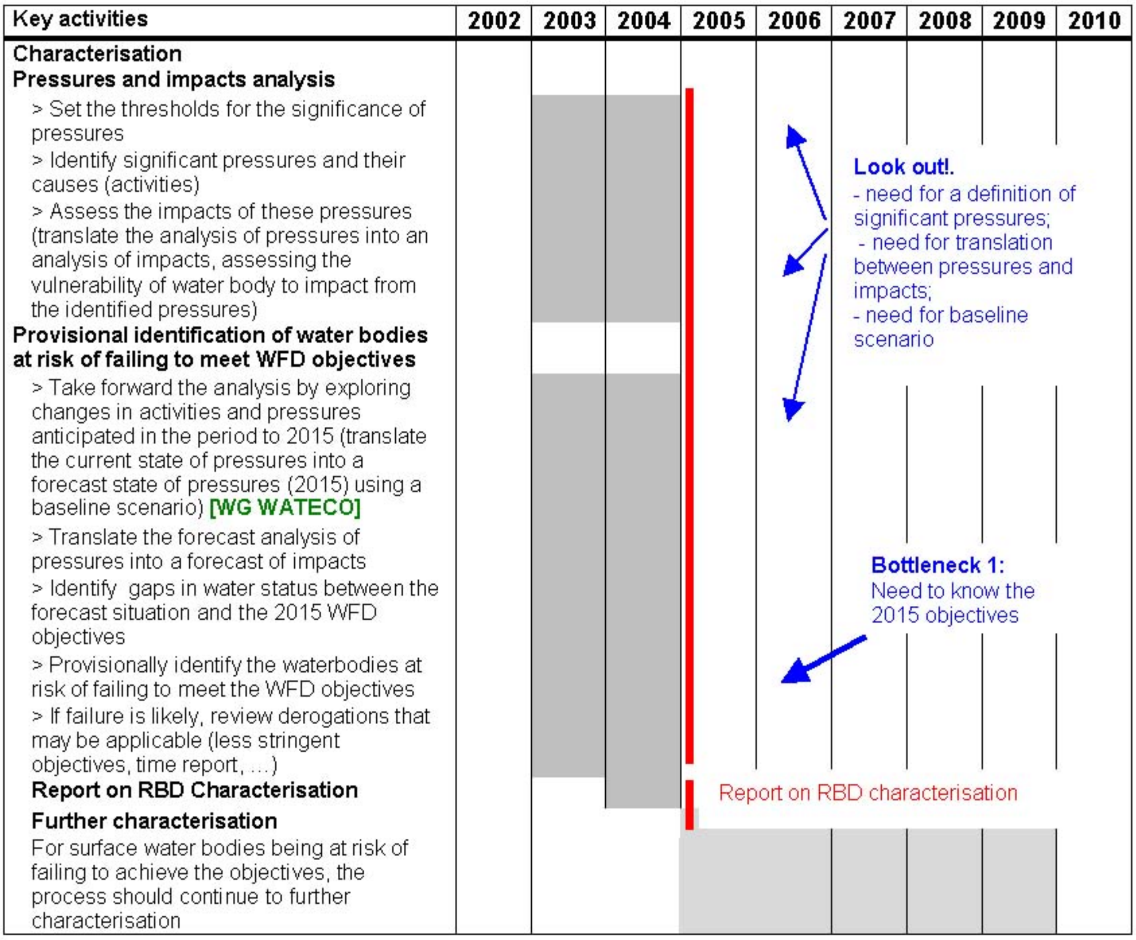
Note that this is a preliminary identification of the possible bottlenecks in the planning process. Testing in Pilot River Basins (PRB) will deal more deeply and at a more local scale with bottlenecks, since one of the main objectives is to check for inconsistencies between Guidance Documents. The results of testing will probably help to identify other bottlenecks and provide more information on the possible solutions. This new information could be integrated in further updated version of this Guidance on Planning Process, as it is considered as a "living" document.

From the bottlenecks listed above, the following have been developed into information sheets:

Number	**Title**
1	Gap analysis*
2	Intercalibration*
3	Public participation*
4	River basin management plan and programme of measures**

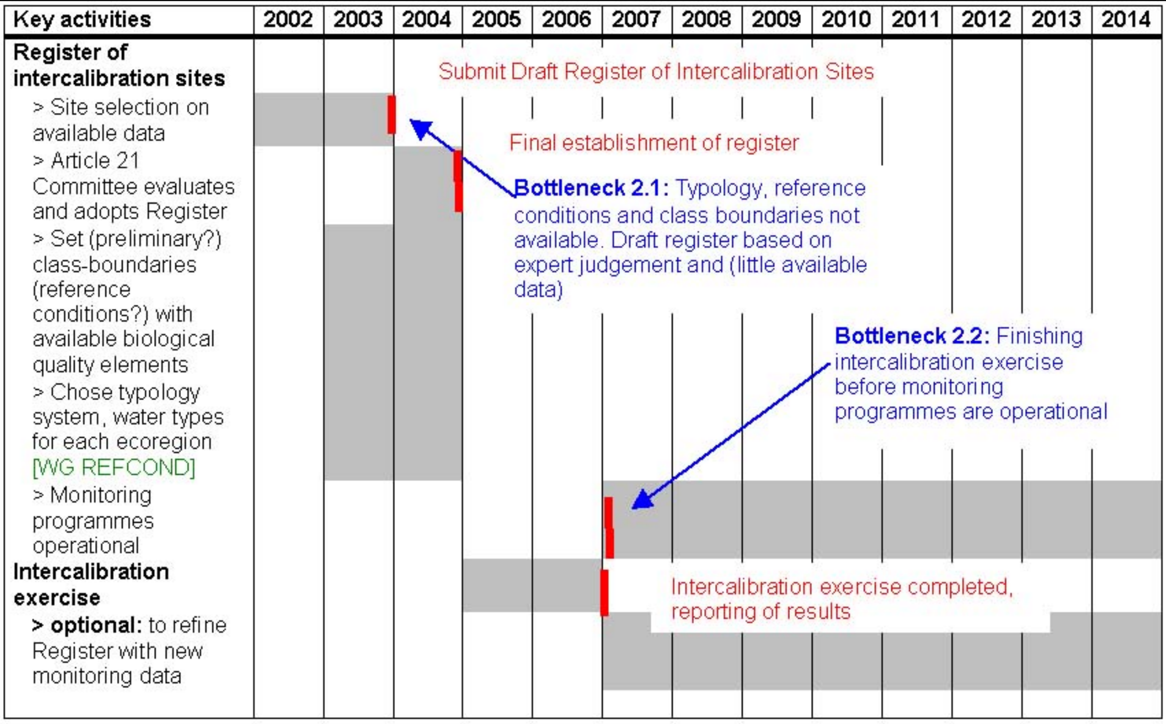
* Sheets provided in this Guidance.
** Topic to be dealt with in more detail in the Manual for Integrated River Basin Management to be developed by the future "cluster group".

Bottleneck 1: Gap analysis: assessment of the likelihood that water bodies will fail to meet the environmental objectives

Related to	Data availability, objectives of the Directive
Scale	General
Sources	• WFD Annex II 1.4-2.5, (Annex V) • Guidance for the analysis of Pressures and Impacts in accordance with the WFD (WFD CIS Guidance Document No. 3)
Pilot River Basin testing	Yes
Flow chart	

Explanatory text	The role of the gap analysis (making use of the pressure and impact analysis and the baseline scenario) is to assess the likelihood that water bodies will fail to meet the environmental objectives of the Directive. It tells if there is a gap (and how big) between the current status of the water body and the good status that is to be achieved by 2015 This analysis is a central issue in the implementation of the Directive but not mentioned very explicitly in the main text (only Annex II 1.5). The bottleneck lies in the fact that the first pressures and impacts analysis must be complete by the end of 2004 while the environmental objectives of the Directive are not established yet. The objectives depend on issues such as the definition of ecological class boundaries and reference conditions (scheduled 2004) which in their turn need to be verified by the monitoring programme that won't be in place until 2006.
Recommen-dations	Carry out a preliminary gap analysis by 2004, which gives a first insight in the water bodies at risk. A start can be made with the development of the Programme of Measures. Along the line, when more and more precise information becomes available this gap analysis shall be refined and measures adapted accordingly. While performing the preliminary gap analysis, one should be aware and take account of the uncertainties in the environmental conditions required to meet the Directive's objectives and the uncertainties in the estimated impact.

Bottleneck 2: Intercalibration

Related to	Data availability, objectives of the Directive
Scale	General
Sources	• WFD Annex V 1.4.1 • Guidance on establishment of the intercalibration network and on the process of the intercalibration exercise (WFD CIS Guidance Document No. 6)
Pilot River Basin testing	No
Flow chart	

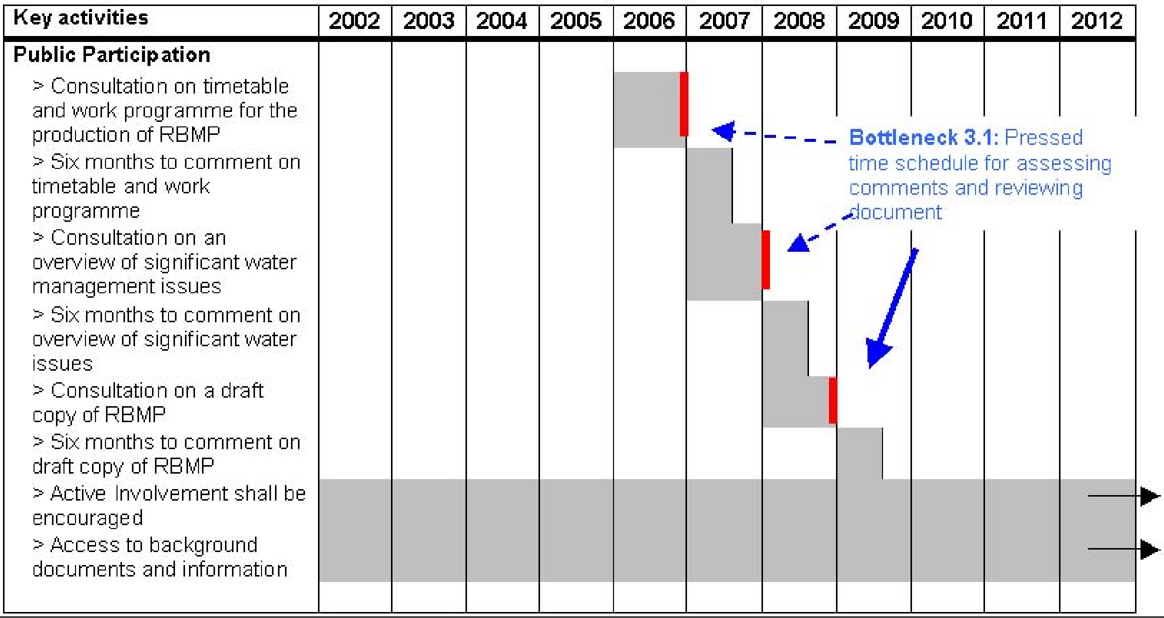
Explanatory text	The aim of the intercalibration exercise is to compare between Member States types of water bodies which represent the ecological quality boundaries for high-good and good-moderate status. The result shall be expressed in ecological quality ratios (EQR). The intercalibration timetable does not match the implementation timetable of the Directive in the Member States. Crucial information for the intercalibration will be available during the progress in implementation. The major bottlenecks are: 2.1) Water body types selected for intercalibration networks (2003) may not be compliant with water body types differentiated by Member States, because sites for the draft register are selected before the typology in Member States needs to be ready (2004); moreover the choice for parameters used for establishing the sites depends on choices made for reference conditions and ecological quality elements (ready earliest 2004); 2.2) At present (2002) there is not sufficient data available to carry out a scientifically sound site selection, since not all parameters necessary for site selection have been monitored by Member States until now. The monitoring programme for the Directive will start in 2006, after the finalisation of the intercalibration exercise. The objectives of the intercalibration exercise - agreement on class boundaries and harmonised classification systems - can be only partially met in the single intercalibration exercise that is required by the Directive. The intercalibration network established will not reflect the impacts of all pressures and all biological quality elements.
Recommen-dations	• Site selection targeted to water body types where most data is available; • Establish a review mechanism at a time when more data with better quality and compatible with the requirements of the Directive will be available (after 2006); • Clarify the legal possibilities and practical implications for such a revision.

Bottleneck 3.1: Public Participation

<table>
<tr><td>Related to</td><td>Publication of draft River Basin Management Plan (RBMP)</td></tr>
<tr><td>Scale</td><td>General</td></tr>
<tr><td>Sources</td><td>

- WFD Article 14, Annex VII.9
- Guidance on Public Participation in relation to the WFD: active involvement, consultation and public access to information (para 2.6, 4.7) (WFD CIS Guidance Document No. 8)

</td></tr>
<tr><td>Pilot River Basin testing</td><td>No</td></tr>
<tr><td>Flow chart</td><td>



</td></tr>
<tr><td>Explanatory text</td><td>

At the end of 2008 a draft copy of the RBMP shall be published and made available to the public. The public shall be given half a year (June 2009) to comment on this draft. Then the comments of the public shall be considered, when relevant incorporated in the plan, and the plan itself shall be finalised and published by 22 December 2009. In the plan it shall be indicated what consultation measures have been taken and what their results and changes to the plan as a consequence of the consultation have been made.

3.1) Since there is scarcely time between June and December 2009 to change the RBMP (and strategy) based on the comments of the public, there is a risk that these comments will not be taken into account due to lack of time which is against the spirit and requirements of the Directive. This comment is to a lesser degree also valid for the consultation on the timetable and work programme and the overview of significant water management issues.

</td></tr>
<tr><td>Recommen-dations</td><td>

- Consult and inform (if even possible: to involve) the public more intensively at an earlier stage, this will help to overcome surprises and can prevent a too large adaptation of the RBMP at a later stage;
- Publication of the draft RBMP at an earlier stage, this however will often be difficult since it shortens the duration of other activities;
- Another possibility would be to organise the two first public consultations before the obligatory deadlines (respectively 2006 and 2007 at the latest). This would allow more time to prepare and organise the third public consultation on the draft RBMP and then, to take account of the comments, which will be probably more numerous than for the two previous consultations.

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Bottleneck 3.2: Public Participation

Related to	Institutional aspects
Scale	International River Basin Districts (RBD), Member States
Sources	• WFD Article 14, Annex VII.9, Article 13.2 • Guidance on Public Participation in relation to the WFD: active involvement, consultation and public access to information (Section 4) (WFD CIS Guidance Document No. 8)
Pilot River Basin testing	Yes (?)
Flow chart	-
Explanatory text	Several documents shall be presented to the public for information and consultation. Also background information shall be available on request at the contact points listed in the RBMP. Member States need to plan in advance how to reach the public, where to collect the comments, how to process the comments and at what level these activities will take place. Especially international River Basin Districts, which are often dealing with several languages and with local public which are confronted with international/transboundary matters, should think twice about how to organise this.
Recommen-dations	The solution is different for every Member State or RBD. The following questions might help to orientate: • Should the public be confronted with (detailed) information of the whole area to which the RBMP refers? Or should tailor-made information be prepared, targeted to that part of the area where the public is affected and most likely interested in? Recognise that measures taken in one area can have an effect somewhere else; • Will there be one central contact point to obtain background information for the whole area where the plan refers to, or several local ones? How are these points communicated to the public? • Shall the comments of the different consultation rounds be collected and processed locally or at a central point? How will feedback to the public be organised? • Will Member States in an international RBD report one single plan for this RBD to the Commission (Article 13.2) or separately for each Member State?

Bottleneck 4: River basin management plan and programme of measures

Related to	Timing problems between the river basin management plan and the programme of measures
Scale	International River Basin Districts (RBD), Member States
Sources	• WFD Articles 11 and 13, Annex VII • Flowcharts for the planning process
Pilot River Basin testing	Yes
Flow chart	-
Explanatory text	Necessity to have the programme of measures finished before the RBMP so to include the summary into the RBMP as required by Annex VII. This topic will be examined within the future activities of the Working Group Integrated River Basin Management.
Recommen-dations	-

Annex 1 – List of Abbreviations

The following abbreviations are used throughout the text of this Guidance:

AWB	Artificial Water Body
BAU	Business As Usual
BESTPRACT	Working group on BEST PRACTices in river basin planning
CAP	Common Agricultural Policy
COAST	Working group on typology, classification of transitional and COASTal waters
DPSIR	Driving forces, Pressures, States, Impacts, Responses
EAF	Expert Advisory Forum
EEA	European Environment Agency
EC	European Commission
EQR	Ecological Quality Ratio
GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	Geographical Information System
GROUNDWATER	Working group on tools on assessment
HMWB	Heavily Modified Water Body
ICZM	Integrated Coastal Zone Management
IMPRESS	Working Group on the analysis of PRESSures and IMPacts
INTERCALIBRATION	Working Group on a protocol for INTERCALIBRATION
IRBM	Integrated River Basin Management
MEP	Maximum Ecological Potential
MS	Member States
NGO	Non-Governmental Organisation
PRB	Pilot River Basin

RBD	River Basin District
RBMP	River Basin Management Plan
RC	Reference Conditions
REFCOND	Working group on classification and REFerence CONDitions
WD	Water Directors
WFD	Water Framework Directive
TOC	Table Of Contents
TOR	Terms Of Reference
WATECO	Working group on (WATer) ECOnomic analysis
WG	Working Group

Annex 2 – Preambles and articles of the Water Framework Directive relevant to this Guidance

The planning process in the preambles

Preamble 13
There are diverse conditions and needs in the Community which require different specific solutions. This diversity should be taken into account in the planning and execution of measures to ensure protection and sustainable use of water in the framework of the river basin. Decisions should be taken as close as possible to the locations where water is affected or used. Priority should be given to action within the responsibility of Member States through the drawing up of programmes of measures adjusted to regional and local conditions.

Preamble 28
Surface waters and groundwaters are in principle renewable natural resources; in particular, the task of ensuring good status of groundwater requires early action and stable long-term planning of protective measures, owing to the natural time lag in its formation and renewal. Such time lag for improvement should be taken into account in timetables when establishing measures for the achievement of good status of groundwater and reversing any significant and sustained upward trend in the concentration of any pollutant in groundwater.

Assessment on current water status

Article 5

Each Member state shall ensure that for each river basin district or for the portion of an international river basin district falling within its territory: an analysis of its characteristics, a review of the impact of human activity on the status of surface waters and on groundwater and an economic analysis of water use, is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.

Monitoring

Article 8

1. Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district:
- for surface waters such programmes shall cover:
(i) the volume and level or rate of flow to the extent relevant for ecological and chemical status and ecological potential; and
(ii) the ecological and chemical status and ecological potential;
- for groundwaters such programmes shall cover monitoring of the chemical and quantitative status,
- for protected areas the above programmes shall be supplemented by those specifications contained in Community legislation under which the individual protected areas have been established.

Economic analysis and recovery of the costs of water services

Article 9

1. Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle.
Member States shall ensure by 2010:
- that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III and taking account of the polluter pays principle.
Member States may in so doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected.
2. Member States shall report in the river basin management plans on the planned steps towards implementing paragraph 1 which will contribute to achieving the environmental objectives of this Directive and on the contribution made by the various water uses to the recovery of the costs of water services.
3. Nothing in this Article shall prevent the funding of particular preventive or remedial measures in order to achieve the objectives of this Directive.
4. Member States shall not be in breach of this Directive if they decide in accordance with established practices not to apply the provisions of paragraph 1, second sentence, and for that purpose the relevant provisions of paragraph 2, for a given water-use activity, where this does not compromise the purposes and the achievement of the objectives of this Directive. Member States shall report the reasons for not fully applying paragraph 1, second sentence, in the river basin management plans.

Definition of environmental objectives and gap analysis

Article 4

1. In making operational the programmes of measures specified in the river basin management plans:

(a) for surface waters

(i) Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8;
(ii) Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive, in accordance with the provisions laid down in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;
(iii) Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years from the date of entry into force of this Directive, in accordance

with the provisions laid down in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;
(iv) Member States shall implement the necessary measures in accordance with Article 16(1) and (8), with the aim of progressively reducing pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous substances without prejudice to the relevant international agreements referred to in Article 1 for the parties concerned;

(b) for groundwater

(i) Member States shall implement the measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8 of this Article and subject to the application of Article 11(3)(j);
(ii) Member States shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status at the latest 15 years after the date of entry into force of this Directive, in accordance with the provisions laid down in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8 of this Article and subject to the application of Article 11(3)(j);
(iii) Member States shall implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order progressively to reduce pollution of groundwater.
Measures to achieve trend reversal shall be implemented in accordance with paragraphs 2, 4 and 5 of Article 17, taking into account the applicable standards set out in relevant Community legislation, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8;

(c) for protected areas

Member States shall achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of this Directive, unless otherwise specified in the Community legislation under which the individual protected areas have been established.

2. Where more than one of the objectives under paragraph 1 relates to a given body of water, the most stringent shall apply.

Programmes of measures

Article 11

1. Each Member State shall ensure the establishment for each river basin district, or for the part of an international river basin district within its territory, of a programme of measures, taking account of the results of the analyses required under Article 5, in order to achieve the objectives established under Article 4. Such programmes of measures may make reference to measures following from legislation adopted at national level and covering the whole of the territory of a Member State. Where appropriate, a Member State may adopt measures applicable to all river basin districts and/or the portions of international river basin districts falling within its territory.

2. Each programme of measures shall include the "basic" measures specified in paragraph 3 and, where necessary, "supplementary" measures.
3. "Basic measures" are the minimum requirements to be complied with and shall consist of:
(a) those measures required to implement Community legislation for the protection of water, including measures required under the legislation specified in Article 10 and in part A of Annex VI;
(b) measures deemed appropriate for the purposes of Article 9;
(c) measures to promote an efficient and sustainable water use in order to avoid compromising the achievement of the objectives specified in Article 4;
(d) measures to meet the requirements of Article 7, including measures to safeguard water quality in order to reduce the level of purification treatment required for the production of drinking water;
(e) controls over the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water, including a register or registers of water abstractions and a requirement of prior authorisation for abstraction and impoundment. These controls shall be periodically reviewed and, where necessary, updated. Member States can exempt from these controls, abstractions or impoundments which have no significant impact on water status;
(f) controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies. The water used may be derived from any surface water or groundwater, provided that the use of the source does not compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater. These controls shall be periodically reviewed and, where necessary, updated;
(g) for point source discharges liable to cause pollution, a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, or for prior authorisation, or registration based on general binding rules, laying down emission controls for the pollutants concerned, including controls in accordance with Articles 10 and 16. These controls shall be periodically reviewed and, where necessary, updated;
(h) for diffuse sources liable to cause pollution, measures to prevent or control the input of pollutants. Controls may take the form of a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community legislation. These controls shall be periodically reviewed and, where necessary, updated;
(i) for any other significant adverse impacts on the status of water identified under Article 5 and Annex II, in particular measures to ensure that the hydro-morphological conditions of the bodies of water are consistent with the achievement of the required ecological status or good ecological potential for bodies of water designated as artificial or heavily modified. Controls for this purpose may take the form of a requirement for prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community legislation. Such controls shall be periodically reviewed and, where necessary, updated;
(j) a prohibition of direct discharges of pollutants into groundwater subject to different provisions(.../...)
(k) in accordance with action taken pursuant to Article 16, measures to eliminate pollution of surface waters by those substances specified in the list of priority substances agreed pursuant to Article 16(2) and to progressively reduce pollution by other substances which would otherwise prevent Member States from achieving the objectives for the bodies of surface waters as set out in Article 4;
(l) any measures required to prevent significant losses of pollutants from technical installations, and to prevent and/or to reduce the impact of accidental pollution incidents for example as a result of floods, including through systems to detect or give warning of such

events including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems.
4. "Supplementary" measures are those measures designed and implemented in addition to the basic measures, with the aim of achieving the objectives established pursuant to Article 4. Part B of Annex VI contains a non-exclusive list of such measures.
Member States may also adopt further supplementary measures in order to provide for additional protection or improvement of the waters covered by this Directive, including in implementation of the relevant international agreements referred to in Article 1.
5. Where monitoring or other data indicate that the objectives set under Article 4 for the body of water are unlikely to be achieved, the Member State shall ensure that:
- the causes of the possible failure are investigated,
- relevant permits and authorisations are examined and reviewed as appropriate,
- the monitoring programmes are reviewed and adjusted as appropriate, and
- additional measures as may be necessary in order to achieve those objectives are established, including, as appropriate, the establishment of stricter environmental quality standards following the procedures laid down in Annex V.
Where those causes are the result of circumstances of natural cause or force majeure which are exceptional and could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, the Member State may determine that additional measures are not practicable, subject to Article 4(6).
6. In implementing measures pursuant to paragraph 3, Member States shall take all appropriate steps not to increase pollution of marine waters. Without prejudice to existing legislation, the application of measures taken pursuant to paragraph 3 may on no account lead, either directly or indirectly to increased pollution of surface waters. This requirement shall not apply where it would result in increased pollution of the environment as a whole.
7. The programmes of measures shall be established at the latest nine years after the date of entry into force of this Directive and all the measures shall be made operational at the latest 12 years after that date.
8. The programmes of measures shall be reviewed, and if necessary updated at the latest 15 years after the date of entry into force of this Directive and every six years thereafter. Any new or revised measures established under an updated programme shall be made operational within three years of their establishment.

River Basin Management Plans and their reporting

Article 13

1. Member States shall ensure that a river basin management plan is produced for each river basin district lying entirely within their territory.
2. In the case of an international river basin district falling entirely within the Community, Member States shall ensure co-ordination with the aim of producing a single international river basin management plan. Where such an international river basin management plan is not produced, Member States shall produce river basin management plans covering at least those parts of the international river basin district falling within their territory to achieve the objectives of this Directive.
3. In the case of an international river basin district extending beyond the boundaries of the Community, Member States shall endeavour to produce a single river basin management plan, and, where this is not possible, the plan shall at least cover the portion of the international river basin district lying within the territory of the Member State concerned.
4. The river basin management plan shall include the information detailed in Annex VII.
5. River basin management plans may be supplemented by the production of more detailed programmes and management plans for sub-basin, sector, issue, or water type, to deal with

particular aspects of water management. Implementation of these measures shall not exempt Member States from any of their obligations under the rest of this Directive.
6. River basin management plans shall be published at the latest nine years after the date of entry into force of this Directive.
7. River basin management plans shall be reviewed and updated at the latest 15 years after the date of entry into force of this Directive and every six years thereafter.

Article 15

1. Member States shall send copies of the river basin management plans and all subsequent updates to the Commission and to any other Member State concerned within three months of their publication:
(a) for river basin districts falling entirely within the territory of a Member State, all river management plans covering that national territory and published pursuant to Article 13;
(b) for international river basin districts, at least the part of the river basin management plans covering the territory of the Member State.
2. Member States shall submit summary reports of:
- the analyses required under Article 5, and
- the monitoring programmes designed under Article 8
undertaken for the purposes of the first river basin management plan within three months of their completion.
3. Member States shall, within three years of the publication of each river basin management plan or update under Article 13, submit an interim report describing progress in the implementation of the plan.

Annex 3 – Members of the Drafting Group of this Guidance and list of the experts of Working Group 2.9

The Drafting Group responsible for preparing this Guidance on the planning process was composed of the following members:

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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.º 12

The role of wetlands in the Water Framework Directive

COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 12

Horizontal Guidance on the Role of Wetlands in the Water Framework Directive

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int).

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Foreword

The EU Member States[1], Candidate Countries[2], EFTA countries[3] and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy, hereafter referred to as Common Implementation Strategy (CIS) for the Water Framework Directive (WFD). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the WFD.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to experts and stakeholders involved in the implementation of the WFD in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, the European Commission (Directorate General for the Environment, Unit B.1) was invited to set up an informal process for drafting a Horizontal Guidance on the Role of Wetlands in the Water Framework Directive.

A drafting group was established in January 2003 and a first draft was discussed at the wetlands kick-off meeting on the 21st January, 2003. This was followed by discussions at two Strategic Co-ordination Group (SCG) meetings (5th May 2003; 27th & 28th October, 2003) and a further two drafting group meetings. The document combines the opinions and conclusions of experts from Member States, New Member States and candidate countries, stakeholders and expert groups, as well as experts from the Expert Advisory Forum (EAF) on Groundwater. Due to intensive discussions between these groups, it was possible to present a final draft to the Water Directors meeting in Rome, Italy, on the 24th and 25th November, 2003, where the Water Directors reached the following conclusions:

"We, the Water Directors have examined and endorsed this Guidance during our informal meeting under the Italian Presidency in Rome (24/25 November 2003). We would like to thank the participants of the Drafting Group and, in particular, the leaders, Italy, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the guidance is applicable in practice.

[1] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia,

[2] Bulgaria, Romania

[3] Iceland, Liechtenstein, Norway, Switzerland

We also commit ourselves to assess and decide upon the necessity for reviewing this document in 2004 following the pilot testing exercises and the first experiences gained in the initial stages of the implementation."

Why this document?

The 1995 Commission Communication to the Council and the European Parliament on the *Wise Use and Conservation of Wetlands* recognises the very critical situation of Europe's wetlands and the very urgent need for action. It underlines the widespread loss and degradation of wetlands that has resulted in a significant reduction of the beneficial functions they perform in renewing natural resources. By promoting the wise use and conservation initiative the Commission stresses the EU's involvement in wetland protection and enhancement and its commitment in setting up strategic policies for sector integration.

The Water Framework Directive (2000/60/EC) clearly identifies the protection, restoration and enhancement of the water needs of wetlands as part of its purpose at Article 1(a):

> *The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:*
>
> *(a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems.*

However, it does not provide any specific definition of what a wetland is, nor does it clearly state the extent to which wetlands should be used for the achievement of environmental objectives. Member States and stakeholders felt that it would be helpful to explore and clarify the role of wetlands in implementing the Water Framework Directive.

The Water Directors Meeting in November 2002 provided common text (cited in 1.1) to be inserted in Common Implementation Strategy Guidance Documents, in which the Directors acknowledge pressures on wetlands, highlight their potential important role in river basin management (RBM) and in helping to achieve WFD environmental objectives, and recommend the preparation of a Horizontal Guidance on Wetlands to implement these principles.

Support for the present document can be found in the WFD CIS Guidance Document No. 2 *Horizontal Guidance on the Identification of Water Bodies* (Water Bodies), compiled in order to provide additional guidance on the definition and protection of "water bodies" as intended by the Directive), in the *WFD CIS Guidance Document No.5 on Typology, Reference Conditions and Classification Systems for Transitional and Coastal Waters* (COAST), in the *WFD CIS Guidance Document No. 4 on Identification and Designation of Heavily Modified and Artificial Water Bodies (HMWB)* and in the *WFD CIS Guidance Document No. 3 for the Analysis of Pressures and Impacts in accordance with the WFD* (IMPRESS). These documents have undergone a negotiated participatory drafting process, therefore the present Guidance Document will build upon definitions and recommendations proposed in them. In addition, this document will provide a description of how wetlands are relevant to WFD implementation, and will describe and provide guidance on the role of wetlands in the achievement of the environmental objectives of the WFD.

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1 INTRODUCTION

1.1 Background to the document

Scope for the initiative has been acquired through the endorsement of the *Common text on wetlands* agreed upon at the Water Directors Meeting in Copenhagen, November 2002.

> *Common text to be inserted in the Guidance Documents:*
>
> *Wetland ecosystems are ecologically and functionally significant elements of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in CIS Horizontal Guidance Documents on Water Bodies (WFD CIS Guidance Document No. 2) and are further considered in a Guidance on Wetlands.*
>
> *Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.*
>
> *Wetland creation and enhancement can in appropriate circumstances offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to: abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater re-charge. The relevance of wetlands within programmes of measures is examined in the horizontal Guidance paper on wetlands*.

Following an initiative from some NGOs involved in the Common Implementation Strategy for the Water Framework Directive (WFD), a drafting group composed of the delegates of several Member States (see foreword) developed this Horizontal Guidance on Wetlands to fulfil the mandate set by the Water Directors.

1.2 Purpose of Guidance

The purpose of the WFD in relation to wetlands as stated in Article 1 is unambiguous. Article 1(a) states that the Directive will:

> '*establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, which:*
>
> '*prevent further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and* ***wetlands*** *directly depending on the aquatic ecosystems.'*

The protection and enhancement of surface water and groundwater will be achieved through the application of the WFD's environmental objectives, and where appropriate through the use of wetland protection and restoration to help fulfil these objectives in a cost effective and sustainable manner. These aspects of implementation are outlined in the main body of the paper.

As wetlands are a crosscutting issue, the purpose of this Guidance is to elaborate a common understanding of the WFD requirements regarding wetlands and identify their role in its implementation.

In some cases, where additional effort could lead to considerably enhanced results, the Guidance goes one step further and illustrates best practices beyond the legal requirements of the WFD.

The text of the Guidance Document is aimed at making as clear as possible a distinction between legal obligations and best practice recommendations; best practice recommendations are given in the blue boxes presented within the Guidance, as well as within the text itself. It is recognised that Member States have the flexibility to establish stricter environmental protection according to their particular national concerns.

1.3 Structure of Guidance

The following Section on the status of wetlands within the WFD brings forward a functional description of wetlands coherent with WFD purposes (Section 2.1) and in agreement with the consideration of wetlands in other Horizontal Guidance Documents, with particular reference to the Water Bodies Guidance (WFD CIS Guidance Document No. 2). Furthermore, an illustration of the main wetland attributes recognised under the WFD (Section 2.2) introduces the analysis of relationships between wetlands and surface water bodies (Section 2.3), terrestrial ecosystems (Section 2.4) and other elements of surface water having an influence on water bodies and catchment management (Sections 2.5 and2.6).

The specific role of wetlands in achieving WFD environmental objectives is illustrated in Chapter 3, specifying minimum WFD requirements (Section 3.1), the relationship between wetlands and WFD objectives for surface water (Section 3.2), the relevance of wetlands for the achievement of environmental objectives for groundwater (Section 3.3) and for transitional and coastal waters (Section 3.4).

Chapter 4 illustrates the relationship between wetland systems and Heavily Modified and Artificial Water Bodies. Chapter 5 addresses Protected Areas. Chapter 6 clarifies impacts and pressures relative to wetlands, following the general issues highlighted by the IMPRESS WFD CIS Guidance Document No. 3. Chapter 7 illustrates the role of wetlands in the Programme of Measures (PoM) and discusses wetlands in relation to basic and supplementary measures (Section 7.1). Particular attention is given to the consideration of wetland restoration and recreation as measures to be assessed, among other technical means, to prevent catchment degradation and the loss of environmental quality, also taking into account the concept of cost effectiveness (Section 7.2). Chapter 8 illustrates issues concerning wetland monitoring. Chapter 9 lists some conclusions and outlines issues that may be developed further.

2 IDENTIFYING WETLANDS UNDER THE WATER FRAMEWORK DIRECTIVE

2.1 What is a wetland?

Wetlands are diverse, hydrologically complex ecosystems, which tend to develop within a hydrological gradient going from terrestrial to mainly aquatic habitats.

There is a wide range of definitions and interpretations of the term ‘wetland’. These definitions tend to reflect different national traditions as well as differences in the characteristics of the environment across Europe. From an ecological perspective, wetlands are heterogeneous but distinctive ecosystems which develop naturally, or are the product of human activities. Their biogeochemical functions depend notably on a constant or periodic shallow inundation by fresh, brackish or saline water, or saturation at, or near, the surface of the substrate. They are characterised by standing or slowly moving waters. Common features include hydric soils, micro-organisms, hydrophilous and hygrophilous vegetation and fauna which has adapted to chemical and biological processes reflective of periodic or permanent flooding and/or water-logging.

Wetlands perform regularly, and to a high capacity, a range of processes that in combination result in the delivery of significant benefits for human welfare, wildlife and for the maintenance of environmental quality. Some wetlands have been recognised for their international conservation values.

The particular temporal and spatial patterns of the hydrological regime as well as other special wetland characteristics, such as distinctive plant and animal communities, ecosystems actively accumulating biomass and the provision of seasonal spawning sites for fish, combine to explain the unique features which characterise wetlands. These features bear the potential to generate benefits such as water quality improvement, hydrological regulation, food web support and preservation of important environmental and cultural values.

Wetlands are part of the hydrological continuum. They comprise parts of other surface water bodies and may significantly influence their status. When not immediately contiguous to surface waters, wetlands are often linked to these through hydrological pathways. Their common occurrence at the interface between surface waters and agro-ecosystems underlines the potential relevance of wetlands for the protection of surface waters.

Situations in which there has been artificial separation between water bodies and their adjacent wetlands, or the disruption of the wetland’s ecological health and/or hydrological regime, result in the degeneration of wetland functions.

Rather than attempting to establish a new international definition of wetlands for the purposes of the WFD, this Guidance explains their relevance to the achievement of the Directive’s environmental objectives.

2.2 Wetlands within the operational structure of the Water Framework Directive

One of the greatest contributions of the Directive in setting up a new framework for river basin management (RBM) is in the attention given to key relationships among significant elements of the hydrological network. The role of wetlands in this respect could be useful.

The recognition of these interdependencies is a major strength of the WFD as a management tool, in contrast to previous water pollution control or nature conservation Directives (see WFD CIS Guidance Document No. 5). This recognition supports the real purpose of the WFD as stated in Article 1.

Although the WFD refers to wetlands (Recitals 8 and 23, Article $1_{(a)}$ and Annex $VI_{(vii)}$) it does not define them or provide a size range to indicate their dimension. Nor does the Directive set obligations or recommendations for wetlands or other terrestrial ecosystems *per se*. However, the environmental objectives of the WFD are to be applied to, and monitored through, 'water bodies', therefore it is important for Member States to have a clear understanding of the relationship between water bodies (ground and surface) and wetlands, in order to understand how these systems might be encompassed within the cycle of river basin planning.

The WFD's environmental objectives of: (i) preventing deterioration in status; (ii) achieving good surface water status or, for artificial or heavily modified surface water bodies, good ecological potential and good surface water chemical status; (iii) good groundwater status; or (iv) any less stringent objective applicable under Article 4.5, apply exclusively to water bodies. WFD CIS Guidance Document No. 2 provides guidance on the identification of surface water and groundwater bodies and forms the starting point for the discussion and diagrams which follow.
The WFD's focus on water bodies and their relationships helps to highlight the functional role of wetland systems within the hydrological cycle and the river basin. This is reflected in the Directive by means of a complex set of provisions which are illustrated in the Figure 1 and the text in this Chapter.

Figure 1 (bubble chart) represents the different ecosystems that may be present in a river basin district and which may be relevant, in different ways, to the achievement of the Directive's objectives. The relative sizes and overlaps of the bubbles depend on the sorts of ecosystems present within each river basin district. The central bubble represents the 'universe' of wetlands. The following sections of the Guidance describe the role of these different ecosystems in the river basin management planning process.

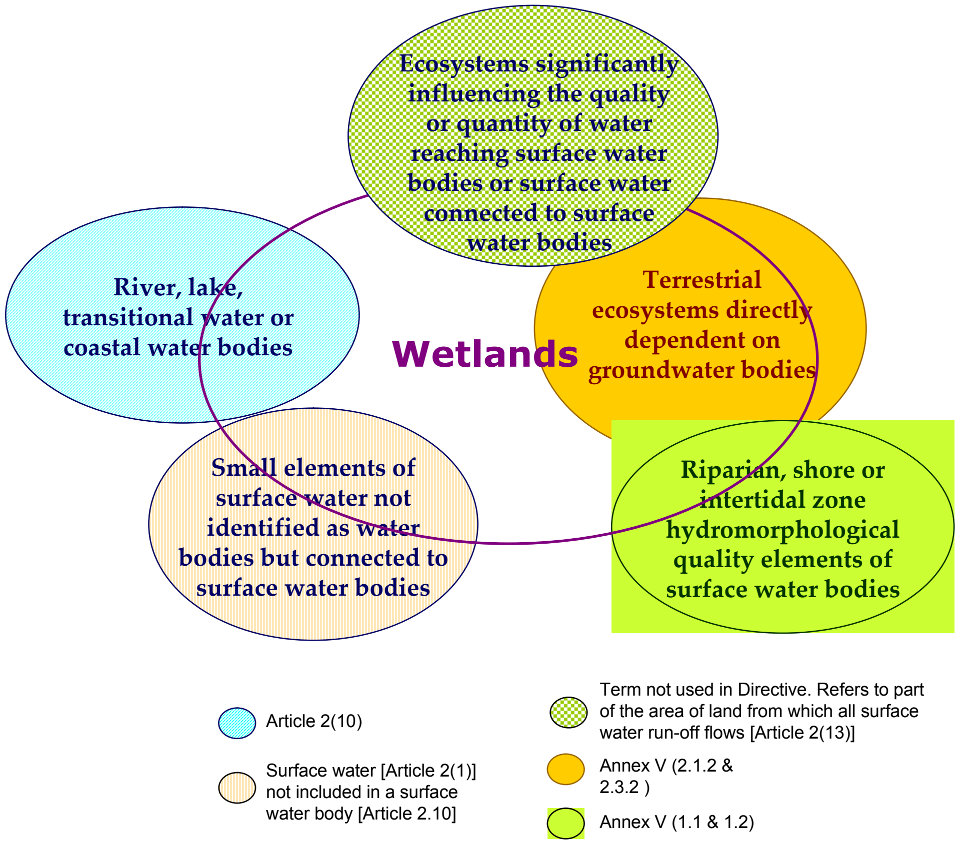


Figure 1: Ecosystems relevant to the achievement of the Directive's objectives (bubble chart)

Case Study 1. Biebrza: a floodplain at reference condition

In Europe, many formerly dynamic rivers have become highly managed, single thread channels, isolated from their floodplains. However, in an undisturbed condition, channels in lowland floodplain systems may be part of an interconnecting series of biotopes that constitute the riverine ecosystem. The river in its natural state tends to migrate across the floodplain, producing a range of lotic and lentic aquatic environments such as side channels, dead arms connected at one end, abandoned braids, ox bow lakes and ponds. This can result in a mosaic of habitat patches, ecotones and successional stages, characterised by different communities and enhanced by natural forms of disturbance.

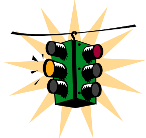
The physical modification of rivers generally prevents the formation of such complex floodplain ecosystems. For example, on the Isar floodplain in Germany, relatively unmodified areas have an abundance of short-lived ponds close to the stream system, whilst in sections more strongly influenced by water engineering, the abundance and diversity of ponds has declined due to embankments restricting the river to a single channel. New ponds cannot be created and existing ponds are isolated from the river (Homes *et al.,* 1999).

A lowland floodplain river water body in a totally undisturbed condition should be unchannelised, intact and connected, and include the full complement of seral stages. Parts of the Biebrza River in Poland illustrate these concepts. The river meanders 164 km through a large floodplain of peat fens and marshes. Although its major tributaries have been channelised for agriculture, the River Biebrza itself remains unregulated. Large meanders are divided by mineral islands and the floodplain contains a complex network of waters including oxbow lakes, backwaters and abandoned channels. In Spring, natural flooding swells the river to form a vast shallow lake up to 1 km wide. This heterogeneous wetland complex allows great species diversity – 186 species of breeding bird have been recorded including 21 threatened species and there are over 60 plant communities present including nearly all the water, marsh and peatland plant communities found in Poland. The delineation of the river water body and the understanding of the extent of the riparian zone hydromorphological quality element should reflect the dynamic nature of the river and the ecological diversity this generates.

River Biebrza, Poland (Photograph: Zbigniew Mroczkowski)

The following paragraphs describe the nature of the role of each single category of wetland typology identified in Figure 1; obligations related to each wetland type are indicated using the symbol  .

2.3 Surface water bodies (river, lake, transitional and coastal waters)



Look out! For protected areas which may be included under these water bodies, please refer to Chapter 5.

a) Wetland ecosystems identified as water bodies

Many wetland ecosystems are composed of mosaics of surface water, permanently and temporarily inundated or waterlogged land, such as lowland mire systems, or floodplain wetlands. WFD provisions in relation to surface waters will *in themselves,* help to protect and enhance wetland ecosystems, by defining parts of them as water bodies, and setting objectives for them, where they fall within the WFD categories of rivers, lakes, transitional or coastal waters.

In paragraph 3.5 and Figure 8 of the Water Bodies Guidance (WFD CIS Guidance Document No. 2), a step-wise approach is suggested to guide in the identification of small elements of surface water and their potential designation as significant and discrete water bodies. The Guidance discusses in detail the issue of 'size limits' following Annex II.1.2, introducing systems A and B for defining surface water typology. It proposes that the identification of water bodies should reflect the ecological significance of surface waters within a river basin district. It states (paragraph 3.3):

> *Member States may identify "surface water bodies" using additional criteria designated to take account of local circumstances and therefore assist in the river basin management planning process.*

Case Study 2. The UK Biodiversity Action Plan:
a resource to assist with implementation of the WFD

The UK has identified a range of species and habitats which are priorities for conservation action, and developed an 'Action Plan' to support them, as part of its contribution to the Convention on Biological Diversity.

This plan includes provisions for the identification, protection and enhancement of wetland habitats such as floodplain grasslands, and habitats supporting important wetland species such as the natterjack toad, water vole and charophyte beds. Information about the whereabouts and features of interest of such habitats is held by a variety of Government and Non-Government organisations, who together make up the 'biodiversity partnership'. Plans to bring this information together by means of a web-based 'National Biodiversity Network' are underway, and much data is already available through local and national site registers. This important resource could be used during WFD implementation, to assist in the selection of water bodies and to help identify features of interest in groundwater receptor sites.

Among such criteria there is consideration of geographical, hydromorphological and nature protection features (e.g. Natura 2000 sites) as well as of human use and of other elements consistent with the context of the Directive's purposes and objectives.

Member States may thus use existing information about the presence and value of wetland features of interest, including biodiversity and cultural significance, to help to select water bodies. We recommend that the multiple role of wetlands within river basin management be given due consideration in the definition of "water body" status.

☞ Obligations to achieve the objectives for surface water bodies specified under Article 4 and Annex 5.

b) Riparian, shore, and intertidal zone quality elements of surface water bodies

The hydromorphological quality elements of surface water bodies include the structure and condition of the riparian zone of rivers, the shore zone of lakes and the intertidal zones of transitional and coastal waters (See WFD Annex V Sections 1.1–1.4). The Water Bodies Guidance (WFD CIS Guidance Document No. 2) makes it clear that these zones may include ecosystems regarded as wetlands, where the structure and condition of such wetlands is relevant to the achievement of the objectives for a surface water body. Reference conditions should be set in accordance with Annex 2.

As stated in WFD CIS Guidance Document No. 2 (paragraph 3.6):

In concrete terms this means that, e.g., a river water body comprises:

(a) the hydromorphological quality elements, which include the water flow, the bed of the channel, that part of the land adjacent to the channel that's structure and condition is directly relevant to the achievement of the values for the biological quality elements (i.e. the riparian zone;, and

(b) the relevant biological elements.
In relation to wetlands, this means that those wetlands must be associated with a "water body", which are directly influencing the status of the related "water body". The boundaries of such wetlands must be identified in a pragmatic way in order to meet the requirement of a "discrete and significant" element.

☞ Obligation to ensure that the hydromorphological quality elements at reference condition are subject to no more than minor alterations; and

☞ Obligation to ensure that the hydromorphological elements are in the condition needed to achieve the objectives of Article 4.

Where rivers are found within naturally functioning floodplains, wetlands in the riparian zone may have important implications for the development of an appropriate reference condition.

Case Study 1 illustrates a river water body representing a relatively undisturbed hydromorphology.

2.4 Terrestrial ecosystems directly depending on groundwater bodies

The WFD's objectives of achieving good groundwater quantitative status (Annex V.2.1.2) and good groundwater chemical status (Annex V.2.3.2) require that, among other things, the groundwater needs of terrestrial ecosystems that depend directly on bodies of groundwater be protected, and where necessary restored to the extent needed to avoid or remedy significant damage to such ecosystems.

Terrestrial ecosystems that depend directly on a body of groundwater will include types of terrestrial ecosystems that occur in areas where the water table is at or near the surface of the ground.

> ☞ Obligation to achieve good groundwater status to manage quality and quantity of groundwater to avoid significant damage to terrestrial ecosystems directly dependent on groundwater bodies, in accordance with WFD Article 4, Annex 5.

2.5 Small elements of surface water connected to water bodies but not identified as water bodies

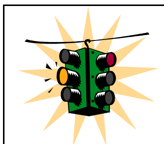
As noted in the Water Bodies Guidance (WFD CSI Guidance Document No. 2), it will not be practical to identify every element of surface water in a river basin district as a water body or part of a water body. Member States will have to decide within the river basin management planning process which elements of surface water are not sufficiently discrete and significant to be identified as water bodies. Many of the elements of surface water that are not identified will nevertheless be connected to surface water bodies. In accordance with the WFD CIS Guidance Document No. 2, such elements will need to be protected or, in some cases, enhanced and restored to the extent needed to ensure that any impacts of human activity on them do not compromise the achievement of the environmental objectives of the water bodies to which they are connected. In some cases, Member States may even choose to artificially create such surface waters where they determine that this is an appropriate or necessary means of achieving the objectives of the WFD for surface water bodies. For example, some Member States use artificially created detention ponds to help mitigate the impacts of urban run-off on river water bodies.

> ☞ Obligation to achieve objectives for connected surface water bodies.

2.6 Ecosystems significantly influencing the quality and quantity of water reaching surface water bodies, or surface waters connected to surface water bodies

Ecosystems which are adjacent to water bodies and which may influence the status of those water bodies should be encompassed within the riparian, lakeshore or intertidal zones (see Section 2.3b), in order to ensure the most effective operation of WFD environmental objectives. However, there may be other wetland ecosystems in river basins which, although they are not adjacent to water bodies and do not therefore form part of the riparian, shore or intertidal zones, may nevertheless significantly influence the quality and quantity of water reaching those bodies, or reaching small elements of surface waters connected to those bodies. Member States will need to ensure that the quality and quantity of water entering surface water bodies via these ecosystems is such as to ensure the achievement of the relevant objectives for the water bodies. In doing so, Member States may determine where appropriate, relevant actions to, protect, enhance, restore or even artificially create such ecosystems.

> ☞ Obligation to achieve objectives for surface water bodies influenced by such ecosystems.



Look out! The WFDs objectives of protecting, enhancing or restoring surface water status apply to BODIES of surface water - lakes, rivers, transitional waters, and stretches of coastal water. Its groundwater status objectives apply to BODIES of groundwater.

Figure 2 (map chart) provides a schematic summary of the different types of ecosystem within a river basin that may be relevant to the achievement of the Directive's objectives, and which may include ecosystems regarded as wetlands.

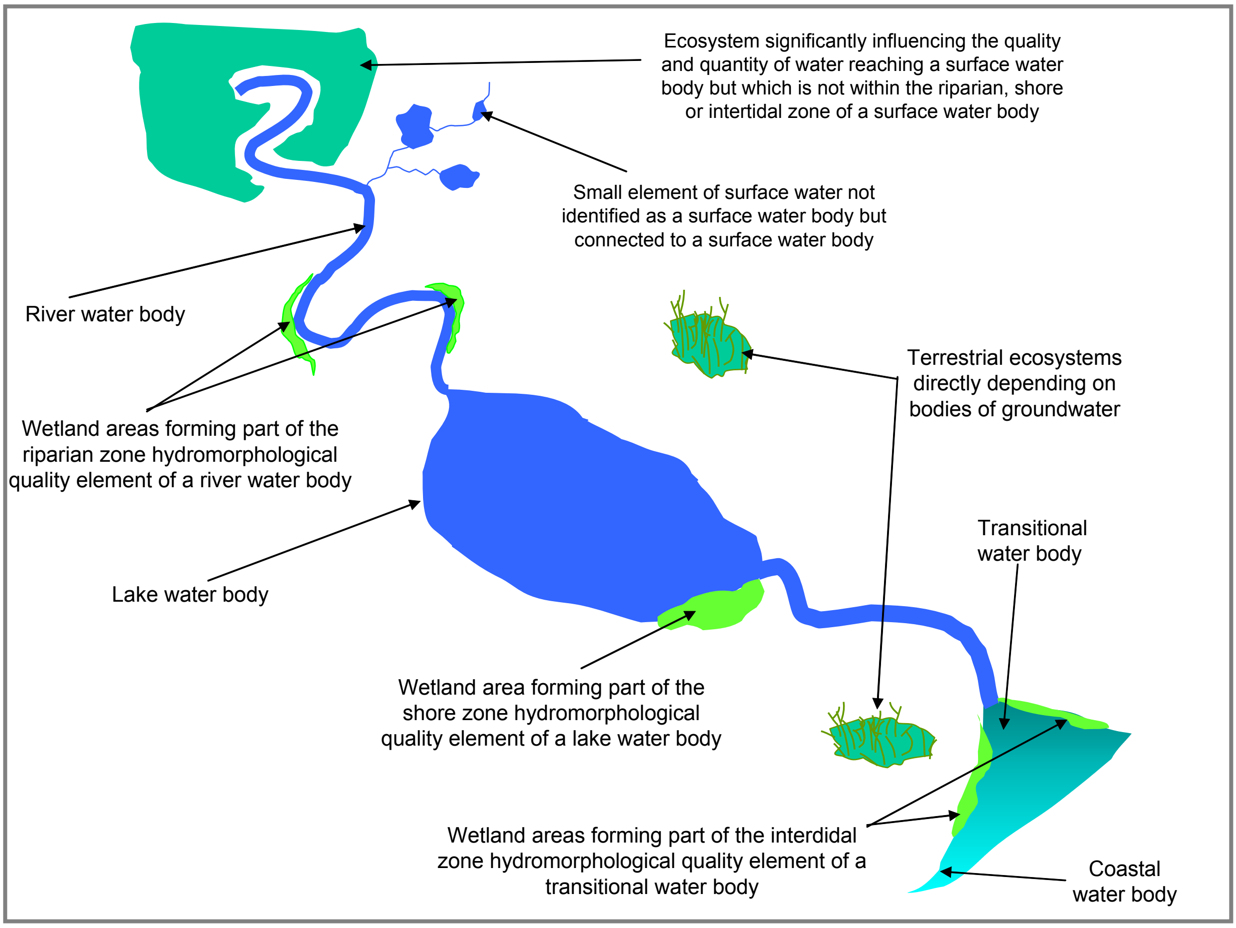


Figure 2: Ecosystems within a river basin that may be relevant to the achievement of the Directive's objectives (map chart)

3 WFD ENVIRONMENTAL OBJECTIVES AND WETLANDS

This Chapter addresses ways in which wetlands may be relevant to the achievement of surface and groundwater body objectives.

3.1 Summary of the main requirements

The WFD does not set independent ecological objectives for wetlands other than where those wetlands, or parts of them, are surface water bodies.

The WFD does however: (a) set groundwater objectives that include obligations towards these ecosystems; and (b) identify the use of wetland functions as a possible means of achieving the Directive's objectives.

The most important WFD provisions in relation to wetlands are:

- ☞ Obligations to surface waters, which will apply to those 'open water' wetlands which are identified as water bodies [Article 4.1(a)$_{(i)}$] (see Chapter 2) and belong therefore either to rivers, lakes, transitional waters or coastal waters;

- ☞ Obligations to prevent more than very minor anthropogenic disturbance to the hydro-morphological condition of surface water bodies at high ecological status (HES). The hydro-morphological quality elements of a surface water body include the structure and condition of riparian, lakeshore or inter-tidal zone, and hence the condition of any wetlands encompassed by these zones. This protection is necessary to achieve the objective of preventing deterioration from HES [Article 4.1(a)$_{(i)}$; Annex V 1.2], bearing in mind the exceptions identified at Article 4.6, 4.7 and the additional requirement in Article 4.8;

- ☞ Obligations to protect, enhance and restore wetlands identified as water bodies, where this is necessary to support the achievement of: (a) good ecological status (GES) or good ecological potential (GEP); (b) good surface water chemical status; or (c) a less stringent objective [Article 4.1(a)$_{(i\ \&\ ii)}$; Article 4.5]. If damage to any such surface water body, wherever it occurs within a river basin district, is causing a failure to achieve one of the WFDs environmental objectives, then appropriate measures will be required;

- ☞ Obligations towards wetlands that are not individual water bodies, but part of the riparian zone. Member States are required under Article 11.3(i) to establish measures to control and mitigate modifications to the structure and the condition of these zones, including that of any wetland they contain, to the extent necessary to ensure that the hydromorphological conditions of the water bodies are consistent with the required ecological status or ecological potential;

- ☞ Obligations to achieve good groundwater status [Article 4.1(b)$_{(i\ \&\ ii)}$, as defined in Annex V 2.1.2 and 2.3.2.] and to reverse any significant and sustained upward trends in the concentration of any pollutant in groundwater in order to progressively reduce pollution of groundwater [Article 4.1(b)$_{(iii)}$]. Member States must, among other things, control and remedy anthropogenic alterations to groundwater quality and water levels to the extent needed to ensure that such alterations are not causing, and will not cause: (a) significant damage to terrestrial ecosystems that directly depend on bodies of groundwater; and (b) significant diminution in the chemical or ecological quality of bodies of surface water associated with bodies of groundwater. This also includes an obligation to ensure that dependent surface waters achieve their environmental objectives under Article 4, as far as these depend on groundwater quality and quantity. Fens and marshes, that are dependent on groundwater to maintain their characteristic structure and function, may fall within the category of dependent terrestrial ecosystems; and

- ☞ Obligations, as requested specifically under the Habitats (92/43/EEC) and Wild Birds (79/409/EEC) Directives, to take protective or restorative action in the management of wetlands which are included in the register of protected areas following Annex IV(v).

Furthermore, wetlands could play a relevant role in facilitating the achievement of other WFD requirements concerning Protected Areas that do not target wetlands directly. The list below largely refers to objectives established under other Community legislation, the achievement of some of which may conceivably be assisted by the management of wetlands. These are:

- ☞ Obligations to take protective or restorative action in the management of areas designated for the abstraction of drinking water and areas relevant for the protection of economically significant aquatic species (WFD Annex $IV_{(i \& ii)}$);

- ☞ Obligations to take protective or restorative action in the management of recreational water bodies under the Bathing Water Directive (76/160/EEC) (WFD Annex $IV_{(iii)}$); and

- ☞ Obligations to take protective or restorative action in the management of sensitive areas and vulnerable zones designated under the Nitrate Directive (91/676/EEC) and the Urban Wastewater Directive (91/271/EEC) (WFD Annex $IV_{(iv)}$).

Please refer to Chapter 5 for further details concerning obligations established under the Protected Areas Register.

3.2 Surface waters objectives and wetlands

The description of wetlands adopted for the purposes of this Guidance includes areas of surface water. The WFDs status objectives [Article $4.1a_{(i)}$, $_{(ii)}$ and $_{(iii)}$] apply to surface waters identified as a "water body". In the WFD (2.1) "surface water" is defined as:

> *Inland waters, except groundwater, transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters;*

and "body of surface water" (Article 2.10) is :

> *A discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.*

Chapter 2 discussed in detail the ways in which some wetland systems may be encompassed within the definition of surface water bodies, either as lakes, rivers, coastal or transitional waters in themselves, or as part of the riparian, lakeshore or inter-tidal zones of such water bodies. This section of the Guidance will explore in more detail the implications of achieving the relevant environmental objectives for such water bodies.

3.2.1 Biological quality elements for surface water bodies

River Basin Districts (RBDs) typically include complex mosaics of surface waters, temporarily inundated and terrestrial habitats. The Water Bodies Guidance (WFD CIS Guidance Document No.2) provides a pragmatic approach to determine the area of surface water which constitutes the water body *per se* and parts of 'wetland' ecosystems that may be identified as, or form parts of, water bodies.

The following paragraphs provide a guideline for identifying the area of adjacent land which is included when assessing water bodies' *biological quality elements* described in Annex V, and the relationship between these and water bodies' *hydro-morphological quality elements.*

Case Study 3. The Great Ouse: effects of river regulation on fish species composition in an English lowland river

Continued and extensive regulation of lowland rivers such as the Great Ouse has caused considerable changes in fish populations. The Great Ouse is strongly regulated by weirs, dredging, flood embankments and navigation locks, and is largely disconnected from its floodplain. Since there are no lowland rivers in the UK that can be considered to be at reference condition, the Great Ouse has been compared to the unregulated River Biebrza in Eastern Poland, which had similar characteristics to the Great Ouse prior to its regulation.

On the Ouse, generalist species (roach and minnow) dominated the system and often made up more than 70% of the fish population. Gudgeon, three spine stickleback, chub, bullhead and silver bream occasionally co-dominated. When compared to the relatively unmodified River Biebrza, the Great Ouse has a poor recruitment of specialist fish - both limnophilic (slow-flowing and standing water specialists) and rheophilic (characteristic of faster flowing water). In the River Biebrza limnophilic species such as silver bream, tench and rudd were found throughout the length of the river, principally in adjacent oxbows and abandoned side channels. The Ouse has few connected floodplain waters and therefore reproduction of limnophilic species is restricted to downstream sites. The absence of the rheophile burbot was notable, as it is a common species of unregulated lowland rivers and their floodplain waters, and historical records indicate that it was common in the Great Ouse prior to modification. The general absence of salmonids also suggests that modification has lead to the severe reduction of more sensitive rheophilic fish and a dominance of generalist species.

Copp G.H. (1990) Effect of regulation on fish recruitment in the Great Ouse, a lowland river. Regulated Rivers: Research and Management ***5:****251-263.*

3.2.1.1 Rivers

Depending on river morphology, riverine systems may be characterised at reference condition (and therefore at High Status) by complex and dynamic patterns of channels, oxbow lakes and temporary surface waters. In such cases, it may not be appropriate to assess biological quality elements from single parts of the river environment without consideration of the condition of other parts (for example, by treating 'main channels' as separate from backwaters, side arms and oxbows).

Large channels vary in their course over time, and biological quality elements can depend on the presence of a range of habitats within the river and floodplain ecosystem to sustain their life-cycles and abundance. In these contexts, the river water body, and its biological reference condition, should reflect this dynamism and ecological integrity.

The following biological quality elements are required for the assessment of the ecological status of rivers (Table 1):

Table 1. Biological quality elements relevant in the assessment of the ecological status of rivers (WFD Annex V)

Biota	Characteristics				
Phytoplankton	Taxonomic composition	Abundance			
Macrophytes and phytobenthos	Taxonomic composition	Abundance			
Macro-invertebrates	Taxonomic composition		Proportion of disturbance sensitive to insensitive taxa	Level of diversity	
Fish	Species composition	Abundance	Presence of disturbance sensitive taxa		Age structure of communities

The following case studies demonstrate the interaction between relevant biological quality elements and the condition and delineation of the floodplain river water body.

Case Study 4. The importance of flood disturbance for maintenance of macrophyte communities

A natural alluvial floodplain contains areas of water created as the channel moves across the floodplain which are variously disturbed by flooding. Flood disturbance has a positive role in the maintenance of Charophyte species diversity in cut-off channels. Charophytes are usually considered pioneer species occurring in disturbed habitats supplied with groundwater. They occur abundantly in large river floodplains influenced by floods. Data collected from 63 cut off channels on the Doubs, Saône, Ain and Rhône rivers showed that *Chara vulgaris* and *Nitella conferuacea* were more frequent in and even limited to channels with high flood disturbance. In contrast, *C. major* and *C. globularis* occurred in channels with little or no flood disturbance indicating that some species can survive under low disturbance conditions. In order to maintain optimal species diversity a range of ages of cut off channels are required, containing different successional stages of vegetation. If rivers are channelised and cut off from side channels the early successional stages and therefore pioneer species will be lost as all channels gradually reach climax vegetation.

*Bornette, G. and Arens, M. (2002) Charophyte communities in cut-off river channels – the role of connectivity. Aquatic Botany **73:**149-162.*

Lowland floodplains historically suffered radical physical modification in many parts of Europe, as a result of land drainage and flood management activities, aimed at maximizing agricultural production and protecting people and property. In many cases, decisions about how practical or desirable it will be to restore the hydro-morphology (and the associated biology) of such river systems to the extent needed to achieve good ecological status, will be determined through the application of the tests for the heavily modified water body (HMWB) designation (see Chapter 4). However, the principle of the WFD in relation to the development of a type-specific reference condition for natural waters is clear. The reference condition for such systems should reflect no (or only very minor) anthropogenic impacts on the biological quality elements, whilst good status should represent an acceptable, but slight deviation from this condition. The reference condition for heavily modified or artificial water bodies is maximum ecological potential (MEP).

For some floodplain river types, the reference condition values for the biological quality elements may be strongly dependent on the range of surface water and adjacent riparian zone habitats that would be present under totally, or nearly totally, undisturbed conditions. Such dependency should be taken into account when defining the good status values for the biological quality elements and identifying the hydromorphological conditions consistent with the achievement of those values.

In the uplands, river channels are often clearly distinguishable even at reference condition; the identification of the water body, and its associated riparian zone, (the land adjacent to the channel whose condition directly influences its ecology), is less complex. However, the requirement to ensure that this riparian zone, including any relevant wetlands, are in a physical condition capable of supporting the biological elements found in the water body at good status, will remain. This is discussed in more detail in Section 3.2.3, which describes the role of hydro-morphological elements at reference condition, and as supporting elements for the biological quality elements at good status.

3.2.1.2 Lakes

Lakes with substantial, shallow littoral zones (which might in many cases be defined as 'wetlands'), including areas of seasonal inundation, derive much of their ecological character from their characteristic littoral communities. This should be reflected in the development of an appropriate biological reference condition for the relevant biological quality elements.

The following biological quality elements are required for the assessment of the ecological status of lakes (Table 2):

Table 2. Biological quality elements relevant in the assessment of the ecological status of lakes (Annex V)

Biota	Characteristics			
Phytoplankton	Taxonomic composition	Biomass		
Macrophytes and phytobenthos	Taxonomic composition	Abundance		
Benthic invertebrate fauna	Taxonomic composition	Ratio of disturbance sensitive to insensitive species	Level of diversity	
Fish	Species composition	Abundance	Presence of type-specific sensitive species	Age structures

Case Study 5 illustrates the relevance of seasonal inundation in water bodies with naturally fluctuating water levels, and demonstrates how in such contexts the biological quality elements will encompass taxa and communities associated with 'wetland' and semi-terrestrial habitats.

Case Study 5. Turloughs and Breckland Meres: Lakes with high levels of natural fluctuation in water level and associated biological diversity

Naturally fluctuating water levels in these lakes result in characteristic plant and animal communities that may appear almost or wholly terrestrial at certain times of the year. In the UK, a habitat action plan exists for these lakes which describes their typical fauna and flora.

As a result of the fluctuating water levels, aquatic vegetation is absent (or, in Northern Ireland, restricted to residual pools) at some periods in the cycle of these lakes and abundant at others. An element common to both turloughs and meres is the prevalence of aquatic and semi-aquatic mosses such as *Fontinalis antipyretica* and *Cinclidotus fontinaloides*, which are more resistant to desiccation than higher (vascular) aquatic plants. Rare plants of the inundation zone include the moss *Physcomitrium erystomum* in the meres and the rare fen violet *Viola persicifolia* in the turloughs of Northern Ireland. Although some permanent pools in the Northern Irish turloughs support white water lily *Nymphaea alba* and other water plants, in the Breckland meres, where deep flooding can occur for long periods, aquatic vegetation becomes better established and more diverse than in most turloughs. Water plants typical of the meres are shining pondweed *Potamogeton lucens* and various-leaved pondweed *Potamogeton gramineus*, sometimes accompanied by their hybrid, long-leaved pondweed *Potamogeton x zizii*, which is scarce nationally.

The aquatic fauna of these fluctuating water bodies is adapted to intermittent desiccation. Fish are generally absent, but a range of amphibians can be found, including the protected great crested newt *Triturus cristatus* in the Breckland. Invertebrates include many insect species such as dragonflies, water boatmen and diving beetles, which are highly mobile and are therefore able colonisers. Typically, there is also a rich assemblage of micro-crustaceans such as water fleas, which have resting stages that can remain viable in the soil during dry phases. Snails such as the marsh snail *Lymnaea palustris*, which breathe air and can persist during periods of drought under stones and in damp vegetation, are common in both turloughs and meres. Numerous rare invertebrates have been recorded, including the large mussel-shrimp (ostracod) *Cypris bispinosa*, the small diving beetle *Bidessus unistriatus* and the scarce emerald damselfly *Lestes dryas* from the Breckland meres. During their wet phase the meres support breeding coot *Fulica atra*, tufted duck *Aythya fuligula*, mallard *Anas platyrhynchos*, shelduck *Tadorna tadorna*, pochard *Aythya ferina* and gadwall *Anas strepera*.

UK Habitat Action Plan for Naturally Fluctuating Aquifer Fed Water Bodies, UK Biodiversity Group Tranche 2 Action Plans - Volume II: Terrestrial and freshwater habitats HMSO (December, 1998) Tranche: 2, Volume: II, 25 pages.

3.2.1.3 Coastal and Transitional Waters

As with rivers and lakes, there will be contexts in which the biological quality elements of coastal and transitional water bodies encompass taxa and communities traditionally associated with ‘wetlands’; this is well illustrated by the importance of wetland vegetation in assessing the environmental quality of the Solway and Forth estuaries (Case Study 6).

Case Study 6. The Solway and Forth estuaries: significance of vegetation in assessing the biological quality of saltmarshes

1 The transitional nature of a saltmarsh leads to a zonation of vegetation from pioneer species that require frequent inundation to those that are more terrestrial in character, growing up the shore. Saltmarsh vegetation naturally traps sediment, slows water movement and encourages sediment deposition raising the level of the marsh which allows successional change and gradual terrestrialisation of the habitat. Within the pioneer, upper and lower marsh zones, 28 communities of saltmarsh vegetation have been described throughout the UK, each of them providing a unique habitat for invertebrates and fish and bird fauna.

2
The Solway and Forth estuaries are saltmarshes of international importance, harbouring large winter bird populations (Solway 120 000 birds, Forth 20 000 birds) and include mudflats and sandflats providing nursery and feeding areas for many fish species. At the Solway estuary the land abutting the saltmarshes is lowland grazing marsh, which allows controlled winter flooding and the majority of the coastline is unembanked. The transition from saltwater to freshwater habitats is wide and complete. Vegetation is present from *Puccinellia* pioneer communities through four distinct lower and mid marsh zones to terrestrial transition zones of mature upper marsh dominated by *Phragmites*.

In contrast, the area adjacent to the Forth estuary has high human population density. Land use includes agriculture and industry and much mudflat and saltmarsh has been reclaimed. Bird numbers have been reduced due to loss of invertebrate food, net loss of mudflats and saltmarshes. Vegetation surveys showed that 52% of the vegetation belongs to the *Puccinellia* community. A further 20% of vegetation belongs to the *Festuca rubra* community which tends to occur above the *Puccinellia* community. Vegetation of the upper marsh or later successional stages is missing due to the fact that most of the marsh is a thin 5-80 m strip backed by a sea wall which prevents the natural sequence moving up the shore. The community is extremely poor in species and community richness, reflecting the high level of disturbance resulting from land claim activities.

GeoData Institute (2002). Inner Solway. Potential for managed realignment. Report by GeoData Institute to Scottish Natural Heritage.

Section 2.1.5 of the WFD CIS Guidance Document No. 5 (COAST) recognizes that:

> *The Directive gives no indication of the landward extent of either transitional or coastal waters. One of the hydromorphological quality elements for both transitional and coastal waters is the structure of the intertidal zone. Since it is likely that some of the quality elements may be monitored within the intertidal area, it is recommended that transitional and coastal water bodies include the intertidal area from the highest to the lowest astronomical tide.*

In particular, this is relevant to the monitoring of inter-tidal vegetation, whose composition and abundance are relevant to the assessment of ecological status as shown in the case study above which demonstrates how the condition and extent of intertidal mudflats (a ‘coastal wetland’) bears a direct influence on the biological quality elements measured in the WFD.

The biological quality elements illustrated in Table 3 are required for the assessment of status for coastal and transitional water bodies.

Table 3. Biological quality elements relevant in the assessment of the ecological status of coastal and transitional waters (WFD Annex V)

Biota	Characteristic				
Phytoplankton	Taxonomic composition	Abundance	Biomass		
Macro-algae	Taxonomic composition (transitional)			Cover	Disturbance sensitive taxa (coastal)
Angiosperms	Taxonomic composition (transitional)	Abundance			Disturbance sensitive taxa (coastal)
Benthic invertebrate fauna	Diversity	Abundance			Ratio: disturbance sensitive to insensitive taxa
Fish (not coastal)	Species composition	Abundance			

3.2.2 Physico-chemical quality elements for surface water bodies

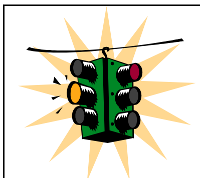
The general physico-chemical elements of ecological status for surface water bodies, such as thermal conditions, salinity, nutrient condition and acidification status (WFD Annex V 1.1.1), may be affected by the condition of wetlands within the riparian, lakeshore or inter-tidal zones, or in the wider catchment. These potential impacts will need to be considered during the impacts and pressures analysis and subsequently in the design of programmes of measures to achieve the Directive's environmental objectives.
For example, nutrient levels and cycling in a lowland river with intact riparian wetlands may be significantly different to those in a river channel adjacent to drained land under intensive agricultural production.

In order to restore nitrogen and phosphorous fluxes to levels capable of supporting the functioning of the type-specific ecosystem, one option may be to consider the role which wetland restoration or enhancement could play as part of a programme of measures (see Chapter 7).

3.2.3 Hydro-morphological quality elements for surface water bodies

The quality elements comprised in the assessment of surface water status include hydro-morphological elements *supporting biological ones* (WFD Annex V,1.1.2.). Hydro-morphological quality elements include the structure and condition of the riparian zone of rivers, the shore zone of lakes and the inter-tidal zones of coastal and transitional waters; many of these include wetlands.

The definitions proposed here are compatible with, and form an elaboration of, similar definitions proposed in the Water Bodies Guidance (WFD CIS Guidance Document No.2). The Water Bodies Guidance Document makes it clear that the water body itself '*comprises the quality elements described in the Directive for the classification of ecological status*', which includes the structure and condition of the riparian, lakeshore or inter-tidal zone.



Look out! For some water bodies, the structure and condition of wetlands in the riparian, shore or intertidal zones will be important for supporting the achievement of the good status values for the biological quality elements.

The WFDs inclusion of hydro-morphological elements is designed to encompass the interactions between physical conditions in the catchment, hydrological processes and the biological condition of surface waters. In developing definitions of the riparian, lake-shore and inter-tidal zones, therefore, it is appropriate to consider first and foremost how adjacent land and ecosystems (including wetlands) help to determine the physical, chemical and biological characteristics of water bodies, rather than to rely on definitions based on size thresholds or return flood events. The definitions given here are designed to ensure that the land defined as riparian, shore or inter-tidal zone directly influences other quality elements within the WFD.

There is no requirement to map the boundaries of riparian and shore zones (nor the location of any other quality elements), however the significance of their influence on the status of water bodies should be given due consideration by Member States when assessing risks to the achievement of the WFDs environmental objectives for surface water bodies, and designing programmes of measures.

The level of effort required in determining the extent of the riparian and the shore zones should be proportional to the potential risks to the WFDs objectives caused by pressures, which may alter the structure and condition of those zones.

Riparian zone: Land immediately adjacent to a river, the structure and condition of which significantly influences the river's other hydro-morphological quality elements, biological quality elements and physico-chemical quality elements, and which may in turn be influenced by the river. The zone will include relevant parts of islands and floodplains. It may include a variety of wetland habitats that rely on over-bank flows for their maintenance, but which in turn influence the conditions in the river. The extent of the riparian zone will be variable depending on the significance of its influence on the biological quality elements relevant to the classification of ecological status. Rivers flowing through gorges may depend on only a very narrow riparian zone, whereas rivers in delta areas may be directly dependent on the structure and condition of a more extensive area of land.

Shore zone: That part of the land immediately adjacent to a lake, the structure and condition of which significantly influences the values attained by other hydro-morphological quality elements, the biological quality elements or the physico-chemical quality elements, and which may in turn be influenced by lake flooding or wave action.

The level of effort required to determine the extent of the riparian and the shore zones should be proportional to the potential risks to the WFDs objectives from pressures which may alter the structure and condition of those zones.

Intertidal zone: The zone between mean high water spring tides and mean low water spring tides. The zone typically includes a variety of terrestrial and aquatic ecosystems such as salt, brackish and freshwater tidal marshes, mud flats, rock pools, beaches etc. (see Section 3.4). Table 4 illustrates the Hydro-morphological quality elements of surface waters (Annex V.1.2).

Table 4. Hydro-morphological quality elements of surface waters

Rivers	Lakes	Transitional Waters	Coastal Waters
Hydrological regime (flow and connection to groundwater)	Hydrological regime (flow, level, residence time, connection to groundwater)	Tidal regime (freshwater flow)	Tidal regime (freshwater flow, dominant currents)
River continuity			
Morphological Conditions (Channel patterns, width and depth variations, flow velocities, substrate conditions, structure and condition of riparian zone)	Morphological Conditions (depth variation, substrate, structure and condition of lake shore zone)	Morphological Conditions (depth variation, substrate conditions, structure and condition of inter-tidal zone)	Morphological Conditions (depth variation, substrate conditions, structure and condition of inter-tidal zone)

3.2.4 Categories of environmental quality

a) Objectives for water bodies at HES or MEP

The provisions of the WFD for water bodies at HES and MEP differ from those for other water bodies. HES water bodies must demonstrate, for their hydro-morphology, the conditions reported in Table 5.

For the purposes of classification, the definitions of ecological status set out in Annex V (1.2.1-1.2.4) describe the values for the quality elements of ecological status for each surface water category. Where a water body is at HES, the relevant values specified for the biological, hydromorphological, and physico-chemical quality elements in these tables must be maintained to achieve the WFDs objective of preventing deterioration in status.

To prevent a water body deteriorating from HES, Member States must prevent any more than minor alterations to the water body's hydromorphological conditions, since the values of the biological quality elements on the boundary of the high good status class are defined in WFD Annex V as those that are compatible with only very minor alterations to the hydromorphological quality elements. The hydromorphological conditions include the structure and condition of the riparian, shore or inter-tidal zones. These provisions have important implications for wetlands. For a river, lake, transitional or coastal water to be at HES, adjacent land, which significantly influences its ecology (the riparian, lake or inter-tidal zone) must show no or only very minor disturbance. This may in turn, provide the conditions necessary for the development and maintenance of wetland ecosystems. In practice, this means that the WFD will help provide protection for our remaining 'natural' wetland ecosystems, where these are riparian zones, lake shores or intertidal zones of high status water bodies.

Table 5. Definitions of hydro-morphological quality elements at HES (Annex V.1.2)

Rivers	Hydrological Regime	River Continuity	Morphological Conditions
	The quantity and dynamics of flow, and the resultant connection to groundwater, reflect totally, or nearly totally, undisturbed conditions.	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions
Lakes	Hydrological Regime		Morphological Conditions
	The quantity and dynamics of flow, level, residence time, and the resultant connection to groundwater, reflect totally or nearly totally undisturbed conditions.		Lake depth variation, quantity and structure of the lake shore zone correspond totally or nearly totally to undisturbed conditions.
Transitional	Tidal Regime		Morphological Conditions
	The freshwater flow regime corresponds totally or nearly totally to undisturbed conditions		Depth variations, substrate conditions, and both the structure and condition of the inter-tidal zones correspond totally or nearly totally to undisturbed conditions.
Coastal	Tidal Regime		Morphological Conditions
	The freshwater flow regime and the direction and speed of dominant currents correspond totally or nearly totally to undisturbed conditions		The depth variation, structure and substrate of the coastal bed, and both the structure and condition of the inter-tidal zones correspond totally or nearly totally to the undisturbed conditions.

Concerning HMWBs at MEP, the condition of the hydro-morphological quality elements must be consistent with the only impacts on the surface water body being those which result from the artificial or heavily modified characteristics of the water body, once all the mitigation measures have been taken to ensure the best approximation to ecological continuum.

b) Objectives for water bodies at good status and below

At GES, (or for any less stringent objective) the hydro-morphological elements of a water body must be in a condition to support the values established for relevant biological quality elements (see also Art.11.3$_{(i)}$).

In reality, GES is unlikely to be achieved where there are substantial changes to the flow and velocity of a river, the depth and residence time of a lake, or the tidal patterns of an estuary; changes of the kind which frequently result from damage to wetlands within the riparian, lake or inter-tidal zones. The mutual dependence of water bodies and associated wetlands should be included within the impact/pressure analysis when relevant as recognised by the WFD CIS Guidance Document No. 3 (IMPRESS) Guidance (Section 2.3.7):

> *"Pressures on wetlands (for example physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive."*

Where pressures on the floodplain have resulted in an impact on the status of a river, for example, the restoration of the floodplain to a more natural condition may be an effective remedy. In some cases, such restoration may form part of a combination of measures to achieve the WFDs objectives unless economic tests demonstrate that it is not a practical or appropriate option (WFD Art. $4.5_{(a)}$ and Annex III).

In all cases wetland management can be proposed as a supplementary measure at the discretion of Member States to assist in achieving RBM objectives (see Chapter 7).

3.3 Wetlands and groundwater

Although not all groundwater is within an aquifer, the WFDs environmental objectives for good groundwater status apply *only* to groundwater bodies identified within aquifers.

Specifically, WFD Article 2.2 defines 'groundwater' as:

> *all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil*;

and 'body of groundwater' is given (Article 2.12) as:

> *a distinct volume of groundwater within an aquifer or aquifers.*

The first step in identifying groundwater bodies is to determine which geological strata qualify as aquifers. Following the definitions cited above and the requirements set by WFD Article 7 and Article 1(a), Section 4.2 of the Water Bodies Guidance (WFD CIS Guidance Document No. 2) recommends (see Figure 3 below) that an aquifer is a subsurface layer or layers of rocks or other geological strata that:

- *Is capable of supporting abstraction of 10 cubic meters per day on average or sufficient to serve 50 or more people;*

or:

- *Provides a flow of groundwater the reduction of which may result in a significant diminution of the ecological quality of an associated surface water body, or significant damage to a directly dependent terrestrial ecosystem.*

The identification of aquifers is therefore partly dependent on determining whether groundwater supports directly dependent terrestrial ecosystems. Where such ecosystems are supported by groundwater, the groundwater upon which they depend will qualify as an aquifer.

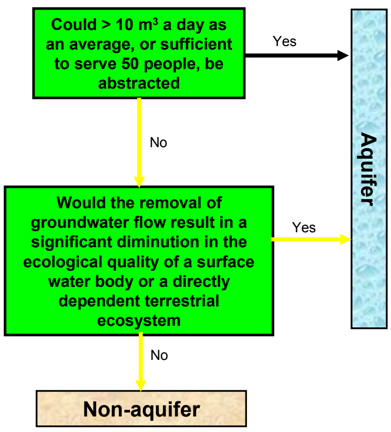


Figure 3: Illustration of the process for determining whether a geological stratum qualifies as an aquifer reproduced from the WFD CIS Horizontal Guidance No. 2 (Water Bodies)

Figure 4 outlines a suggested approach to determining which terrestrial ecosystems to consider in deciding if a geological strata provides significant flow to directly dependent terrestrial ecosystems, and should therefore qualify as an aquifer.

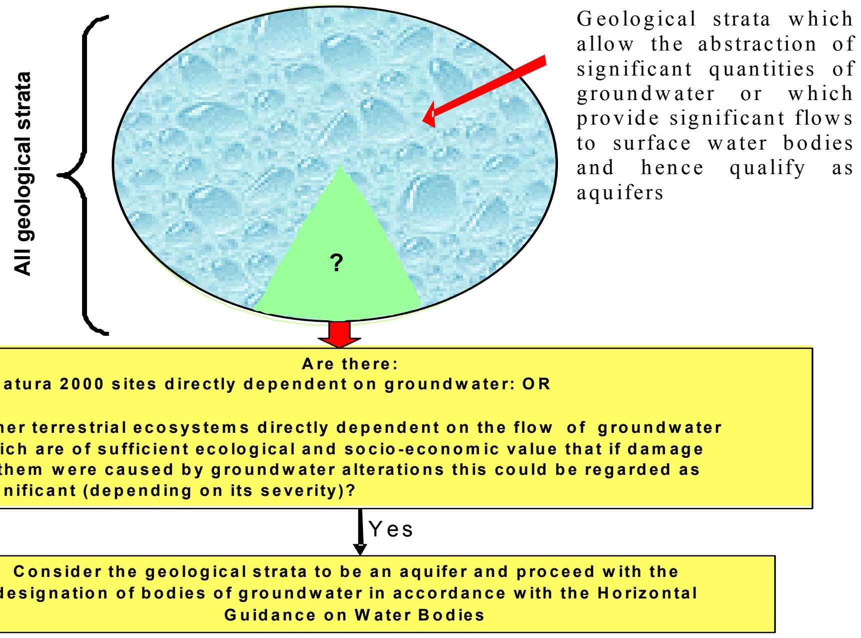


Figure 4: Suggested approach to deciding if a geological stratum qualifies as an aquifer on the basis of the significance of groundwater flow to directly dependent terrestrial ecosystems

The achievement of good groundwater status will require that the groundwater needs of directly dependent terrestrial ecosystems are protected, and where necessary restored to the extent needed to avoid or remedy significant damage to such ecosystems. It will also require that the groundwater needs of surface water bodies are protected and where necessary restored to: (a) ensure the achievement of relevant WFD objectives for surface water bodies; and (b) avoid significant diminution in the ecological or chemical quality of such bodies.

For groundwater quantitative status [Annex V.2.1.2], the WFD requires that:

> *'the level of groundwater is not subject to anthropogenic alterations such as would result in…….*
> *any significant damage to terrestrial ecosystems which depend directly on the groundwater body.'*

For groundwater chemical status [Annex V.2.3.2], good status requires that the concentrations of pollutants:

> *'are not such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.'*

These provisions protect dependent terrestrial ecosystems from significant adverse impacts resulting from a reduction in the water table or from groundwater pollution. However, they are not designed to protect terrestrial ecosystems directly dependent on bodies of groundwater from other sources of damage, for example: drainage.

Figure 5 illustrates the general approach, within the river basin management planning process, to considering risks of significant damage to terrestrial ecosystems directly dependent on groundwater as a result of anthropogenic alterations to groundwater quality or levels.

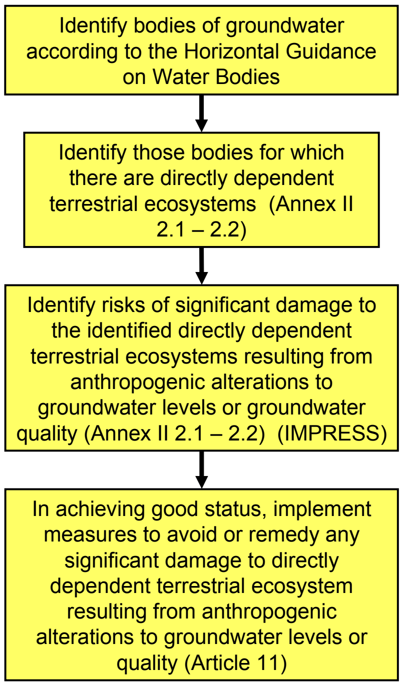


Figure 5: General approach to protecting and restoring the groundwater needs of terrestrial ecosystems directly dependent on groundwater bodies

There are potentially very large numbers of terrestrial ecosystems that are directly dependent on groundwater within the Community. Whilst many support features of value (ecological or socio-economic), a screening tool will be essential to focus action on the most important sites and areas, so that Member States do not face an impossible administrative burden. Member States may use their own, nationally developed criteria for identifying those dependent terrestrial systems which they believe are of sufficient importance that damage to them, as a result of anthropogenic groundwater alterations, could legitimately be described as 'significant'.

The WFD is concerned with significant damage indicating that its intent is to provide a mechanism by which Member States can protect the water needs of wetlands already protected at Community level as part of the Natura 2000 network, and the groundwater needs of other important terrestrial and wetland resources if significantly affected by anthropogenic groundwater alterations. To enable Member States to use their management resources to achieve the greatest benefits for wetland protection and improvement, the practical approach outlined in Figure 6 is recommended.

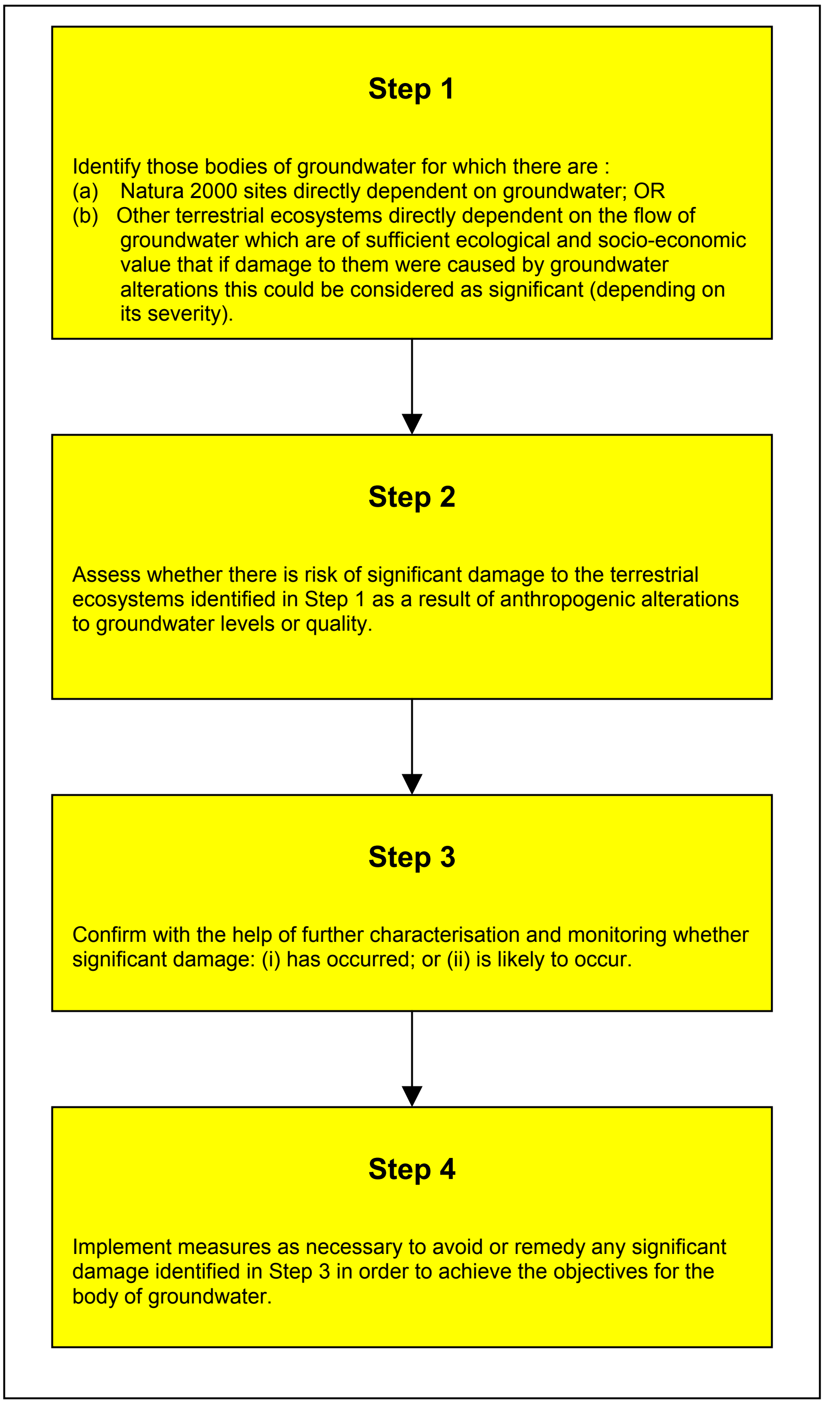


Figure 6: Outline practical approach to identifying terrestrial ecosystems which could be significantly damaged by alterations to groundwater level or quality

An example of how this approach is being implemented in the United Kingdom is illustrated in Figure 7. Because of the limited time available for the 2004 pressures and impacts analysis, work will focus on identifying risks of damage to the most important terrestrial ecosystems in conservation terms. After 2004, other directly dependent terrestrial ecosystems of conservation importance will be considered.

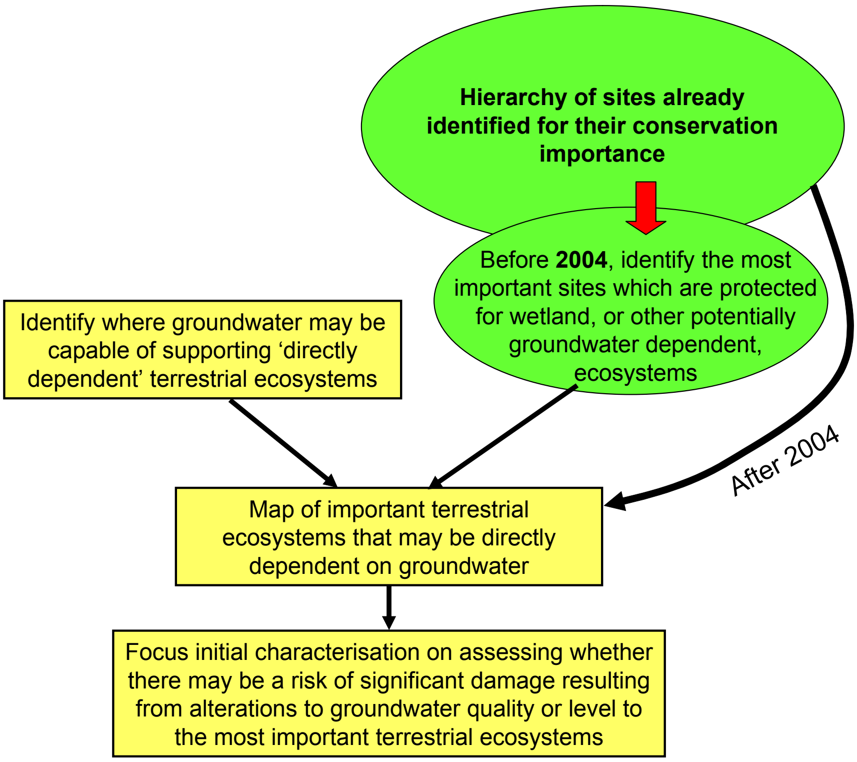
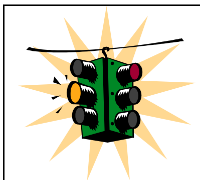


Figure 7: Outline of phased approach being developed in the UK

3.3.1 What is significant damage and how should it be measured?

The environmental objectives for groundwater bodies require the protection of dependent terrestrial ecosystems from *significant damage*. However, the WFD does not provide a definition of the term 'significant'. The term '*significant damage'*, should be interpreted primarily with respect to the ecological quality of terrestrial ecosystems that depends on the inter-linkage with groundwater. Beside this, other factors should be taken into account. Existing data held by Member States about the ecological and socio-economic significance of dependent systems could be used to form the basis of a 'significance test' in this context. For example, where a wetland is of conservation importance, impairment of its conservation objectives as a result of alterations to groundwater could be regarded as constituting significant damage. In such a situation Member States may need to assess the risk of incurring into significant damage by relating it to the water needs of critical species and habitats and may determine a boundary of tolerable alteration of groundwater levels defined specifically for each type of ecosystem.



Look out! Wetlands linked to unsaturated strata or karstic systems, may play a crucial role in protecting the saturated zone from pollution. In these cases Member States may need to design specific conservation measures for these ecosystems.

3.4 Wetlands in relation to transitional and coastal waters

Most brackish wetlands fall under the definition of transitional waters given in Article 2.6 of the WFD:

> *Transitional waters are bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows.*

The WFD CIS Guidance No. 5 (COAST) recommends that surface waters in the vicinity of river mouths that are ecologically significant in the river basin district be identified as transitional water bodies. The WFD gives no indication of the minimum size of transitional waters to be identified as separate water bodies. The expression '*discrete and significant elements of surface water'*, which is used to help identify significant water bodies (Article 2.10), can be interpreted in terms of the risk of failing to meet good ecological status following assessment by Member States.

Operational needs for the achievement of the main environmental objectives dictate whether a given transitional water should be identified as a discrete surface water body or not. The intertidal area, defined as the discrete area between the highest and the lowest astronomical tides, should be included among water bodies as recommended by Section 2.7.3 of the WFD CIS Guidance No. 5 .

In a similar way, coastal lagoons are defined in respect to the function within the river basin. They fall within transitional waters when they are found *'in the vicinity of river mouths'* and *'substantially influenced by freshwater flows'* (WFD Article 2.6). In other cases, lagoons can be identified as lakes if larger than 0.5 km^2. As suggested in the WFD CIS Guidance No. 5, lagoons smaller than 0.5 km^2 can be included by Member States in the water body definition if they are significant elements of surface water in the context of the purposes of the WFD.

Case Study 7. Groundwater and wetland interactions on a UK floodplain

The River Idle washlands comprise four isolated floodplains covering 84 ha of low lying land in Nottinghamshire and South Yorkshire (UK). The washlands have been designated as a Site of Special Scientific Interest (SSSI) for the wet grassland communities and waterfowl they support.

The River Idle has been subject to modification since the 19th century culminating in the *"River Idle Improvement Scheme"* that saw the construction of flood defence banks and a pumping station which allows drainage to the River Trent during periods of flood and/or high tides when, historically, hundreds of ha of land would have been flooded.

As a result of these modifications the washlands that survive today represent a tiny fragment of the historic wetland landscape and there has been a long-standing concern that even these are subject to drying and degradation.

Initial suspicion fell on the operating regime of pumping station which was thought to be drawing water levels down so quickly after storm events that the period and depth of inundation was insufficient to maintain the shallow water-table depth.

A series of shallow groundwater monitoring boreholes were installed to verify this hypothesis and develop control rules for the pumping station that would restore and maintain the wetland interest. However, the data that was gathered suggests that the shallow water table drops rapidly after flooding to levels below that of the river. This indicates that the fundamental control on the shallow water table in the washlands is the regional aquifer and not the level at which the river is maintained.

While the exact nature of the interaction between river, aquifer and washland is still being investigated, these findings have serious implications for the long-term management of the underlying aquifer, which is heavily exploited for public water supply and has water levels lying below sea level.

4 THE RELATIONSHIP BETWEEN WETLAND SYSTEMS AND HEAVILY MODIFIED WATER BODIES

4.1 Heavily Modified Water Bodies and Wetlands

The HMWBs category of the WFD is the subject of WFD CIS Guidance Document , the principles of which underpin the following discussion (WFD CIS Guidance Document No. 4 on the Identification and Designation of Heavily Modified and Artificial Water Bodies):

> *'Heavily Modified Water Bodies are ones which as a result of physical alterations by human activity are substantially changed in character and cannot, therefore, meet the 'good ecological status' (GES).*
>
> *In this context:*
> - *Physical alterations mean changes to the hydro-morphological characteristics of a water body; and*
> - *A water body that is substantially changed in character is one that has been subject to major long-term changes in its hydro-morphology as a consequence of maintaining the specified uses listed in Article 4(3). In general, these hydro-morphological changes alter morphological and hydro-logical characteristics.'*

If the current specified uses of the water body (i.e., navigation, hydropower, water supply or flood defence) or the wider environment are significantly adversely affected by restoration measures required to achieve GES, and if no other technically feasible and cost effective environmental option exists, then these water bodies may be designated as HMWB. The environmental objectives for such water bodies imply reaching Good Ecological Potential (GEP), which may represent a less stringent requirement than achieving GES.

Riparian, lakeshore or inter-tidal zones, including the wetlands comprised within water bodies, constitute part of the hydro-morphological characteristics of a water body. Where the condition and extent of these is relevant to the achievement of the environmental objectives for the associated water body, modifications to, or destruction of, these wetlands should be taken into account in the HMWB designation process.

The identification of water bodies at risk, and the role of wetlands in this process, is described in the section of this Guidance Document on *Impacts and Pressures* (Section 6). The current chapter considers the relevance of wetlands to the HMWB designation tests and to establishing appropriate values for GEP.

Significant hydromorphological changes which may be judged as incompatible with the achievement of GES, even in the long term, and therefore could prompt HMWB designation may include structural changes such as embankments, drainage, etc., that cannot be removed without significant adverse effects on specified uses or on the wider environment (see WFD Article $4.3_{(a)}$). Actual designation is subject to a series of clear tests outlined in Article 4.3. These are outlined in the following section, along with their relevance for wetland (re)creation, maintenance or enhancement.

4.1.1 Steps in HMWB Designation Process, and their possible relevance to wetlands

There are two key 'designation tests' for HMWBs identified in the WFD and explored in the HMWB Guidance Document (WFD CIS Guidance Document No. 4).

Designation test 4.3$_{(a)}$: Do the restoration measures necessary to achieve GES have significant adverse effects on the wider environment or the 'specified uses'?

In some cases, impacts on wetlands in the riparian, lakeshore or intertidal zones of a water body may result in a risk of failure to achieve GES. Wetland restoration may constitute part or all of the 'measures necessary to achieve GES'. In these cases, the 'designation test' may require an assessment of whether restoration measures can take place without significant impacts on the wider environment or compromising the specified uses. Where this use is flood defence, for instance, wetland restoration linked to the provision of additional flood storage capacity may be possible without significant adverse effects and such a water body would not require designation as an HMWB.

'Designation test 4.3$_{(b)}$: Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

There may be contexts in which the restoration or creation of wetlands can help to deliver the beneficial objectives in a way that meets the requirements of this designation test. Examples of the roles which wetlands can play in delivering flood defence benefits are described in Chapter 7.

4.1.2 The Establishment of Good Ecological Potential

Following the designation process, Member States will be required to establish environmental objectives for each HMWB. This process is outlined below, identifying where and how the development of a reference condition (MEP) and an appropriate environmental objective (Good Ecological Potential (GEP)) may be relevant to wetland systems.

Table 6. Development of ecological objectives for HMWBs relevant to wetlands

HMWB Ecological Objectives	Relevance to wetlands
Establishment of MEP. Comparison with closest comparable surface water body (Annex V.1.2.5), considering all mitigation measures, which do not have a significant adverse effect on the specified uses or the wider environment.	! Opportunities may exist for restoring relevant wetland function without significant adverse affects on the specified uses or the wider environment. These should be investigated when identifying the closest comparable surface water body. Where no comparable 'natural' system exists (which may be the case when considering heavily modified rivers disconnected from their floodplains), expert judgement may be used to identify the best possible environmental outcome in the context. ! An appropriate reference condition will reflect the restoration of hydro-morphology, in so far as this does not have significant adverse impacts on the wider environment or specified uses.
Establishment of GEP. Only slight changes in the biological elements found at MEP, otherwise measures have to be taken to ensure GEP is achieved (Art. 4.1(a)$_{(iii)}$ and Annex V.1.2.5).	GEP represents only slight changes concerning biological quality elements from MEP, and should therefore provide a driver for the restoration of the physical condition of the water body, in so far as this is compatible with the HMWB designation.

4.2 Artificial Water Bodies and Wetlands

According to the WFD CIS Guidance Document No. 4 (HMWBs), an artificial water body (AWB) is defined as (4.3):

> *'a surface water body which has been created in a location where no significant surface water existed before and which has not been created by the direct physical alteration of an existing water body or movement or re-alignment of an existing water body.'*

A similar, but not identical process to the identification of HMWBs applies to the identification of AWBs and the establishment of MEP and GEP. The potential relevance of this process to wetlands is identified in Table 7 below.

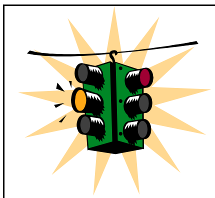
Table 7. Identification of AWBs and their relevance to Wetlands

Is the water body artificial?	Relevance to wetlands
Designation test 4.3(b): Can the beneficial objectives served by the AWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?	
Establishment of MEP. Comparison with closest comparable surface water body (Annex V.1.2.5), considering all mitigation measures, which do not have a significant adverse effect on the specified uses or the wider environment.	! Care should be taken to ensure that in selecting a natural type for comparison, hydro-morphological condition is properly considered and reflected in the biological standards for maximum ecological potential. Thus, for a relevant lake type, the condition of the lakeshore zone, and of littoral communities associated with it, should help to determine MEP, if mitigation measures could enhance these elements without adverse impacts on the specified uses or the wider environment. This might be particularly relevant to the design or improvement of reservoirs. An appropriate reference condition will reflect the enhancement of hydro-morphology, in so far as this does not have adverse impacts on the wider environment or specified uses.
Establishment of GEP. Only slight changes in the biological elements found at MEP, otherwise measures have to be taken to ensure GEP is achieved (Art. 4.1(a) (iii) and Annex V. 1.2.5).	GEP represents only slight changes in biology from MEP, and should therefore provide a driver for the enhancement of the physical condition of the water body, in so far as this is compatible with the AWB designation.

5 PROTECTED AREAS AND THE WATER FRAMEWORK DIRECTIVE

Article 6 of the WFD requires Member States to establish a register or registers of Protected Areas by 22/12/2004. The Register must include all areas lying within each river basin district that have been designated as requiring special protection under specific Community legislation for the protection of their surface water or groundwater and conservation of habitats and species directly depending on such water. The purpose of the Register is to ensure that the integrated river basin planning system created by the WFD helps to deliver the objectives of other water-related legislation, as it applies to environmentally vulnerable or important parts of the river basin. The Protected Areas register will include some sites designated under the Birds and Habitats Directives as part of the Natura 2000 network.

Under WFD Article 4.1$_{(c)}$, by 22/12/2015, unless otherwise specified in the Community legislation establishing the Protected Area, Member States must achieve compliance with relevant groundwater-related and surface water-related standards and objectives. This requirement concerns areas identified pursuant to Article 6 and Annex IV, designated for the conservation of habitats or species for which the maintenance or improvement of the status of water is an important factor in their protection.



Look out! Under the WFD, "Protected Areas" include areas designated for the abstraction of water intended for human consumption, recreational waters, nutrient-sensitive areas as well as areas for the protection of economically significant aquatic species and areas designated for the protection habitats or species where the maintenance or improvement of the status of water is an important factor in their protection (see Annex IV).

5.1 Ecological criteria for water dependency

Some of these Protected Areas will include wetland habitats and species directly depending on surface water or groundwater.
A crucial part of the development of the Protected Areas Register will therefore be the identification of those habitats and species within the Natura 2000 network which qualify under WFD criteria. The following discussion and criteria offer a starting point for considering how this process might be developed.

Natura habitats include specific surface water habitats, such as oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea,* and Natura species include those that live in surface waters, such as lampreys and Atlantic salmon.

Other Natura habitats and species may depend on saturated conditions, groundwater at or near the surface of the ground, or frequent flooding. Others may depend directly on aquatic processes (e.g. sand dunes reliant on the movement of sediment in adjacent coastal waters) or on increased humidity associated with nearby water (Table 8).

Table 8. Ecological criteria for identifying Natura Habitats and Species that are directly dependent on the status of water

Natura 2000 SPECIES	Natura 2000 HABITATS
1.a Aquatic species living in surface waters as defined in Article 2 of the WFD (e.g. bottle-nose dolphin, freshwater pearl mussel)	**2.a** Habitats which consist of surface water or occur entirely within surface water, as defined in Art. 2 of the WFD (e.g. oligotrophic waters; estuaries; eelgrass beds)
1.b Species with at least one aquatic life stage dependent on surface water (i.e. breeding; incubation, juvenile development; sexual maturation, feeding or roosting - including many Natura bird and invertebrate species)	**2.b** Habitats which depend on frequent inundation, or on the level of groundwater (e.g. alluvial alder wood, blanket bog, fens)
1.c Species that rely on the non-aquatic but water-dependent habitats relevant under 2.b and 2.c in the HABITATS column of this Table (e.g. Killarney fern)	**2.c** Non-aquatic habitats which depend on the influence of surface water - e.g. spray, humidity (bryophyte-rich gorges) should be considered

5.2 Identifying relevant standards and objectives

The WFD requires that any relevant standards and objectives for Protected Areas should be achieved by 2015, unless stated otherwise in the Community legislation under which the sites were designated. The single most significant standard for Natura 2000 sites is the achievement of Favourable Conservation Status for the designated features of interest. This will generally be expressed in biological terms and it is appropriate that this biological outcome remains the final measurement against which WFD obligations are judged. However, it is also widely acknowledged that for the purposes of the pressures and impacts analysis, and the establishment of a PoM, such standards and objectives will need, where practicable, to be understood in terms of relevant physico-chemical or hydro-morphological attributes.

A second, vital step in delivering WFD obligations towards Natura 2000 wetlands is therefore to determine the surface water and groundwater related needs of sites, to the extent required to decide if there is a significant risk of failing to achieve their water-related standards and objectives, and to ensure that measures are taken to address this. The water-related standards needed to meet the objectives for Natura Protected Areas may be more or less stringent than those required to achieve good surface water status, good groundwater status, other Protected Area objectives or other relevant objectives specified under paragraph 1 of Article 4 of the WFD. In accordance with WFD Article 4.2, the most stringent objective will apply.

RBMPs should also include any water management action required to meet the wider provisions of the Birds and Habitats Directives in relation to habitats outside the Natura 2000 network. Article 10 of the Habitats Directive states that:

> *'Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.'*

Where Member States create compensatory habitat (including wetlands), as part of their action to implement the Birds or Habitats Directives, the water needs of such additional habitats will also need to be integrated into the river basin planning process.

5.3 Using GIS to assist with developing the Protected Areas Register

To assist in the river basin management planning process, the register of Protected Areas could be incorporated into a GIS layer, capable of performing complex tasks needed to enhance and support decision-making. Such an approach is being developed by the Danube Ecological Expert Group (DEEG).

6 WETLANDS AND THE IMPACTS AND PRESSURES ANALYSIS

The impacts and pressures analysis required by the WFD is a key part of the River Basin Planning Cycle. The WFD CIS Guidance Document No. 3 (IMPRESS) reviews the action Member States will need to take to identify water bodies at risk of failing their WFD objectives. This section of the Wetlands Guidance builds on the IMPRESS Guidance to establish the relevance of wetlands in assessing risks to the environmental objectives of the WFD.

6.1 Relevant Objectives in the Impacts and Pressures Analysis

The following objectives (Table 9), relevant to wetlands, will be considered during the impacts and pressures analysis:

Table 9. Objectives of the IMPRESS analysis
(Text in italics is based on the WFD CIS Guidance Document No. 3)

Prevent deterioration in the status of all bodies of surface water This will include preventing deterioration in the hydro-morphological condition of water bodies at high status (including the condition of any wetlands in the riparian, lakeshore or intertidal zones). Preventing deterioration in the hydro-morphological condition of water bodies at good status and below, in so far as it is necessary to support the achievement of the relevant standards for biological quality elements.
Prevent deterioration in the status of all bodies of ground water, including preventing significant damage to any terrestrial ecosystem (including wetlands) directly dependent on the groundwater body.
Protect, enhance and restore all bodies of surface water with the aim of achieving good ecological status by 2015. This will include protecting, enhancing or restoring the hydro-morphological conditions of water bodies to the extent necessary to support the achievement of the relevant standards for the biological quality elements The hydrological conditions include the structure and condition of the riparian, shore and intertidal zones. These zones may include wetlands.
Protect, enhance and restore all bodies of ground water including the reversal of significant damage to any terrestrial ecosystem (including wetlands) directly dependent on the groundwater bodies, by 2015.
Protect, enhance and restore all artificial and heavily modified bodies of surface water with the aim of achieving good ecological potential and good surface water chemical status by 2015. This will include protecting, enhancing or restoring the hydro-morphological conditions of artificial and heavily modified water bodies to the extent necessary to support the achievement of the relevant standards for the biological quality elements required at good ecological potential. The hydromorphological conditions include the structure and condition of the riparian, shore and intertidal zones. These zones may include wetlands. NOTE: WFD CIS Guidance Document No. 4 on HMWB states that Member States would not be expected to assess risks to the achievement of GEP in HMWBs before the end of 2004.
Compliance with the standards and objectives for Protected Areas by 2015 at the latest, including the objectives for areas designated for the abstraction of drinking water under Article 7. This will include standards and objectives for wetlands included within the Natura 2000 network, identified in order to implement the Habitats and Birds Directive; similarly consider regulations prescribed by the Drinking Water Directive (see Chapter 5).

6.2 Understanding relevant pressure-impact relationships

The IMPRESS Guidance (WFD CIS Guidance Document No. 3) points out that the achievement of the broad range of objectives established by the WFD will require an understanding of a greater number of impact/pressure relationships than has been required by previous European legislation, or is common practice in most Member States.

> *'The objectives include new ecological objectives, the achievement of which may be compromised by a very wide range of pressures, including point source discharges, diffuse source discharges, water abstractions, water flow regulation, morphological alterations and artificial recharge of groundwater. These and any other pressures that could affect the status of aquatic ecosystems must be considered in the analyses.'*

This is particularly relevant to understanding pressures on wetlands, and their relevance to WFD objectives. Whilst the IMPRESS Guidance (WFD CIS Guidance Document No. 3) recognises that the initial characterisation process (deadline 2004) may rely heavily on existing data, it also emphasises the need for Member States to ensure that this can be refined and supplemented during the river basin planning cycle(s) which follow. Less significant elements of surface waters such as small streams, canals and wetlands, often form networks which play a relevant role in sustaining catchment stability acting as pressure indicators; impacts on these may reveal existing pressures increasing catchment vulnerability.

Table 10 identifies some of the key driver/pressure/impact (DPI) relationships that may need to be better understood, to meet the objectives relevant to wetlands.

Table 10. DPI relationships and wetlands

Pressure	Impact	Information	WFD relevance
Drainage of floodplain wetlands.	Changes to physical extent, biological composition of water body. Changes to condition of the riparian zone and its vegetation. Changes to other hydro-morphological elements of the water body, including flow regime, depth, substrate. Changes to the physico-chemical and chemical quality of water reaching water bodies.	Understanding of the interaction between floodplain wetland condition and the physical, chemical and biological condition of the water body.	Objectives for surface water bodies.
Flood embankments resulting in reduction of floodplain.	Changes to physical extent, biological composition of water body. Changes to condition of the riparian zone and its vegetation. Changes to other hydro-morphological elements of the water body, including flow regime, depth, substrate. Changes to the physico-chemical and chemical quality of water reaching water bodies.	Understanding of the interaction between floodplain extent and connectivity and the physical, chemical and biological condition of the water body.	Objectives for surface water bodies.

Table 10 (continued). DPI relationships and wetlands

Pressure	Impact	Information	WFD relevance
Drainage or destruction of peatlands and other wetland systems in the wider catchment.	Changes to catchment hydrology affecting the quality and quantity of flow reaching downstream water bodies.	Understanding the interactions between wetlands in the wider catchment, hydrological regimes of water bodies, and the elements making up good status.	Objectives for surface water bodies.
Groundwater abstraction.	Reduction in water available to support wetland ecosystems.	Hydrological regime necessary to support relevant components of wetland ecosystems. Interactions between groundwater bodies and wetland hydrology	Preventing deterioration and achieving good status for groundwater bodies.
Groundwater pollution.	Deterioration of quality of water reaching dependent terrestrial ecosystems, including wetlands.	Water quality necessary to support relevant components of wetlands ecosystems. Interactions between groundwater and surface water quality.	Preventing deterioration and achieving good status for groundwater bodies.
Abstraction from surface water bodies.	Reduction in amount of water available to support the achievement of relevant conservation objectives for wetland sites in the Natura 2000 network.	Understanding of the water needs of Natura 2000 wetlands, including interactions with relevant water bodies.	Objectives for Protected Areas.
Pollution of surface water bodies.	Reduction in the quality of water available to support the achievement of relevant conservation objectives for wetland sites in the Natura 2000 network.	Understanding of the water quality needs of Natura 2000 wetlands, including interactions with relevant water bodies.	Objectives for Protected Areas.

6.3 Understanding the impact of future pressures

A key requirement of the impacts and pressures analysis will be to identify future activities in the river basin which may put at risk the achievement of WFD objectives (WFD CIS Guidance Document No. 3 - IMPRESS, Policy Summary):

> *'Accordingly, in assessing risks to the achievement of these objectives, the analyses of pressure and impacts must identify:*
>
> - *Existing pressures and impacts (identified in 2004) likely to be causing the status of water to be lower than good;*
> - *How pressures would be likely to develop prior to 2015, in ways that would cause a failure to achieve good status if appropriate programmes of measure were not designed and implemented.*

These observations also apply to any plan or project likely to cause deterioration in status, from the date at which the 'no deterioration' objective is deemed to apply.

This is particularly relevant when considering the possible impacts on water status of major hydro-morphological modification projects, for example to support agricultural production or the construction of transport infrastructure. Pressure-impact relationships between wetlands and water bodies will need to be investigated, as part of the assessment of such future pressures, if river basin planning is to secure the long-term ecological status of water. The relevance of this point to the protection of Europe's few remaining pristine or near pristine floodplain environments cannot be over stated.

6.4 Pressure screening and threshold values

In order to undertake the analysis of impacts and pressures in a cost effective manner, the IMPRESS Guidance (WFD CIS Guidance Document No. 3) recommends that screening criteria are used in relation to particular pressures. This will lead to the gradual 'narrowing' down of the analysis to those water bodies whose risk of failure is subject to greatest uncertainty, and where it is therefore appropriate to invest resources in investigating pressure-impact relationships.

Member States need to consider risks to the achievement of the Directive's objectives resulting from impacts on hydromorphological quality elements in undertaking the pressure and impacts analysis. This should include consideration risks of deterioration in the type-specific hydromorphological conditions of high status water bodies.

Member States may also find that data acts as a useful bench-mark, from which to develop threshold criteria for the assessment of water bodies likely to fail to achieve GES as a result of hydro-morphological modifications (this is proposed in links between the IMPRESS and HMWB Guidance Documents (WFD CIS Guidance Documents No. 3 and 4 respectively)). These threshold criteria will include a measure of acceptable deviation from reference condition for any wetlands included within the riparian, lakeshore and intertidal zones.

Wetlands outside of these zones will be under pressures that impact on the status of water bodies, broader threshold criteria for assessing such pressures will be needed to undertake a comprehensive impacts and pressures analysis. Wetlands functional evaluation is useful to highlight pressure on the river basin as illustrated in the case study below.

Case Study 8. Impact assessment through wetland functional evaluation: the Cheimaditida case

Functional evaluation, using appropriate physicochemical and biological indicators, may identify the degraded processes, the possible sources of degradation, and the functions that should be restored. The impact assessment through functional evaluation is taking into account the characteristics of the entire watershed, not just the degraded wetland. Activities throughout the watershed can have adverse effects on the aquatic resources. A single wetland management project may not be able to change conditions in the whole watershed. Several methods of functional evaluation have been developed, these are: (a) cost effective, in proportion to the value of information derived; (b) easily interpreted, provide unambiguous information and are easily understood; and (c) policy relevant, address key environmental issues. These methods are used to assess the impacts on wetland ecosystems and furthermore to evaluate proposed management solutions.

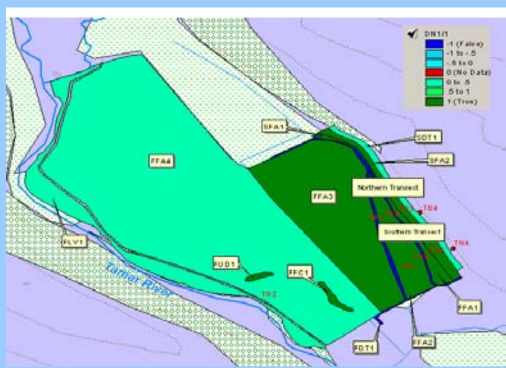
Lake Cheimaditida in Greece is a characteristic case where the functional evaluation at watershed level was used for impact assessment and development of a sustainable restoration plan. Ground water recharge and water storage were found degraded due to water abstraction for agricultural purposes. Although the wetland hosts several rare bird species, the functional evaluation revealed that the foodweb support function was not performed to the desirable degree and biodiversity problems were to arise in the near future if no measures were taken. The poor performance of the above mentioned functions resulted in: i) drop of groundwater levels; ii) shortage of irrigation water; iii) loss of wetland habitats; and iv) gradual decrease of biodiversity. These environmental problems had direct impacts on the local economy. Reduced crop production and deterioration of fisheries led to lower family income and higher social instability. In order to cope with the above-mentioned problems, wetland evaluation was used to set a sustainability reference levels for wetland restoration. Today a program for the restoration of the degraded wetland is under way.

Zalidis G., B. Takavakoglou, and Th. Lazaridou, is part of the work: Zalidis et al., 2001. Study and proposals for restoring the functions of Cheimaditida and Zazari wetaland. Aristotle University of Thessalonki, pages 231,Thessaloniki. (In Greek).

Assessment of wetland function can be performed by means of specific tools and spatial analysis such as the Wetland Evaluation Decision Support System illustrated in Case Study 9.

Case Study 9. A wetland evaluation tool: WEDSS

One of the key outputs of the EVALUWET project is the development of a Wetland Evaluation Decision Support System (WEDSS) (Mode *et al.*, 2002; www.rhbnc.ac.uk/rhier/evaluweb/index.shtml). In simple terms the WEDSS links a functional assessment knowledge base with methods of socio-economic valuation within a GIS environment. The knowledge base carries out assessments of hydrological, biogeochemical and ecological wetland functions using data which can be rapidly gathered in desk studies or field visits. The WEDSS is supported by a simple user interface with input data and outputs being displayed as GIS layers (see Figures below). Users will be able to access the WEDSS online so that they are not required to invest in expensive GIS software. The use of a GIS environment permits decision support at the various scales, from individual wetlands up to catchments. By integrating functional and valuation information within a single tool, decision makers can consider all of the relevant information within wetland management and can fully consider wetlands within integrated catchment management. In this way, the WEDSS will facilitate wetland management in the context of the WFD and support the implementation of other national, European and international policies such as the Habitats Directive, Birds Directive, Convention on Wetlands (Ramsar), Convention on Biodiversity (CBD) and Convention on Sustainable Development (CSD). The WEDSS will be tested in each of the seven study catchments, which represent a variety of wetland types and climatic regions. The WEDSS can be used for a variety of purposes, such as targeting sites for restoration or establishment of buffer zones, comparison of wetland sites and testing of management scenarios.



Figures: WEDSS input layer (left) showing wetland hydrogeomorphic units (HGMUs) to be assessed (blue areas) and output layer (right) showing degree of denitrification occurring in HGMUs (denitrification is an important process improving or maintaining water quality and has higher rates in darker areas).

E Maltby, D V Hogan & R J McInnes (1996). Functional Analysis of European Wetlands Ecosystems .Phase I (FAEWE). Ecosystems Research Report No 18, European Commission Directorate General Science, Research & Development, 448 pp ISBN: 92-827-6606-3 Brussels;

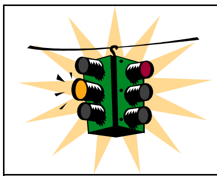
Mode M., Maltby E. & Tainton V. (2002), WEDSS: Integrating Wetlands into River Basin Management to Support the Implementation of the WFD In Ledoux L & Burgess D. (Eds.) Proceedings of Science for Water Policy: The implications of the Water Framework Directive, University of East Anglia, Norwich, UK.

7 THE PROGRAMME OF MEASURES AND WETLANDS

Article 11 of the WFD requires Member States to establish a PoM in order to achieve the objectives stated under Article 4.

As part of the PoM, wetland creation, restoration and management, may prove a cost-effective and socially acceptable mechanism for helping to achieve the environmental objectives of the Directive [WFD Article 11.4; Annex VI, Part B(vii)].

Wetlands have the potential to offer benefits in terms of flood prevention, nutrient and pollutant load abatement, wildlife protection, tourism and recreation. This Section of the document examines the role which wetlands can play in the PoM, in helping to achieve the WFDs environmental objectives.



Look out! The greatest value of measures involving wetland enhancement (creation, restoration, management) is in the multi-purpose solutions they offer.

7.1 Basic and Supplementary Measures

Each programme of measures must include ‘basic’ measures, which are described in detail in Article 11.3, and, where necessary, ‘supplementary’ measures (see WFD Article 11. 2).

7.1.1 Wetlands and Basic Measures

Basic measures may include action directly to protect, enhance or restore wetlands, where:

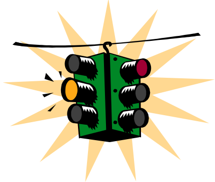
- the wetland is a terrestrial ecosystem that is directly dependent on groundwater (Article 1(a), and the achievement of good groundwater status requires measures to ensure that anthropogenic alterations to groundwater levels and chemical quality are not such as would result in significant damage to that wetland (Annex V.2.1.2 and 2.3.2);
- the wetland concerned is a river, lake, transitional or coastal water body (Article 4.1(a));
- the wetland is part of a hydromorphological quality element of a surface water body and requires protection, enhancement or restoration to ensure that the hydro-morphological conditions of the water body are consistent with the achievement of the relevant good status values for the biological quality elements (Annex V.1.2); and
- the wetland is a Natura 2000 Protected Area and depends, in part, for the achievement of its standards and objectives, on appropriate measures to protect, enhance or restore a surface water body or groundwater body in accordance with Article 4.1(c).

Some measures described in WFD Article 11 might gain benefit from wetland management such as those included under the combined approach principle illustrated in Article 10 (see Section 7.3).

7.1.2 Wetlands and Supplementary Measures

Supplementary measures are those designed and implemented in addition to the basic measures, with the aim of achieving the objectives of the WFD (see Article 11, paragraph 4). Part B of Annex VI of the WFD provides a non-exclusive list of such measures, including *the recreation and restoration of wetland areas*.

In some circumstances, wetland management may be a necessary measure to achieve the objectives of the WFD. In such cases, wetland restoration and recreation may be obligatory. In other circumstances, Member States may choose to use wetland management measures if they judge it would help ensure the most cost-effective approach, or otherwise most appropriate combination of measures. At their discretion, Member States may also choose to use supplementary measures to provide for any additional level of protection or improvement of surface waters or groundwater over and above that required by the WFD.



Look out! Supplementary measures are not always discretionary. Where the achievement of the objectives of the WFD can only be secured with the help of supplementary measures, Member States will be obliged to use them.

7.2 Wetlands and the Concept of Cost Effectiveness

The economic analysis required under Article 5 and Annex III is designed to help Member States make judgements about the most 'cost effective combinations of measures' to achieve the Directive's objectives. The analysis itself should contain enough information in sufficient detail (taking account of the costs of collecting information) to make considered judgements about cost-effectiveness, with a principal focus on basic measures. The comparison of the costs and benefits (including environmental costs and benefits) of measures involving the creation and restoration of wetlands with other options for achieving the WFDs Article 4 objectives may therefore form part of the assessment of cost effectiveness.

In many instances, the appropriate evaluation and costing of wetland management measures may reveal the great value of goods and benefits provided by wetlands. This is illustrated in many of the case studies included in this Chapter of the Guidance.

7.3 Using Wetlands in Programmes of Measures

This Section of the document describes the practical role of wetlands in managing pressures on the water environment. Where wetlands are relevant to the application of a particular basic measure (see Section 7.1 above), the section headings refer to the appropriate provisions of Article 11.3. Otherwise, section headings refer to the *functions* of wetlands, which may help in controlling significant pressures on the water environment (including pollution and the depletion of groundwater resources) and hence assist in the achievement of the WFDs environmental objectives outlined in Article 4.

Throughout, case studies are used to illustrate the role which wetlands can play in managing water status within the river basin.

7.3.1 Measures required to implement Community legislation

WFD Article 11.3(a) refers to measures required to implement Community Legislation for the protection of water, including those specified in Article 10, for instance the use of wetlands to improve water quality (see Section 7.3.4), and part A of Annex VI, which includes the Birds and the Habitats Directives relevant to wetland protection and wetland management.

7.3.2 The role of Wetlands in Cost recovery

WFD Article 11.3 (b) states that basic measures will include those:

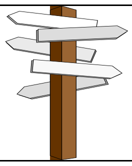
deemed appropriate for the purposes of Article 9

Article 9.1 requires Member States to take account of the principle of the recovery of the costs of water services, including environmental and resource costs, and to ensure, by 2010, that:

- Water pricing policies provide adequate incentives for users to use water resources efficiently;
- An adequate contribution of the different water uses to the recovery of the costs of water services.

Water services are defined in Article 2.38 as all services which provide for households, public institutions or any economic activities:

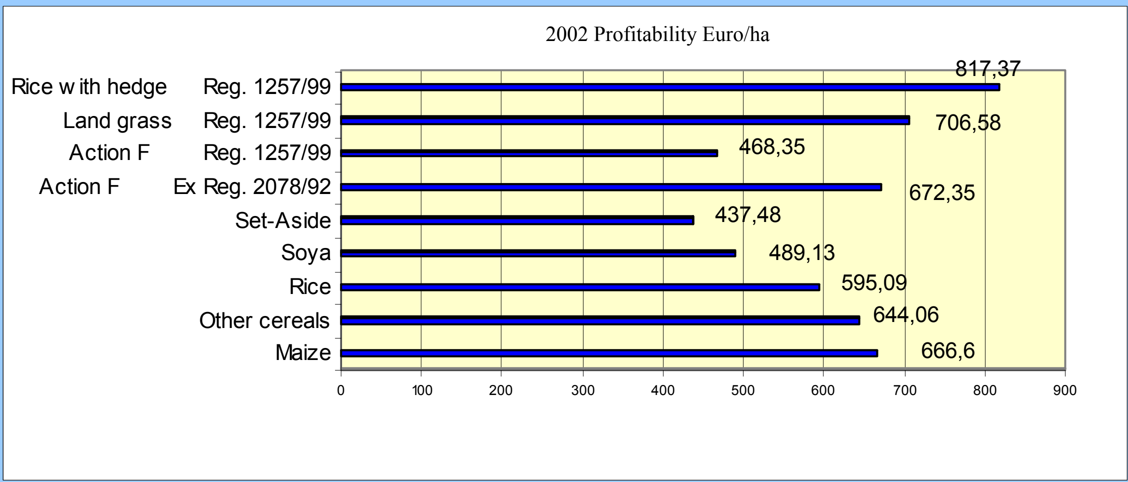
a) Abstraction, impoundment, storage, treatment and distribution of surface water or groundwater;
b) Waste water collection and treatment facilities which subsequently discharge into surface water.



Concerning methods on how to determine the environmental and resource costs readers should refer to the drafting group under WG 2B on Environmental Costs.

Case Study 10. The "wet farm" Cassinazza: interaction between agriculture and water policy

The Cassinazza estate covers approximately 400 ha within the Po floodplain, at the southern edge of the Milan district. Traditional farming patterns included rice, winter cereals, maize, soya beans and sunflowers. Since 1996 intensive production has given way to extensive land management systems aimed at revitalising the natural environment. Under the CAP (Common Agricultural Policy) agri-environment instruments: Regulation 2078/92, the recent Rural Development Regulation 1257/1999, and with the support from the Italian Ministry of Agriculture, a biodiversity enhancing agricultural landscape has been achieved over just 7 years. The farm consists of: marshland (50 ha), wet grassland (15 ha), meadow (100 ha) and woodland (70 ha). Agricultural fields are crossed by a network of streams and 75 km of hedgerows with shrubs and trees planted in double or triple rows. A large pond (11 ha) stores more than 200.000 m^3. Agricultural infrastructures for rice production (dams, bridges, roads) have been restored for agriculture and alternative use. Fifty-nine ha are under traditional farming, while 38 ha developed into "integrated farming". The Figure below illustrates gross margins related to commodities and agri-environment provisions in 2002.



Significant returns are achieved through the sale of small quantities of hay and rice supported through Regulation 1257/99. In comparison to traditional intensive rice cultivation, the Cassinazza rice paddies are smaller in size and contained within hedgerows thus reducing agro-environmental impacts. Under the perspective of direct economic returns extensive rice production revealed to be overall more profitable than intensive farming and than solutions aiming at reducing diffuse pollution supported through 'set-aside' incentives or new Action F.

In November 2002 part of the wet farm was used as a flood prevention basin to collect the stormwater and reduce risk of flooding at a nearby village. Estimated potential storm damages greatly overcome the public funds invested in wetland management at the farm.

CAP agri-environment measures have potential to be much more progressive towards the protection and improvement of water quality and landscape. On the basis of those principles a project called Energy Agriculture and Environment is funded by the Lumbardy Administration to develop an "assembly line", sited at Cassinazza, including wetland recreation from rice fields, cultivation and energy production from biomass. The project wants to overcome typical farmers attitudes whereby "tidiness" equals efficiency, while uncropped areas are seen as wastelands.

The nature of environmental and resource costs, and methods to include them in economic analysis, are highlighted in the WFD CIS Guidance Document No. 1 (WATECO), and discussed in detail in its Annex IV.I, 'Estimating Costs (and Benefits)[4]'.

Where wetland management forms part of a programme of measures, or wetlands are impacted by programmes of measures, relevant environmental and resource costs relating to their functions and values may need to be included in the economic analysis proposed under the WFD.

7.3.3 Managing hydro-morphological impacts

Case Study 11. Heritage value of UK wetlands

The archaeological resource of England's wetlands alone is estimated at 13,400 monuments, of which 11,600 can be found in lowland wetlands (Van der Noort *et al*., 2001). The value of wetlands to England's inhabitants, as far back as the Mesolithic Age, is demonstrated by the large numbers of ritual deposits and monuments they contain (e.g. Roos Carr, Seahenge, Flag Fen, Fiskerton). The anaerobic wetland environment preserves evidence of human activity that is normally lost, particularly the organic remains of buildings and artefacts. Wetlands also preserve long palaeo-environmental sequences. These are the year-by-year accumulations of plants and micro-fauna which tell us how past environments were affected by human influences and climatic change. This rich archaeological storehouse is highly vulnerable, both to habitat destruction and drainage. Even seasonal drying can cause the rapid decay of organic evidence. It is difficult to give statutory protection to archaeological sites in wetlands, because they are hard to locate without disturbing the very environment that preserves them.

Wetlands are a vital component of the evolution of our cultural and historical landscape. This principle has been advocated by the Assynt Crofters Trust's objection to the establishment of forestry on their hard-won in-bye land. In restoring wetland ecosystems, this inheritance should be acknowledged as part of the history of the intimate connections between people, the water cycle and the wetland environment.

The cultural value of wetlands is more than historical. People who live and work around wetlands today celebrate them in the arts, drama, literature, poetry, and folklore, and use them as a valuable educational tool. The recent "Confluence" project, organised by Common Ground for the River Stour in Dorset, promoted the awareness of the importance of rivers and wetlands to the everyday lives of thousands of residents in the Stour catchment from Stourhead to Poole Harbour.

WFD Article 11.3(i) requires controls over any other significant adverse impacts on the status of water bodies not covered by Articles 11.3(a) to (h). In particular, it requires measures to ensure that the hydro-morphological conditions of water bodies are consistent with the required ecological status objectives. Mechanisms for controlling pressures on wetlands within the riparian, lakeshore and inter-tidal zones may be a basic measure where alterations to such wetlands cause a significant adverse impact on the status of water.

The relationship between wetland ecosystems, hydro-morphology (including the condition of the riparian, lake and inter-tidal zones) and ecological status is described in Section 3.2.3.

In order to determine an appropriate controls regime to comply with Article 11.3(i), Member States will need to consider the major pressures on hydro-morphology which may create a risk failing to meet the environmental objectives of the WFD. Assistance in this process is provided in the

[4] Note: WATECO Annexes were not adopted by the Water Directors.

IMPRESS Guidance (WFD CIS Guidance Document No. 3). The following check-list of hydro-morphological pressures is provided in Chapter 4 of the cited Guidance Document. Many of the pressures identified could affect the structure and condition of the riparian shore or inter-tidal zones of water bodies, and that of the wetlands those zones contain.

Table 11. Indicative lists of hydro-morphological pressures relevant to the application of Article 11. 3$_{(i)}$

Flow regulation hydroelectric dams	Fisheries enhancement
Water supply reservoirs	Land infrastructure (road/bridge construction)
Flood defence dams	Dredging
Diversions	Estuarine/coastal dredging due to transitional and coastal management
Weirs	Marine constructions, shipyards and harbours
Physical alteration of channel due to river management	Land reclamation and polders
Engineering activities	Coastal sand suppletion (safety)
Agricultural enhancement	Other morphological barriers

This list of potentially significant pressures includes traditional ‘hard’ engineering solutions to flooding and drought problems (such as the canalisation of rivers, and the construction of walls, culverts and reservoirs), which may have significant impacts on the hydro-morphology of water bodies. They may also prove unsustainable in the long-term on the scale necessary to support people, property and the environment in the context of increased population growth and accelerating climate change. The role which wetland creation can play in offering alternatives to such ‘hard’ solutions is increasingly recognised, and is illustrated in the case studies 12 to 14 below.

Case Study 12. Wetlands for flood mitigation: the Lafnitz River, Austria

The Lafnitz is one of the few remaining natural lowland rivers in Austria. Since the mid 1980s about 220 ha of agricultural land have been purchased and managed more extensively. Another 610 ha have been taken out of intensive agricultural production through compensation payments to landowners. The area is used for natural flood storage. The original plan was to build dams along the river, but this would have caused a higher flood risk for the villages further downstream and it would have been more expensive.

Extensive agricultural management on land surfaces prone to flooding is part of risk avoidance strategies practiced by floodplain peoples since ancient times. Such “soft” solutions are being revived by integrating high quality agricultural products grown under an extensive fashion with integrated river basin management and hold the promise of contributing to a more sustainable future cultural landscape.

The recent update of the UN/ECE *Guidelines on Sustainable Flood Prevention* (*2000*) presented at the Water Directors meeting in Athens, June 2003, provides numerous best practices on flood prevention, protection and mitigation. Non-structural measures such as the storage effect of vegetation, soil, ground and wetlands are vital to mitigate effects of medium scale floods and beneficial in reducing sediment yield. The conservation, protection and restoration of degraded wetlands and floodplains, including river meanders, oxbows, and especially reconnecting rivers with their floodplains is a main preventive non-structural measure.

Case Study 13. Enhancing the effectiveness of coastal flood defence through inter-tidal habitat creation

The Environment Agency of England and Wales assessed the economic impacts of inter-tidal habitat creation in relation to coastal flood defences. 'Managed re-alignment' is the term used to describe the deliberate breaching of current sea defences to allow flooding to a new line, landward of the present structures. The newly created salt marsh or inter-tidal flats can act as a 'buffer' between the sea and the land during high tides and storm floods, dissipating wave energy and allowing the coast to respond more naturally to changes in sea-level.

The economic advantages of managed re-alignment are significant. Re-alignment to rising ground will usually result in a lower and/or shorter length of flood defence, and therefore reduced maintenance costs. In addition, there may be longer-term savings where a natural defence is provided by the newly created area of inter-tidal land. The Environment Agency estimate that where there is an 80 metre width of saltmarsh fronting a flood defence, maintenance costs would be reduced in the order of £3,000 (4,700 euro approximately) per kilometre. This is due to the buffering effects of the inter-tidal habitat in attenuating wave action.
Seas of Change, A report by the RSPB, January 2002. www.rspb.org.uk

Consideration of how wetlands can be used to manage floods and droughts in a manner compatible with WFD objectives could greatly assist Member States with implementation, and in integrating flood management strategies with RBMPs. It is highly likely that a mixed range of flood management options will be part of sustainable flood management in the future.

Case Study 14. Retention zones in Twente, Netherlands

The Twente rural estates located in the basins of the rivers Regge and Dinkel, drain into the Overijsselse Vecht, a transnational river (Germany and the Netherlands) have high cultural historical and natural value. Urbanisation and river channelization have accelerated the discharge of the water. During heavy precipitation, rising water levels, cause flooding in nearby cities; conversely in summer the farmland tends to suffer from drought. A current restoration project aims to store water during periods of heavy precipitation, restore the streams network, control drought, develop natural landscape features, and restore rural estates to their historical condition.

7.3.4 Wetlands and Pollution Control

Achieving the environmental objectives of the WFD will require Member States to take action to control significant impacts of both point source and diffuse pollution pressures on water bodies (Article 10).

It has long been recognised that wetland vegetation and soil processes can play an important role in cycling nutrients, retaining pollutants and trapping suspended solids that 'carry' pollutants into aquatic environments. The reductions in clean-up costs, along with the added biodiversity and leisure benefits accruing from wetland creation, should be considered when assessing the financial viability of options for water treatment in case of both point and non-point source pollution. When considering this function of wetlands, it is also important to safeguard the wildlife and cultural value of existing sites, which might be compromised if these wetlands were treated as nutrient sinks. 'Created' wetlands (constructed wetlands), on the other hand, may provide greater opportunities for nutrient cycling, with areas of increasing nature conservation value potentially 'zoned' around the areas carrying the greatest pollutant loads.

The potential role of wetlands in respect to water supply and pollution management is highlighted in the *Common Text on Wetlands* agreed by the Water Directors in November 2002 and in the 1995 Commission Communication on the *Wise Use and Conservation of Wetlands* to the European Council and Parliament.

The case studies given in this document illustrate the important contribution offered by wetlands in reducing the technical and financial burden of pollutants removal (in particular nutrients).

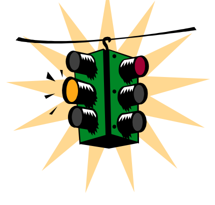
Case Study 15. Nutrient retention value of the lower Morava River

The Morava River is one of the main tributaries of the Danube, extending for some 328 km. Its lower reaches pass through Austrian (right bank) and Slovak (left bank) territory. Of the original 160 km^2 of floodplain on the Slovak side, only about 25% remains, with much of this being under arable agriculture. GIS analysis of historical maps showed that the area of arable land in the functional floodplain had doubled between 1920 and 1999, leading to a corresponding 50% reduction in semi-natural meadows with declines in flora and fauna and in the floodplain nutrient abatement value.

Traditional meadow management in the lower Morava floodplains had an indicative nitrogen retention value of 434 t per year. The monetary value of this natural nutrient removal is equivalent to the operating cost of a wastewater treatment plant for a city of 216,000 citizens – approximately 700,000 Euro per year. Moreover, the initial cost of building such a treatment plant would be around 7 million Euro. These results provided a powerful economic argument in favour of restoring 140 ha of former arable land into meadow. The overall economic investment required in floodplain restoration is far below that for conventional water treatment.

Ongoing restoration of the Morava meadows is enhancing the status of several habitats and species which have declined across Europe, it is improving flood storage through the re-establishment of a more natural flood regime and it fosters tourism/recreation opportunities. Farmers producing hay from the Morava meadows find a ready market across the border in Austria, where the demand for organic products is not currently satisfied by domestic production.

Šeffer, J. and Stanova, V., 1999, Morava River Floodplain Meadows: importance, restoration and management. DAPHNE – Centre for Applied Ecology, Bratislava



Look out! It is recommended that wetlands should be protected from pollution in order to maintain their value. The discharge of anthropogenic wastewaters has to be prevented to maintain the appropriate quality status of wetlands and connected aquatic ecosystems. Such areas should not be compromised by the imposition of an inappropriate pollution control function.

Case Study 16. Le Meleghine, a reconstructed wetland for pollution control

Natural wetlands receive and transform, through biogeochemical processes, large fluxes of water carrying concentrated loads of dissolved and suspended pollutants. In many instances the most efficient way to improve pollution abatement consists of measures aiming at restoring the natural self-purification capacity of the rivers.

Situated in the lower Po valley, near the city of Modena, Le Meleghine consists of 36 ha of shallow ponds and vegetated marshland. The reconstructed wetland, functional since 1994, receives water from the Canalazzo main artificial drainage channel characterised by an average flow of 0,37 m^3/s, draining 8,380 ha of intensively cultivated farmland. The main artificial pond extends over 18 ha with an average depth below 1m.

Before extensive drainage, the area used to host vast marshlands accumulating hydromorphic clayey soils. Today the surrounding farmland has low agricultural potential and can be easily converted into a reconstructed wetland due to a natural impermeable substrate consisting of a 4 m thick layer of impermeable clay deposits which separate surface waters from the underlying shallow sandy alluvial aquifer connected to the Po River system. Spontaneous vegetation includes associations dominated mainly by *Phragmites communis*, species of *Typha, Carex, Scirpus* and alluvial forest. Bird counts totalled 138 including 30 species nesting within the reconstructed wetland.

Ideal conditions for nutrient load abatement are provided by modulating water residence time (nominal maximum residence time is about two weeks) and expanding the vegetated surface. Overall nutrient retention was shown to vary significantly along with changes in hydrological and climatic conditions; nonetheless the wetland demonstrated a distinct capacity to control peaks in nutrient loading due to strong concentration variability at the inlet.

Intensive monitoring programmes show that the wetland is very efficient in reducing nutrient fluxes especially through nitrification and denitrification, as shown in the table below.

	Load abatement
Ammonia	75%
Dissolved Inorganic Nitrogen	64%
Total Phosphorus	63%
Dissolved Phosphorus	94%
Chemical Oxygen Demand	40%
Total Suspended Solids	63%

This reconstructed wetland is the only effective instrument that could have been deployed to control diffuse pollution produced by farming, treated and untreated industrial discharges (including food processing activities) and effluents produced by sewage treatment plants discharging into Canalazzo which drains into the Po River and then further into the highly euthrophic north Adriatic Sea (sensitive area according to Directive 91/271/EEC).

7.3.5 Using wetlands to enhance groundwater recharge.

The achievement of good groundwater status includes requirements to protect and restore the quantitative status of aquifers, in some cases this may be facilitated through the protection and restoration of wetlands.

Case Study 17. Drinking Water from the Danube National Park

The water quality in 45 km stretch of the Danube riverine fringe is high and can provide 250,000 people with clean drinking water. If this area were dammed for hydropower (as was and is suggested), the cost of compensating for the loss in water quality could amount to 6.3 million Euro per year.

(Technical University Vienna 1995)

The winter storage capacity of wetlands can contribute to aquifer recharge. Wetlands retain more water than, for instance, arable land, which is often drained as quickly as possible to aid crop growth. Water from the wetland is thus able to re-infiltrate the aquifer over a longer period, achieving greater re-charge than would be likely where land-drainage and soil conditions direct water rapidly and in greater quantity into main river systems. Infiltration of this kind takes place via infiltration areas in most direct connection to the underlying aquifer, such as ditches, trenches, ponds and lagoons. In this way, wetland creation on flood plains could contribute to improving the quantitative status of alluvial aquifers, as well as alleviating the impacts of flood peaks in winter. It is also possible that small-scale wetland creation in chalk uplands could create a more amenable environment for percolation, and hence aquifer recharge. Further benefits could accrue where more surface water was available in wetlands adjacent to arable land, limiting the agricultural demand for groundwater.

Case Study 18. Wetlands providing drinking water for the Netherlands

As from the 1960s, when most of the rivers in the Netherlands progressively became too polluted to provide sources of drinking water at an acceptable cost; the Dutch government started looking into natural water purification strategies by letting streamwater percolate through sand dunes. The main processes include mechanical filtration through the sand and bacterial remediation within the aquifer. In this way natural landscape features significantly contribute in reducing the technological and financial burden involved in drinking water preparation. Drinking water for the city of The Hague is still pretreated using sand dune infiltration; the same used to occur for the drinking water for Amsterdam until year 2000 when large reservoirs were built.

In some parts of the country such as the South of the Holland Province, there are no sand dunes suitable for water purification. Here the main source is the river Meuse (Maas); a river characterized by an erratic discharge with low summer minima. The natural morphology of the Meuse estuary region was definitely changed by the building of the large Haringvliet dam constructed in 1970 as part of the Delta Plan. A large freshwater basin interrupted the gradual succession between inland freshwater and coastal saline habitats, significantly affecting the estuarine flora and fauna. The project contributed to extend the accessibility of land and water to human uses.

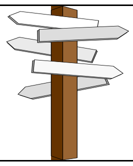
Further inland from Haringvliet, water managers decided to store water to supply the city of Dordrecht and further reclaim land for agriculture. The Biesbosch district, once upon a time a wild shallow coastal zone characterized by estuarine islands, was chosen for the siting of three shallow reservoirs covering an area of 673 ha. Flowing from one reservoir to next, the river water reduces its suspended and dissolved load, reaching values, in the last reservoir, that are close to water fit for human consumption. Today the Biesbosch is a National Park extending over some 7100 ha which forms a very popular recreation resort and artificial aquatic habitats providing a precious resource for wildlife. The reservoirs supply an abundant and high quality source of drinking water.

As part of the Rhine "vision", a look ahead at the condition of the river in a generation's time, the Dutch government is undertaking a series of collaborative projects involving a large number of public organizations. New plans aim at recreating a brackish water zone between the estuary of the Rivers Rhine and Meuse and the North Sea partially restoring a tidal environment in the former sea inlet and in the Biesbosch tidal area which lies behind it. By ultimately opening a third of the Haringvliet sluices permanently, plants and animals that live in fresh and brackish water tidal environments will be able to flourish again and migratory fish such as salmon will be able to swim unhindered from the sea to their spawning areas along the rivers.

Plans are underway in the Netherlands to give the river more space, primarily in the existing and restored winter beds. These recreated wetlands are an opportunity for the development of flood retention areas, water purification schemes, nature conservation areas and other functions provided by natural and restored wetlands.

8 MONITORING AND WETLANDS

Article 8 of the WFD requires the establishment of monitoring programmes (in accordance with Article V) in order to progressively reach a comprehensive overview of water status within each river basin district. The WFD calls for the monitoring of surface water, groundwater and Protected Areas.



CIS WG 2.7 have produced a comprehensive Guidance on Monitoring (WFD CIS Guidance Document No. 7) to which readers are advised to refer to

Section 2.6 of the Monitoring Guidance (WFD CIS Guidance Document No. 7), mentions the relevance of wetlands for the achievement of the Directives environmental objectives but does not focus on wetland monitoring specifically

On the basis of characterisation and impact assessment, Member States are required to set up surveillance and operational monitoring programmes and eventually conduct investigative monitoring activities. Definitions are summarized in Table 12 below, and further details are described in the Monitoring Guidance (WFD Guidance Document No. 7).

Table 12. Definitions of surface water monitoring according to Annex V.

Monitoring	Reference	Objective	Relevance
Surveillance	Annex V, 1.3.1	Provide information for: - supplementing and validating the impact assessment procedure (Annex II); - the efficient and effective design of future monitoring programmes; - the assessment of long-term changes in natural conditions; - the assessment of long-term changes resulting from widespread anthropogenic activity.	Water bodies, at risk and not at risk, of failing the objectives.
Operational	Annex V, 1.3.2	Undertaken to: - establish the status of those water bodies identified as being at risk of failing to meet their environmental objectives; - assess any changes in the status of such bodies from the programmes of measures.	Water bodies identified as being at risk of failing the environmental objectives under Article 4, for those bodies of water into which priority list substances are discharged and bodies at risk of significant hydro-morphological pressure.
Investigative	Annex V, 1.3.3	Required to be carried out: - where the reason for any excedences is unknown; - where surveillance monitoring indicates that the objectives set under Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; - to ascertain the magnitude and impacts of accidental pollution.	Case by case.

For surface waters, the results of well designed surveillance, operational and investigative monitoring programmes should help improve understanding of the relationship between the hydro-morphological quality elements (including the structure and condition of the riparian, shore and intertidal zones) and the condition of the biological quality elements. This will enable increased confidence in the results of future pressures and impacts analyses, and improvements to the design of programmes of measures.

The scope of the monitoring programmes applies to wetlands which are designated as water bodies or form part of them (see Section 2.3), as well as for those included in the Register of Protected Areas. Monitoring requirements concerning Protected Areas (*sensu* Annex IV) are to be carried out according to the requirements set by the specific legislation establishing each area.

Wetlands which are river, lake, transitional or coastal water bodies or form part of them (see Section 2.3), as well as for those identified as Protected Areas (see Chapter 5) fall within the scope of the Directive's monitoring programmes. Monitoring requirements concerning Protected Areas (*sensu* Annex IV) are to be carried out according to the requirements set by the specific legislation establishing each area. The amount of monitoring in relation to surface water bodies that is necessary will depend on the information needed to assess risks to, design measures for, and monitor the achievement of, the WFDs environmental objectives.

The monitoring of other wetlands is not required as part of the surface water monitoring programmes. However, in case of uncertainty about water body ecological status, the assessment of the ecological health and functioning of dependent wetlands may be useful in helping to evaluate the likelihood of failing to meet the WFDs objectives.

8.1 Monitoring groundwater bodies and dependent ecosystems

In order to assess groundwater status, information will be required about groundwater levels and quality needed to prevent significant damage to terrestrial ecosystems directly dependent on groundwater (Annex V.2). Once these water needs have been defined, monitoring results for groundwater levels and quality can be used to determine whether the needs of the ecosystems are being met. In many cases an investigation of the typical water requirements of different wetland types and critical species, which are not as yet clearly understood, may be needed. This will mean monitoring wetland habitats and species directly to determine their response to groundwater levels and quality variations, where suitable information to make such estimates is not already available.

Defining the groundwater needs of directly dependent terrestrial ecosystems is likely to require an initial assessment of the typical water requirements of different wetland types and critical species. In many cases, these needs are not yet fully understood. The lack of understanding means that, where a risk has been identified, a direct assessment of the condition of a terrestrial ecosystem may be required to help design appropriate measures for controlling alterations to groundwater quality and levels, and to confirm whether these measures are being effective in avoiding or remedying significant damage to the terrestrial ecosystem (see Figure 8).

Investigations of specific water requirements of individual wetlands are strongly recommended where a body of groundwater is at risk of failing its objectives because of impacts on the water needs of these ecosystems. For example, agricultural drainage disrupting surface water supply to wetlands may significantly reduce recharge in the near groundwater preventing the groundwater body from reaching its environmental objectives. This obligation depends on the potential risk of water needs not being met.

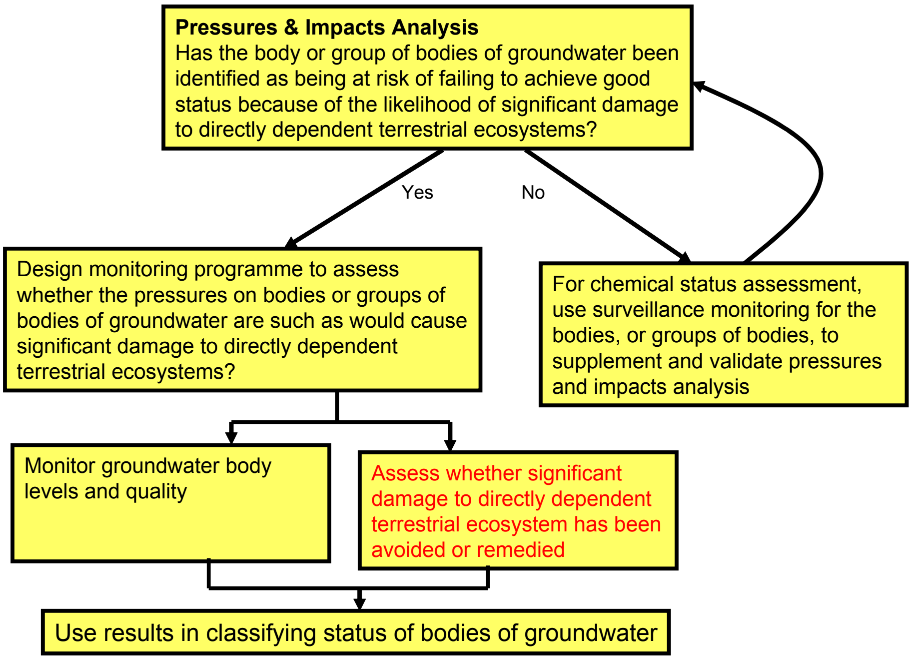


Figure 8: General principles for the design of a monitoring programme and for the assessment of status in relation to the interaction of groundwater and directly dependent terrestrial ecosystems

In the Technical Report on Statistical Aspects of the Identification of Groundwater, Pollution Trends, and Aggregation of Monitoring Results (WFD CIS Technical Report No.1), Annex 2 (Section 6.3) the following elements are listed as essential factors to be considered in the interpretation of groundwater quality data, for the characterisation of groundwater bodies or groups of groundwater bodies (as requested in WFD Annex II):

- Depth to groundwater;
- Annual groundwater level amplitude;
- Hydraulic conductivity;
- Recharge situation;

These indicators are relevant to wetland function and are likely to reveal impacts on wetlands.

Collection of information is required under Annex II of the Directive during the initial characterization and impact assessment phases for the establishment of reference conditions for surface water body types and to describe hydro-morphological quality elements for sites (including riparian, lake and inter-tidal zones) at HES and MEP (Reference Sites). Obtaining information about wetlands may be warranted to improve the understanding of catchment system functions which is a prerequisite for a successful impact and pressures study as highlighted by Section 3.3.2 of the IMPRESS Guidance (WFD CIS Guidance Document No. 3). Targeted monitoring of specific wetland characteristics and ecological processes (nutrients uptake, floodwater retention etc) within reasonable cost, is considered good practice especially in cases when links are not clear and when wetlands protection and restoration is carried out as a supplementary measure.

For water bodies at GES or GEP and below, the WFD will require information about hydro-morphology, where a water body is at risk of failing its biological objectives because of impacts on these quality elements.

Although not specifically requested by the WFD, an investigation of hydrological connectivity, may be useful and could be carried out at the discretion of Member States. Case study 7 in Section 3.4 illustrates this point. In case of evident potential damage to dependent ecosystems or to the degree of connection between these and water bodies, detailed targeted investigations are advisable. The effort required in any assessment should be proportionate to the difficulty in understanding and managing the risks to the WFDs objectives.

9 CONCLUSIONS

Wetlands play a role in the achievement of the environmental objectives of the WFD and help in the fulfilment of the programme of measures and in its adjustment to regional and local conditions.

This Guidance Document introduces recommendations clarifying the role of wetlands in the river basin management process. Case studies provide an illustration of the circumstances under which Member States may choose to use wetland management measures to ensure the most environmental and cost-effective approach.

Some issues could benefit from further development and some topics should be revisited in future activities (e.g. through the Pilot River Basin Testing Exercise). Consideration to be given to:

- Defining more in detail how to include wetlands in the programme of measures when preparing the programme of measures themselves;
- Recognizing the diversity of wetlands in the EU and therefore understanding the different ways in which wetlands restoration may contribute to RBM;
- Setting indicators for assessing the progress achieved regarding wetland restoration as part of the river basin management plan;
- Defining indicators and monitoring methods to establish a relationship between wetland health and groundwater quality and quantity status;
- Identifying wetlands within protected areas;
- Elucidating the contribution of wetlands to the environmental cost recovery; and,
- Investigating links concerning reporting and monitoring for wetland management under both the WFD and the Ramsar Convention.

Finally, it is important to consider that the outcome of the Wetlands Guidance Document testing within the Pilot River Basin Exercise could provide precious practical advice on the role of wetlands in river basin planning.

10 REFERENCES

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ANNEX I

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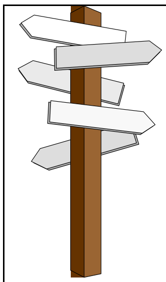
ANNEX II

Examples of wetland functions relevant to delivery of the objectives of the WFD (based on Maltby *et al.*, 1996)

Function	Article 1 – Purpose
Flood Water Detention	“mitigating the effects of floods and droughts” “water needs, (of) terrestrial and wetlands”
Groundwater Recharge	“mitigating the effects of floods and droughts” “water needs, (of) terrestrial and wetlands”
Groundwater Discharge	“mitigating the effects of floods and droughts” “water needs, (of) terrestrial and wetlands”
Sediment Retention	“protects and enhances the status of aquatic systems”
Nutrient Retention	“protects and enhances the status of aquatic systems” “reduction of pollution of groundwater”
Nutrient Export	“protects and enhances the status of aquatic systems” “reduction of pollution of groundwater”
In-situ Carbon retention	“protects and enhances the status of aquatic systems” “reduction of pollution of groundwater”
Trace Element Storage	“protects and enhances the status of aquatic systems” “reduction of pollution of groundwater”
Organic Carbon Concentration Control	“protects and enhances the status of aquatic systems” “reduction of pollution of groundwater”
Ecosystem Maintenance	“protects and enhances the status of aquatic systems”
Food web Support	“protects and enhances the status of aquatic systems”

ANNEX III

Recent projects financed by the European Union



Wetland functions and values have been reviewed in the 1995 *Wise Use and Conservation of Wetlands*, Communication from the Commission to the European Parliament on Wetlands. Readers are asked to consult this document for a more detailed review of these issues, as well as the following EU financed (concluded) projects:

- *Ecological-economic analysis of wetlands: functions, values and dynamics* (Project Ref: ENV4960273) 1996-1999, gives a complete assessment of wetland processes, functions and their related economic values;
- *European River Margins: role of biodiversity in the functioning of riparian systems* (ERMAS Project) (Ref: ENV4950061) 1996-1999, provides information on the processes controlling the structure and function of river margin ecosystems;
- *Dynamics and stability of reed dominated ecosystems in relation to major environmental factors that are subject to global and regional anthropogenically induced changes*, 'EUREED II', 1996-1999, (Ref: ENV4950147), importance of wetland functions and of reed beds in securing these functions (http://botanik.aau.dk/eureed/);
- *Biodiversity of micro-organisms in aquatic ecosystems,* 1996-1999, (Ref: ENV4950026), is an assessment of microbial diversity from an ecologically relevant perspective;
- *Impacts of climate change flux in freshwater ecosystems* 1998-2001, (Ref: ENV4970570) reviews the impacts of rising CO_2 levels on the structure and dynamics of lake ecosystems;
- *Microbenthic communities in European Rivers used to assess effects of land-derived toxicants* 1996-1999 (Ref: ENV4960298), study on the Community effects of toxic fluxes in rivers;
- *Nitrogen cycling in estuaries* 1996-1999, 'NICE' (Ref: MAS3960048), 1996-1999, a study on the fate of anthropogenic nitrogen discharged into estuaries and coastal waters. Quantification of nitrogen removal to evaluate to what extent nitrogen is being transported from land to sea;
- *Response of European freshwater lakes to environmental and climatic change*, 'REFLECT' (Project Ref: ENV4970453), 1998-2000, a study to show the natural and anthropogenic factors influencing the dynamics of plankton in lakes in 3 climatic zones;
- *Techniques and Procedures for the Functional Analysis of Wetland Ecosystems (TECWET),* 2003, ref: EVK1-CT-2001-80001, this study developed two publications: *A Generic Wetland Functional Evaluation Tool* and *A Generic Manuel of Wetland Investigation Approaches and Methods*;
- *Functional Analysis of European Wetlands – FAEWE,* 1991 – 1994, ref. STEP-CT90-0084.

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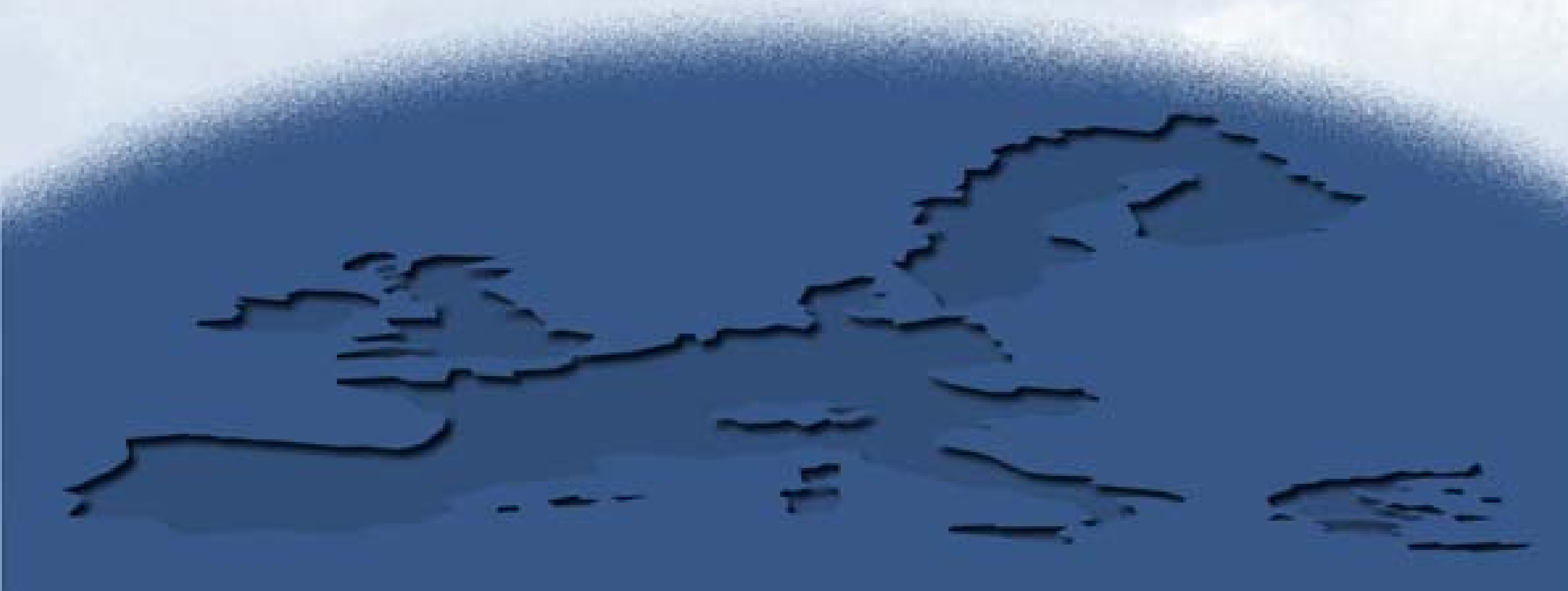
European Commission

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance document n.° 13

Overall approach to the classification of ecological status and ecological potential



COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No 13

Overall Approach to the Classification of Ecological Status and Ecological Potential

Produced by Working Group 2A

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FOREWORD

The Water Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical guidance documents on various technical issues of the Directive. These guidance documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, an informal working group dedicated to the ecological status of surface water bodies within implementation of the Water Framework Directive was set up in November 2002 and named ECOSTAT WG 2.A. Within the current work of the ECOSTAT WG, the United Kingdom and Germany have the responsibility of the secretariat and co-ordination of the activity on the development of guidance on ecological classification which has been developed with the assistance of a drafting group.

The present guidance document contains the output of two drafting group meetings and two meetings of the WG 2.A held in 2003. It summarizes the overall ecological classification rules provided by REFCOND, COAST, HMWB and Monitoring guidance documents (WFD CIS Guidance Document Nos 10, 5, 4 and 7, respectively). Further, this new guidance focuses on certain specific technical issues which had not been resolved in the previous guidance documents, in particular the role of physico-chemical parameters in the ecological status classification.

The development of ecological assessment and classification systems is one of the most important and technically challenging parts of the implementation of the Water Framework Directive. It is the first time such systems have been required under Community legislation and all Member States are in a position of needing to significantly expand their technical knowledge and experience. Consequently, the development and improvement of appropriate systems will involve a learning process. The guidance document provides a starting point for this learning process. It sets out some key principles and ideas on practical approaches. It is hoped these will help Member States build on their existing expertise to develop practical and reliable systems for assessment and classification that satisfy the requirements of the Water Framework Directive.

Much of the guidance document is based on Member States' existing national experiences of assessing and classifying surface waters or on the interim outcomes of some of the development work currently underway. As implementation progresses and Member States begin to monitor and assess the ecological status of water bodies, the richness of Member States' practical experiences with ecological classification in relation to all surface water categories will increase. New ways of dealing with some of the technical challenges, such as controlling the risk of misclassification, may be identified. The sharing of this growing body of experience among Member States will benefit all and should be encouraged.

"We, the Water Directors have examined and endorsed this guidance during our informal meeting under the Italian Presidency in Rome (24/25 November 2003). We would like to thank the participants of the Working Group and, in particular, the leaders, Germany and United Kingdom, for preparing this high quality document.

We strongly believe that this and other guidance documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive. It facilitates the common understanding of ecological classification under the Directive and provides useful tools, in particular as regards the use of physico-chemical parameters in the classification process.

Because of the potentially significant economic consequences of misclassification, this guidance and on-going exchanges of experiences on the assessment and classification of ecological status is important. Therefore, this guidance document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work."

Table of Contents

1. Introduction

1.1 The purpose of this document is to provide general guidance on the assessment of ecological status and potential leading to the overall ecological classification of water bodies for the purposes of the Water Framework Directive (WFD) (see Section 2). The document also provides specific guidance on the role of the general physico-chemical quality elements in ecological classification (see Sections 3 and 4). The guidance document draws on the existing guidance documents REFCOND; COAST; MONITORING and HMWB&AWB (WFD CIS Guidance Document No's 10, 5, 7 and 4, respectively).

1.2 The Directive requires the establishment of classification schemes to reflect the ecological status or potential of surface water bodies as measured by the condition of specific biological, hydromorphological and chemical and physico-chemical quality elements. The relevant elements, and the specific conditions required for these elements in each of the classes of the classification schemes, depend partly on the surface water category and type to which the water body belongs, and on whether the body is artificial or heavily modified.

1.3 Annex II 1.3 of the WFD requires Member States to achieve adequate confidence and precision in classification, and to give estimates of the level of confidence and precision achieved in the River Basin Management Plans. Guidance on getting better conclusions from monitoring data is provided in Annex I of this document.

2. The Ecological Status and Ecological Potential in the Water Framework Directive

2.1 For surface waters the overall aim of the WFD is for Member States to achieve “good ecological status” and “good surface water chemical status” in all bodies of surface water by 2015. Some water bodies may not achieve this objective for different reasons. For example, under certain conditions the WFD permits Member States to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB) in accordance with Article 4(3). Instead of "good ecological status", the principal environmental objective for HMWBs and for AWBs is “good ecological potential” (GEP) and “good surface water chemical status”, which has to be achieved by 2015.

Article 2(17):
”Surface water status” is the general expression of the status of a body of surface water, determined by the poorer of the ecological status and the chemical status.

Article 2(21):
”Ecological status” is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V.

Article 2(23):
”Good ecological potential” is the status of a heavily modified or an artificial body of water, so classified in accordance with the relevant provisions of Annex V.

2.2 The WFD requires surface water classification through the assessment of ecological status or ecological potential, and surface water chemical status. WFD **Annex V, Table 1.1**, explicitly defines the quality elements that must be used for the assessment of ecological status/potential (see Table 1 below). Separate lists are provided for rivers (section 1.1.1), lakes (section 1.1.2), transitional waters (section 1.1.3) and coastal waters (section 1.1.4). Section 1.1.5 specifies that the quality elements for the classification of heavily modified and artificial water bodies are those relevant to whichever of the four surface water categories the heavily modified or artificial water body most closely resembles. The lists of quality elements for each surface water category are subdivided into 3 groups of ‘elements’: (1) **biological elements**, (2) **hydromorphological elements** supporting the biological elements; and (3) **chemical and physico-chemical elements** supporting the biological elements. The chemical and physico-chemical quality elements supporting the biological elements include:

- General physico-chemical quality elements (specified in Annex V, table 1.1 of the WFD);
- Specific non-priority pollutants identified by Member States as being discharged in significant quantities; and
- Specific priority pollutants as being discharged (specified in Annex X of the WFD)

Nevertheless it should be noted that once environmental standards have been adopted at Community level for the priority substances listed in Annex X, these substances should only be taken into account in the classification of surface water chemical status and should not be used as supporting elements for the classification of ecological status (see 2.7 and 3.8).

2.3 WFD **Annex V, Table 1.2**, provides a general definition of ecological status in each of the five status classes. For each relevant quality element more specific definitions for ecological status at high, good and moderate status in rivers (Table 1.2.1), lakes (Table 1.2.2), transitional waters (Table 1.2.3) and coastal waters (Table 1.2.4) are given. In addition, a similar approach has been used for HMWBs and AWBs with definitions for maximum, good and moderate ecological potential being given (Table 1.2.5). For the purposes of mapping and reporting, the two upper classes for HMWBs and AWBs (i.e. maximum and good ecological potential) are combined as "good and above"[1].

2.4 As a basic step, the values of the **biological quality elements** must be taken into account when assigning water bodies to any of the ecological status and ecological potential classes. In order to ensure comparability the results of the biological monitoring systems shall be expressed as ecological quality ratios for the purposes of ecological classification. The ratio shall be expressed as a numerical value between zero (worse class) and one (best class).

2.5 The values of the **hydromorphological quality elements** must be taken into account when assigning water bodies to the high ecological status class and the maximum ecological potential class (i.e. when downgrading from high ecological status or maximum ecological potential to good ecological status/potential). For the other status/potential classes, the hydromorphological elements are required to have "conditions consistent with the achievement of the values specified [in Tables 1.2.1 - 1.2.5] for the biological quality elements." Therefore, the assignment of water bodies to the good, moderate, poor or bad ecological status/ecological potential classes may be made on the basis of the monitoring results for the biological quality elements and also, in the case of the good ecological status/potential the physico-chemical quality elements (see paragraph 2.6 below). This is because if the biological quality element values relevant to good, moderate, poor or bad status/potential are achieved, then by definition the condition of the hydromorphological quality elements must be consistent with that achievement and would not affect the classification of ecological status/potential.

2.6 The values of the **physico-chemical quality elements** must be taken into account when assigning water bodies to the high and good ecological status classes and to the maximum and good

[1] If Member States wish to illustrate all the ecological potential classes, all five classes may be used for mapping and reporting, although this approach is not required by the Directive.

ecological potential classes (i.e. when downgrading from high status/maximum ecological potential to good ecological status/potential as well as from good to moderate ecological status/potential). This is discussed in detail in Section 4. For the other status/potential classes the physico-chemical elements are required to have "conditions consistent with the achievement of the values specified [in Tables 1.2.1 - 1.2.5] for the biological quality elements." Therefore, the assignment of water bodies to moderate, poor or bad ecological status/ecological potential may be made on the basis of the monitoring results for the biological quality elements. This is because if the biological quality element values relevant to moderate, poor or bad status/potential are achieved, then by definition the condition of the physico-chemical quality elements must be consistent with that achievement and would not affect the classification of ecological status/potential.

2.7 The "physico-chemical quality elements" identified in WFD Annex V, Tables 1.2.1 – 1.2.5 mean the "chemical and physico-chemical elements supporting the biological elements" listed in Section 1.1 of Annex V for each surface water category, except those for which an Ecological Quality Standard (EQS) has been set at EU-level.

2.8 The relationships between the biological, hydromorphological and physico-chemical quality elements in status classification are presented in Figure 1 for all natural water categories and types. This is discussed in detail in Section 5.

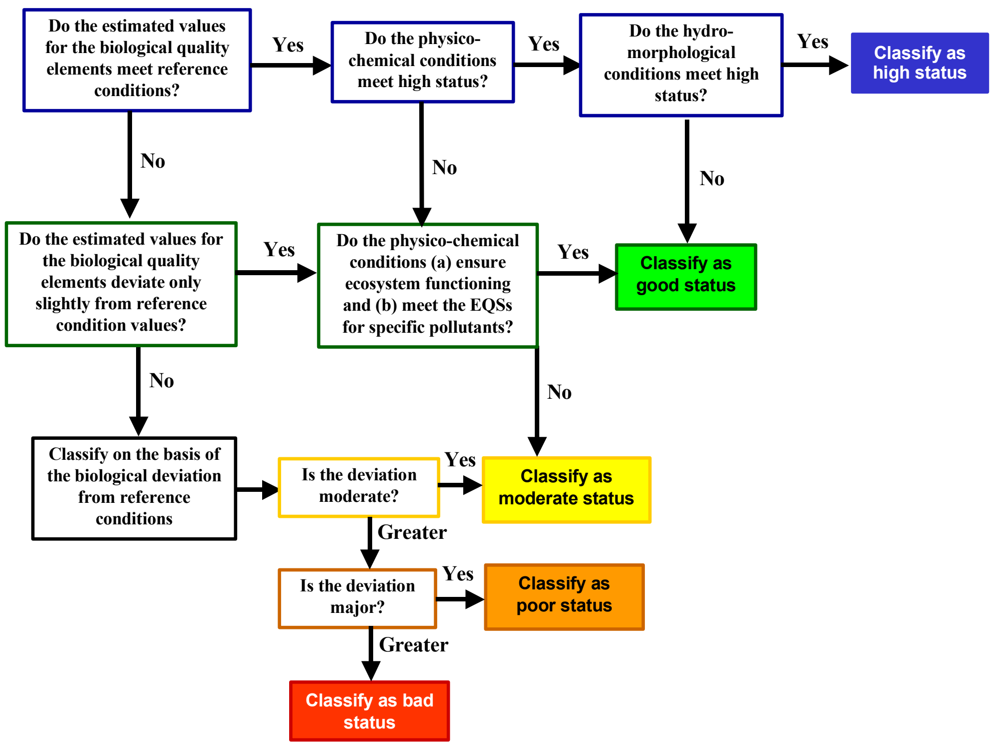

Figure 1. Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according the normative definitions in WFD Annex V:1.2. [Note: Figure reproduced from WFD CIS Guidance Documents 10 and 5].

2.9 A comparable approach for HMWB and AWB is shown in Figure 2. The reference conditions of these water bodies mainly depend on the hydromorphological changes necessary to maintain the specified uses listed in Article 4(3)(a). Maximum ecological potential (MEP), as the reference conditions for HMWB and AWB, is intended to describe the best approximation to a natural aquatic ecosystem that could be achieved given the hydromorphological characteristics that cannot be changed without significant adverse effects on the specified use or the wider environment[2]. Accordingly, the MEP values for the biological conditions should reflect, as far as possible, the biological conditions associated with the closest comparable natural water body type at reference conditions, given the MEP hydromorphological and associated physico-chemical conditions (see WFD CIS Guidance Document No. 4 Section 6.2.3).

<u>WFD Annex V No. 1.2.5:</u>

> *[Maximum Ecological Potential (MEP) is defined as the state where] "the values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body."*

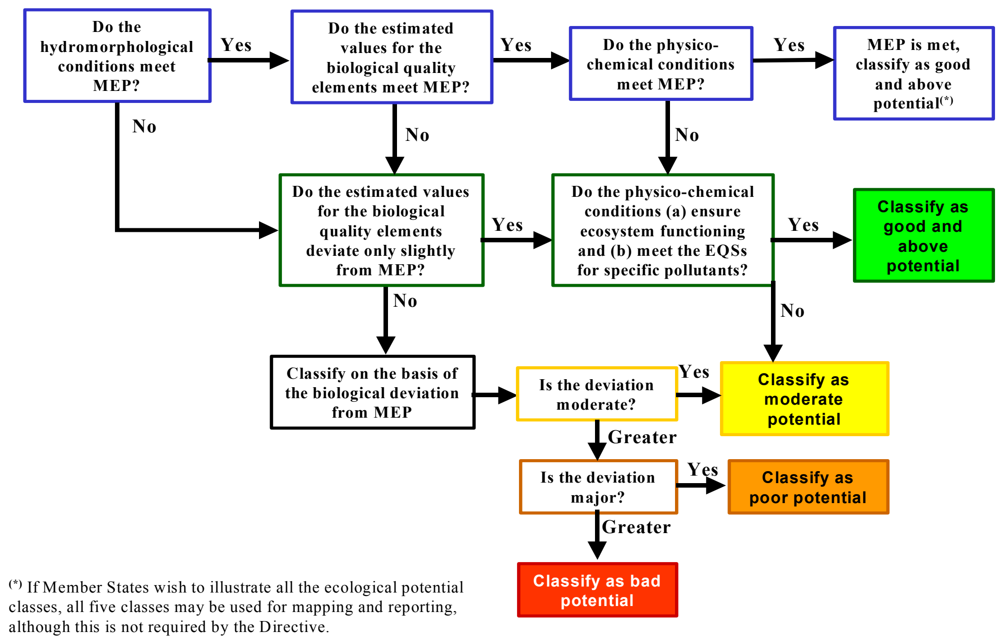

Figure 2. Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological potential classification according the normative definitions in WFD Annex V:1.2. The two upper classes MEP and GEP are combined for reporting purposes to good and above potential. WFD Annex V (1.4.2) requires that results are presented in equal green/yellow/orange or red (depending on the classification) combined with light grey (AWB) or dark grey (HMWB) stripes.

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[2] As an illustration, significant adverse effects were calculated by HMWB case studies using local production loss, loss of agricultural land, loss of revenue etc. In general losses of < 1-<10% were considered as insignificant in the case studies, whereas losses of > 30% were considered as significant. For the assessment of the significance of adverse effects on the specified use or the wider environment see WFD CIS Guidance Document No. 4, in particular chapter 5.7.1.

2.10 The WFD requires that Member States achieve an adequate level of confidence that water bodies are assigned to their true status classes. The level of confidence achieved must be reported in the river basin management plans. Further guidance is given in the technical Annex I to this guidance document and may also be found in REFCOND Guidance and specifically in the Monitoring Guidance (WFD CIS Guidance Document 10 and 7).

WFD Annex V, Section 1.3 (3rd paragraph)
In selecting parameters for biological quality elements Member States shall identify the appropriate taxonomic level required to achieve adequate confidence and precision in the classification of the quality elements. Estimates of the level of confidence and precision of the results provided by the monitoring programmes shall be given in the Plan.

WFD Annex V, Section 1.3.4 (3rd paragraph)
[Monitoring] frequencies shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring system used shall be stated in the River Basin Management Plan.

3. How to Derive the Ecological Status and Potential

3.1 To classify ecological status/potential, the WFD stipulates that the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements should be used (Annex V, 1.4.2. (i)). This implies, de facto, that Member States will need to establish methods/tools for assessing ecological status/potential for both the biological and physico-chemical quality elements. Figures 1 and 2 illustrate that there are separate criteria in WFD Annex V, 1.2, for establishing appropriate ranges for physico-chemcial elements at high and good ecological status and at maximum and good ecological potential.

<u>WFD Annex V, section 1.4.2. Presentation of monitoring results and classification of ecological status and ecological potential</u>

> (i) *For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below. ....*
>
> (ii) *For heavily modified and artificial water bodies, the ecological potential classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below. ....*

3.2 The quality elements for the classification of ecological status/potential are listed in Annex V Section 1.1 of the WFD and reproduced in Table 1 below. WFD Annex V Sections 1.2.1 – 1.2.5 provide definitions of the condition of the quality elements in each status class for each surface water category.

Table 1. Quality elements to be used for the assessment of ecological status/potential based on the list in Annex V, 1.1, of the Directive (for further details see text in 2.2).

Annex V 1.1.1. RIVERS	**Annex V 1.1.2. LAKES**	**Annex V 1.1.3. TRANSITIONAL WATERS**	**Annex V 1.1.4. COASTAL WATERS**
BIOLOGICAL ELEMENTS			
• *Composition and abundance of aquatic flora*[3] • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora*[4] • *Composition and abundance of benthic invertebrate fauna* • *Composition, abundance and age structure of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora*[5] • *Composition and abundance of benthic invertebrate fauna* • *Composition and abundance of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora*[5] • *Composition and abundance of benthic invertebrate fauna*
HYDROMORPHOLOGICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS			
• *Hydrological regime* ➔ *quantity and dynamics of water flow* ➔ *connection to ground water bodies* • *River continuity* • *Morphological conditions* ➔ *river depth and width variation* ➔ *structure and substrate of the river bed* ➔ *structure of the riparian zone*	• *Hydrological regime* ➔ *quantity and dynamics of water flow* ➔ *residence time* ➔ *connection to the ground water body* • *Morphological conditions* ➔ *lake depth variation* ➔ *quantity, structure and substrate of the lake bed* ➔ *structure of the lake shore*	• *Tidal regime* ➔ *freshwater flow* ➔ *wave exposure* • *Morphological conditions* ➔ *depth variation* ➔ *quantity, structure and substrate of the bed* ➔ *structure of the intertidal zone*	• *Tidal regime* ➔ *direction and dominant currents* ➔ *wave exposure* • *Morphological conditions* ➔ *depth variation* ➔ *structure and substrate of the coastal bed* ➔ *structure of the intertidal zone*
CHEMICAL AND PHYSICOCHEMICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS			
• *General* ➔ *thermal conditions* ➔ *oxygenation conditions* ➔ *salinity* ➔ *acidification status* ➔ *nutrient conditions* • *Specific pollutants* ➔ *pollution by priority substances identified as being discharged into the body of water* ➔ *pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *transparency* ➔ *thermal conditions* ➔ *oxygenation conditions* ➔ *salinity* ➔ *acidification status* ➔ *nutrient conditions* • *Specific pollutants* ➔ *pollution by priority substances identified as being discharged into the body of water* ➔ *pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *transparency* ➔ *thermal conditions* ➔ *oxygenation conditions* ➔ *salinity* ➔ *nutrient conditions* • *Specific pollutants* ➔ *pollution by priority substances identified as being discharged into the body of water* ➔ *pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *transparency* ➔ *thermal conditions* ➔ *oxygenation conditions* ➔ *salinity* ➔ *nutrient conditions* • *Specific pollutants* ➔ *pollution by priority substances identified as being discharged into the body of water* ➔ *pollution by other substances identified as being discharged in significant quantities into the body of water*

[3] Phytoplankton is not explicitly included in the list of quality elements for rivers in Annex V, 1.1.1, but is included as a biological element in Annex V, 1.2.1. It should therefore be possible to use phytoplankton as a separate element, if needed and appropriate especially in low land large rivers where phytoplankton may be important. The other aquatic flora specifically referred to in the normative definitions for rivers (Annex V 1.2.1) are macrophytes and phytobenthos.

[4] The other aquatic flora specifically referred to in the normative definitions for lakes (Annex V 1.2.2) are macrophytes and phytobenthos.

[5] The other aquatic flora specifically referred to in the normative definitions for transitional waters and coastal waters (Annex V 1.2.3 and Annex V 1.2.4) are macroalgae and angiosperms.

3.3 Member States must monitor parameters indicative of the condition of biological quality elements as part of their monitoring programmes (see WFD Annex V Sections 1.3.1 and Sections 1.3.2). The WFD requires the assessment of the ecological status or /potential class of a water body to be based on the estimate of the condition of the quality element provided by these monitored parameters. In some circumstances, achieving a reliable assessment of the condition of a particular biological quality element may require consideration of the monitoring results for several parameters indicative of that element. A list with all parameters and quality elements is presented in Table 1, but this list could be interpreted in different ways. Therefore in addition Table 1a illustrates, with examples, the understanding of the definitions of parameters, quality elements and groups of quality elements. Further examples of parameters indicative of the condition of the biological quality elements are provided with Table 2.

Table 1a. Examples illustrating the meaning of parameters, quality elements and groups of quality elements, based on the list in WFD Annex V, 1.1; the tables in Annex V, 1.2; and the monitoring requirements in Annex V, 1.3.

Groups of Quality Elements	**Examples of Quality Elements**	**Examples of parameters**
General physico-chemical elements	Oxygenation conditions	COD, BOD, Dissolved oxygen (see point 12 of Annex VIII)
Non-priority, specific pollutants	Copper discharged in significant quantities	Concentrations of copper in water, sediment **or** biota
Hydromorphological elements	Hydrological regime	Quantity of flow, dynamics of flow
Biological elements	Composition and abundance of benthic invertebrate fauna	Composition, abundance (for further examples see Table 2)

3.4 Examples of the sorts of parameters that may be useful in estimating the condition of a biological quality element are given with Table 2. Table 2a provides recommendations on how and under what circumstances monitoring results for parameters indicative of a particular biological quality element may be combined, particularly if pressure related multi metric approaches are used. Further details are given in Annex I of this document.

Table 2: Examples of the sorts of parameters that may be useful in estimating the condition of a biological quality element

(a) Example Biological Quality Element	**(b) Example (type-specific) conditions specified for the element at good status**	**(c) Examples of indicative parameters (metrics) based on measurements of composition and abundance**	
Benthic Invertebrate Fauna (rivers)	THERE MUST BE NO MORE THAN SLIGHT CHANGES IN COMPOSITION AND ABUNDANCE THERE MUST BE NO MORE THAN SLIGHT CHANGES IN THE RATIO OF DISTURBANCE SENSITIVE TAXA TO INSENSITIVE TAXA THERE MUST BE NO MORE THAN SLIGHT SIGNS OF ALTERATION TO THE LEVEL OF DIVERSITY	Presence or absence of particular species or groups of species Overall richness or richness of particular taxonomic groups Relative number of taxa in particular taxanomic groups Abundance of particular species or groups of species Relative abundance of particular species or groups of species Overall diversity, or diversity within particular taxonomic groups	Taxa could be selected and/or grouped by known sensitivity/tolerance, feeding type, habitat preferences, etc

Table 2a. Guidance on combining parameters to estimate the condition of the biological quality element through operational monitoring, if pressure related multi metric approaches are used (i.e. use of multi-metric indices to assess whether the element has been affected by the pressures to which the water body is subject)
(i) Any number of parameters (see column c in Table 2) that are indicative of the biological quality element and relevant to assessing the effects of particular pressures may be combined, for example, by averaging their results. Combining parameters can help reduce the risk of misclassification by improving confidence in the assessment. (ii) Parameters that are sensitive to different pressures should not be combined unless they are also considered independently, since averaging results for non-sensitive and sensitive parameters may conceal failures to meet the relevant type-specific conditions (see column b in Table 2 and point v below). (iii) **The results for parameters likely to respond to a range of pressures may also be combined to estimate the condition of a biological quality element** (iv) The combination of parameters **indicative of the biological quality element** is optional, and the results for individual indicative parameters may be used directly to estimate whether the condition of the biological quality element meets the relevant type-specific conditions. (v) The results for several parameters or groups of parameters, each sensitive to a different pressure, or set of pressures, may be used in estimating the condition of the biological quality element. A one-out, all-out rule, rather than averaging, should be applied in this case such that the condition of the biological quality element is determined by whichever of the grouped or ungrouped parameters sensitive to the different pressures shows the greatest anthropogenic disturbance.

3.5 Figure 3 illustrates the relationship between biological quality elements and indicator parameters and their use in classification decisions. The example in the upper part of the figure illustrates the results for individual parameters of a biological quality element like phytobenthos with general sensitivity to a broad range of pressures (e.g. pressures resulting in morphological and hydrological changes as well as in changes to nutrient conditions). Parameters may be combined by, for example, averaging or weighting (see Section 6 of Annex I to this guidance) to estimate the status of the quality element.

3.6 The second example in Figure 3 illustrates the procedure of combining parameters, if pressure-related, multi-metric approaches are used. Under this approach, individual parameters indicative of the effects of a particular type of pressure on a biological quality element are identified. Where several parameters responsive to the same pressure are identified, these may be grouped and the results for individual parameters in the group combined in order to increase confidence in the assessment of the impact of that pressure on the quality element. If several groups of parameters are identified, each indicating the effects of a different pressure on the quality element, the status of the quality element will be indicated by the results for the group that indicates the greatest impact on the element. However, if the parameters in a group are actually responding to the effects of a range of pressures on the quality element (see paragraph 3.5 above) or there is low confidence in the results for a group of parameters, such pressure-related, multi-metric approaches may not be possible. In such cases, where the groups of parameters are not clearly signalling how the quality element has been affected by different pressures, the approach outlined in paragraph 3.5 and the upper part of Figure 3 may be more appropriate.

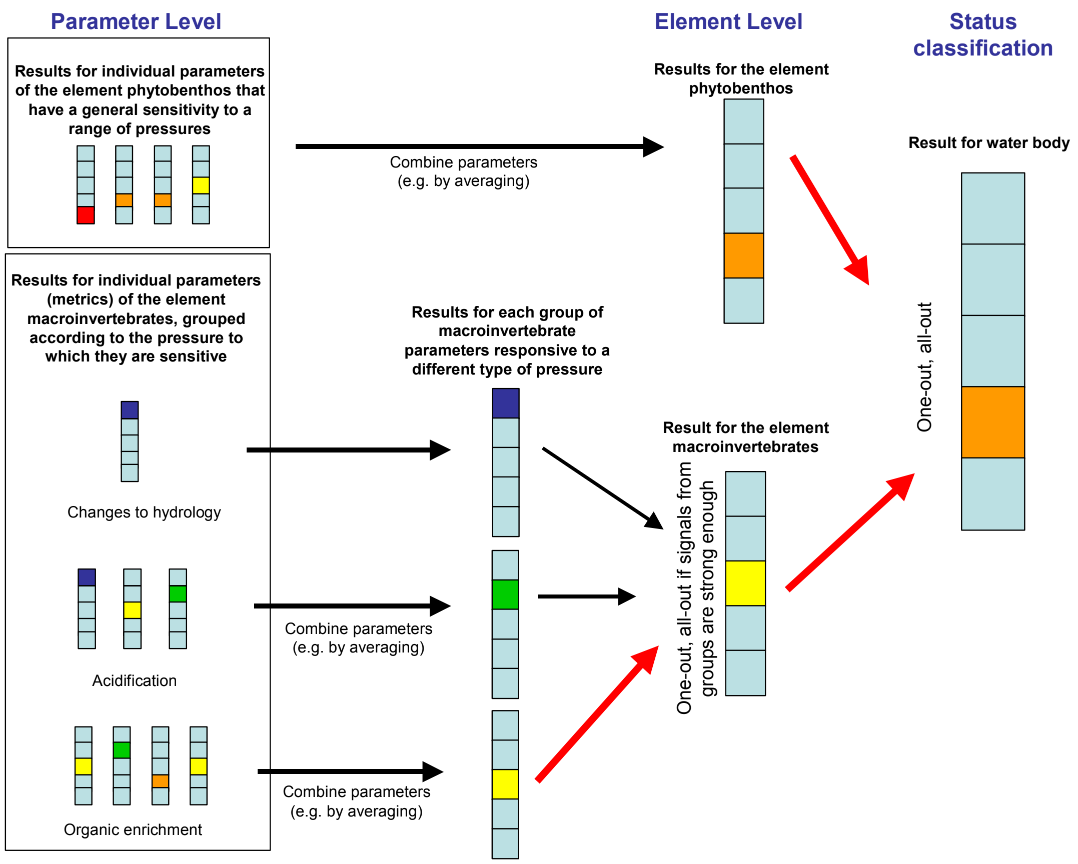

Figure 3. Examples of how indicative parameters may be combined to estimate the condition of the biological quality elements. The one-out all-out principle has to be used on the quality element level as indicated with the phytobenthos example.

3.7 The WFDs normative definitions for ecological status and potential also describe the conditions required for the general physico-chemical quality elements and the specific pollutants at good status/potential. The general physico-chemical quality elements should not reach levels outside the range established to ensure ecosystem functioning and the achievement of the values specified for the biological quality elements [See point (a) in the middle box in Figures 1 and 2]. The concentrations of specific pollutants should not exceed environmental quality standards (EQSs) set in accordance with WFD Annex V, Section 1.2.6 [See Figure 4].

3.8 It has been agreed under the Common Implementation Strategy (CIS) that once environmental quality standards have been adopted at Community-level for the priority substances (WFD Art. 16, Annex X), the concentrations of these substances in water bodies should only be taken into account in the classification of **surface water chemical status** and not in the classification of ecological status/potential. This does not affect the overall classification of a water body because for good surface water status, both ecological and chemical status must be good. However, if any of the biological quality elements are found, from biological monitoring, to be showing adverse effects from exposure to priority substances (e.g. direct ecotoxicological effects), these effects must be taken into account when classifying ecological status/potential.

3.9 Similarly, compliance with EQSs for other substances for which EQSs have been set at Community level (e.g. substances relevant to the Directives listed in Annex IX of the WFD, see Annex V, 1.4.3) should also be taken into account in the classification of surface water chemical status and not in the classification of ecological status/potential.

3.10 For the purpose of assessing ecological status/potential, the specific pollutants listed in WFD Annex V, 1.1 and 1.2 (“specific synthetic pollutants” and “specific non-synthetic pollutants”) must be considered and for good status/potential the environmental quality standards established for them at Member State-level using the procedure set out in Annex V 1.2.6 must be met (like list II substances under the Dangerous Substances Directive (76/464). In addition to the general approach presented in the IMPRESS guidance (WFD CIS Guidance Document No. 3), specific guidance on the selection of those substances may be prepared by EAF Priority Substances.

4. The Role of the General Physico-chemical Quality Elements in the Ecological Classification of Good and Moderate Status/Potential

4.1 For the general physico-chemical elements, the WFD Annex V, Tables 1.2.1 – 1.2.5 specify that for good ecological status/potential to be achieved **the values for the general elements must not reach levels outside the range**[6] **or exceed the levels**[7] established so as to ensure:

(a) The functioning of the (type specific) ecosystem; and

(b) The achievement of the values specified for the biological quality elements.

> **WFD Annex V, Section 1.2**
> General definitions for rivers, lakes, transitional waters and coastal waters for **Good status/potential** for "General Conditions":
> *Temperature (R, L, T, C)*[8]*, oxygen balance (R, L, T, C)*[8] *, pH (R, L)*[8]*, acid neutralising capacity (R, L)*[10] *transparency (L, T, C)*[8] *and salinity (R, L)*[8] *do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements.*
> *Nutrient concentrations (R, L, T, C)*[8]*, do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.*

4.2 The ranges and levels established for the general physico-chemical quality elements must support the achievement of the values required for the biological quality elements at good status or good potential, as relevant. Since the values for the biological quality elements at good status will be type-specific, it is reasonable to assume that the ranges and levels established for the general physico-chemical quality elements should also be type-specific. Several types may share the same ranges or levels for some or all of the general physico-chemical quality elements (Figure 4).

[6] Applies for transparency, thermal conditions, oxygenation conditions, salinity and acidification status
[7] Applies for nutrient conditions
[8] R = applies for rivers; L = applies for lakes; T = applies for transitional waters; C = applies for coastal waters

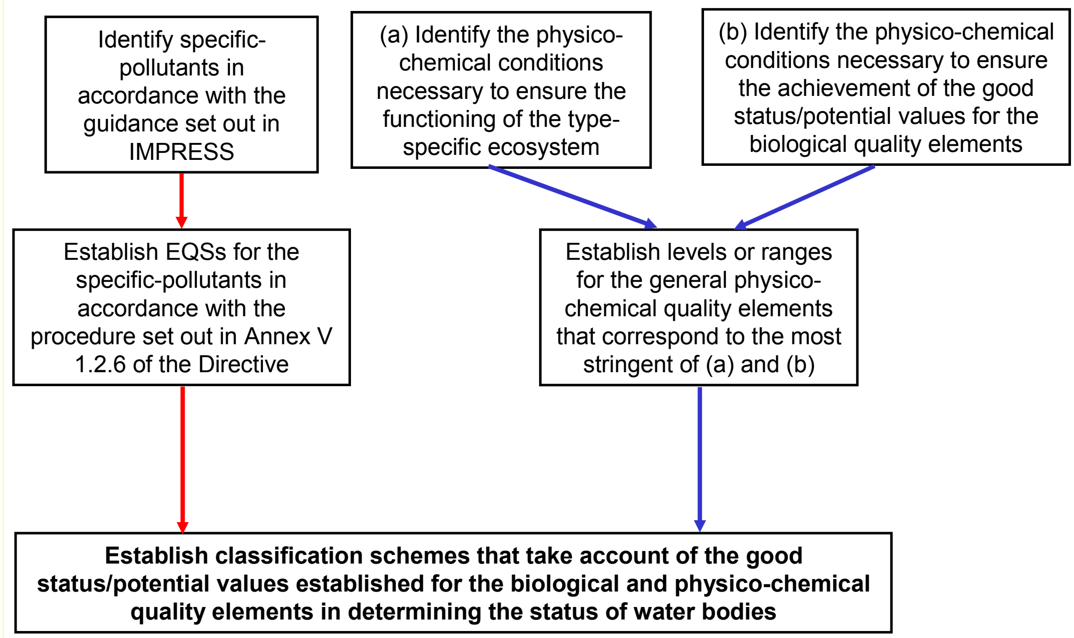

Figure 4. The establishment of ranges and levels for the physico-chemical quality elements at good ecological status/potential. Cases (a) and (b) should be recognised, but from practical reasons it is proposed to establish only one range or level including both aspects.

4.3 If the monitoring results for both the biological quality elements and the general and specific physico-chemical quality elements in a water body meet the conditions required for good ecological status/potential, the overall ecological status/potential of the water body will be good. However, if one or more of the general physico-chemical quality elements or specific pollutants do not meet the conditions required for good ecological status/potential but the biological quality elements do, the overall ecological status/potential will be moderate.

4.4 The following sections outline a checking procedure designed to ensure that the type-specific values established for the general physico-chemical quality elements are no more or no less stringent than required by the WFD, and hence do not cause water bodies to be wrongly downgraded to moderate ecological status or potential. The checking procedures apply only in relation to values for the good-moderate status/potential boundaries. They apply where Member States are confident that there is a real mismatch between the monitoring results for the biological and general physico-chemical quality elements, and not just a mismatch resulting from uncertainties from monitoring. For example, this will usually require evidence that there is a consistent mismatch from a significant number of water bodies in the type. In checking whether the physico-chemical ranges are valid, there is a balance between the scale of the discrepancy that can be demonstrated and the number of sites where the physico-chemical data and the biological data are not compatible. For example, where there are only a few sites monitored, it will be possible only to confirm large discrepancies. Even where the checking procedure applies, it may not be appropriate to revise the level or ranges using the checking procedures if the established levels or ranges are being exceeded because of temporary alterations to the values for the general physico-chemical conditions due to unusual natural conditions, such as prolonged droughts or flooding.

4.5 In individual water bodies, there will be cases where the monitoring results for the biology are good but the results for the general physico-chemical quality elements appear, at face value, to be less than good (i.e. the ranges or levels established for the type appear to have been exceeded). Because of the statistical errors in sampling and analysis described in section 3.3 in Annex I of this document, this situation could be common even though the physico-chemical ranges are thought to be valid. In these cases, Member States may decide to classify the body as less than good only when they have checked that the statistical confidence that the general physico-chemical elements are really less than good is adequate. Where it is not, Member States may take steps to improve confidence, for example, by doing more monitoring.

4.6 The ranges or levels that Member States establish for the general physico-chemical quality elements should be as ecologically relevant as current expert knowledge permits. Specifically, Member States should establish levels or ranges that they consider would, if not exceeded, ensure the functioning of the type-specific ecosystem and the achievement of good status/potential values specified in WFD Annex V, Tables 1.2.1 – 1.2.5 for the biological quality elements.

4.7 In addition to enabling classification, the establishment of ranges or levels for the general physico-chemical quality elements will be needed by Member States to set appropriate controls on discharges liable to adversely affect the general physico-chemical conditions and hence the achievement of the values specified for the biological quality elements at good status/potential or the functioning of the ecosystem.

4.8 The initial levels or ranges established by Member States are likely to be based on an incomplete knowledge of the general physico-chemical conditions needed to ensure the functioning of the type-specific ecosystem and the achievement of the good status/potential values for the biological quality elements. Member States may therefore wish to revise the levels and ranges established for the types as their knowledge improves through the river basin planning cycles.

4.9 There may be cases where the levels or ranges proposed for a general physico-chemical quality element in a type are being exceeded as a result of anthropogenic alterations to the conditions of the general physico-chemical quality elements but no biological impacts are being detected. In such cases, it is recommended that a checking procedure should be undertaken. This procedure should be used to assess whether the established type-specfic levels or ranges for the elements are more stringent than is necessary to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements at good status/potential. An outline checking procedure is presented in Figure 5.

4.10 The mismatch between the biological monitoring results and the general physico-chemical monitoring results may be because the biological methods being used in monitoring are not sensitive to the effects of anthropogenic changes in the condition of the physico-chemical quality element. In such cases, improvements to the biological methods should be made on an on-going basis with the aim of developing methods that are sufficiently sensitive. This improvement work should not stop after the first classification decisions are made.

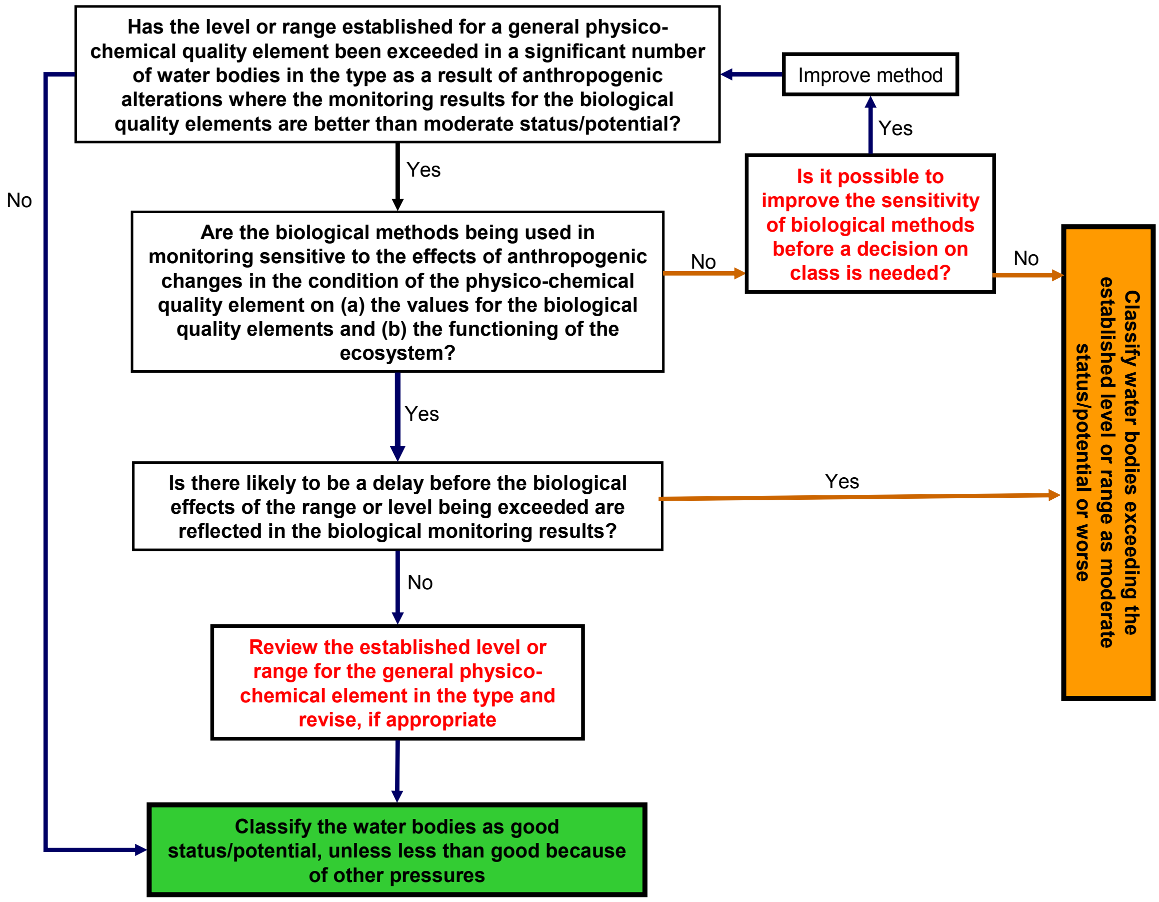

Figure 5. *Checking procedure for assessing whether a level or range established for a general physico-chemical quality element is more stringent than required by the WFD, according to the normative definitions of ecological status/potential.*

4.11 Water bodies in which an established level or range for a general physico-chemical quality element is exceeded should be classified as moderate status/potential or worse unless the established level or range for the type is revised as a result of the checking procedures outlined in Figure 5.

4.12 In establishing and revising the ranges or levels for the general physico-chemical quality elements, Member States should ensure that the same level of protection as provided for under existing Community legislation is guaranteed.

4.13 A checking procedure, such as that illustrated in Figure 6, could be used where the levels or ranges proposed for a general physico-chemical quality element in a type are not exceeded but, because of anthropogenic alterations to the general physico-chemical conditions:

(a) The good status/potential values for the biological quality elements in water bodies in the type are not being met; or
(b) There is evidence of impairment to ecosystem functioning in water bodies in the type.

In this case, the checking procedure would assess whether the established levels or ranges for the general physico-chemical quality elements:

(a) Met the Directive's requirements; or
(b) Were insufficiently stringent to ensure the functioning of the ecosystem and the achievement of the good status/potential values for the biological quality elements.

The procedure would not be applicable where temporary alterations to the physico-chemical conditions had occurred because of unusual natural conditions, such as prolonged droughts or flooding.

4.14 The purpose of the procedure is to check whether there is a need to review the ranges or levels established for the type. If a review is initiated, this may not always indicate that a revision of the established levels or ranges is appropriate. For example, it may not be appropriate to revise the ranges or levels where:

(a) The biological monitoring results are detecting the effects on the biology of intermittent anthropogenic alterations to the physico-chemical conditions but the actual alterations to the physico-chemical conditions are not being detected by monitoring of the general physico-chemical quality elements. Instead, it may be appropriate to change the sampling design; or

(b) The biological elements are responding to the combined effects of alterations to a number of different general physico-chemical quality elements (e.g. the combined effects on the biological elements are greater or lower than would be the effects of alterations to only one of the physico-chemical quality elements). In such cases, however, it may be possible to devise a level or range for the general physico-chemical quality element that takes account of combination effects.

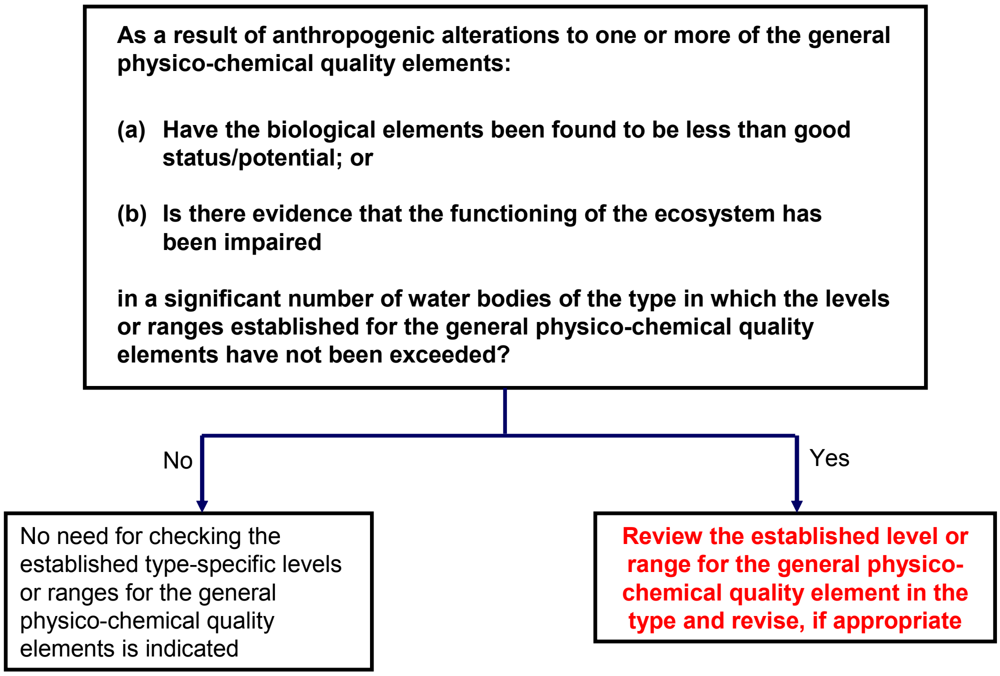

Figure 6. *Checking procedure to assess whether a level or range established for a general physico-chemical quality element is insufficiently stringent to meet the Directive's requirements, according to the normative definitions of ecological status/potential.*

4.15 Member States are recommended to keep in mind when applying the checking procedures that physico-chemical methods have been developed over a long period of time and may, at first stage, give a better, more reliable indication of ecological impact than some less well tried and tested biological methods. This does not mean that physico-chemical methods can ever replace biological methods. Both are required by the WFD.

4.16 For each planning cycle, it is recommended that Member States should complete the checking procedures in sufficient time to enable the classification of water bodies and the design of suitable programmes of measures.

4.17 To support the proposed practical approach, the relevant box in the general Figures 1 and 2 on ecological classification should be expanded for clarification as illustrated in Figure 7 below:

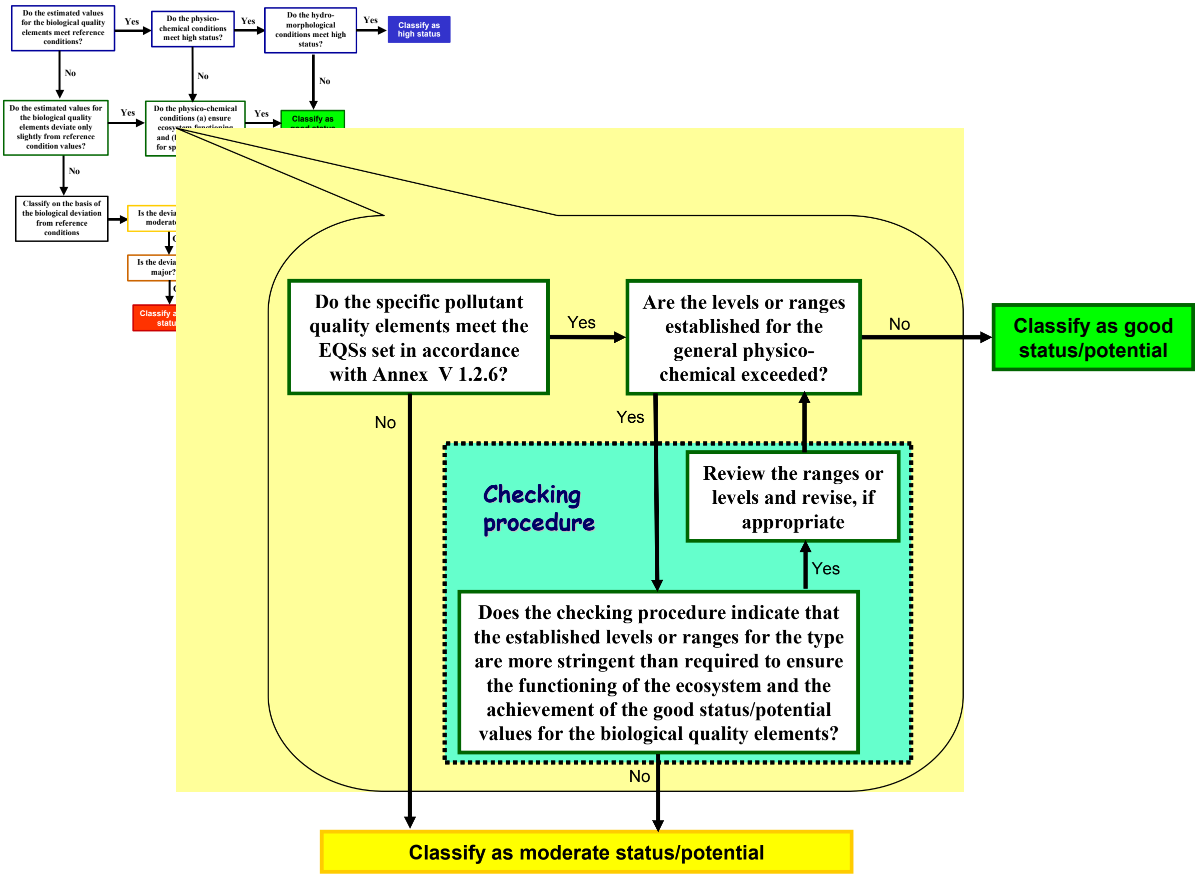

***Figure** 7. Elaboration of second box in the good status/potential line of the ecological classification diagrams (see Figures 1 and 2). Details of the checking procedure are given in Figure 5 and paragraphs 4.3 – 4.9.*

4.18 It is important to note that the use of non-biological indicators for estimating the condition of a biological quality element may complement the use of biological indicators in groups of bodies, as for example in the way described below, <u>but it cannot replace it</u>. Representative biological monitoring is required by the WFD (see WFD CIS Guidance Document No. 7). Where a reliable dose response relationship has already been established between the condition of a biological element and that of a general physico-chemical quality element, monitoring results for the physico-chemical quality element could, in certain circumstances, provide for a reliable estimate of the condition of the biological element. For example, imagine groups of similar water bodies subject to pressures that may affect their pH, such as lakes in Norway, Scotland, Finland and Sweden. If the dose response relationship between pH and the condition of a biological element is well established and there are no confounding effects of other pressures, it may be possible to estimate the condition of the biological elements in the water bodies in the group by monitoring (a) biological parameters in a few of the water bodies to check the dose response relationship is correct for that group, and (b) by monitoring pH in a sufficient proportion of the bodies in the group to obtain sufficient data to enable the bodies to be classified as resource-efficiently as possible but still with an adequate level of confidence and precision.

5. Stepwise Approach for the Ecological Classification

5.1 Step 1: High Ecological Status (HES) and Maximum Ecological Potential (MEP)

5.1.1 WFD Annex II 1.3 requires Member States to establish type-specific biological, hydromorphological and physico-chemical conditions representing the values defined in Tables 1.2.1 – 1.2.5 of Annex V for HES or MEP.

5.1.2 A slightly different approach has to be used for natural and HMWBs or AWBs according to Figures 1 and 2. Generally, the assessment of whether a HMWB or an AWB is at MEP should start with an assessment of whether the condition of the hydromorphological quality elements is consistent with the condition expected for them if all mitigation measures were taken to ensure the best approximation to ecological continuum.

5.1.3 The mitigation measures must be compatible with the use for which the water body is designated (see Section 4.1.3), making them and the resulting values for MEP hydromorphology potentially very specific to particular water bodies or groups of water bodies. Since the MEP hydromorphology dictates the MEP biological and physico-chemical conditions, it is appropriate in the case of those HMWBs and AWBs that may be at MEP to check if their hydromorphology is at MEP before considering the condition of the other quality elements.

5.1.4 Only if the values for all the biological, hydromorphological and physico-chemical quality elements reflect their type-specific conditions can the resulting class be high ecological status or MEP.

Biological Quality Elements

5.1.5 For natural water bodies, the values of the relevant biological quality elements at high status reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion; i.e. the biological quality elements correspond totally, or nearly totally, to undisturbed conditions (HES).

5.1.6 For HMWBs and AWBs, the values of the relevant biological quality elements at MEP, reflect, as far as possible given the MEP values for the hydromorphological and associated physico-chemical conditions, those of the closest comparable surface water body type.

Physico-chemical Quality Elements

5.1.7 For natural water bodies, the values for the **general physico-chemical quality elements** at high ecological status correspond totally or nearly totally to undisturbed conditions. A further qualification specifies that the values for the physico-chemical quality elements must remain within the ranges normally associated with undisturbed conditions.

5.1.8 For HMWBs and AWBs, the MEP values for the general physico-chemical quality elements are derived from the ”undisturbed conditions” for the surface water body type most closely comparable to the HMWB or AWB concerned, given the MEP values for the hydromorphological conditions. The CIS guidance on HMWBs and AWBs (WFD CIS Guidance Document No. 4) recognises that in the case of some MEP values for the hydromorphological conditions, the values for some of the general physico-chemical quality elements will be very different to those of the closest comparable type. The guidance therefore suggests that, provided the differences are an inevitable and direct result of the MEP values for the hydromorphological conditions, they may be taken into account when establishing the MEP values for the general physico-chemical quality elements. The following example illustrates how to define MEP physico-chemical reference conditions: The hydromorphological characteristics of impoundment created for hydropower and water supply can dictate the oxygen and temperature conditions in the impounded water and the downstream river. These may be different from those in a natural water body. These differences can be taken into account when defining MEP.

5.1.9 The specific pollutant quality elements have been subdivided into **specific synthetic pollutants** and **specific non-synthetic pollutants**. For HES/MEP to be achieved the concentrations of the specific synthetic pollutants must be close to zero and at least below the limits of detection of the most advanced analytical techniques in general use. The concentrations of the specific non-synthetic pollutants must be within the range normally associated with undisturbed conditions. IMPRESS provides guidance on the identification of specific pollutants (WFD CIS Guidance Document No. 3).

Hydromorphological Quality Elements

5.1.10 For **HES,** the values for the hydromorphological quality elements correspond totally or nearly totally to undisturbed conditions.

5.1.11 For **MEP,** the hydromorphological conditions are consistent with the only impacts on the surface water body being those resulting from the characteristics of the HMWB or AWB once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds. The mitigation measures should not include those that would have a significant adverse effect on the specified uses of the water body or the wider environment.

5.2 Step 2: Good Ecological Status (GES) and Good Ecological Potential (GEP)

5.2.1 For natural and HMWBs or AWBs the same approach has to be used according to Figures 1 and 2.

5.2.2 Only if the values for the biological and physico-chemical quality elements reflect, as relevant, the values defined for GES or GEP should a water body be classified as GES or GEP.

Biological Quality Elements

5.2.3 For natural water bodies, the values of the relevant biological quality elements for the surface water body show low levels of distortion resulting from human activity, but deviate only slightly[9] from those normally associated with the surface water body type under undisturbed conditions (HES).

5.2.4 For an HMWB or AWB to be classified as being at GEP there must be no more than slight changes in the values of the relevant biological quality elements as compared to their values at MEP.

Physico-chemical Quality Elements

5.2.5 For a water body to be classified as being at GES/GEP, the values for the **general physico-chemical quality elements** must comply with the ranges or levels established so as to ensure:

(a) the functioning of the type specific ecosystem; and

(b) the achievement of the values specified for the relevant biological quality elements.

5.2.6 Where the levels or ranges proposed for a general physico-chemical quality element in a type are being exceeded, a checking procedure should be used to assess whether the established levels or ranges for the elements are more stringent than is necessary to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements at good status/potential. An outline checking procedure is presented in Figure 5. Similarly, where the levels or ranges proposed for a general physico-chemical quality element in a type are not exceeded but, because of anthropogenic alterations to the general physico-chemical conditions:

(a) The good status/potential values for the biological quality elements are not being met; or

(b) There is evidence of impairment to ecosystem functioning

A second checking procedure could be used as a means of assessing whether the established levels or ranges meet the WFDs requirements or are insufficiently stringent to ensure the functioning of the ecosystem and the achievement of the good status/potential values for the biological quality elements. An outline checking procedure is presented in Figure 6.

[9] The meaning of slight deviation is being considered as part of the intercalibration exercise.

5.2.7 GES/GEP also requires that the concentrations of the **specific pollutant quality elements** are not in excess of the EQS set at Member State level in accordance with the procedure laid down in WFD Annex V, Section 1.2.6.

Hydromorphological Quality Elements

5.2.8 The conditions of the hydromorphological quality elements at GES and GEP must be consistent with the achievement of the values specified for the relevant biological quality elements at GES/GEP level.

5.3 Step 3: Moderate Ecological Status and Moderate Ecological Potential

5.3.1 For natural, HMWBs or AWBs the same approach has to be used according to Figures 1 and 2. A water body should be classified as moderate status/potential where:

(a) The values for the biological quality elements differ moderately[10] from the type specific communities;

(b) The values for the biological quality elements differ moderately and the physico-chemical quality element values are less than good or;

(c) The values for the biological quality elements are better than moderate but the physico-chemical quality element values are less than good.

5.3.2 If the biological quality elements are at moderate status or potential, the condition of the physico-chemical and hydromorphological quality elements must, by definition, be consistent with the achievement of those biological values.

5.3.3 If the biological quality elements reflect GES/GEP, but the values of the general physico-chemical quality elements do not ensure the functioning of the type specific ecosystem or the concentrations of one or more of the specific pollutant quality elements are not in compliance with relevant EQSs, the resulting ecological status/potential is "moderate" (see chapter paragraph 5.2.6).

[10] The meaning of moderate deviation is being considered as part of the intercalibration exercise.

5.4 Step 4: Poor Ecological Status (PES) and Poor Ecological Potential (PEP)

5.4.1 For natural, HMWBs or AWBs the same approach has to be used according to Figures 1 and 2.

5.4.2 In accordance with WFD Annex V, Section 1.2, if the values for the relevant biological quality elements show evidence of major alteration from their type specific values [i.e. the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions], the water body must be classified as ”poor”. The decision on whether a water body is at PES/PEP or not is dictated by the condition of the biological quality elements. The condition of the physico-chemical and hydromorphological quality elements only affects that decision indirectly through their influence on the condition of the biological elements.

5.5 Step 5: Bad Ecological Status (BES) and Bad Ecological Potential (BEP)

5.5.1 For natural, HMWBs or AWBs the same approach has to be used according to Figures 1 and 2.

5.5.2 In accordance with WFD Annex V, Section 1.2, if the values for the relevant biological quality elements show evidence of severe alteration from their type specific values [i.e. large portions of the relevant biological communities normally associated with the type are absent], the water body must be classified as bad”. The decision on whether a water body is at BES/BEP or not is dictated by the condition of the biological quality elements. The condition of the physico-chemical and hydromorphological quality elements only affects that decision indirectly through their influence on the condition of the biological elements.

6. Presentation of Monitoring Results and Mapping of the Ecological Status and Ecological Potential

6.1 WFD Annex V, Section 1.4.2 (i, ii) requires that the ecological status/potential classification for a body of surface water be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements as indicated in Figures 1 and 2. The monitoring results for the physico-chemical quality elements must therefore be taken into account when classifying surface water bodies.

6.2 WFD Annex V, Section 1.4.2 (iii) requires Member States to also indicate, by a black dot on the map, those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards (EQS) which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants (in accordance with the compliance regime established by the Member State). So for example, if a water body is classified as moderate ecological status/potential because of a failure to achieve an EQS for a specific pollutant, this must be reported by (a) colouring the water body yellow in the maps included in the river basin management plan and (b) indicating, using a black dot, that the reason for classifying the body as moderate status/potential is non-compliance with the requirements for specific pollutants.

6.3 The analysis set out in the sections above concludes that the WFD requires the establishment of, and compliance with, specific values for the physico-chemical quality elements for the HES and GES classes as well as for the MEP and GEP. For the lower ecological status/potential classes (i.e. moderate, poor and bad status/potential) it only appears to require the establishment of, and compliance with, values for the biological quality elements. Where monitoring results indicate that the condition of the physico-chemical quality elements is worse than good, the status/potential class assigned to the water body must also be less than good, and should be determined with reference to the type specific condition of the biological quality elements as outlined in Figures 5 and 6.

WFD Annex V, Section 1.4.2: Presentation of monitoring results and classification of ecological status and ecological potential

(i) *For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below:*

Ecological Status Classification	***Colour Code***
High	*Blue*
Good	*Green*
Moderate	*Yellow*
Poor	*Orange*
Bad	*Red*

(ii) *For heavily modified and artificial water bodies, the ecological potential classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in accordance with the first column of the table set out below:*

Ecological Potential Classification	***Colour Code***		
		AWBs	***HMWBs***
Good and above	*Equal green and…*	*light grey stripes*	*dark grey stripes*
Moderate	*Equal yellow and…*	*light grey stripes*	*dark grey stripes*
Poor	*Equal orange and..*	*light grey stripes*	*dark grey stripes*
Bad	*Equal red and…*	*light grey stripes*	*dark grey stripes*

(iii) *Member States shall also indicate, by a black dot on the map, those bodies of water where failure to achieve good status … is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants (in accordance with the compliance regime established by the Member State).*

7. Conclusions

1. The normative definitions of the WFD (Annex V, Table 1.2) provide the basis for classifying the ecological status or potential of surface water bodies, and each Member State must develop classification systems that conform to these definitions. Biological as well as supporting hydromorphological and physico-chemical quality elements are to be used by Member States in the assessment of ecological status/potential. The relative roles of these elements are illustrated in Figures 1 and 2. The estimates of the condition of the biological quality elements provided by the monitored parameters should be used in classification decisions. The monitoring results for several parameters may be combined, where appropriate, to provide these estimates.

2. The use of non-biological indicators for estimating the condition of a biological quality element may complement the use of biological indicators but it cannot replace it.

3. Deciding if a particular ecological status or potential class can be assigned to a water body depends on whether the quality element worst affected by anthropogenic alterations matches its normative definition for that class. In short, the classification scheme is a one-out, all-out scheme at the level of the quality elements.

4. The condition of a biological element, such as benthic invertebrates, may be estimated using one or more parameters that are indicative of that element, bearing in mind the normative definitions for the element. Where more than one parameter is monitored, the results for each may be combined to estimate the condition of the element. This may be achieved by averaging, unless the parameters are sensitive to different pressures. In the latter case, the condition of the element should be estimated by the results for the worst affected parameter, or group of parameters, indicative of the effects of different pressures on the element.

5. The condition of the biological element estimated to be worst affected by anthropogenic alterations will dictate the class that can be assigned to the water body, unless the monitoring results for the physico-chemical or hydromorphological quality elements indicate a lower class (see Figures 1 and 2).

6. A decision to assign a water body to the good status/potential class rather than the moderate status/potential class should be made on the basis of the relevant biological and physico-chemical results. The ecological status/potential class is represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements.

7. Where the levels or ranges proposed for a general physico-chemical quality element are being exceeded as a result of anthropogenic alterations to the conditions of the general physico-chemical quality elements but no biological impacts are being detected in a significant number of water bodies in a type, it is recommended that a checking procedure should be undertaken. This procedure should be used to assess whether the established type-specific levels or ranges for the elements are more stringent than is necessary to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements at good status/potential. In some cases it may be that the biological method is insufficiently sensitive. An improvement in the biological methods may be appropriate rather than a revision of the range or level established for the general physico-chemical quality element (Figure 5). Similarly, where the levels or ranges are not exceeded but, for example, the good status/potential values for the biological quality elements are not being met as a result of anthropogenic alterations to the general physico-chemical conditions, a second checking procedure could be used as a means of assessing whether the established levels or ranges are insufficiently stringent and consequently need to be revised to meet the WFDs requirements (Figure 6).

8. The specific synthetic and non-synthetic pollutants relevant to the classification of bodies at HES/MEP or GES/GEP (see Figures 1 and 2) do not include those pollutants for which relevant environmental quality standards have been established at Community-level. Guidance on identifying specific pollutants is provided in IMPRESS Guidance (WFD CIS Guidance Document No. 3)**.**

8 References

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Annex I: Technical Approach on Achieving and Reporting Adequate Confidence and Precision in Classification

1. Introduction

1.1 This annex provides guidance on getting better conclusions from monitoring data by using general statistical principles to manage errors. The approach deals mainly with the use of numeric data from operational monitoring in classification decisions. Appendix 1 looks at the surveillance monitoring programmes.

1.2 Information on the confidence and precision that can be achieved using particular methods and monitoring designs is not provided in this guidance. Other international initiatives focused on specific issues or monitoring methods may include such information [e.g. OSPAR (www.ospar.org); FAME (www.fame.boku.ac.at); AQEM (www.aqem.de); STAR (www.eu-star.at); ECOFRAME (Contact Brian Moss, Liverpool University UK); CEN (http://www.cenom.be/cenom/index.htm)]

1.3 In an ideal world with comprehensive monitoring data containing no errors, water bodies would always be assigned correctly to their true class with 100 per cent confidence. But estimates of the truth based on monitoring data are subject to error if monitoring is not done everywhere and all the time, and because monitoring systems, equipment and people are less than perfect. A key recommendation of this guidance is that Member States estimate and report (see Section 9) the risk that a water body is assigned to the wrong class because of the errors in monitoring data.

1.4 Managing the risk of misclassification is important because of the potential to waste resources on water bodies that have been wrongly downgraded or to fail to act because a water body has been wrongly reported as better than it is.

2. Background

2.1 In general, the risk of misclassification is likely to be lower if the quality element is in truth, nearer the middle of the class than the class boundaries. The consequence of this is that enhanced monitoring is likely to be needed for water bodies close to the good-moderate class boundary.

2.2 The results of the pressures and impacts analysis will be used to help design, and subsequently refine, the monitoring programmes and, in turn, information from the monitoring programmes will be used to improve the analysis of which bodies are at risk of failing to achieve their objectives (see Section 2.1.2 WFD CIS Guidance Document No 3 & Section 2.2 WFD CIS Guidance Document No. 7).

2.3 One of the reasons a water body may be identified as being at risk is if the pressures and impacts analysis suggests that it is currently less than good status. Once identified as being at risk, the water body must be considered within the operational monitoring programme for the river basin district, although it may be grouped with other bodies at risk for this purpose under certain conditions. The results of operational monitoring programme must be used to establish the status of the body.

2.4 If the results of monitoring subsequently provide adequate confidence that the status of the body is good or better and there is no significant risk of deterioration in the body's status, the body would no longer need to be considered as being at risk of failing to achieve its status objectives. The results of the pressures and impacts analysis could be updated accordingly. If, on the other hand, the results of operational monitoring confirmed, with adequate confidence, that the water body is less than good status the water body would remain at risk, and be subject to on-going consideration within the operational monitoring programme. It would also be subject to the application of suitable measures aimed at restoring its status to good.

2.5 The confidence in the results of operational monitoring may not always be adequate, and a Member State could find itself uncertain as to whether the body is at good status or not. An adequate level of confidence should be achieved in time to enable the achievement of the WFDs objectives.

3. Sources of error and their management

3.1 An estimate of the confidence and precision provided by the methods used in monitoring is necessary for assessing the confidence in the results of monitoring and the confidence that the class assigned to a water body is the true class. The need for such estimates should be an important consideration in the development and the application of methods.

3.2 There are several ways in which errors in a method can be estimated, one of which is to test the method using replicate sampling and simulations to produce quantitative estimates. In other cases, it may be appropriate to ask independent experts to provide a suitable estimate.

3.3 A water body can be subject to some or all of the following variations (or ways of describing variation), for whatever mixes of natural or other causes:

(a) Apparent random variations from second to second, minute to minute, or hour by hour;
(b) Diurnal patterns;
(c) Seasonal patterns;
(d) Longer term trends, cycles and random influences, including year to year variation;
(e) Step changes (random, regular or permanent);
(f) Variation with depth of water;
(g) Variation with location (spatial variation);
(h) Correlations with physical and other biological properties (though these can be thought of as causing the above);
(i) Serial correlation, for example, clusters of bad months or bad years;

(j) Bias and random errors from equipment; and

(k) Human error.

3.4 Subsequently in this Annex, where we refer to "error and uncertainty", we mean the outcome of all the factors listed in paragraph 3.3 that is produced when a monitoring programme is applied to a water body. This may take the form of a total error in the numerical results from monitoring and in the EQRs that are calculated from those results. The errors might be quantified as the standard deviation, standard error, error bands or confidence limits, or other in other ways by which scientists normally assign a range to the numerical values produced by monitoring. As discussed later (in paragraph 4.3 and Table 1), the probability that a water body is in a particular class is estimated as the proportion of the range in error that is cut by the boundaries of the class.

3.5 If measured everywhere and continuously, with an error-free monitor operated by infallible people, we get the full picture of the property and perfectly true and exact estimates of temporal and spatial distributions, or summary statistics like the mean and variance.

3.6 For any particular water body property one or more of variations may be large and others may be known to be absent. There is no need to determine all errors, only the dominant ones. For all monitoring systems, it is recommended that sources of error are analysed and quantified, for example, by replicate sampling programme, by the examination of long or extensive series of historic data, or by simulations.

3.7 For some biological parameters, we will be able to exploit the natural averaging that means we need not worry much about short term fluctuations and cycles [variations (a), (b) and (c) above] that do not damage the biology. For chemical parameters it will be more important to demonstrate lack of bias due to unrepresentative sampling against diurnal and seasonal cycles [variations (b) and (c) above], and to manage random temporal variation [variation (a) above] through statistical estimation of confidence limits on summary statistics like means and percentiles. Where the source of potential error is, for example, seasonal variation, [variation (c) above] this may be managed by selecting appropriate monitoring frequencies.

3.8 The spatial errors [variations (f) and (g) above] should also be quantified and managed, as far as possible, by an informed selection of monitoring sites. Failure of a sampling method and operator to capture or detect species actually present may produce errors that dominate. This source of error can be reduced by precisely defining sampling seasons, sampling methods, sorting procedures and identification levels supported by training and analytical quality control. Errors may also result if the biological method used is based on a taxonomic level that is, for example, insufficiently sensitive to the pressures.

4. The use of estimates of confidence in class

4.1 Information on confidence and precision in monitoring results will help quantify the uncertainty from errors and gaps in data, allowing an estimate to be made of the confidence, or probability, that the true class of a water body is:

(a) As reported;
(b) Worse than reported; or,
(c) Better than reported.

4.2 The main recommendation of this paper is that the estimates for (a), (b) and (c) should always be made. Such an outcome for data with errors is shown in Table 1. In this hypothetical example the error leads to a range of uncertainty that spans the classes from High to Bad.

Table 1	
Class	Probability of Class (per cent)
High	10
Good	60
Moderate	25
Poor	4.9
Bad	0.1

4.3 In Table 1, there is confidence of 70% for the result of good or better status. The confidence that the class is less than good is 30 per cent. These percentages are calculated in the following way. Suppose that the upper and lower class limits for the good class are ecological quality ratios of 0.9 and 0.7 respectively. Suppose further that the measured ecological quality ratio is 0.78. At face value this would place the water body in the good class. Because of errors in monitoring, the value of 0.78 may actually be associated with a range, say, 0.62 to 0.92. This range crosses the class limits of 0.9 and 0.7, leading to a probability that the true class is worse than good, or better than good.

4.4 Technically it is best if the error band, 0.62 to 0.92, is a pair of confidence limits; say the pair of 95 per cent confidence limits. The facility to estimate these confidence limits relies on the fact that the error band is two points from a probability distribution, sometimes called the error distribution. The confidence that the water body is in any class is calculated by looking at where the class limits cross this distribution. In Table 1, 60 per cent of the distribution falls between the good class boundaries, 25 per cent falls between the moderate class boundaries, and so on.

4.5 Ideally, we would like to get closer to the position illustrated in Table 2. In this case there is 100 per cent confidence that the water body is in the good class. This outcome occurs if the error bands on the estimated EQR are small. To continue with the example in the last paragraph, the confidence limits about the estimate of 0.78 might have been 0.75 to 0.85, lying entirely within the good class boundaries of 0.9 and 0.7

Table 2	
Class	Probability of Class (per cent)
High	0
Good	100
Moderate	0
Poor	0
Bad	0

4.6 We might expect to move from Table 1, towards an outcome like that in Table 2, by getting better or more appropriate data. It should be noted that in doing this we might find that a water body which starts out having a probability of only 4.9 per cent of being in the poor status class ends up being classed as poor status with near 100 per cent confidence when better data is taken into account.

4.7 We have to decide how to use information on the error in monitoring results, and in particular whether and how to be influenced by the error in assigning and reporting the status class of a water body. Where the errors are small, and consequently the confidence that the water body is in a particular class is high and therefore clearly adequate, classification decisions will be straightforward (see Section 8).

4.8 In the example given in Table 1, the most likely class is good status (60 per cent confidence). Generally most old classification systems, including those that ignored errors, would report this as the outcome if required to answer the question: "What is the class?" The data in Table 1 could then be used to decide if the water body should still be identified as being at risk of failing good status because of the 30 per cent chance that its class is worse than good compared to the 70 per cent chance that it is at least good.

4.9 The subsequent sections of this annex describe the ways in which errors can be reduced so that more water bodies can be assigned a class with high confidence. But even if these techniques are used, Member States are likely to end up with lots of water bodies like the one in Table 1, and will need to reach a view on how to answer to the question "What is the class?" in such cases.

5. Summary of possible approaches to managing the risk of misclassification

5.1 Figure 1 represents a generalised view of the WFDs classification scheme. The number of quality elements (QEs) relevant in principle in classification will vary, depending on, for example, the number of specific pollutants being discharged in significant quantities. Under the scheme, the class of a water body is determined by the condition of the quality element most affected by the pressures to which the water body is subject. In shorthand, classification is based on a one-out all-out system.

5.2 Based on experience with existing classification schemes, the error and uncertainty in monitoring results (see paragraph 3.4), coupled with the fact that a proportion of waters will, in truth, be close to a class boundary, tends to lead to a risk that about 20 per cent of assignments of class will be wrong. Where water bodies are, in truth, extremely HIGH or extremely BAD, this risk will be very much lower. The risk of wrongly deciding that the class of a water body has changed (i.e. that a deterioration in status has occurred) tends to be closer to 30 per cent[11].

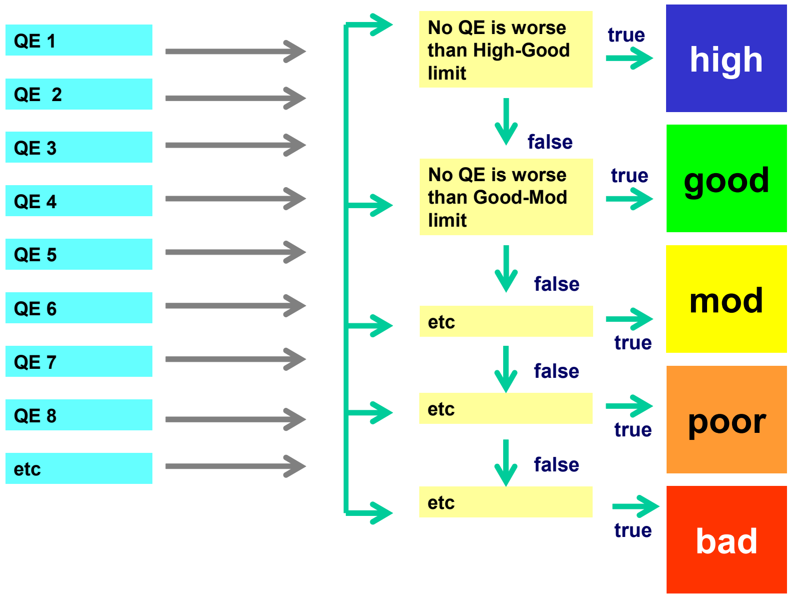

Figure 1: Representation of the WFDs classification scheme for ecological status. The ecological potential classification scheme for HMWBs and AWBs operates according to the same principles. Note that the number of relevant elements (e.g. benthic invertebrates, specific pollutants, etc) depends on (a) the status class (see Section 2 of the main guidance document); and (b) factors such as the number of specific pollutants being discharged in significant quantities.

5.3 Low confidence and precision leads to a risk of misclassification. The main components of a strategy for reducing the risk of misclassification by managing errors are outlined in following section and summarised below:

(i) Estimate the errors in the monitoring results for each quality element (e.g. quote the value of the classification variable as, say, plus or minus X % - see paragraph 3.4). This will enable the probability that a water body is in a particular class to be estimated;

[11] Given an estimate of the errors and uncertainty in monitoring results, the risk of misclassification can be calculated by, for example, Monte Carlo simulation for any classification system and are recommended to be calculated for the classification procedures set up for the purposes of the Directive.

(ii) Decide what level of confidence is adequate for assigning a water body to a particular class. There will be many cases where there is less that 100 per cent probability that a water body is in any of the classes. In Table 1, for example, there is only 60 per cent probability that the class is good. It is necessary to decide the level of confidence that is considered adequate in order to declare that a water body is in a particular class;

(iii) If the errors in the results of monitoring are too large to achieve adequate confidence about the class that should be assigned, reduce them through, for example, more monitoring[12], the use of more reliable monitoring systems, better monitoring design[13], improved assessment and modelling, and/or by combining the monitoring results for different indicative parameters to estimate the condition of the quality element;

(iv) Minimise the number of different quality elements used in making classification decisions by only taking into account the monitoring results for those elements most sensitive to the pressures to which the water body is subject (i.e. by excluding the monitoring results for elements that are NOT among the most sensitive to the pressure).

5.4 There will be clear cut situations where the class is clear even though the confidence in biological monitoring results, if considered on their own, would be low. For example, it may be clear that the entire river length upstream of a weir that is not equipped with a fish ladder will be worse than good ecological status until improvements to river continuity are made, even though the monitoring results for the fish fauna themselves are equivocal because of errors in the method used.

6. Managing errors in monitoring data for individual elements

6.1 The risk of error in classification cannot be assumed to be zero just because a method of calculating it has not been developed. Monitoring results that do not include an estimate of their errors should not be used in classification. If they were, it would not be possible to estimate the level of confidence achieved in classification, as required by the WFD.

6.2 The measurements for any quality element will involve error. For example, the mean from 12 samples can have an uncertainty of plus or minus 50 per cent[14]. A monitoring result that detects 12 species might need to be qualified by an error ranging from 11 to 15[15]. Such errors can be reduced in a predictable way if they are preventing the achievement of an adequate level of confidence in classification by, for example, extra monitoring and assessment, improved monitoring design[16], the use of better monitoring systems or by combining the

12 At its simplest increasing the number of samples by n reduces errors by the square root of n.
13 Controlling the variability contributed by the natural environment allows anthropogenic contributions to changes in quality elements to be detected with increased confidence.
14 50% is a typical figure where the standard deviation equals the mean.
15 The quoted figures are derived from an assessment of errors in monitoring for the UK river invertebrate monitoring system, RIVPACS. There were random errors and biologists missed, on average, two species of invertebrates in sampling.
16 Natural sources of environmental variation and measurement error can contribute significantly to uncertainty in estimates of a quality element. These can be controlled by sampling design, allowing anthropogenic influences to be more readily detected.

results for different parameters that are indicative of the condition of an element into an index for that element.

6.3 The sensitivity of biological elements and of the parameters monitored to estimate their condition may be considered in terms of (a) their actual sensitivity to the pressure; and (b) the degree of confidence that can be achieved in monitoring results. For example, a fish species might be sensitive to a particular toxin but it might not be possible to obtain low error monitoring data for that species using existing sampling methods.

6.4 Figure 2 illustrates how metrics A, B and C are combined, perhaps by averaging, to assess the condition of element 1 (see also Section 3 of the main guidance document). Combining the metrics can produce a smaller error in the estimate of the quality element than that provided by the original metrics. For this reason, combining metrics may allow a number of individually weak indicators of impact to come through as a statistically significant conclusion.

6.5 The term "averaging" may involve taking the arithmetic average, or a weighted average, median or percentile of the monitoring results for a number of parameters and using this statistic to classify rather than the individual ecological quality ratios calculated for each parameter. There need be no restriction in how the data are combined provided the outcome is ecologically sensible and provided the error in the resulting summary statistic can be estimated.

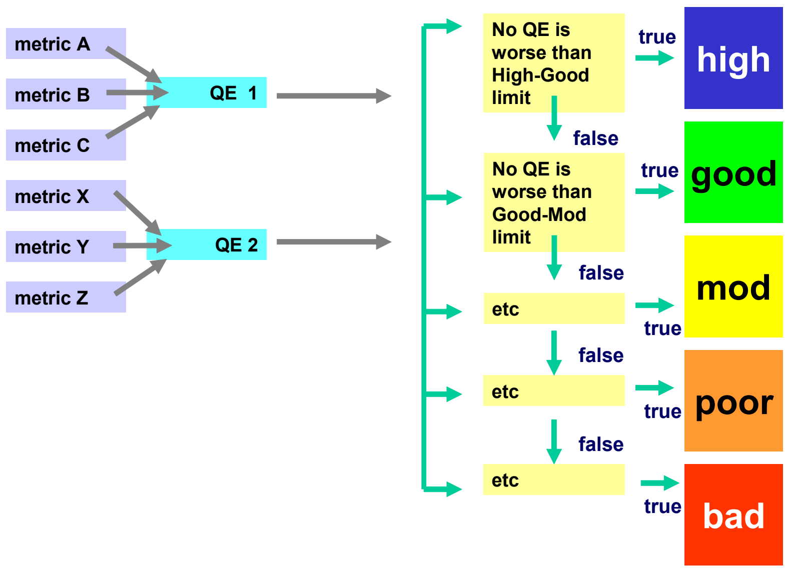

Figure 2: Representation of the WFDs ecological classification scheme, using multiple indicative parameters, or metrics, to estimate the condition of individual elements

6.6 The average for five independent metrics, each with 30 per cent error, will come through as an error of around 13 per cent. The reduction from 30 per cent to 13 per cent is the result of the Central Limits Theorem and applies to all sets of data that are independent. This would be a good reduction but the error should still to be taken into account in estimating the risk that the assigned class is not the true class (i.e. in assessing confidence in class). Care is needed where the metrics are correlated as, for example, in the use of the same set of data to calculate several metrics. In the case of 100 percent correlation, the reduction in error vanishes.

6.7 Averaging the results for a parameter with low error with those for parameters with much bigger errors could increase the risk of misclassification rather than reduce it, and would therefore defeat the purpose of combining results for different parameters. Similarly, averaging the results for parameters that are sensitive to a pressure with those that are relatively insensitive to that pressure could conceal failures to meet the conditions specified in the WFDs normative definitions of ecological status (Annex V, Section 1.2.1 – 1.2.5).

6.8 It should be noted that different types of metrics are differently affected by errors. The most stable results are usually delivered by metrics whose derivation includes a step involving averaging taxa, such as Saprobic Indices or Average Score Per Taxon. Metrics reflecting the proportion of taxa with particular preferences, such as feeding or microhabitat preferences, will also tend to have lower errors than metrics such as taxonomic richness (e.g. number of Ephemeroptera taxa).

7. Managing the effect of combining results for individual elements

7.1 The potential for misclassification is amplified by the number of quality elements that are taken into account in the one-out all-out system. If a water body is truly in the high status class and the monitoring results for any quality element included in the classification scheme can place the water body wrongly in a lower class, the probability of misclassification multiplies up with increasing numbers of quality elements. This is illustrated in Figure 3 below. The outcome is dominated by the quality elements with the biggest errors – the biggest probability of putting the water body in the wrong class.

7.2 The dotted line in Figure 3 occurs as follows. Suppose, for simplicity, that there are 10 quality elements and each is associated with a risk of 10 per cent that it will assign a class that is worse than the true class. In reality the risk may differ for each quality element. It may be zero for some and very large for others. If all the risks are zero there is no problem and the dotted line would run along the full line.

7.3 For 10 quality elements each with 10 per cent risk, the risk of declaring a wrong class increases as each quality element is introduced. It is 10 per cent for the first quality element, 19 per cent for two, 27 per cent for three, rising to 65 per cent for all 10.

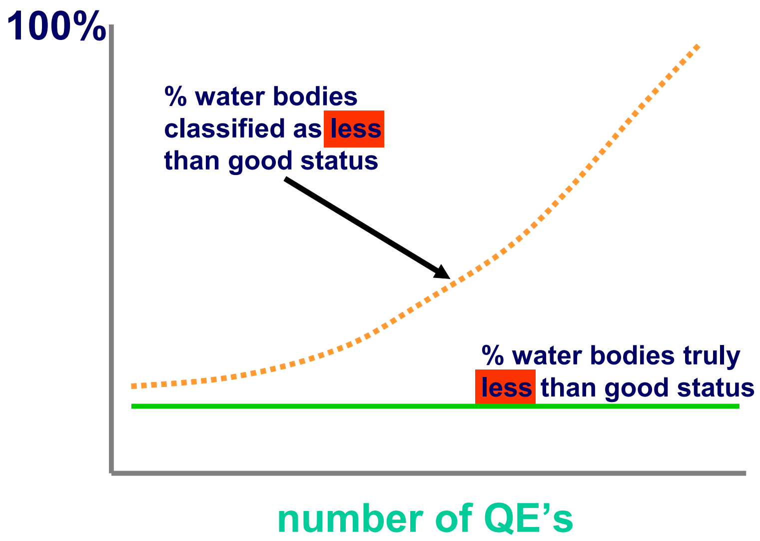

Figure 3: Effect of increasing the number of different elements in a one-out, all-out classification scheme

7.4 WFD Annex V, Section 1.3.2 specifies that, for operational monitoring, Member States should monitor among other things parameters indicative of the biological quality element, or elements, most sensitive to the pressures to which the water bodies are subject[17] and pollutants discharged in significant quantities. The Directive specifies that the results of operational monitoring are to be used in establishing the status of bodies at risk of failing to achieve environmental objectives.

7.5 WFD Annex II, Section 1.3 (paragraph VI) also says that where it is not possible to establish reliable reference conditions due to high natural variability, a quality element may be excluded from the assessment of ecological status. The number of quality elements that need to be considered in classifying bodies at risk can be reduced according to these provisions.

7.6 When making difficult classification decisions for bodies at risk (i.e. deciding the status of bodies which may be less than good status but which are not obviously very bad), Member States should focus on obtaining, and basing their decisions on, reliable operational monitoring programme results for those elements most sensitive to the pressures to which the water body is subject. The AQEM[18] system for example, aims to use only metrics that show a dose-response across a gradient of human influence that is "reliable, interpretable and not obscured by natural variation". Figure 4 represents how the principle of minimising the number of quality elements considered in any one classification decision can be applied using the results of operational monitoring.

17 Annex V 1.3.2 Design of Operational Monitoring.
18 http://www.aqem.de

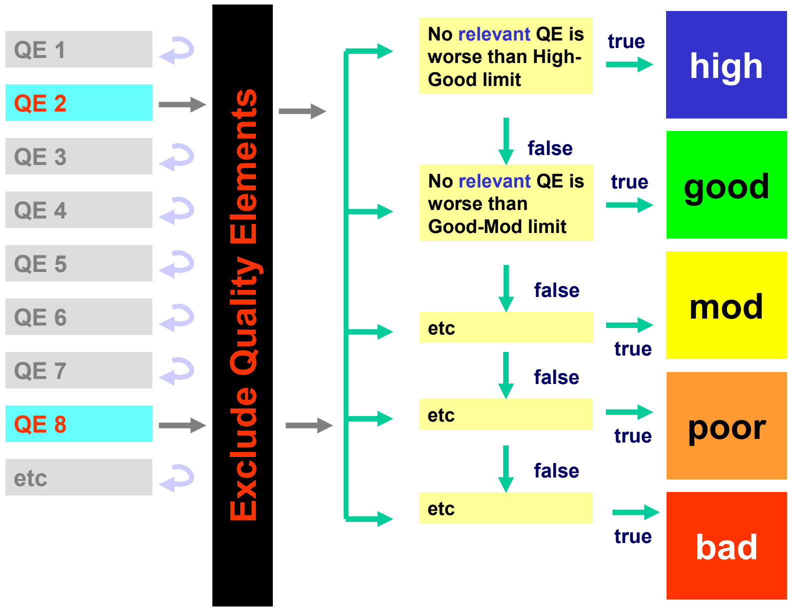

Figure 4: Representation of the WFDs ecological classification scheme, taking account only of operational monitoring results for those elements (a) most sensitive to the pressures to which the water body is subject; and (b) for which reliable type-specific reference conditions can be established.

7.7 As illustrated in Figure 5, when deciding the class of a water body (a) minimising the number of quality elements considered in the decision [See Section 7]; (b) the use of averaging of multiple indicative parameters in estimating the condition of the individual elements that are considered [See Section 6]; (c) obtaining results for the indicative parameters from well designed and operated monitoring [See Monitoring Guidance]; and (d) ensuring appropriate consideration is given to the statistical confidence in the final assessment will help ensure that the class assigned (the short blue line) can be made to stay close to the green line (the truth).

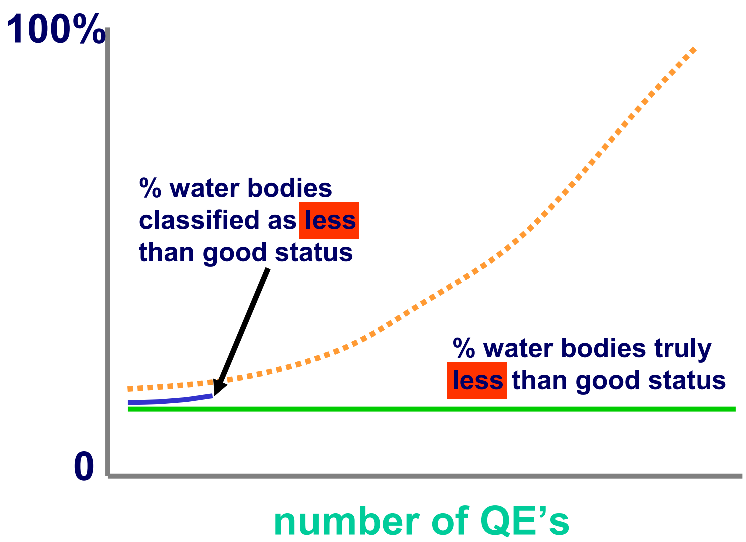

Figure 5: Illustration of the objective of managing the risk of misclassification

8. Deciding on the level of confidence that can be considered adequate

8.1 The following guidance on confidence and precision is reproduced from Section 2.5 (see paragraphs 8.2 – 8.4 below) and Section 2.8.1 (see paragraphs 8.5 – 8.7 below) of the CIS Monitoring Guidance (WFD CIS Guidance Document No. 7). The status of water bodies must be classified in time to enable a presentation in map form in the River Basin Management Plans of the results of the monitoring programmes for the status of surface water. The first Plans must be published by the end of 2009. This means that by this date, Member States will have to have achieved an acceptable level of confidence and precision for assigning water bodies to an appropriate class. Estimates of the level of confidence and precision of the results provided by the monitoring programmes must also be given in the Plan.

8.2 Choosing levels of precision and confidence will set limits on how much uncertainty can be tolerated in the results of monitoring programmes. The level of acceptable risk of misclassification will affect the amount of monitoring required to estimate a water body's status. In general terms, the lower the risk of misclassification desired, the more monitoring (and hence costs) required to assess the status of a water body. It is likely that there will have to be a balance between the costs of monitoring against the risk of a water body being misclassified. Misclassification may mean that measures to improve status could be inefficiently and inappropriately targeted. It should also be borne in mind that in general the cost of measures for improvement in water status would be orders of magnitude greater than the costs of monitoring. The extra costs of monitoring to reduce the risk of misclassification might therefore be justified in terms of ensuring that decisions to spend larger sums of money required for improvements are based on reliable information on status. Further, from an economic point of view, stronger criteria should be applied to avoid a situation where water bodies fulfilling the objective are misjudged and new measures applied.

8.3 The Directive does not specify the levels of precision and confidence required from monitoring programmes and status assessments. This perhaps recognises that demanding a too rigorous level of precision and confidence may entail a much-increased level of monitoring for some, if not all, Member States. On the other hand the actual precision and confidence levels achieved should enable meaningful assessments of status in time and space to be made. Member States will have to quote these levels in RBMPs and will thus be open to scrutiny and comment by others. This should serve to highlight any obvious deficiencies or inadequacies in the future.

8.4 The starting point for many Member States will probably be an assessment of existing monitoring programmes to see what level of precision and confidence they are achieving. It is likely that this will have to be an iterative process with modification and revision of monitoring programmes to achieve levels of precision and confidence that allow meaningful assessments and classification.

Key Question For operational monitoring, what is the acceptable level of risk of a body being wrongly classified?

8.5 The answer partly depends on what action is likely to be required if the objective is failed. Expensive measures would require higher certainty of failure to obtain environmental quality objectives to justify them than would low cost measures. Because the implications of misclassification could be serious for water users, there should be a high level of confidence in the estimates produced from operational monitoring data. In some cases failing objectives can be serious for water users, but in many cases implementation of unnecessary measures have more serious consequences for the community and therefore it is important to judge whether or not a water body is fulfilling its objectives.

8.6 Thus the required confidence in establishing the status of a water body will be highest where the implications of a misclassification to below good status are high with costs potentially being wrongly imposed on a water user. Similarly there needs to be high confidence in ensuring that water bodies of less than good status are not misclassified as good. In short a high level of confidence will be required close to the boundary of good/moderate status.

8.7 The more water bodies identified as being at risk of failing to achieve an environmental objective, the more operational monitoring will be required. Put more accurately: the more significant pressures there are upon the water environment, the more monitoring will be required to provide the information for managing those pressures. Generally it should be easier to achieve high levels of confidence in status classification where the pressure is very high and well identified, than at sites that lie close to the good/moderate status boundary.

9. Options for reporting confidence and precision in monitoring results

9.1 The WFD does not specify how the level of confidence and precision achieved in the results of monitoring should be reported in the river basin management plans. It is recommended that the confidence and precision in the status class assigned to water bodies or groups of water bodies be reported, and appropriate information on the reasons for classification as less than good be given.

9.2 It is recommended that the main sources of uncertainty in the class assigned should be identified, with particular reference to monitoring frequencies and taxonomic resolution and how these have been used to achieve adequate confidence. As discussed above (paragraph 3.4) this is done using the normal methods by which scientists estimate the errors and confidence limits in the numerical results produced by their monitoring.

10. Conclusion

10.1 To control misclassification, Member States are recommended to apply the following principles to help achieve an adequate level of confidence in classification, as required by the WFD:

- Only use procedures (e.g. monitoring and analysis) for classification that quantify their errors and use the information on errors to calculate the risk of misclassification;

- Aim to reduce errors in the status assigned to a water body by minimising the number of different quality elements used in making the classification decision. This can be done by using only the operational monitoring results for those elements most sensitive to the pressures to which the water body, or group of bodies, is subject; and

- Aim to reduce errors, where necessary, in the results for individual quality elements by using more and better monitoring and assessment, and by estimating the condition of the biological elements using more than one indicative parameter, and then combining the results for these parameters by, for example, averaging.

11. Appendix 1: Confidence and precision in the surveillance monitoring

11.1 The objectives of surveillance monitoring are to provide information for:

a. Supplementing and validating the impact assessment procedure detailed in Annex II;
b. The efficient and effective design of future monitoring programmes;
c. The assessment of long term changes in natural conditions; and
d. The assessment of long term changes resulting from widespread anthropogenic activity.

11.2 For surveillance monitoring, Member States must monitor parameters indicative of each of the biological, physico-chemical and hydromorphological quality elements [Annex V Section 1.3.1]. This means that a larger number of different quality elements may need to be monitored in surveillance monitoring compared with operational monitoring. Suppose we monitor all the quality elements in a water body that has been declared not at risk on the basis of the pressures and impacts analysis. An initial view of the data, ignoring errors, and looking at the worst quality element might indicate the possibility that the water body is less than good status/potential and therefore at risk.

11.3 If this happens the water body should be reviewed in the pressures and impacts analysis, and if appropriate identified as being at risk. For this review, we could:

- Look at which of the results of surveillance monitoring for the different quality elements appear to dominate the result;
- Check the confidence in these particular results;
- Review the identification of pressures to see if there are any pressures that could affect these elements [Where an impact indicated by the surveillance monitoring results does not appear to be related to any known pressures, investigative monitoring may be appropriate]; and,
- Decide if the water body should be identified as being at risk and therefore subject to operational monitoring to determine its status.

11.4 The basic principles recommended in this paper for operational monitoring apply to other forms of monitoring. Monitoring results that do not include an estimate of their errors should not be used.

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Status: 20.10.2003

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FOREWORD

The Water Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, “establishing a framework for Community action in the field of water policy” (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In November 2002 the Water Directors endorsed the document ‘Towards a guidance on establishment of the Intercalibration network and on the process of the Intercalibration exercise’ (CIS Guidance Document nr. 6; “Intercalibration Guidance”).

The Intercalibration Guidance contains a detailed description of a two-step procedure for the establishment of a network of intercalibration sites in 2002-4. As a first step, water body types, pressures and quality elements were selected to focus the intercalibration. As a second step, Member States and Accession Countries selected sites representing their interpretation of the high-good and the good-moderate class boundaries. For all intercalibration sites, metadata on typology, reference conditions, and biological and physico-chemical monitoring results was provided, together with information on the criteria used for classification. According to the timetable required by the Water Framework Directive (WFD), a draft register of sites for the intercalibration register was established in December 2003, and the final register will be established by December 2004.

The Intercalibration Guidance contains a preliminary description of the process of the intercalibration exercise in 2005-6. This section was not complete, because at the time the guidance was written, it was uncertain to what degree the sites in the intercalibration network would represent an agreed view of the high-good and the good-moderate class boundaries. It was also unclear what data would be available from the sites. A “metadata analysis” was executed to make this information available, and to enable a realistic planning for the intercalibration exercise.

The purpose of the present document is to provide further guidance for the intercalibration process, which started in 2004 and will continue up to the end of 2006, The document is based on the Intercalibration Guidance, taking into account the results of the metadata analysis, ongoing discussions in Working Group A Ecological Status (WG A), and the recommendations of the expert networks on lakes, rivers, and coastal and transitional waters.

The document was edited by Wouter van de Bund (EC-Joint Research Centre), and has been developed between December 2003 and September 2004 by a drafting group consisting of Peter Pollard (UK), Ulrich Irmer (DE), Pierre-Jean Martinez (FR), Jean-Gabriel Wasson (FR), Gisela Ofenboeck (AT), Andrea Buffagni (STAR project), Kari Nygaard (EEA), Jose Ortiz-Casas (ES), Manuel Toro (ES), Anna-Stiina Heiskanen (JRC), and Wouter van de Bund (JRC).

The Water Directors have examined and endorsed this guidance during our informal meeting under the Dutch Presidency in Amsterdam (2/3 December 2004)[1].”

[1] “The Water Directors endorsed the intercalibration guidance while taking note that the parts of the text and the annexes which refer to the upcoming Commission decision on the register of sites will need to be updated when the formal decision is taken”

CONTENTS

1. Key Principles of the intercalibration process

1.1 The intercalibration process is aimed at consistency and comparability of the classification results of the monitoring systems[2] operated by each Member State for the biological quality elements[3]. The intercalibration exercise must establish values for the boundary between the classes of high and good status, and for the boundary between good and moderate status, which are consistent with the normative definitions of those class boundaries given in Annex V of the WFD[4].

1.2 The essence of intercalibration is to ensure that the high-good and the good-moderate boundaries in all Member State's assessment methods for biological quality elements correspond to comparable levels of ecosystem alteration. Intercalibration is not necessarily about agreeing common ecological quality ratio (EQR) values for the good status class boundaries as measured by different assessment methods. Common EQR values only make sense, and are only possible, where very similar assessment methods are being used or where the results for different assessment methods are normalised using appropriate transformation factors. This is because different assessment methods (e.g. using different parameters indicative of a biological element) may show different response curves to pressures and therefore produce different EQRs when measuring the same degree of impact.

1.3 The first phase of the process is the establishment of an intercalibration network for a limited number of water body types consisting of sites representing boundaries between the quality classes High-Good and Good-Moderate, based on the WFD normative definitions. The WFD requires that selection of these sites is carried out "using expert judgement based on joint inspections and all available information[5]".

1.4 The Intercalibration Guidance states that "some artificial or heavily modified water bodies could be considered to be included in the intercalibration network, if they fit in one of the natural water body types selected for the intercalibration network. Artificial and heavily modified water bodies that are not comparable with any natural water bodies should only be included in the intercalibration network, if they are dominant within a water category in one or more Member States; in that case they should be treated as one or several separate water body types". An artificial or heavily modified water body is considered to fit in a natural water type if the maximum ecological potential of the artificial or heavily modified water body is comparable to the reference conditions of the natural type for those quality elements considered in the intercalibration exercise[6].

[2] The term 'monitoring system' in the way it is commonly used includes the whole process from sampling, measurement and assessment including all quality elements (biological and other). In the context of WFD Annex V, 1.4.1, the term 'monitoring system' only refers to a biological assessment method, applied as a classification tool, the results of which can be expressed as ecological quality ratios. This guidance uses the term 'WFD assessment method' in place of the term 'monitoring system' that may be misleading in this context.

[3] The WFD intercalibration as described in Annex V, 1.4.1 does not concern the monitoring systems themselves, nor the biological methods, but the classification results

[4] WFD Annex V, 1.4.1 (ii), (iii), (iv), (vi)

[5] WFD Annex V, 1.4.1 (v)

[6] This is not the case for those quality elements that are significantly impacted by the hydromorphological alteration that has led to the water body to be designated as heavily modified.

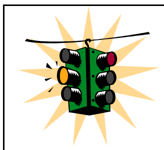
1.5 In the second phase of the process, each Member State's assessment method must be applied to those sites on the register that are both in the ecoregion (or, as pointed out in section 1.8, in the Geographical Intercalibration Group (GIG)) and of a surface water body type to which the system will be applied. The results of the second phase must be used to set the EQR values for the relevant class boundaries for each Member States' biological assessment system. The results of the exercise will be published by the Commission by 22 December 2006 at the latest.

1.6 Intercalibration sites are selected by the Member States, and represent their interpretation of the WFD normative definitions of high, good and moderate status. There is no guarantee that different Member States will have the same views on how the normative definitions should be interpreted. Differences in interpretation are reflected in the intercalibration network[7]. A common interpretation of the normative definitions should be the main outcome of the intercalibration exercise. At the end of the intercalibration exercise the intercalibration network may need to be revised according to this common interpretation.

1.7 The Intercalibration Exercise is focused on specific type/biological quality element/pressure combinations[8]. The selection of these combinations is based on the availability of adequate data within the time constraints of the exercise. This means that the exercise will not identify good status boundary EQR values for all the type/biological quality element/pressure combinations relevant for the implementation of the WFD. However, the Intercalibration Exercise will identify, and test the use of, a procedure and criteria for setting boundaries in relation to any such combinations[9].

1.8 The intercalibration process described in this guidance is aimed at identifying and resolving:
  (a) Any major/significant inconsistencies between the values for the good ecological status class boundaries established by Member States and the values for those boundaries indicated by the normative definitions set out in Section 1.2 of Annex V of the WFD; and,
  (b) Any major/significant incomparability between the values established for the good status class boundaries by different Member States.

1.9 The process will identify appropriate values for the boundaries of the good ecological status class applicable to the EQR scales produced by the Member States' assessment methods.



The EQR values appropriate for the good ecological status class boundaries will depend on the particular characteristics of each assessment method. This means that the Intercalibration Exercise may identify unique boundary EQR values for each national assessment method. These different values will nevertheless, after the Intercalibration Exercise, reflect a comparable level of anthropogenic alteration to the biological quality element

[7] Intercalibration Guidance, section 3.5
[8] as described in the document' Overview of common Intercalibration types' (available at the intercalibration site submission web pages, http://wfd-reporting.jrc.cec.eu.int/Docs/typesmanual)
[9] If the results of the method are significantly affected by biogeographical or other ecological differences within the intercalibration type, different boundary EQR values may be appropriate for different parts of the type

1.10 The Intercalibration Exercise will be undertaken within GIGs rather than the ecoregions defined in Annex XI of the WFD. This is to enable intercalibration between a maximum number of Member States.

1.11 The Intercalibration Exercise assumes that all Member States will have developed their national WFD assessment methods to a sufficient extent to enable the consistency with the normative definitions, and the comparability between Member States, of the good status boundary EQR values for those methods to be assessed during 2005. It was recognized however that this assumption might be problematic. An inventory on the state-of-the-art in the developments of WFD compliant methods is carried out during the process of finalisation of the intercalibration network[10].

1.12 The Intercalibration Exercise will set boundary EQR values for the biological quality elements using parameters, or combinations of parameters Member States intend to use in their WFD assessment methods. For better readability, the term ‘metric’ is used in this guidance as an alternative to the WFD term ‘parameter indicative of a biological quality element’.

1.13 The Intercalibration Exercise should be carried out for all agreed common intercalibration types[11]. If this is not possible, the reasons for not including a type should be reported by the GIG to WGA, which will make recommendations to Strategic Co-ordination Group (SCG) and/or WFD Committee, as appropriate.

[10] The metadata questionnaire is available at the intercalibration site submission web pages, http://wfd-reporting.jrc.cec.eu.int/Docs/ metadata
[11] As described in the document’ Overview of common Intercalibration types’ (available at the intercalibration site submission web pages, http://wfd-reporting.jrc.cec.eu.int/Docs/typesmanual)

2. Process options for intercalibration

2.1 This Section outlines different options for the process of intercalibration. Subject to the conditions for their use as outlined, each option could provide an appropriate means of ensuring the consistency and comparability of the values established for the good status class boundaries.

2.2 Taking account of the requirements of the options, and their strengths and weaknesses, GIGs should identify the most appropriate approaches for the different common intercalibration types. These approaches should then be harmonised and agreed by WG A.

2.3 All three options as well as any hybrid options require agreement on principles to derive type-specific reference conditions, and the establishment of data sets illustrating gradients of biological alteration, if possible along a pressure gradient, and at least including the two relevant class boundaries. These data sets do not necessarily need to be limited to sites from the Intercalibration Network. The normative definitions for the ecological quality classes are then applied to these data. The main difference between the options is whether this is done at Member State level using national metrics (option 3), or at GIG level using common metrics (option 1 and 2).

2.4 An outline of the main components of such a class boundary setting procedure is presented in Annex I. In the course of the intercalibration process, the GIGs should regularly report the progress. To facilitate this, the EC Joint Research Centre (JRC) will establish a simple web-based reporting system, where GIGs can report the progress made in each of the steps of this procedure on a regular basis. This makes it possible to check whether approaches followed in different GIGs are sufficiently comparable. WG A is responsible for the consistency and harmonisation of the process between GIGs and between categories (lakes, rivers, and coastal and transitional waters).

2.5 An overview of Option 1 for the intercalibration process is provided in Figure 2.1 and Table 2.1.

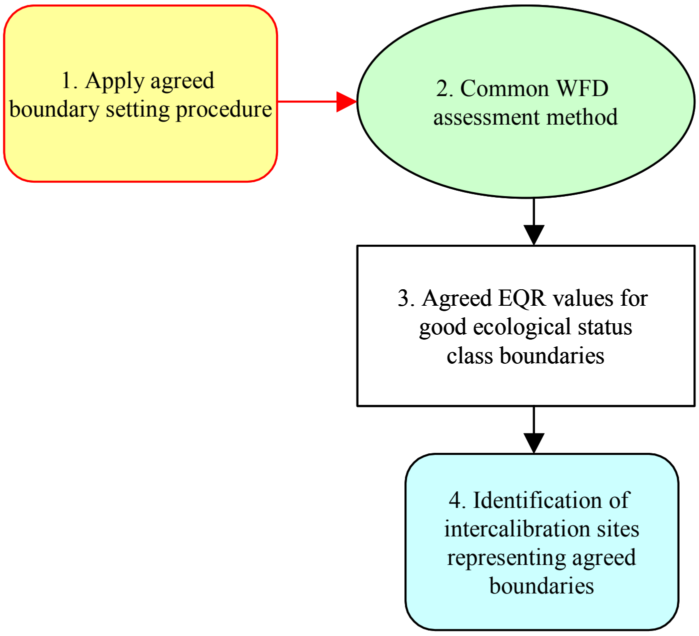


Figure 2.1. Outline of Option 1: Member States in a GIG area are using the same WFD assessment method

Table 2.1. Information on Option 1

Conditions for use	All Member States in a GIG agree to use the same method as their national assessment method for a quality element considered in the intercalibration exercise - based on the same metrics and the same means of identifying reference conditions. The metrics are calculated in the same way from data collected and analysed according to a standard procedure.
Application	Where a common assessment method is the best WFD assessment method available in the GIG area, this should always be the preferred option. For quality elements for which most Member States have not sufficiently established national assessment methods, and where a common assessment method is available[12] Where the Member States in a GIG have not sufficiently established their national WFD assessment methods for the purposes of the intercalibration exercise but can identify an interim common WFD assessment method for the purposes of the intercalibration exercise (i.e. a partial application of option 2)
Features	Does not require intercalibration of the results of different WFD assessment methods. It only requires agreement on high-good and good-moderate class boundaries of the EQR scale for the common method, by applying the class boundary setting procedure[13]

[13] e.g. (a) Reference conditions; (b) Type characteristics; (c) data on the biological quality element and the condition of

Role of the intercalibration network	Intercalibration sites are not directly used in the process of setting the boundaries. After setting the class boundaries, sites in the Intercalibration Network representing the boundary conditions will be identified.
Data requirements	Data requirements are limited to those required to apply the boundary setting procedure (i.e. the minimum requirement for setting boundaries consistent with the normative definitions). To ensure sufficient statistical confidence of the results it is recommended that the data should include a range of quality from high to at least moderate but preferably also including classes of worse status[14].
Advantages	The most straightforward option since the difficulties and uncertainties involved in comparing the results of different assessment methods are avoided. Comparability between Member States is assured. WG A can readily monitor the application of the agreed boundary setting procedure. WG A can easily make refinements to the boundary setting procedure.
Disadvantages	The opportunity to use this approach is likely to be very limited as few Member States are planning to use common WFD assessment methods.

the supporting elements across the range of status classes; (d) a means of taking into account the effects of any differences in the way biological information in the data set has been collected and analysed (the effect of bias)

[14] This condition is unlikely to be satisfied using only data from Intercalibration Sites.

2.6 An overview of Option 2 for the intercalibration process is provided in Figure 2.2 and Table 2.2.

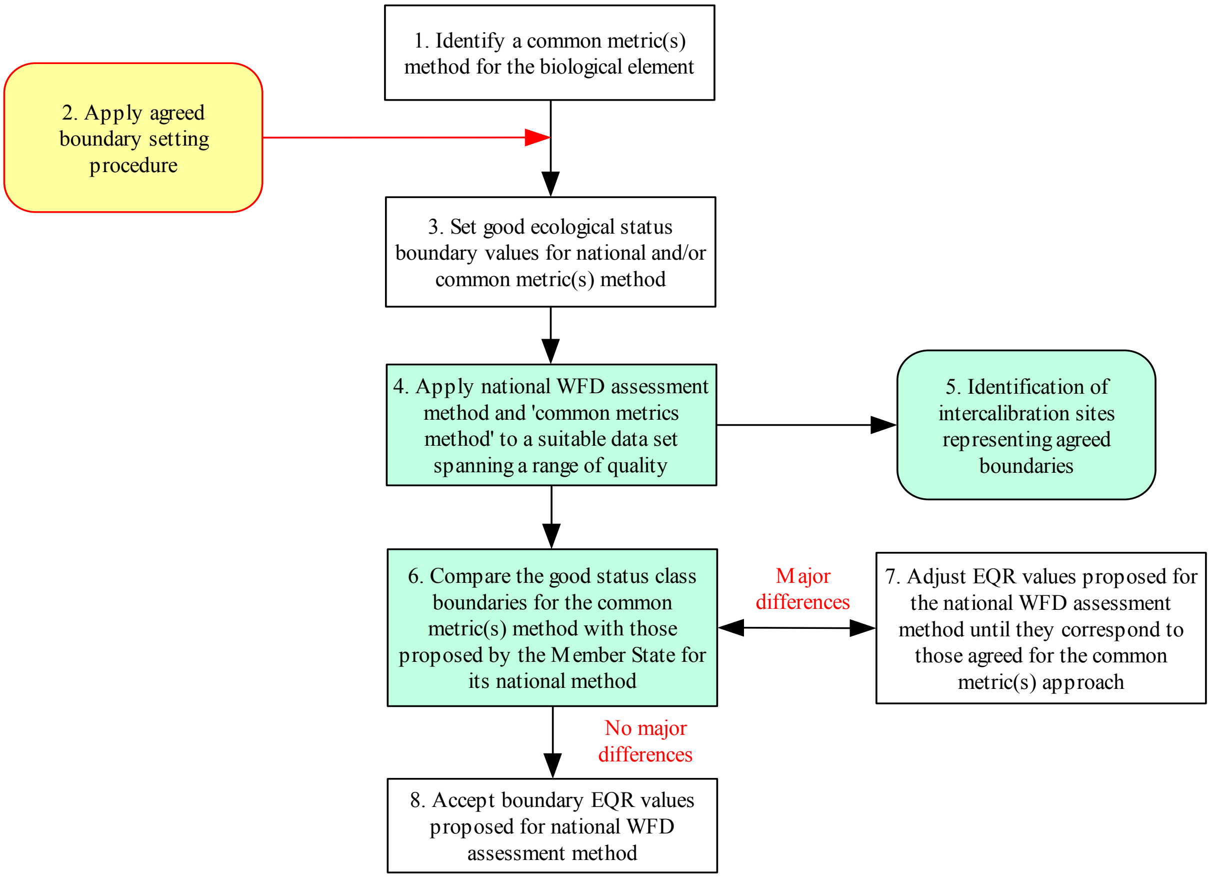


Figure 2.2. Outline of Option 2: Use of a common metric(s) method identified specifically for the purposes of the intercalibration exercise

Table 2.2. Information on Option 2.

Conditions for use	Suitable common metrics should be identified. These metrics should be indicative of the relevant biological quality element and sensitive to the pressure that is assessed. Common metrics may be selected from one of the Member State's existing assessment methods, if acceptable for the other Member States in the GIG. Availability of a suitable data set from which these common metric(s) can be calculated to enable reliable application of the agreed boundary setting procedure[15] (or the possibility to establish such a data set in the given timetable). Availability of data sets relating Member State's assessment methods to the common metric (or the possibility to establish such data sets in the given timetable). Availability of a means of estimating and taking into account differences in the bias of the methods when applied to the data set referred to above[16].

[15] e.g. (a) Reference conditions; (b) Type characteristics; (c) data on the biological quality element and the condition of the supporting elements across the range of status classes; (d) a means of taking into account the effects of any differences in the way biological information in the data set has been collected and analysed (the effect of bias)
[16] e.g. if the data set has been collected using different sampling and analysis procedures to the standard procedures

Application	Where option 1 is not possible Where suitable common metrics can be agreed upon within GIGs
Features	Involves the agreement on a common WFD method by the Member States in a GIG for the purposes of the intercalibration exercise. Such methods can be specifically developed in the GIGs, but also existing methods can be used[17]. For the common method, type-specific good status boundary values are established in the GIGs following the application of the agreed boundary setting procedure using a data set assembled for the purposes of the intercalibration exercise. The results of the common assessment method are used as the basis for adjusting the boundary EQR values of the national assessment methods. This is done by establishing quantitative relationships between common and national metrics, enabling to directly translate agreed boundary values for the common metrics into EQR values of the national assessment methods.
Role of the intercalibration network	Intercalibration sites are not necessarily used in the process of setting the boundaries. After setting the class boundaries, sites in the intercalibration network representing the boundary conditions will be identified.
Data requirements	Common metric data set for application of the boundary setting procedure for each common intercalibration type[18]. Data establishing quantitative relationships between common metrics and each national WFD assessment method[19]. To ensure sufficient statistical confidence of the results it is recommended that the data should include a range of quality from high to at least moderate but preferably also including classes of worse status[20].
Advantages	WG A can readily monitor the application of the boundary setting procedure because it is applied to one common dataset rather than to many national data sets. The expert judgements needed in the application of the boundary setting procedure are made by experts from across a GIG area. Refinements to the boundary setting procedure can be readily made by WG A. The process of agreeing on class boundaries (using common metrics) is clearly separated from the checking/adjusting of the EQR values of national assessment methods within a GIG. The approach has been at least preliminarily tested for rivers by the STAR/AQEM project The effects of random errors on the identification and adjustment of boundary values can be adequately controlled, for example, by using sufficiently large data sets

intended for the common assessment method, any significant effects of this on the results for the common method must be resolved

[17] for some water categories such common methods have already been developed (e.g. metrics developed in research projects as AQEM and STAR)

[18] The data set should be adjusted for any bias that may result from methodological differences in sampling and analysis between countries in a GIG

[19] In some cases, such relationships may already be available. E.g., the STAR project has already established relationships between many national assessment methods and a proposed common metric for rivers.

[20] This condition is unlikely to be satisfied using only data from Intercalibration Sites.

Disadvantages	Relies on the ability of each GIG to collate suitably quality assured and large data sets for the purposes of applying the agreed boundary setting procedure and setting class boundary values for the common assessment method. The quality of the data used for the boundary setting procedure to the common method may be lower than that which Member States could assemble nationally for applying the procedure directly to their national assessment methods (see Option 3).

2.7 An overview of Option 3 for the intercalibration process is provided in Figure 2.3 and Table 2.3.

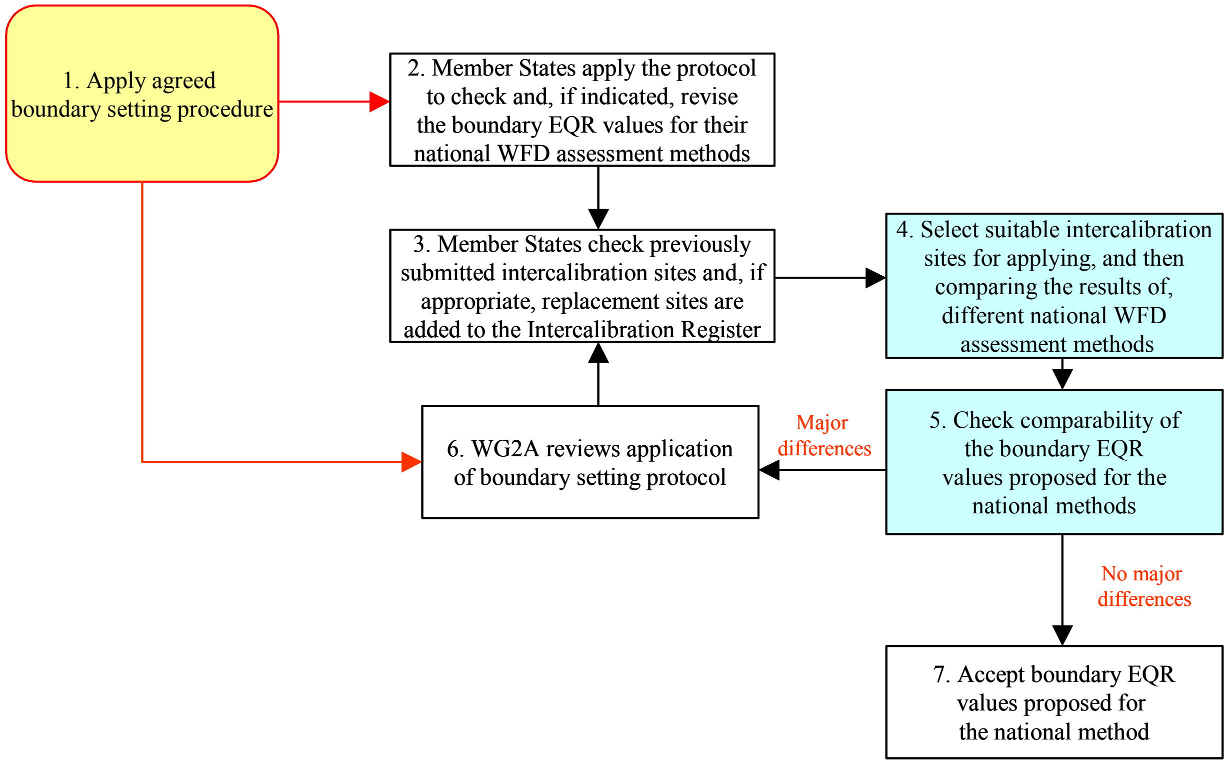


Figure 2.3. Outline of Option 3: Use of a common metric(s) method identified specifically for the purposes of the intercalibration exercise

Table 2.3. Information on Option 3.

Conditions for use	All Member States in a GIG have sufficiently developed their national WFD assessment methods for application in 2005. Availability of suitable data sets for each Member State's assessment method to enable reliable application of the agreed boundary setting procedure[21] (or the possibility to establish such data sets in the given timetable). Availability of data from intercalibration sites relating different Member State's assessment methods to each other (or the possibility to establish such data sets in the given timetable). Availability of a means of estimating and taking into account differences in the bias of the methods when applied to the data set referred to above[22].
Application	Except where Option 1 is available

[21] e.g. (a) Reference conditions; (b) Type characteristics; (c) data on the biological quality element and the condition of the supporting elements across the range of status classes; (d) a means of taking into account the effects of any differences in the way biological information in the data set has been collected and analysed (the effect of bias)]
[22] e.g. if the data sets have been collected using different sampling and analysis procedures, any significant effects of this on comparability of the results must be resolved

Features	Member States apply the boundary setting procedure using their own data sets and identify intercalibration sites representing the high-good and good-moderate class boundaries. It is assumed that all Member States within a GIG possess sufficiently developed assessment methods for the biological quality elements. The proper application of the procedure is tested by checking whether there are major differences in the results given by different Member States' assessment methods when applied to the same intercalibration sites WG A has a major role in ensuring comparability. Where there are major differences, WG A would check the application of the procedure in relation to the Member States' data sets and propose adjustments to those boundary EQR values not in line with the boundary setting procedure.
Role of the intercalibration network	Unlike Options 1 and 2, selected intercalibration sites play a central role in checking consistency and comparability of Member State's WFD assessment methods.
Data requirements	For each national assessment method included in the intercalibration exercise, Member States need to compile data sets for application of the boundary setting procedure for each common intercalibration type. To ensure sufficient statistical confidence of the results it is recommended that the data should include a range of quality from high to at least moderate but preferably also including classes of worse status[23]. For the intercalibration sites representing the high-good and good-moderate boundaries, data is needed allowing to compare the results of different Member State's assessment methods within a GIG. Collection of additional data may be needed where existing data from the selected intercalibration sites are insufficient for the purposes of applying one or more of the relevant Member States' national WFD assessment methods Information to enable expert judgements to be made about whether apparent differences between the results of Member States' methods are caused by real differences in the level of anthropogenic alteration represented by the boundary EQR values they have proposed for their national assessment methods[24]
Advantages	Simpler in principle than Option 2 in that it does not require the development of, and calibration of the results of, a common metric(s) assessment method Most clearly follows the procedure specified by the WFD. Adjustments to the good status boundary EQR values of Member States' WFD assessment methods are dictated directly by the application and refinement of the agreed boundary setting procedure rather than indirectly via a common metric(s) method (see Option 2).

[23] This condition is unlikely to be satisfied using only data from Intercalibration Sites.
[24] e.g. estimates of the errors produced by the assessment methods; information on biogeographical differences between the intercalibration sites and the sites to which the national methods are normally applicable or other ecological differences such as those that may be associated with differences in site characteristics; information on the condition of the supporting elements

Disadvantages	Relies on each Member State within a GIG being able to find at least some intercalibration sites that are considered, with adequate confidence, to be on, or close to, the good status class boundaries – or which will at least allow interpolation of the boundaries. Consistent application of the class boundary setting procedure between Member States may be difficult because this is done separately by each Member State using different data sets (using a common procedure) rather than jointly in the GIG. Iterative refinement of the boundary setting procedure may be less easy to achieve in a coordinated way than under Option 2 where a common data set is available. Organisation of the data flow may be complicated. Although WGA would not be required to hold the national data sets used for the application of the boundary setting procedure, it would need access to these data sets to check the application of the procedure, should major differences in the boundaries set by Member States be identified.

2.8 A number of hybrid options may be possible; for example:

- It may be possible to identify a simple common metric(s) method (see option 2) to underpin the development of the boundary setting procedure, but to follow Option 3 for the application of the procedure to each Member State's data, establishing boundary EQR values. This would have the advantage compared to option 3 of allowing WG A to more readily monitor the application of, and iteratively refine, the setting of the class boundaries;
- Boundary values are first established with national classification assessment methods (as in Option 3). The subsequent comparison of the boundary values could then be done with the help of a common metrics method (as in Option 2). An example of this approach, that is presently being tested in the Alpine, Central/Baltic and Mediterranean river GIGs, is presented in Annex III.

3. Contents of the final intercalibration report

3.1. According to the timetable set out in the WFD[25], the final report of the Intercalibration Exercise should be published before 22 December 2006 by the Commission. This chapter gives an outline of the expected key elements of this report.

Section 1 Overview of GIGs and Common Intercalibration Types considered in the intercalibration exercise[1]

Section 2 Results of the intercalibration for each common intercalibration type

1. Description of the Common Intercalibration Type
2. List of Member States in which the type is present
3. Biological element(s) considered in Intercalibration Exercise for the type
   e.g. Benthic invertebrates
4. Pressure(s) considered in the Intercalibration Exercise for the type
   e.g. Nutrient enrichment
5. Summary description of the 'procedure and criteria that were agreed to derive reference conditions and good ecological status class boundary values from the normative definitions for the type ('class boundary setting procedure'), with a reference to the data used in the application of the procedure for the common intercalibration type[1].
6. Intercalibration register sites representing (a) the high-good boundary; and (b) the good-moderate boundary [+ reference to where data from site can be found]
7. Overview of quantitative relationships established between common and national metrics (option 2) or between different national metrics (option 3), including an estimate of statistical uncertainty
8. Boundary EQR values established for the type/quality element/pressure combination for the common metric (where applicable) and each national WFD assessment method

For example:

Member State	Classification Method	EQR High-Good boundary	EQR Good-Moderate boundary
	Common metric	0.85	0.65
MS1	Method 1	0.85	0.60
MS2	Method 2	0.85	0.75
MS3	Method 3	0.70	0.60
MS4	Method 4	0.90	0.75
MS5	Method 5	0.85	0.60

Section 3 Conclusions stating what is achieved and what is not achieved in the intercalibration exercise

[25] WFD Annex V, 1.4.1, ix

4. Organisation of the work and timetables

4.1 The intercalibration process will be carried out under the umbrella of WG A. The Lakes, Rivers, and Coastal/Transitional Waters expert groups are subdivided in GIGs that will carry out the practical work. An Intercalibration Steering Group consisting of the JRC and representatives of the water category expert groups will summarise the results of the different GIGs and water categories and present those to WG A. An overview of the organisational structure is given in Figure 4.1.

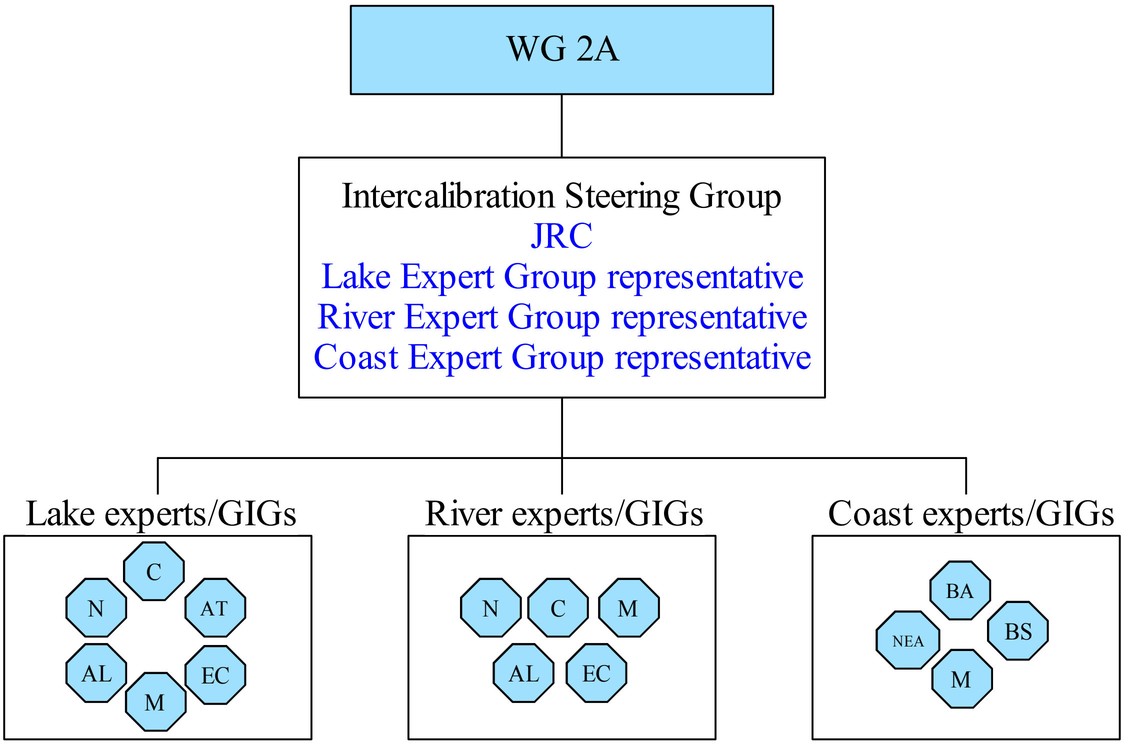


Figure 4.1: Overview of the organisational structure for the intercalibration process.

4.2 WG A is responsible for evaluating the results of the intercalibration exercise and making recommendations to the SCG or WFD Committee, as and when appropriate.

4.3 The practical work will be carried out in the GIGs, following the timetables set out in this guidance document. One of the Member States in each GIG will act as an informal GIG co-ordinator[26]. An overview of the GIGs including the participating Member States and the informal co-ordinators is given in Annex 2.

4.4 The process needs to be transparent and the results need to be coherent and consistent between GIGs and between water categories.

[26] Co-ordination of larger GIGs (e.g. Central rivers and Central lakes) may be too large a task for a single Member State. In those cases, a GIG steering group of several Member State experts could be formed.

4.5 An intercalibration steering group consisting the JRC and representatives of the water category expert groups will be established that will summarise the progress of the different GIGs and evaluate inconsistencies within and between GIGs, and report those to WG A. It is the task of WG A to resolve such inconsistencies.

4.6 The intercalibration process is facilitated by the JRC. JRC will establish a simple reporting structure where GIGs can report and update the results of the different steps of the boundary setting procedure for the different intercalibration types, and will compile the draft final report of the intercalibration exercise.

4.7 In principle, only the final results of the intercalibration procedure (as specified in Section 4 of this guidance document) are centrally reported to JRC using uniform templates. These results will be discussed in WG A, presented to the SCG and WFD Committee, and included in the final intercalibration report.

4.8 The Member States in the GIGs have the collective responsibility to bring together the data to set and/or illustrate the class boundaries, and the data enabling comparison of the classification results of different countries within the GIG. Additional sampling during the Intercalibration Exercise may be considered in the GIGs. The GIGs are free to specify the aggregation level and format for this data. To ensure transparency of the intercalibration process the original data source(s) should be specified, and the data should be made publicly available in such a form that the correct application of the boundary setting procedure can be verified.

4.9 JRC is responsible to regularly report the progress of the intercalibration process to the SCG, the Water Directors, and the WFD Committee.

	2004						2005												2006											
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
GIG milestones	M1		M2					M3							M4				M5				M6							
Steering Group	Summarise GIG progress reports and prepare WG meetings																													
WG2A	X		↳	X				↳	X						↳	X			↳	X			↳	X						
SCG	Regular progress reports																													
IC Report																**D1**				**D2**				**F**	Translation, Committee agreement					

Figure 4.2: General timetable including GIG milestones (M1-M5), WGA, and draft (D1-D2) and final (F) reports of the intercalibration exercise

4.10 The general timetable of the Intercalibration Exercise (Figure 4.2) is constrained by the legal deadline to finalise the intercalibration report by December 2006. This requires that WG A agrees on the report in June 2006. A first and second draft of the intercalibration report will be prepared in October 2005 and February 2006, respectively. WG A will meet twice every year and regularly provide progress reports and recommendations to the SCG and the WFD Committee.

4.11 Table 4.1 presents the different steps of the timetable for the Intercalibration Exercise in more detail, with the tasks of the GIGs, the complete. If needed, GIGs can propose modifications to this timetable depending on their specific needs (e.g. the options chosen, data availability, possibility to collect additional data, etc.), provided that this does not affect the overall process. Such modifications require agreement of WGA.

4.12 The principle milestones of the work of the GIGs are further specified in Table 4.2. The milestones are linked to the meetings of WGA. GIGs are expected to report two weeks before each WG A meeting. The Intercalibration Steering Group will then summarise the reports and present the results to WG A.

Table 4.1: Proposed overall timetable for the Intercalibration exercise

	GIGs	JRC / Steering Group	WG A
June-July 04	Agree on first suggestions on intercalibration options and carry out pilot work where possible		
July 04	**M1** Report of progress to WG A: - Composition and co-ordination - First suggestions re. options - First results if pilot work	Establishment of steering group	Meeting 7-8 July 04: - Discussion on guidance - Discussion on GIG organisation - Discussion on GIG options and pilot work
July-Sept	Meet and agree on: - Options & common metrics - Boundary setting procedure - Comment on draft guidance - New data collection needs and possibilities - Timetable of the work	Prepare template for GIG work plan	- Comments on guidance (deadline 7 September) - Drafting group on intercalibration process finalises guidance
Sept - Oct 04	**M2** Preparation GIG work plan: - Proposed option(s) - Proposed common metrics (if applicable), identify needs for new data collection - First proposal boundary setting procedure - Outline of timetable	Summarises GIG work plans and presents this to WG A	Meeting 7-8 October 04: - Agreement on guidance - Agreement on options for the GIGs and common metrics (where applicable) - Agreement on GIG timetables
Oct 04-Jan 05	- Development of boundary setting procedure[27] - Agreement on data needs for intercalibration types (depending on option chosen[28]) - Agree on principles of reference condition setting, e.g. by collating and comparing methods and values for national type-specific reference conditions for selected quality elements	- Establishment of a simple internet-based reporting structure where GIGs can report and update different steps of BSP for the different intercalibration types - Develop specific proposals for comparability checking depending on options and metrics chosen	
Feb-Mar 05	**M3** Report GIG progress (using internet reporting structure) - First report of boundary setting procedure (including principles to set reference conditions)[29] - Overview of data requirements	Summarise GIG progress reports and prepare WG A meeting	Meeting March 05: - Agreement on boundary setting procedures and data requirements
Feb-Aug 05	- Collate data sets to apply boundary setting procedure at GIG level (option 1/2) or at Member State level (option 3) for all types - Apply boundary setting procedure for all types (including setting values for reference conditions and good ecological status boundary values for common metrics (Option 1/2) or national metrics (Option 3) - Identify intercalibration sites		

[27] At this stage, GIGs may decide to focus on specific common intercalibration types/pressures/quality elements
[28] Option 1/2 – data quantifying the relations between common and national metrics. Option 3 – data directly comparing assessment methods between Member States using intercalibration sites
[29] For this first report GIGs may choose to focus on specific common intercalibration types, pressures and/or quality elements

	representing agreed class boundaries (all options) and start compiling data for assessing comparability between Member States using those sites (Option 3) - Collate data sets relating common metrics with Member State's national metrics and propose EQR values for national metrics using these data (Option 2)		
Sep-Oct 05	**M4** Report GIG progress - Report on ongoing application of boundary setting procedure - Identification of intercalibration sites representing agreed class boundaries	Summarise GIG progress reports and prepare WG A meeting	Meeting October 05: - Identify inconsistencies between MS classification results
Oct 05 – Jan 06	- Finalise data compilation for intercalibration sites, assess comparability between Member State's assessment methods and identify consistencies (Option 3) - Finalise collating data sets relating common metrics with Member State's national metrics and set EQR values for national metrics (Option 2) - Continue developing and reviewing the boundary setting procedure (Option 1)		
Jan-Feb 06	**M5** Report GIG progress - Report on ongoing application of boundary setting procedure - Identification of inconsistencies within the GIG	Summarise GIG progress reports and prepare WG A meeting; proposals to resolve inconsistencies between MS classification results	Meeting February 06: - Resolve inconsistencies between Member State classification results where possible
Feb-May 06	GIGs implement proposals to resolve inconsistencies between Member States classification results, and propose revisions of the intercalibration register according to those revisions		
May-June 06	**M6** GIGs produce type-specific reports including EQR boundary values and identification of sites representing good status boundaries	Final draft from steering group integrating reports from GIGs	Meeting June 06: - Intercalibration report including EQR boundary values agreed by WG A to be submitted to SCG and WFD Committee.
June-Dec 06	Agreement by SCG, WFD Committee Translation Formal agreement by WFD Committee		
Dec 06	Final Intercalibration Report published		

Table 4.2 - Summary of milestones for the work in the GIGs d the intercalibration process

		Reporting date	WG A meeting date
M1	Report of progress to WG A: - Composition and co-ordination - First suggestions re. Options - First results if pilot work	7-8 July 2004	7-8 July 2004
M2	Preparation GIG work plan: - Proposed option(s) - Proposed common metrics (if applicable), identify needs for new data collection - First proposal boundary setting procedure - Outline of timetable	17 Sept 2004	7-8 Oct 2004
M3	Report GIG progress - First report of boundary setting procedure (using internet reporting structure) (including principles to set reference conditions)[30] - Overview of data requirements	2 weeks before WG A meeting	March 2005
M4	Progress report: - Report on ongoing application of boundary setting procedure (using internet reporting structure) - Identification of intercalibration sites representing agreed class boundaries	2 weeks before WG A meeting	October 2005
M5	Report GIG progress - Report on ongoing application of boundary setting procedure (using internet reporting structure) - Identification of inconsistencies within the GIG	2 weeks before WG A meeting	February 2006
M6	Type-specific reports including EQR boundary values and identification of sites representing good status boundaries	2 weeks before WG A meeting	June 2006

[30] For this first report GIGs may choose to focus on specific common intercalibration types, pressures and/or quality elements

Annex I. Framework for deriving class boundary values consistent with the WFD normative definitions

[To be implemented iteratively with the expert groups at water category or GIG level]

The table below sets out a procedure designed to ensure that, if applied correctly, the good status boundary EQR values established for an assessment method will be consistent with the WFD Annex V normative definitions. The procedure relies on the establishment of data illustrating the degradation of biological quality element for a common intercalibration type.

GIGs are expected to apply this boundary setting procedure for each of the common intercalibration types, and to report how they have applied the different steps to WG A on a regular basis. The steps do not necessarily need to be completed in the order indicated. It should be rather thought of as an iterative process. However, GIGs should complete all steps before the end of the intercalibration exercise (2006),

Outline components of a boundary setting procedure	
1. Describe type-specific reference conditions for biological quality elements	*Reference conditions are the starting point of WFD classification. Agreement on reference conditions for the common intercalibration type is a requirement for intercalibration of the classification outcome. GIGs should describe a procedure and criteria for deriving reference conditions, and apply this to their common intercalibration types.* *A comparison of Member States views on what very minor disturbance means in practice is likely to highlight any potentially significant differences between Member States view of the class boundaries*
2. Agree rules for deriving high-good boundary for biological quality element consistent with the normative definitions	*An explicit description of what constitutes a 'slight deviation from reference conditions' should be given.* *Intercalibration requires agreement on the way the high-good biological boundary value is derived[31]. This may include a relation to the physico-chemical and hydromorphological conditions.* *A comparison of Member States' approaches should highlight any potentially significant differences*
3. Establish a data set illustrating reference conditions and the degradation of the biological quality element along a pressure gradient[32]	*The ecological status classes represent different degrees of degradation from reference conditions in the condition of biological quality elements. Data about on the degradation path is needed to interpret and illustrate the normative definitions.* *The description of the degradation path should be relatable to the criteria specified in the normative definitions. The descriptions should be in terms of metrics derived from the*

[31] If a spatial network of reference sites is used to quantify reference conditions and/or class boundaries using statistical criteria, the criteria used to select sites for this reference network should be specified (e.g. pressure criteria, 'best available, etc.)
[32] Using common metrics (Option 1-2) or Member State's assessment methods (Option 3)
[33] The pressure gradient does not need to be quantified – although it would be useful for the purposes of checking comparability if it was

		basic biological data. The pressure gradient itself should preferably be quantified in relation to the biological changes, since this is necessary to arrive at certain pressure reductions required to reach good status for the biological element[33]
4.	Describe criteria for good status and moderate status classes derived from the normative definitions and related to the way in which the quality element degrades from reference conditions with increasing pressure	*Boundary setting has to be based on a common understanding of what the normative definitions of high, good and moderate class mean in the context of each intercalibration type/quality element/pressure combination.*
5.	Method/criteria used to derive good-moderate status boundary values	*The criteria developed in point 4 may be translated into a framework of rules for setting boundaries – the final component of the boundary setting procedure*
6.	Apply the criteria to the data set(s) established in step 3 and establish EQR values for the high-good and the good-moderate ecological status boundaries	*The outcome of the boundary setting procedure is reference values and good status boundary EQR values established consistent with the WFD normative definitions.*

Annex II: List of Geographical Intercalibration Groups (GIGs)

Informal GIG co-ordinator(s) (Steering Group members for Central Lakes and River GIGs) indicated in **bold**

Geographical Intercalibration Groups

1) Rivers

Name of the GIG	Countries comprising rivers GIGs
Northern	Finland Ireland Norway **Sweden** United Kingdom
Central/Baltic	Austria Belgium Czech Republic Denmark Estonia **France** **Germany** Ireland Italy Latvia Lithuania Luxemburg Netherlands Poland Spain Sweden **United Kingdom**
Alpine	**Austria** France Germany Italy Slovenia Spain
Eastern Continental **(ICPDR)**	Austria Bulgaria Czech Republic Greece Hungary Romania Slovakia

Mediterranean	Cyprus France Greece Italy Malta **Portugal** Spain

2) Lakes

Name of the GIG	Member States comprising lakes GIGs
Northern	Finland Ireland Norway **Sweden** United Kingdom
Central/Baltic	Belgium **Denmark** Estonia France Germany Hungary Latvia Lithuania **Netherlands** **Poland** **United Kingdom**
Atlantic	**Ireland** Portugal Spain United Kingdom
Alpine	**Austria** France Germany Italy Slovenia
Mediterranean	Cyprus France Greece Italy Malta Portugal Romania **Spain**

3) Transitional and coastal waters

Name of the GIG	Member States comprising coastal GIGs

Baltic	Denmark Estonia Finland Germany Latvia Lithuania Poland Sweden
North-East Atlantic	Belgium Denmark France Germany Ireland Netherlands Norway Portugal Spain Sweden **United Kingdom**
Mediterranean	Cyprus France Greece Italy Malta Slovenia Spain
Black Sea	Bulgaria **Romania**

Annex III: Example of a hybrid intercalibration option

An example of a hybrid intercalibration approach is given in Figure III.1. In this approach boundaries are initially set by the Member State (as in Option 3), then compared to a common metric (as in Option 2), and harmonised where necessary). Common metrics enable a GIG-wide comparison of classification results. Several river GIGs identified this as the most promising option, and tested it in the autumn of 2004. For this approach to be successful it is essential that there is agreement within the GIG on criteria to derive reference conditions.

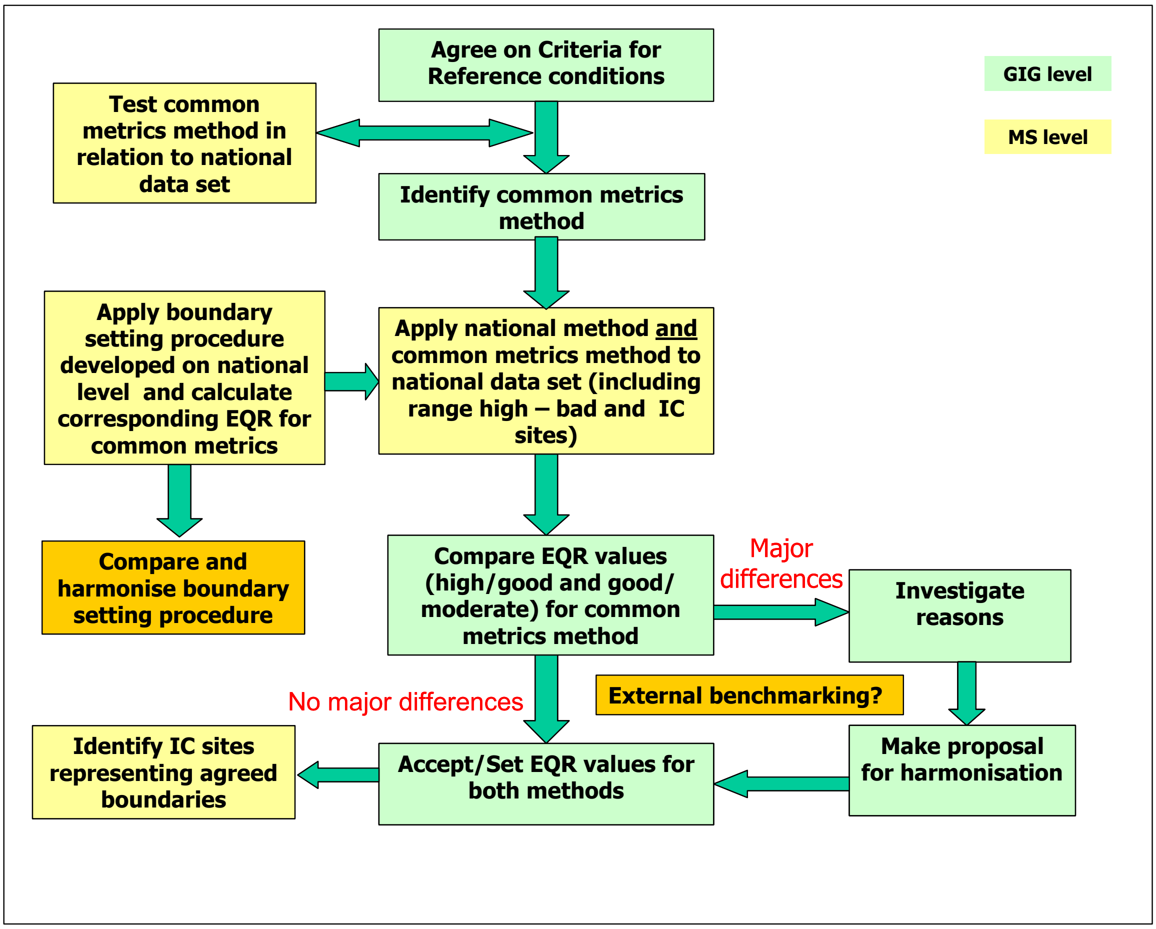


Figure III.1: Example of a hybrid intercalibration approach, combining elements of Options 2 and 3.

In this approach it is not necessary to compile a single data set at the GIG level, avoiding the problem of collating data from different countries applying different methods. Instead, Member States apply a common metric to their own data sets, and compare this to their national assessment results. This approach is especially suitable in cases where Member States have relatively well-developed assessment methods in place at the start of the intercalibration exercise (e.g. macroinvertebrate assessment methods for rivers), and where a robust common metric is available. This procedure is undergoing testing in the Alpine, Mediterranean, and Central/Baltic river GIGs, with very promising results.

Because initially the class boundary setting procedure is only applied by Member States using their own data and methods, it will be necessary to compare and harmonise the different steps of the class boundary setting procedure within the GIG. If the comparison of Member State's classification results using the common metric show that there are no major differences between countries this should be a relatively trivial task; if there are major differences that cannot be resolved within the GIG it may be necessary to directly apply the class boundary setting procedure to a benchmarking data set (best available classification)

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 15

Guidance on Groundwater Monitoring

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 15

Guidance on Groundwater Monitoring

FOREWORD

The Water Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In particular, one of the objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology is therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, a guidance document "Monitoring under the Water Framework Directive" has been developed and endorsed by the Water Directors in November 2002 (CIS Guidance Document Nr. 7). This document provides Member States with Guidance on monitoring of inland surface water, transitional waters, coastal waters and groundwater, based on the criteria provided in Annex V of the Water Framework Directive.

As a follow-up, and in the context of the development of the new Groundwater Directive under Article 17 of the Water Framewortk Directive, Member States have expressed the need to clarify issues of groundwater monitoring related to e.g. quantitative and chemical status monitoring, protected area monitoring, or monitoring linked to prevent/limit measures. A project to develop a guidance document complementing the CIS Guidance Document Nr. 7 has, therefore, been designed in 2004, and an informal drafting group has been established under the umbrella of the CIS Working Group on Groundwater (WG C). This drafting group has been coordinated by Austria and the United Kingdom, and involved a range of experts from other Member States and from stakeholder organisations.

The present Guidance Document is the outcome of this drafting group. It contains the synthesis of the output of discussions that have taken place since December 2004. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the procedure of Guidance development through meetings, workshops, conferences and electronic media, without binding them in any way to this content.

"We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the Finnish Presidency in Inari (30 November-1st December 2006). We would like to thank the participants of the Working Group C and, in particular, the leaders of the monitoring drafting group, Austria and the United Kingdom, for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive and the newly adopted Groundwater Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

We also commit ourselves to assess and decide upon the necessity for reviewing this document in the light of scientific and technical progress and the experiences gained in the monitoring programmes of the Water Framework Directive".

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Monitoring Guidance for Groundwater

THE COMMON IMPLEMENTATION STRATEGY (CIS) OF THE WFD

The Water Framework Directive (2000/60/EC)[1] is a comprehensive piece of legislation that sets out, *inter alia*, “good status” objectives for all waters in Europe. The Directive provides for a sustainable and integrated management of river basins including binding objectives, clear deadlines and comprehensive programme of measures based on scientific, technical and economic analysis including public information and consultation. Soon after its adoption, it has become clear that the successful implementation of the Directive will be equally as challenging and ambitious for all countries, institutions and stakeholders involved.

In order to address the challenges in a co-operative and coordinated way, the Member States, Norway and the Commission agreed on a Common Implementation Strategy (CIS) for the Water Framework Directive only five months after the entry into force of the Directive. Furthermore, the Water Directors stressed the necessity to involve stakeholders, NGOs and the research community in this joint process as well as to enable the participation of Candidate Countries in order to facilitate their cohesion process.

In the first phase of the joint process, a number of guidance documents were prepared and these documents were tested in Pilot River Basins across Europe in 2003 and 2004. In the new Work Programme 2005/2006, the four Working Groups (Ecological Status, Integrated River Basin Management, Groundwater and Reporting) have continued addressing the key issues for implementation. In addition, new groups on ‘WFD and Agriculture’, ‘GIS’ and ‘Chemical Monitoring’ are sharing experiences in this area and a new Pilot River Basin network is supporting the technical activities in all working groups.

1 PURPOSE AND SCOPE OF THE GUIDANCE

This guidance has been drafted in response to a mandate from the WFD Groundwater Working Group (Working Group C). This mandate required the development of practical guidance and technical specifications for groundwater monitoring that builds on, and complements existing WFD guidance[2]. Its primary focus is on the requirements of the Water Framework Directive (WFD), and in particular the obligations set out in Article 8. In addition, it will meet the requirements of the daughter Groundwater Directive (adopted at the end of 2006)[3]. The guidance also forms one of the elements of the WFD Chemical Monitoring Activity.

This document provides guidance on establishing groundwater monitoring programmes to meet the requirements of the WFD and of the new Groundwater Directive. These programmes include both quantitative and chemical (quality) monitoring for status and trend assessment, monitoring to support (ground)water body characterisation and drinking water protected area objectives.

The establishment of high quality long-term monitoring programmes is essential if the implementation of the WFD and the daughter Groundwater Directive is to be effective. It is recognised that monitoring can be very expensive and so the guidance presented here aims to establish cost-effective, risk-based and targeted groundwater monitoring across Europe that enables WFD objectives to be met. However, inadequate investment in monitoring, including network infrastructure and data quality and management will result in a significant risk of failure to meet the WFD’s environmental objectives.

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[1] European Parliament and Council Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22/12/2000, p. 1) as amended by European Parliament and Council Decision 2455/2001/EC (OJ L 331, 15/12/2001, p.1)

[2] Guidance Document No. 2 Identification of Water Bodies (2003);
Guidance Document No. 3: Analysis of Impacts and Pressures – Working Group 2.1 IMPRESS (2003)
Guidance Document No. 7: Monitoring under the Water Framework Directive – WG 2.7 Monitoring (2003);
Technical Report 1: Statistical aspects of the identification of groundwater pollution trends and aggregation of monitoring results – WG 2.8 Statistics (2001);
Chemical Monitoring Activity;
Technical report on groundwater monitoring (workshop report 25th June 2004);
EC Monitoring Guidance for the Nitrates Directive;
EUROWATERNET Guidelines (Technical Report Nr. 7, EEA 1999);
Guidelines on monitoring and assessment of transboundary groundwaters (UN-ECE).

[3] European Parliament and Council Directive on the protection of groundwater against pollution and deterioration (adopted in December 2006)

Recommendations expressed in this guidance paper will help to implement consistent monitoring across Europe. The guidance provides useful elements for the development and maintenance of networks at high standards and thereby provide the necessary information to assess (ground)water status, identify trends in pollutant concentrations, support establishment and assessment of programmes of measures and the effective targeting of economic resources.

2 BACKGROUND

Article 8 of the WFD requires the establishment of programmes for the monitoring of groundwater. WFD groundwater monitoring is focussed primarily on the groundwater body as a whole but it also supports the overall management of the river basin district and the achievement of its environmental objectives.

The groundwater monitoring programmes must provide the information necessary to assess whether relevant Article 4 environmental objectives are met, in particular the assessment of groundwater quantitative status, chemical status and significant, long-term trends in natural conditions and trends in groundwater bodies resulting from human activity. In addition, these may need to be supplemented by additional monitoring programmes to meet requirements relevant to Protected Areas (e.g. Drinking Water Protected Areas) and to support the validation of the Article 5 characterisation and risk assessment procedures. Programmes meeting these requirements must be operational by 22 December 2006 at the latest.

The WFD sets out the requirements for the different groundwater monitoring programmes in Annex V (2.2 and 2.4) and Annex II (2.3), which must include:

- A **quantitative monitoring network** to supplement and validate the Article 5 characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater quantitative status in all groundwater bodies, or groups of bodies. Its principal purpose is therefore to facilitate quantitative status assessment.
- A **surveillance monitoring network** to: (a) supplement and validate the Article 5 characterisation and risk assessment procedure with respect to the risks of failing to achieve good groundwater chemical status; (b) provide information for use in the assessment of long-term trends in natural conditions and in pollutant concentrations resulting from human activity and; (c) to establish, in conjunction with the risk assessment the need for operational monitoring.
- An **operational monitoring network** to: (a) establish the status of all groundwater bodies, or groups of bodies, determined as being ‘at risk’, and (b) establish the presence of significant and sustained upward trends in the concentration of pollutants.
- Appropriate monitoring to support the achievement of Drinking Water Protected Area (DWPA) objectives.

The results of the monitoring must be used to:

- establish the chemical and quantitative status of groundwater bodies (including an assessment of the available groundwater resource);
- assist in further characterisation of groundwater bodies;
- validate the risk assessments carried out under Article 5;
- estimate the direction and rate of flow in groundwater bodies that cross Member States’ boundaries;
- assist in the design of programmes of measures;
- evaluate the effectiveness of programmes of measures;
- demonstrate compliance with DWPA and other protected area objectives;
- characterise the natural quality of groundwater including natural trends (baseline); and
- identify anthropogenically induced trends in pollutant concentrations and their reversal.

Specific provisions concern those bodies of groundwater which cross the boundary between two or more Member States. Bilateral agreement should be reached on monitoring strategies, which requires coordination of conceptual model development, the exchange of data and QA and QC aspects (in line with the requirements of Article 13(2) of the WFD). The provisions for the surveillance monitoring require transboundary groundwater bodies to be monitored for those parameters which are relevant for the protection of all uses supported by the groundwater flow.

An overview of the objectives for each monitoring programme described in detail in this guidance document is shown in Table 1.

The WFD stipulates that surveillance monitoring must be undertaken during each planning cycle, and operational monitoring must be carried out during periods not covered by surveillance monitoring. No minimum duration or frequency is specified for the surveillance programme. Operational monitoring must be carried out at least once a year during periods between surveillance monitoring. Member States should undertake sufficient surveillance monitoring during each plan period to allow adequate validation of Article 5 risk assessments and obtain information for use in trend assessment, and sufficient operational monitoring to establish the status of bodies at risk and the presence of significant and sustained upward trend in pollutant concentrations.

Table 1: Overview of the relationship of monitoring objectives for each monitoring programme defined by, or to support, the WFD and the daughter Groundwater Directive

	WFD Specified Monitoring Programmes			**Drinking Water Protected Area (DWPA) Monitoring**	**Prevent and Limit Monitoring**
Monitoring objective(s)	**Quantity Monitoring**	**Surveillance Monitoring**	**Operational Monitoring**		
Section in guidance document covering details for monitoring	Section 5	Section 4.1	Section 4.2	Section 6	Section 7
Supplement and validate the risk assessment (initial and further characterisation)	✓	✓	(✓[1])		✓
Identify saline or other intrusions resulting from alterations if flow within the groundwater body	✓	✓	✓		
Assess chemical trends in natural conditions		✓			
Assess chemical trends caused by anthropogenic activity		✓	✓	✓	
Transboundary groundwater bodies	✓	✓			
Status assessment – determining status of bodies that are ‘at risk’	✓		✓	✓[2]	
Status assessment – confirming that bodies ‘not at risk’ are at good status	✓	✓		✓[2]	
Assess the effectiveness of Programmes of Measures	✓		✓	✓	✓

[1]) Results will support characterisation in future RBMP cycles

[2]) Assumes new Groundwater Directive will require DWPA objectives to he met for good status

3 GENERAL PRINCIPLES

The monitoring programmes must provide the information necessary to assess whether the WFD environmental objectives will be achieved. This means that a clear understanding of the environmental conditions required for the achievement of the objectives, and of how these could be affected by human activities, is essential for the design of effective monitoring programmes. The monitoring programmes should therefore be designed on the basis of the results of the Article 5 characterisation and risk assessment procedure and the **conceptual model/understanding** of the groundwater system in which the general scheme of ‘recharge-pathway-discharge’ is known. Detail and importance of such models is already laid down in relevant CIS guidance[4]. Chapter 3.1 outlines the principles and relationship of the model to the monitoring programme.

[4] Guidance Document No. 3: Analysis of Impacts and Pressures – Working Group 2.1 IMPRESS (2003)
Guidance Document No. 7: Monitoring under the Water Framework Directive – WG 2.7 Monitoring (2003);

Considering the principles described in this guidance should allow for the establishment of a monitoring network which is **representative** for the groundwater body. The amount of monitoring required (number of points and sampling frequency) will be proportional to the difficulty in (a) judging the status of the groundwater body, (b) the presence of adverse trends, and (c) the implications of errors in such judgements, in particular with regard to setting up programmes of measures.

It should be emphasised that the WFD monitoring programme is intended to focus on phenomena affecting the **overall state of the groundwater body**. Local scale pollution processes which do not affect the overall state of the groundwater body should be the target of different monitoring activities run by the appropriate competent authorities (e.g. a regulatory, local authority etc.) responsible for the relevant legal provisions. Such local impacts are not relevant at the groundwater body scale unless their evolution in time and space endangers the environmental objectives of the groundwater body. They may, however, be relevant with respect to assessments linked to 'prevent/limit' measures covered by Article 11 of the WFD and Article 6 of the daughter Groundwater Directive, which are discussed in a separate guidance document.

The application of the term 'body of groundwater' must be understood in the context of the hierarchy of relevant definitions provided under Article 2 of the WFD. Accordingly, a *body of groundwater* means a distinct volume of groundwater within an aquifer or aquifers. *Groundwater* means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil and *aquifer* means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater. Furthermore, **groundwater bodies may be grouped** i.e. for the purpose of monitoring.

The design of a monitoring network should take into account the **three-dimensional** nature of the groundwater system and both, **spatial and temporal variability**, especially when determining the location of monitoring sites and the selection of appropriate monitoring site types. The network should have a spatial and temporal density which considers the natural characteristics of the groundwater body (conceptual understanding) and the pollution risks, to help focus monitoring activities in areas where significant pressures combined with higher vulnerability exist.

In order to contribute to a three-dimensional representative monitoring network an advanced conceptual understanding of hydrogeological characteristics and pressures is essential, especially where there is evidence of significant vertical variation in the aquifer characteristics and stratification of groundwater quality.

The **selection/location** of appropriate sampling sites and the selection of appropriate site density should be based on the conceptual understanding (hydrogeological characteristics and pressures) and might be supported by using existing information such as:

- existing quality and/or quantity data (length, frequency, range of parameters);
- construction characteristics of existing sites and the abstraction regime;
- the spatial distribution of existing sites compared to the scale the groundwater body; and
- practical considerations relating to easy and long-term access, security, health and safety.

The selection of appropriate monitoring **site types** within a monitoring network at groundwater body level should be based on an understanding of the objectives of monitoring and the understanding (conceptual or otherwise) of travel times and/or groundwater ages that the monitoring site may typically sample. This understanding may be enhanced by groundwater age dating where appropriate.

Detailed information on the site should be available and be routinely reviewed. This information should be used to assess the suitability of the site to be used in the relevant monitoring programme. Elements for characterising sampling sites are summarised in Annex 2 as well as the advantages and disadvantages of different monitoring installations/points (types and uses) in Annex 3.

Integrated monitoring will contribute significantly to cost-efficient monitoring by making best use of appropriate components of existing monitoring networks serving different objective and by designing and operating integrated groundwater and surface water monitoring networks.

3.1 CONCEPTUAL MODELS AS BASIS FOR MONITORING

Conceptual models/understanding are simplified representations, or working descriptions, of the hydrogeological system being investigated. Their development underpins much of the work carried out as part of the characterisation process. As the amount of, and confidence in, the available environmental information increases, the accuracy and complexity of the model improves, so that they become more effective and reliable descriptions of the system.

The conceptual model will represent the current understanding of the groundwater system based on the knowledge of its natural characteristics (e.g. the aquifer type, three-dimensional structure, dynamics and boundary conditions), perceived pressures and knowledge of impacts.

In this guidance, two types of conceptual model/understanding are used:

- the regional conceptual model – an understanding of the factors at groundwater body scale that identifies the need to establish a monitoring network/point and how the data will be used;
- the local conceptual model – an understanding of the local factors influencing the behaviour, both in chemical and quantitative terms, of individual monitoring points.

Within (inter)national river basins large differences may and do occur in the geochemical and hydrogeological characteristics of groundwater bodies. Therefore conceptual models may differ between regions within a(n) (inter)national river basin. A regional conceptual model/understanding will identify the specific requirements for establishing a monitoring network and the degree of monitoring, in terms of number of sites, site density and frequency of monitoring. This model/understanding will be consistent with that developed and used as part of the characterisation and risk assessment process.

Figure 3.1 outlines the principles and relationship of the model to the monitoring programme.

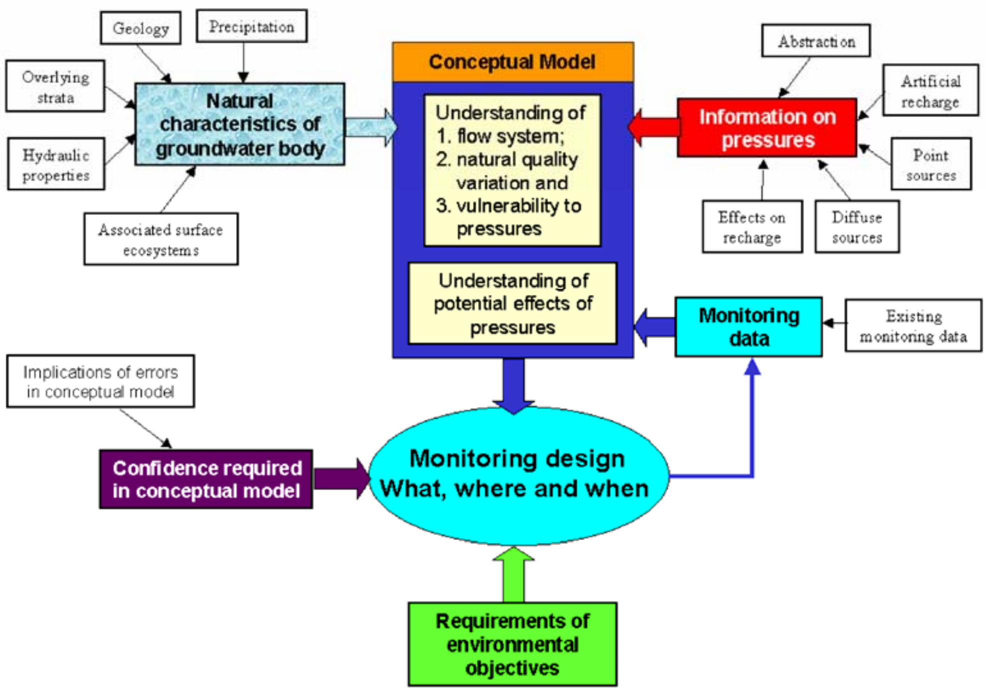

Figure 3.1: Link between the conceptual model/understanding and monitoring (from CIS WG 2.7 Monitoring Guidance)

The selection of groundwater monitoring points also requires knowledge of the local factors influencing the behaviour of the monitoring point. This enables an assessment to be made of the point's suitability for providing representative information and data to support the objectives of the monitoring programme. This conceptual understanding is vital for the effective operation of the monitoring programme.

In developing the local conceptual understanding, information on local hydrogeological and environmental conditions is required. This information includes:

- monitoring point construction details;

- hydrogeological setting;
- understanding of recharge sources and patterns;
- local groundwater flow pattern(s) and regime within the catchment area;
- abstraction impacts;
- existing hydrochemical data;
- approximate size of catchment area;
- land use and pressures within the catchment area.

Information about travel times and/or or groundwater age distribution may be a very useful input to the conceptual model/understanding as well as for validating the model. Monitoring data obtained from the WFD monitoring programmes should be used to test, validate and refine the conceptual model(s). This process should be started before the first data are available and continued until there is adequate confidence in its/their reliability. Testing may include using the conceptual model and measured values of chemistry and/or water level to predict conditions at locations elsewhere within the groundwater body that are not monitored and then installing monitoring to check these predictions to confirm the model or identify what refinements are needed.

In addition to assisting with the design of the monitoring network the conceptual model is also extremely important for understanding and interpreting the monitoring data.

3.2 AQUIFER TYPES

A consideration of the different types of aquifers is an essential part of the conceptual model/understanding. A diverse range of hydrogeological settings and aquifer types is found across Europe. This broad variation has major implications for the suitability of different types of sampling installation and how effectively they represent changes in groundwater systems, and monitoring design needs to be tailored accordingly.

For all groundwater bodies, there is a need to consider the characteristics of the strata forming the aquifers with regard to flow paths and flow mechanisms, storage, unsaturated zone thickness, groundwater recharge and discharge, before determining the most appropriate means of monitoring. The scale of the groundwater body i.e. whether there are local and rapid flow paths or much longer and slower regional ones, and the nature of the geological material, in particular whether groundwater movement is dominantly through the intergranular spaces between the grains of sedimentary rocks or via the fractures in consolidated rocks are key factors in this respect.

Hence a clear understanding is needed of what each monitoring point represents in terms of the groundwater bodies in which they are located, and the response times of the groundwater both to pressures imposed upon them and to measures to control their impacts.

A summary of the range of aquifer settings found across Europe and the range of likely response times is given in Annex 1.

3.3 GROUPING OF GROUNDWATER BODIES

As proposed by the CIS guidance on the Identification of Water Bodies[5], groundwater bodies may be grouped for monitoring purposes provided that the monitoring information obtained provides a reliable assessment of the status of each body in the group and the confirmation of any significant upward trends in pollutant concentrations.

In grouping groundwater bodies, the monitoring programmes must be designed and operated to ensure that the environmental and monitoring objectives for each of the component bodies making up the group can be reliably achieved.

Where groundwater bodies are determined to be **not at risk** according to the Article 5 review process, bodies may be grouped if they are sufficiently similar in terms of aquifer characteristics, pathway susceptibility(ies), pressure(s) and confidence in the risk assessment(s).

In undertaking the grouping:

- bodies do not necessarily need to be adjacent to each other;

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[5] Guidance Document No. 2: Identification of Water Bodies (2003).

- a monitoring point is not required in each of the component bodies within the group provided there is sufficient overall monitoring in the group as a whole to meet the requirements of operational surveillance, quantitative or protected area monitoring, as appropriate.

Where groundwater bodies are determined to be **at risk** according to the Article 5 review process, bodies may be grouped if they are sufficiently similar in terms of aquifer characteristics, pathway susceptibility(ies), pressure(s) and confidence in the risk assessment(s). In undertaking the grouping:

- bodies should be adjacent to each other except in exceptional circumstances (e.g. numerous small comparable groundwater bodies; islands);
- it is recommended that each component body should have at least one monitoring point to determine the relationship between the bodies. However the number of monitoring points will depend on the aquifer characteristics, pathway susceptibility(ies), pressure(s) and confidence in the risk assessment(s);
- operational monitoring may be focused on one or more component bodies selected on the basis of the conceptual model, e.g. the most sensitive body(ies). This prioritised monitoring is designed to deliver cost-effective targeted environmental monitoring.

3.4 INTEGRATED MONITORING

The WFD considers the water environment as a continuum. This is reflected in the groundwater status definition and through the recognition of the role played by groundwater in maintaining the flow, quality and ecology of dependent surface waters and vice versa. Therefore as well as providing an overview of the distribution of contaminants in the body of groundwater, monitoring should be able to provide an understanding and assessment relating to groundwater flows between groundwater bodies and surface water bodies and between groundwater bodies and terrestrial ecosystems. The extent of this monitoring will depend on the significance of the dependency of the surface water bodies and/or terrestrial ecosystems on groundwater and the extent of the risks.

Monitoring programmes for surface water and groundwater should therefore be designed and operated in an integrated way where the environmental objectives of surface waters and groundwater are dependent on each other. Surface waters with a large proportion of groundwater derived base flow can be used to indicate the quality of groundwater and monitoring data from surface water bodies may support the assessment of groundwater body status. In many cases, the correct location of a surface water sampling point, e.g. close to an aquifer discharge point, may function as a monitoring point for both programmes.

The integration of available wells and springs already used for other purposes (monitoring or abstractions) has several advantages as it contributes to a representative reflection of the state of groundwater. It can also contribute significantly to cost-effective monitoring but has to be done carefully in order to avoid bias. Boreholes in regular operation have the advantage of less need of purging before sampling. However, a network dominated by drinking water abstractions might not adequately reflect the overall environmental quality of the groundwater across the whole body. This is because they are often situated in locations where the groundwater quality is good, e.g. away from recharge areas, or abstract only from deeper parts of the aquifer. It is important to note that when drinking water abstraction sites are used for monitoring, it is raw water quality that should be sampled and analysed. A representative monitoring network should ideally be based on a balanced mixture of different sampling site types as well as sampling site uses. The advantages and disadvantages of different monitoring points (types and uses) are summarised in Annex 3.

3.5 NETWORK REVIEW AND UPDATE

As the conceptual model is refined and the understanding of the hydrogeology and hydrochemistry of the groundwater system improves, the network design should be reviewed and adapted if required. The monitoring results obtained from the network should be interpreted regularly and the monitoring network and its operation reviewed at least once every six years, but ideally more frequently.

Updating of the network should take into account the observed variations in the natural processes and/or anthropogenic impacts influencing groundwater quantity and quality, trends and emerging phenomena. As knowledge improves, it can be seen as a network optimisation process. Review and updating of the network should be performed every time the factors influencing the observed phenomena change significantly, and should take account of the likely response times of the aquifers, in relation to the expected ages of the groundwater being sampled.

However, when updating the network, it is important to remember that deleting a monitoring site will lead to a potential loss of useful information and that to correctly assess trends, it is important to keep sampling sites with long time series. It is easier to add a site than delete one. It is also important to maintain the data for sites taken off the network to enable audit and review of previous decisions/management plans based on these data.

The removal of site from the network may also introduce bias. Any changes to the network must be assessed in terms of the impact this will have on the information being derived from the monitoring programme and the decisions being made.

4 CHEMICAL STATUS AND TREND MONITORING

Groundwater monitoring programmes are required to provide a coherent and comprehensive overview of water status within each river basin, to detect the presence of long-term anthropogenically induced trends in pollutant concentrations and ensure compliance with Protected Area objectives. As stressed in the daughter Groundwater Directive, reliable and comparable methods for groundwater monitoring are an important tool for assessment of groundwater quality (and this is applicable to quantity as well).

A groundwater body will be at good chemical status if the following criteria are satisfied:

- *General water quality*: The concentrations of pollutants should not exceed the quality standards applicable under other relevant Community legislation in accordance with Art. 17;
- *Impacts on ecosystems*: The concentration of pollutants should not be such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body*;*
- *Saline intrusion*: The concentrations of pollutants should not exhibit the effects of saline or other intrusions as measured by changes in conductivity.

The WFD requires both surveillance and operational programmes to be established to provide the information needed to support the assessment of chemical status and identification and monitoring of pollutant trends.

Monitoring programmes specifically for addressing protected areas and prevent and limit objectives are covered separately in sections 6 and 7 respectively.

4.1 DESIGN OF THE SURVEILLANCE MONITORING PROGRAMME

Surveillance monitoring is focusing on the groundwater body as a whole. A ‘surveillance monitoring’ programme is required to:

- *Validate risk assessments:* supplement and validate the characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater chemical status;
- *Classify groundwater bodies:* confirm the status of all groundwater bodies, or groups of bodies, determined as not being at risk on the basis of the risk assessments; and
- *Assess trends:* provide information for use in the assessment of long-term trends in natural conditions and in pollutant concentrations resulting from human activity.

Surveillance monitoring is required in bodies or groups of bodies both at risk and not at risk of failing WFD objectives. The programme must be carried out during each River Basin Management cycle, irrespective of whether the groundwater body (or group of bodies) is at risk.

Surveillance monitoring should be undertaken in each plan period and to the extent necessary to adequately supplement and validate the risk assessment procedure for each body or group of bodies of groundwater.

The surveillance monitoring programme will also be useful for defining natural background levels (as defined in the daughter Groundwater Directive) and characteristics within the groundwater body. This will enable future changes in conditions to be assessed, reference data to be acquired and typologies to be investigated. This information will be useful for characterising transboundary water bodies and as a basis for European-wide reporting.

In designing a surveillance programme, the required confidence in the monitoring results must be defined in order to achieve sufficient confidence in the assessment. The required confidence in surveillance monitoring depends upon the variability of the groundwater or aquifer properties in question. In principle, the uncertainty from the monitoring process should not add significantly to the variability of the monitoring data.

The acceptable risk of not identifying a new pollution pressure or a trend change should also be established and this information used when establishing the objectives for the monitoring, managing the monitoring programme(s) and assessing data quality and variability.

4.1.1 Selection of surveillance monitoring determinands

The recommended core set of determinands comprises dissolved oxygen, pH-value, electrical conductivity, nitrate, ammonium, temperature and a set of major and trace ions. Parameters such as temperature and a set of major and trace ions are not formally required by the WFD but may be helpful to validate the Article 5 risk assessment and the conceptual models. Selective determinands (e.g. heavy metals and relevant basic radio nuclides) will be needed for assessing natural background levels.

Additional indicators of anthropogenic contaminants typical of land use activities in the area and with the potential to impact on groundwater will also be required on an infrequent basis (see below) to provide additional validation of WFD risk assessments and to check for any new identified pressure.

In addition at all sites monitoring of the water level is recommended in order to describe (and interpret) the 'physical status of the site' and to interpret (seasonal) variations or trends in chemical composition of groundwater.

Further information on both core and selective determinand suite selection is provided in Annex 3.

4.1.2 Selection of representative surveillance monitoring sites

The selection of sampling sites and their operation is of major importance for the results of the later assessment procedure especially as contaminants are often unevenly distributed across a body of groundwater. The spatial distribution of contaminants is related to the location of different pressures e.g. point and diffuse sources (different types of land use). Additionally a body of groundwater is three dimensional and the concentration of contaminants may vary significantly in vertical and lateral direction. Common variations of hydrodynamic and hydro-geochemical characteristics inside a body of groundwater can have significant impact on the parameter specific spreading of contaminants and should be taken into account during the selection of monitoring sites. Furthermore the physico-chemical parameters (e.g. electrical conductivity, temperature and contaminant concentrations) in shallow aquifers sometimes reveal a distinct variation over the year.

The selection process should be based on three main factors:

- the conceptual model(s) including assessment of the hydrological, hydrogeological and hydrochemical characteristics of the body of groundwater including characteristic travel times, distribution of different types of land uses (e.g. settlement, industry, forest, pasture/farm land), pathway susceptibility, receptor sensitivity and existing quality data;
- assessment of risk and the level of confidence in the assessment; including the distribution of key pressures[6] and;
- practical considerations relating to the suitability of individual sampling points (see Annex 3). Sites need to be easily accessed, secure and be able to provide long-term access agreements.

An effective monitoring network will be one in which the sites are able to monitor for the potential impacts of identified pressures and the evolution of groundwater quality along the flow paths within the body.

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[6] It should be noted that the risk assessment – as carried out under Article 5 of the WFD – and the identification of key pressures should enable identification of specific pollutants that contribute to the determination of groundwater bodies as being "at risk". Under the new Groundwater Directive, consideration will need to be given for establishing threshold values (groundwater quality standards) for these substances by the end of 2008. They should therefore be considered in the list of parameters to be monitored.

Where risk issues relate to specific receptors such as ecosystems, additional sampling points can be focussed in areas that are close to these receptors. In these cases, where the location of pressures (point sources) is well known, sampling points will often be used to help isolate impacts from different pressure types, assess the areal extent of impacts and determine contaminant fate and transport between the pressure and the receptor. In some cases this may involve the use of multi-level samplers although, as noted in Annex 3, such installations can be very expensive.

Site selection factors must be assessed on a site by site basis, but key principles are as follows:

- *Suitable types of site:* Selection should be based on the regional conceptual model of the groundwater bodies (or group of bodies) and a review of existing and candidate monitoring sites, the local conceptual model. Surveillance monitoring is not, on its own, required to isolate the impact of individual pressures and the effectiveness of programmes of measures, but should give an overview of the water quality within the groundwater body or group of groundwater bodies. Large abstractions and springs may therefore provide suitable sampling sites, as they draw water from a large area and volume of aquifer particularly in homogeneous systems. Springs are particularly recommended in karstic or shallow fracture flow dominated aquifers. However, a representative monitoring network should ideally be based on a balanced mixture of different sampling site types as well as sampling site uses (e.g. abstraction, monitoring etc.). In some hydrogeological systems where the groundwater contributes significantly to the (base)flow of the surface water course, then sampling of the surface water may provide a representative groundwater sample.
- *Representativity:* In some aquifer systems, stratification may occur. In this case the location of monitoring points must be focussed on those parts of the groundwater body that are most susceptible to pollution. This will often be the upper parts. However to provide a representative assessment of the distribution of contaminants for the groundwater as a whole additional monitoring in other parts of the groundwater body is also required.
- *'At risk' bodies*: Surveillance monitoring sites will provide the basis for the operational monitoring i.e. based on the results the network can be adapted accordingly. Sites could be used for both programmes.
- *'Not at risk' bodies where confidence in the risk assessment is low:* The number of monitoring points should be sufficient to be representative of the range of pressure and pathway conditions in the groundwater body (or group of bodies) with the aim of providing the data necessary to supplement the risk assessment, i.e. increase confidence. The location of sampling points may therefore be focussed on the most susceptible areas of the groundwater body(ies) for each pressure/pathway combination. The final distribution per grouping will depend on availability of suitable surveillance sites and the distribution of pressures. As a general guide, a minimum of 3 points in a groundwater body or group of bodies is recommended. However where groundwater bodies are large and heterogeneous, it is likely that significantly more monitoring points will be needed to meet the monitoring objectives.
- *Groups of groundwater bodies where pressures are limited (low or absent):* In groups of groundwater bodies that are defined as 'not at risk' and confidence in the risk assessment is high, sampling stations will be required primarily to assess natural background levels and natural trends. Locations should therefore be selected accordingly.

4.1.3 Monitoring frequency

The selection of appropriate monitoring frequency will generally be based on the conceptual model and existing groundwater monitoring data. Where there is adequate knowledge of the groundwater system and a long-term monitoring programme is already established this should be used to determine an appropriate frequency for surveillance monitoring. Where knowledge is inadequate and data are not available, Table 2 suggests frequencies for surveillance monitoring that can be adopted for different aquifer types. Of major importance is the change of concentration patterns with time which influences the selected monitoring frequency as does the increased knowledge of the conceptual understanding. In general, shallow groundwater bodies are rather dynamic with respect to water quantity and quality variation. If such variability occurs, monitoring frequency has to be selected accordingly in order to characterise this variability adequately.

In less dynamic groundwater systems two samples per year may be sufficient initially for surveillance monitoring. If this monitoring shows no significant variation over a river basin cycle (six years) a further reduction of sampling frequency may be appropriate.

Due to possibly time-related changes of concentration patterns, especially in rather dynamic groundwater flow systems, sampling per monitoring location must be executed at the same distance of time (frequency-related). This guarantees comparable monitoring results and a proper trend assessment.

The results of surveillance monitoring should be reviewed on a regular basis and frequencies adjusted accordingly to ensure that the information requirements are fully met and a cost-effective programme maintained.

Table 2: Proposed monitoring frequencies for surveillance monitoring (where understanding of aquifer systems is inadequate).

Note: This table proposes monitoring frequencies that can be used as a guide where the conceptual understanding is limited and existing data are not available. Where there is a good understanding of groundwater quality and the behaviour of the hydrogeological system, alternative monitoring frequencies can be adopted as necessary.

		Aquifer Flow Type				
		Confined	**Unconfined**			
			Intergranular flow significant		**Fracture flow only**	**Karst flow**
			Significant deep flows common	**Shallow flow**		
Initial frequency – core & additional parameters		Twice per year	Quarterly	Quarterly	Quarterly	Quarterly
Long term frequency – core parameters	**Generally high-mod transmissivity**	Every 2 years	Annual	Twice per year	Twice per year	Twice per year
	Generally low transmissivity	Every 6 years	Annual	Annual	Annual	Twice per year
Additional parameters (on-going validation)		Every 6 years	Every 6 years	Every 6 years	Every 6 years	-

4.2 DESIGN OF THE OPERATIONAL MONITORING PROGRAMME

Operational monitoring is focusing on the groundwater body as a whole. An ‘operational monitoring’ programme is required to establish:

- the chemical status of all groundwater bodies, or groups of bodies, determined as being ‘at risk’;
- the presence of any long term anthropogenically induced upward trends in the concentration of any pollutant; and
- it can also be used to assess the effectiveness of programmes of measures implemented to restore a body to good status or reverse upwards trends in pollutant concentrations.

Operational monitoring is required only in bodies 'at risk’ of failing to meet WFD objectives. It should be carried out during the periods between surveillance monitoring. In contrast to surveillance monitoring, operational monitoring is highly focussed on assessing the specific, identified risks to the achievement of the Directive’s objectives.

In designing an operational monitoring programme, the required confidence in the monitoring results must be defined. The required confidence in operational monitoring depends upon the variability of the impact source and the groundwater or aquifer properties in question, as well as the risk in case of error. In principle, the uncertainty from the monitoring process should not add significantly to the uncertainty of controlling the risk.

The acceptability of not identifying a new risk or controlling a known risk should be established, used for setting objectives for the variability of the properties in question and used for control of the monitoring quality with respect to data variability.

4.2.1 Selection of operational monitoring determinands

In most cases, both core and selected determinands will be required at each sampling station (see footnote 6 concerning the requirement to establish groundwater threshold values under the daughter

Groundwater Directive). Guidance on selection of core and selective determinands is provided in Annex 3.

The selection process will be based on:

- Characterisation and conceptual model(s) including an assessment of groundwater pathway susceptibility, receptor sensitivity, the time taken for any programme of measures to be effective and the ability to differentiate between the effects of different measures .
- Assessment of risk and the level of confidence in the assessment; including the distribution of key pressures identified in the characterisation process and which may cause the body to be classified as at poor status.
- Practical considerations relating to the suitability of individual sampling points.

4.2.2 Selection of representative operational monitoring sites

When selecting monitoring sites, their locations should be prioritised on the basis of:

- Availability of suitable existing sites (e.g. from the surveillance monitoring programme) that provide representative samples.
- Potential for supporting different WFD monitoring programmes (e.g. suitable springs can act as quality, quantity and surface water sampling stations).
- Potential for integrated multi-purpose monitoring, e.g. combining requirements for Nitrates Directive monitoring, Drinking Water Protected Area monitoring, monitoring linked to registration of plant protection or biocidal products[7], IPPC Directive monitoring and Groundwater Directive compliance.
- Potential linkages with existing/planned surface water monitoring sites.

Where risk issues relate to specific receptors such as ecosystems, additional sampling points can be focussed in areas that are close to these receptors. This monitoring, as well as contributing to status and trend assessment can also help to distinguish the impacts from different pressure types, assess the spatial extent of impacts and determine contaminant fate and transport between the source and the receptor. This information will be important to the risk assessment and characterisation process. It may include monitoring of the upper parts of the aquifer and possibly water draining from soils, e.g. multi-level samplers, lysimeters and field drain sampling.

Where pressures and risk issues relate to the groundwater itself, e.g. diffuse pressures, sampling points will be more distributed across the body, and will be focussed on the different pressures and their distribution within the groundwater body. Where necessary it may be appropriate to focus resources on the most representative or sensitive combinations of pressures and groundwater susceptibility.

4.2.3 Monitoring frequency

Monitoring frequency selection will generally be based on the conceptual model and in particular, the characteristics of the aquifer and its susceptibility to pollution pressures. Table 3 proposes monitoring frequencies for operational monitoring for different aquifer types where the conceptual understanding is limited and existing data are not available. Where there is a good understanding of groundwater quality and the behaviour of the hydrogeological system, alternative monitoring frequencies can be adopted as necessary.

Sampling frequency and sample timing at each monitoring location should furthermore consider:

- requirements for trend assessment;
- whether the location is upgradient, directly below, or downgradient of the pressure. Locations directly below a pressure may require more frequent monitoring;
- the level of confidence in Article 5 risk assessments, and changes in the assessments over time;

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[7] See recommendations formulated by the Forum for the Co-ordination of pesticide fate models and their use (FOCUS). Final report of the Ground Water Group of Focus, European Commission, DG SANCO, 2006

- short term fluctuations in pollutant concentrations, e.g. seasonal effects. Where seasonal and other short-term effects are likely to be encountered, it is essential that sampling frequencies and timings are adjusted (increased) accordingly and that sampling takes place at the same time(s) each year, or under the same conditions, to enable comparable data for trend assessment, accurate characterisation and status assessment; and
- land use management patterns, e.g. the period of pesticides or nitrate application. This is especially important for rapid flow system like karstic aquifers and/or shallow groundwater bodies.

Sampling for operational monitoring must be continued until the groundwater body is determined, with adequate confidence, to be no longer at poor status <u>or</u> at risk of being at poor status <u>and</u> there is adequate data to demonstrate a reversal of trends.

Table 3: Proposed frequencies for operational monitoring.

		Aquifer Flow Type				
		Confined	**Unconfined**			
			Intergranular flow significant		**Fracture flow only**	**Karst flow**
			Significant deep flows common	**Shallow flow**		
Higher vulnerability groundwater	**Continuous pressures**	Annual	Twice per year	Twice per year	Quarterly	Quarterly
	Seasonal / intermittent pressures	Annual	Annual	As appropriate	As appropriate	As appropriate
Lower vulnerability groundwater	**Continuous pressures**	Annual	Annual	Twice per year	Twice per year	Quarterly
	Seasonal / intermittent pressures	Annual	Annual	As appropriate	As appropriate	As appropriate
Trend assessments		Annual	Twice per year	Twice per year	Twice per year	-

5 QUANTITY MONITORING

A quantitative monitoring network is required to assist in characterisation, to determine the quantitative status of groundwater bodies, to support the chemical status assessment and trend analysis and to support the design and evaluation of the programme of measures.

A groundwater body will be at good quantitative status if:

- the available groundwater resource is not exceeded by the long-term annual average rate of abstraction; and
- the groundwater levels and flows are sufficient to meet environmental objectives for associated surface waters and groundwater dependent terrestrial ecosystems; and
- anthropogenic alterations to flow direction resulting from level change does not cause saline or other intrusion.

As with other networks, the monitoring design should be based on a conceptual understanding of the groundwater system and the pressures. The key elements of the quantitative conceptual understanding will be:

- assessments of recharge and water balance; and/or
- existing groundwater level or discharge assessments and relevant information on the risks for groundwater dependent surface waters and groundwater dependent terrestrial ecosystems.
- the degree of interaction between groundwater and related surface and terrestrial ecosystems where this interaction is important and could potentially cause the surface water body status to be affected.

The development of a quantitative monitoring network can be iterative; data collected from new monitoring points being used to enhance and refine the conceptual model used to locate each monitoring point in the groundwater body as a whole and the operation of the quantitative monitoring programme.

Implementation of a numerical groundwater model or a hydrological model integrating groundwater and surface water are useful tools in compiling and interpreting quantitative monitoring data and identifying resources and ecosystems at risk. Furthermore, the uncertainty estimates that can be obtained with a numerical model can help identify parts of a groundwater body where additional data points will add most to the description of groundwater quantity and flow.

5.1.1 Monitoring parameters

Although the Directive identifies groundwater level as the metric for determining quantitative status, in practice, the requirements of status assessment mean that additional supporting information will be required. Recommended parameters for the purposes of quantitative assessment of groundwater include:

- groundwater levels in boreholes or wells;
- spring flows;
- flow characteristics and/or stage levels of surface water courses during drought periods (i.e. when the flow component directly related to rainfall can be neglected and discharge is sustained substantially by groundwater);
- stage levels in significant groundwater dependent wetlands and lakes.

Selection of the monitoring points and parameters must be based on a sound conceptual model of the water body to be monitored.

Additional monitoring to support groundwater characterisation and classification may include:

- chemical and indicator parameter (e.g. temperature, electrical conductivity) monitoring for saline or other intrusions. For island aquifers it may also be appropriate to monitor the fresh/saline water transition zone. This may include;
- rainfall and the components required to calculate evapo-transpiration (to calculate groundwater recharge);
- ecological monitoring of groundwater dependent terrestrial ecosystems (including ecological indicators); and
- groundwater abstraction (and artificial recharge).

Specific requirements for the supportive monitoring data, to supplement the knowledge gained from groundwater level monitoring will largely be determined by the tools/methods that will be employed to support the assessment of risk or status and the confidence required in this assessment.

Key to parameter selection is how representative the parameter is of the hydrogeological setting being monitored and the significance of its role in determining risk or status.

In some hydrogeological settings monitoring groundwater levels in a borehole may be inappropriate for the purposes of the Directive and in some cases highly be misleading. In these circumstances the flow characteristics of associated watercourses or springs may provide better data with which to undertake an assessment. This is most likely to be the case in low permeability/fractured aquifers. There are cases, when the water level remains more or less stable but water from other aquifers, surface waters or even seawater is intruding. Specific conditions should be considered for groundwater bodies on islands. If there is the risk of waters intruding, then appropriate water quality indicators should be monitored, e.g. electrical conductivity and water temperature.

5.1.2 Selection of monitoring density

Monitoring may be required at two different scales to meet the various requirements of the Article 4 objectives. Firstly, where possible, groundwater levels and flows across a groundwater body should be assessed. These may be related to the water balance assessment for the body as a whole. Secondly, more focussed ‘local’ monitoring of levels and flows that relate to relevant local groundwater supported receptors, i.e. surface water bodies (rivers, lakes, estuaries) and groundwater dependent terrestrial ecosystems, may be needed. The latter may include supporting information e.g. salinity monitoring (with respect to saline intrusions) or supporting information from ecological monitoring as already performed under other relevant community legislation (as evidence of impact on ecosystems from groundwater abstractions).

In groundwater bodies or groups of groundwater bodies assessed as being 'not at risk', the monitoring can be minimised. Indeed, monitoring need not be located in each body within a group, provided that the groups are hydrogeologically comparable.

In groundwater bodies or groups of groundwater bodies assessed as being 'at risk', the distribution of monitoring points will reflect the need to understand the hydrogeological conditions that relate to the receptors identified as being 'at risk' and to their perceived importance. Monitoring density must be sufficient to ensure proper assessment of impacts due to abstractions and discharges on groundwater level.

Specific provisions concern those bodies of groundwater which cross the boundary between two or more Member States, such as the location of groundwater abstraction points providing more than 10 m³ a day or serving more than 50 persons, the abstraction rates, direct discharges to groundwater etc. The number of sampling sites should be sufficient to be able to estimate the direction and rate of groundwater flow across the Member State boundary.

5.1.3 Monitoring frequency

The amount and frequency of monitoring will be determined by the data needed to determine risk and status, and where necessary to support the design and assessment of a programme of measures.

Frequency of monitoring predominantly depends of the characteristics of the water body and the monitoring site respectively. Sites with significant annual variability should be monitored more frequently than sites with only minor variability. In general monthly monitoring will be sufficient for quantity monitoring where variability is low but daily monitoring would be preferred (particularly when measuring flows). The frequency should be revised as knowledge of the aquifer response and behaviour improves and in relation to the significance of any changes in pressures on the groundwater body. This will ensure that a cost-effective programme is maintained.

6 PROTECTED AREA MONITORING

Member States are required to meet the standards and objectives of any Protected Areas established under other relevant community legislation and identified in Annex IV of the WFD. Where these specify a requirement for the monitoring of groundwater it is assumed that as part of the implementation process Member States are complying fully with these requirements and following any relevant guidance. The guidance contained here only addresses the requirements for the WFD.

Further details regarding protected areas are described in the guidance document on 'Groundwater Protected Areas'.

To ensure monitoring programmes are as efficient and as effective as possible, it would be appropriate to ensure that the quantitative and the chemical monitoring programmes described above complement, and are integrated with, the programmes established for Protected Areas so that the groundwater monitoring networks are as far as possible multi-purpose.

6.1 DRINKING WATER PROTECTED AREA MONITORING

The WFD requires that monitoring programmes are able to assess the achievement of Drinking Water Protected Area (DWPA) objectives defined under Article 7. Unlike surface water bodies defined as DWPAs, the WFD does not introduce any additional specific monitoring criteria for DWPAs. However, the DWPA objectives require that any monitoring is also able to provide accurate and reliable data to support DWPA management and assessment. For example this information will be needed to identify any deterioration in the quality of abstracted groundwater that may potentially lead to an increase in the level of purification/treatment. It will not be necessary to monitor for all the parameters specified by the Drinking Water Directive (80/78/EEC as amended by 98/83/EC). Only those parameters that are directly related to the quality of the groundwater (raw water) need to be considered. The list of the parameters will be based on the results of the risk assessment, existing knowledge of groundwater quality and the purification treatment regimes in place at drinking water sources.

Monitoring in groundwater DWPAs should therefore be carried out in accordance with the programmes set out for surveillance and/or operational monitoring as relevant to that groundwater body in order to meet Article 4 objectives, with the added requirement to ensure compliance with

DWPA objectives (Article 7(3)) and the information requirements of ‘further characterisation’ set out in Annex II (2.3c) of the WFD.

The Article 7(3) objective of aiming to prevent deterioration in the water quality of DWPAs in order to reduce treatment implies that there are background quality data for DWPAs at the date of implementation of this objective, against which any subsequent deterioration can be assessed. No specification for this is provided so it may be assumed that only monitoring sufficient to assess this objective is needed. It seems clear that raw water quality data are needed and it is logical to assume that this should be focused on potable abstraction sources.

Regular monitoring of all potable sources would not be practical or necessary where the characterisation processes has indicated no risk. In water bodies or groups of bodies not at risk of meeting DWPA objectives it is recommended that there should be sufficient monitoring of a representative selection of significant potable sources (those to which the Drinking Water Directive applies – see note below[8]) to confirm the risk assessment. This should be incorporated into and may in practice already be part of the surveillance monitoring programme or another national monitoring programme. The relevant criteria for surveillance monitoring therefore apply. It should be noted that the Drinking Water Directive also includes a requirement to meet standards for microbiological parameters and radioactivity and these may need to be include in any DWPA monitoring programme where these may potentially lead to a failure of DWPA objectives.

In water bodies at risk of not meeting DWPA objectives, it is recommended that significant potable sources should be monitored, as a minimum, at least once before and at least once within each RBMP period. Where appropriate, this monitoring may be focussed on, or restricted to, areas where the pressures and/or impacts that are giving rise to the risk are relevant to the quality of abstracted water. Safeguard zones may be used to focus such monitoring (and subsequently to focus any necessary protection measures). If data from drinking water (raw water) monitoring already exist, these can be used as well.

In many cases potable abstraction sources will form part of the surveillance and operational monitoring programmes. In these cases, the specific requirements of the surveillance and operational monitoring programmes will take precedence over the monitoring outlined above. Where sources are part of surveillance and/or operational monitoring programmes, more frequent data than indicated above will be available and should be used for assessing compliance with Article 7 objectives.

In some cases individual groundwater abstraction points may form part of a group of sources that effectively abstract water from the same zone of contribution or safeguard zone within the DWPA. In such cases, providing that the monitoring regime is consistent and representative, not all individual sources may need to be monitored to adequately assess compliance with Article 7 objectives.

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[8] A significant potable source is defined as one intended for human consumption that comes within the requirements of the Drinking Water Directive (Directive 80/778/EEC as amended by Directive 98/83/EC). That is a source where;

- water abstracted from an individual supply provides 10 m³ a day or more as an average or serves at least 50 persons, unless supplied as part of a commercial or public activity in which cases the thresholds do not apply;

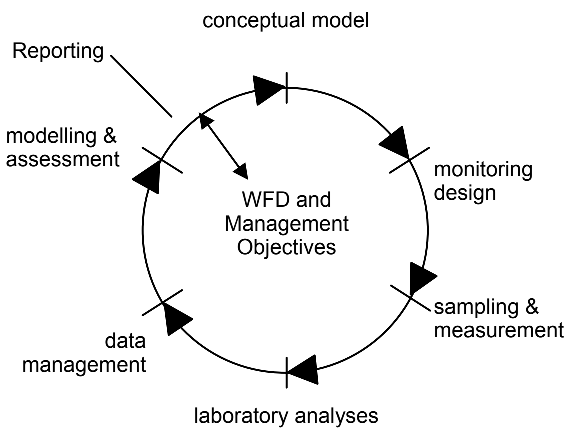
and that is not:

- a natural mineral water recognised as such by the competent national authorities, in accordance with Council Directive 80/778/EEC of 15 July 1980 on the approximation of the laws of the Member States relating to the exploitation and marketing of natural mineral waters; or
- water which is a medicinal product within the meaning of Council Directive 65/65/EEC of 26 January 1965 on the approximation of provisions laid down by law, regulation or administrative action relating to medicinal products.

7 PREVENT AND LIMIT MONITORING

Groundwater quality monitoring is required to assess the effectiveness of the measures introduced to prevent or limit the inputs of pollutants and/or the deterioration of the status of groundwater (in accordance with Article 11(3) of the WFD and Article 6 of the daughter Groundwater Directive). Although surveillance and operational monitoring programmes will contribute significantly to this, there may be a need for specific additional monitoring programmes aimed at point source pressures. Therefore, this guidance distinguishes between surveillance and operational monitoring focused on the groundwater body as a whole and **prevent and limit monitoring** focused on point sources.

Prevent and limit monitoring of this type is designed primarily at ensuring compliance with site conditions and authorisations in the cases of regulated activities or for site specific investigation, i.e. compliance monitoring, or for the purposes of characterising site specific impacts and designing and assessing remedial action programmes, i.e. investigation monitoring.



These programme requirements may already be defined by specific regulation aimed at preventing or limiting the input of pollutants to groundwater, e.g. Landfill Directive requirements for landfill monitoring or Groundwater Regulations requirement for requisite surveillance. It may also be designed specifically to investigate other localised issues, e.g. contaminated land or accidental spillages.

Although prevent and limit monitoring is not explicitly requested in the WFD, the information derived from this monitoring should be used for characterisation and the investigation of specific issues, as well as ensuring that Programmes of Measures are being effective. It should not be used specifically for status and trend assessment, although some monitoring sites may potentially be used for surveillance and/or operational monitoring. However, where such sites are used, they must fully conform to the quality assurance requirements of WFD monitoring programme sites. Where sites do not comply they should be rejected.

8 ENSURING QUALITY OF MONITORING DATA

The quality required for groundwater monitoring depends upon the purpose but must be defined for each step in the entire process which consists of:

- conceptual modelling,
- monitoring design,
- field sampling and measurements,
- laboratory analysis,
- transfer, storage, modelling,
- interpretation of data,
- result reporting

The required quality should be obtained by defining sets of verifiable quality requirements for each step in the process. The quality requirements should not be defined independently from each other, in order to avoid setting higher quality standards for one step than can be accommodated by the others. The variability of the system to be monitored, the uncertainty associated with sampling and analysis, the risks involved in case of error and the costs should be considered in setting quality requirements that are fit for purpose.

8.1 QUALITY REQUIREMENTS

Quality requirements for a **conceptual model** can be defined in terms of the acceptable deviations of measured from predicted properties (frequency and extent). This can be achieved by formulating questions that must be answered by the monitoring data and other relevant information with defined certainty based upon the conceptual model. The conceptual model and changes therein should be documented and subject to peer review.

Quality requirements for a **monitoring design** can be formulated in terms of required maximum allowable confidence interval for the relevant compliance criteria (e.g. average value) in time or space of a parameter within a groundwater body or a group of groundwater bodies. The design should be documented and subject to peer review.

Quality requirements for **sampling** must be formulated in terms of the maximum acceptable uncertainty of sampling.

Quality requirements for the **analysis** must be formulated in terms of the maximum acceptable uncertainty of analysis and the required analytical detection limit.

Quality requirements for **transfer, storage, modelling and interpretation of data** are clear documentation of data management, interpretation and decision rules based on good modelling practices.

8.2 QUALITY CONTROL

During the monitoring process, the achievement of the quality requirements shall itself be monitored. If the defined quality requirements are not met for one or more of the steps during monitoring, as demonstrated by the quality control measures taken, the monitoring must be re-evaluated and if required, improved and repeated.

Controlling the quality of the **conceptual model** against the requirements is best done as an iterative process during the entire monitoring programme and in relation to the required confidence; see Figure 8.1.

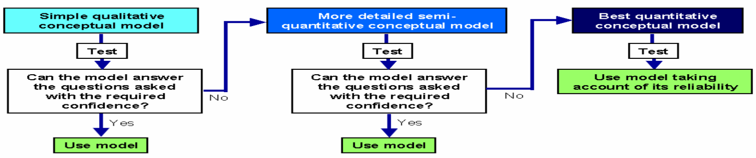


Figure 8.1: Iterative control of the conceptual model against set quality requirements

The control of the quality of the **monitoring design** will ensure that the required confidence intervals are not exceeded.

These confidence intervals may be calculated based upon the established quality requirements or they may be based upon expert judgment that takes into account the expected variability. In either case, the compliance of the monitoring design in relation to the quality requirements should be verifiable. It should be emphasized that the variability of the data will include components from the monitoring design, sampling and analytical methods and the natural variability of the medium. The former components should be considered when improving the quality of the monitoring design, as these can be controlled, whereas the natural variability can not.

For **sampling and analysis**, appropriate quality assurance procedures will enable minimisation of errors in sampling and analysis. Minimum elements to be covered by quality assurance procedures are:

- Identification and records for samples, devices and operators
- Sampling methods, sampling plan and sampling field reports
- Sample transportation, receipt, storage and preservation

- Validation of methods, including uncertainty estimation
- Analytical measurement procedures
- Internal quality control of methods
- Participation in external QC schemes (proficiency testing schemes etc)
- Expression of results
- Traceability of documents
- Traceability of measurements

The user of sampling and analytical data should always request documented information on the quality of the services received and ensure that the necessary quality criteria have been met. The sampling and analysis should be done with third party assessment of the quality procedures applied. For laboratory analysis, accreditation according to the international standard ISO 17025 is recommended, whereas for sampling, laboratories and other sampling service suppliers could choose either accreditation according to ISO 17025 or personnel certification according to ISO 17024. For sampling procedures, see Chapter 9.

For parameters where field measurements are most suitable, field measurements should be subject to method validation and quality control as required for laboratory measurements.

In control of **transfer, storage, modelling and interpretation of data**, spot checks of data consistency (transfer and storage) are mandatory. Model validation with data not included in model development and calibration should be done.

9 METHODS FOR SAMPLING AND ANALYSIS

As the starting point, sampling strategies, sampling techniques, sample treatment, analysis, calculations and reporting should be considered integral parts of the overall monitoring process (monitoring supply chain). A detailed description of the wide-range of tools, techniques and methods for groundwater sampling and analysis is beyond the scope of this guidance. This section therefore only provides a brief overview of the key aspects. For more detailed guidance on methods and instructions, the reader is referred to international and national standards, guidelines and textbooks (reference to ISO 5667 series for sampling and to the Chemical Monitoring Activity). For sampling and analysis, validated methods should be used which also address the issue of fitness-for-purpose (Section 8). Sampling and analysis should be carried out in accordance with published international and national standard methods, unless explicitly justified not to do so due to e.g. the absence of suitable standard methods.

Due to the technical difficulties in accessing groundwater and the rapid changes in chemistry that can take place once the water has been removed from its point of origin, **sampling** for groundwater monitoring requires careful planning and the selection of the most suitable equipment and methods.

Standard methods for sampling are generally less precise than analytical methods, in part because of the varying field conditions at different sites and the varying purposes of sampling, and in part because the process of standardising sampling is presently less advanced than that for chemical analysis. Therefore, even with national and international standards there is a need of harmonisation of approaches and methods to ensure the comparability and representativeness of sampling.

Sampling methods for groundwater monitoring must take into account the regional and the local conceptual model:

- the hydrogeological conditions (layered aquifer, porous/fissure/fracture flow, permeability etc)
- physico-chemical properties (volatility of substances, adsorption properties, reactivity etc) of determinands sampled for;
- the type of parameters being measured (chemical, biological, physical) and;
- the characteristics of the sampling point (e.g. well diameter, screen length, depth of sampling, static/flowing).

Unstable parameters such as pH, temperature, conductivity, dissolved oxygen and where necessary, redox potential and turbidity must be **measured in the field**, as quickly as possible. For this, special calibrated equipment with clear operating instructions and procedures is required.

Similarly, **sample treatment** such as preservation or filtration of water samples must be done in the field without aeration and as rapidly as possible in order to avoid changes in the distribution between dissolved and particulate phases within the sample.

New analytical methods and parameters should be applied to the monitoring programmes to improve the quality of monitoring and to deliver efficiencies. For those emerging analytical methods and new parameters, standard methods may not yet be available. In those cases, 'in-house' validated methods are required (see Section 8 for requirements) and their application must be documented accordingly and the performance of new methods regularly evaluated.

10 REPORTING

Elements of the monitoring programme are subject to reporting under Article 15(2) of the WFD.

Estimates of the confidence in the monitoring results should be determined and reported in accordance with WFD requirements. The reported confidence must as a minimum describe the uncertainty arising from the monitoring processes and the variability (in time or space) of the parameters monitored. If the initially required confidence has not been obtained, the consequences for the monitoring objectives must be evaluated and the need for adjustment of the monitoring programme specified.

Documentation of monitoring programme, operation, and status/trend reporting should be further discussed considering the development of the 'Reporting Sheets' elaborated in WG D. It comprises summary information in 'verbal' form like investigated parameters and monitoring frequency and information in table structure.

GLOSSARY

Groundwater means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.

Aquifer means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.

Body of groundwater means a distinct volume of groundwater within an aquifer or aquifers.

Drinking Water Protected Area (DWPA) means areas designated for the abstraction of water for human consumption under Article 7 of the WFD.

Raw water means groundwater in its natural state prior to any treatment or purification.

ANNEX 1 - AQUIFER TYPES

The European land mass embraces the whole spectrum of geological rock types, ages and histories. Consequently, a diverse range of hydrogeological settings and aquifer types is found across Europe covering e.g.:

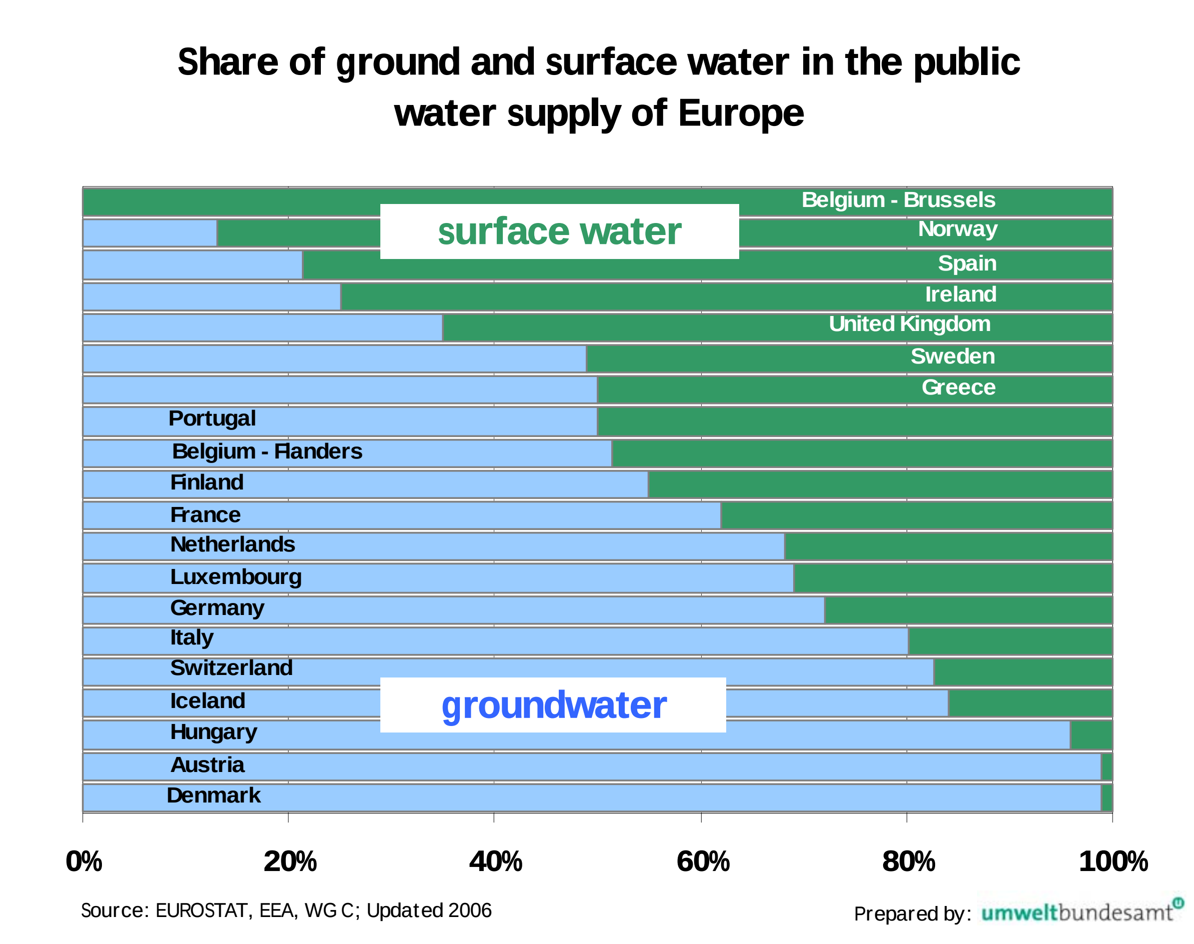
- major alluvial and coastal plain sediments where the relations with surface water systems might be complex;
- intermontane colluvial systems, discharging mainly to springs and/or directly to the base flow of rivers;
- consolidated sedimentary aquifers – limestones, chalk and sandstones;
- karstic (mountain or plain) areas with or without external inflow;
- marls and clays with local aquifers made of limestones or sands;
- recent coastal calcareous formations and islands;
- glacial and associated small alluvial formations;
- extensive volcanic terrains;
- weathered and fresh crystalline basement (including metamorphic rocks such as gneisses and schists).

This broad variation has important implications for the suitability of different types of sampling installation and how effectively they represent changes in groundwater systems, and monitoring design needs to be tailored accordingly. Further, the information obtained, and in particular any changes observed, is required to be reported at national and European levels regularly over several decades. Hence a clear understanding is needed of what each monitoring point represents in terms of the groundwater bodies in which they are located, and the response times of the groundwater both to pressures imposed upon them and to measures to control their impacts. A summary of the range of aquifer settings found across Europe and their response times is shown in the table below.

*Table 4: Summary of groundwater situation in EU Member States (*Proportion of groundwater in public water supply) (based on EEA, 1999, amended by WG C).*

Country (*)	**Principal aquifers**	**Response times**
Finland (55%) Norway (13%) Sweden (49%)	Small, thin, shallow aquifers in fractured crystalline bedrock and glacio-fluvial sands and gravels	Fast to moderate
Denmark (99%)	Some Chalk and recent sands and gravels, mostly shallow with thin unsaturated zone	Fast to moderate
Netherlands (68%) Belgium (52%)	Thick alluvial sequences with water table very close to surface – thin unsaturated zone	Fast
United Kingdom (35%)	Important aquifers are consolidated Chalk, sandstone and limestone in the south, centre and east, some alluvium	Ranges from fast to slow
France (62%)	Some Chalk in the north , thick alluvial plains, limestones in the centre and south, crystalline basement rocks in the West, in the Centre and in mountain areas	Ranges from fast to slow
Germany (72%)	Thick alluvial plains in the north, consolidated sediments in the centre and south	Fast to moderate
Ireland (25%)	Main aquifers are limestones (karstified to varying degrees), fissured sandstones, volcanics and small shallow fluvioglacial sand/gravel deposits. Poorly productive aquifers (muddy limestones, granites, metamorphic rocks) underlie 65% of the country.	Fast
Austria (99%)	Karstic limestones and some alluvial basins and river plains, some older fractured rocks in Alpine regions	Mostly fast

Country (*)	**Principal aquifers**	**Response times**
Spain (21%) Greece (50%) Portugal (50%) Italy (80%)	Karstic limestones, sandstones, coastal alluvial plains and some large alluvial basins (Po, Guadalquivir, Tagus), volcanic aquifers (Italy, Portugal).	Mostly fast. Moderate in alluvial basins and volcanic aquifers
Luxembourg (69%) Switzerland (83%) Iceland (84%)		
Hungary (96%)	Thick alluvial basin in the east and northwest, karstic aquifers in the centre, north and south, consolidated sediments in the west, some fractured rocks in mountain areas	Fast to slow



ANNEX 2 - INFORMATION REQUIREMENTS FOR MONITORING POINTS

Detailed information on the site should be available and routinely reviewed. This information should be used to assess the suitability of the site to be used for the relevant monitoring programme. Elements for characterising sampling sites are summarised below.

Table 5: Monitoring point information – essential and desirable factors

Factor	Chemical monitoring points	Quantitative monitoring points	Reporting Requirement (to be finalised)
Aquifer(s) monitored	E	E	✓
Location (grid reference), name of monitoring point and unique identifier	E	E	✓
Groundwater body that monitoring point is within	E	E	✓
Purpose(s) of monitoring site	E	E	✓
Type of monitoring point – farm borehole, industrial borehole, spring, etc	E	E	✓
Depth and diameter(s) of boreholes/wells	E	D	
Description of headworks – grouting integrity, slope of ground around borehole	E	E	
Depth of screened/open sections of boreholes/wells	D	D	
Vulnerability or indication of subsoil thickness and type at monitoring point	E	D	
Visual appraisal of recharge area (including land use and pressures, potential sources of point pressures)	E	D	
Construction details	E	E	
Amount abstracted or total discharge (at springs)	E	E	
Pumping regime (qualitative description – e.g., intermittent, continuous, overnight, etc.)	D	E	
Drawdown (pumped water level)	D	E	
Zone of contribution/recharge area	D	D	
Pump depth	D	D	
Static or rest water level	D	E	
Datum elevation and description of datum	D	E	
Artesian/ overflowing	E	E	
Borehole log (geological)	D	D	
Aquifer properties (transmissivity, hydraulic conductivity etc)	D	D	

E…Essential, D … Desirable

For quantitative monitoring sites:

- Monitoring points should not be pumped or should only be pumped for very short periods at well-defined times, such that measured water levels reflect natural conditions.
- The locations should be outside the immediate hydraulic influence of the pressure such that day-to-day variations in pumping will not be evident in the data.
- Large springs may be suitable where total flows are in excess of 1 litre/sec.

Note that data from stations which function as continuous abstraction wells may be acceptable if accompanied by detailed (e.g. hourly) pumping records.

ANNEX 3 - ADVANTAGES AND DISADVANTAGES USING AVAILABLE WELLS

Many national monitoring programmes, especially those that have developed overt time depend to a large extent on sampling from existing discharge points. Of these, public supply boreholes have the advantage of being operated more or less continuously. Purging is therefore not required, and sampling from the supply pump (often from a side tap) is easy, relatively inexpensive, and determination of field parameters is usually straightforward. Private domestic, industrial and irrigation boreholes are also widely used, and have many of the same advantages, except that they may be used less regularly.

In some aquifers, dug wells may be plentiful and accessible, but may be open to direct infiltration or shallow pollution pathways, difficult to purge satisfactorily and also shallow and only representative of the uppermost parts of the aquifer.

Where there are spring discharges from groundwater, these may be cheap and easy to sample, and should always be considered, especially for those bodies of groundwater defined by Article 7.1 of the WFD. Large springs may be particularly suitable in mountain and karstic areas, where suitable boreholes intersecting the major fissured flow paths are difficult to find or construct. Smaller springs may have shallow flow paths vulnerable to localised pollution, be unrepresentative of the main body of deeper groundwater, and subject to unreliable or intermittent flow during droughts, or even seasonally. Sometimes spring flow paths may be so short and shallow that they draw only from superficial deposits, rather than the underlying and more extensive aquifers. Where aquifers discharge directly into rivers integration with the surface water monitoring network is advised, and surface water quality may provide the best indication of groundwater quality.

If the groundwater is used for drinking water abstraction, the monitoring network design should take account of this. A representative selection of drinking water wells/springs could be included in the network or existing drinking water monitoring results can be used, but only if they are based on raw water samples and preferably from individual wells rather than those taken from within the distribution system.

Sampling from supply boreholes produces a sample drawn from the screened or open section of the borehole, which may be quite large. The sample may integrate water of different ages over the whole vertical interval in uniform, intergranular sedimentary aquifers or, in fractured aquifers, drawn from separate groundwater flow horizons that the borehole has intersected. Except in the most well-studied and documented public supply boreholes, the true depth origin of the sampled groundwater is uncertain, while vertical variations in groundwater quality can be expected. If the operating supply boreholes are deep, but the upper aquifer horizons are known or expected to have poorer quality water, then sampling from the supply boreholes may provide an over-optimistic picture of groundwater quality.

Where the hydrogeological conditions indicate major vertical variations in aquifer types and characteristics, and an analysis of pressures or of existing quality data suggest the presence of stratified groundwater quality, then adequate monitoring may require discrete sampling points. Several approaches can be used for this, but they all require sound knowledge of the groundwater conditions, specialised construction techniques and are increasingly costly, especially in aquifers with thick unsaturated zones and fissured rocks. In these situations the use of observation wells has the drawback of requiring a dedicated sampling pump or a pump to be brought to the site each time and adequate purging to ensure that the sample is not standing water from within the installation. Therefore, sampling visits are longer and need more and better experienced staff. In situations with shallow granular aquifers with shallow water tables, however, monitoring networks solely made up of observations wells can be cost-effective. For example, a monitoring network of a spatially representative mixture of multi-level and single-level observation wells designed using information on specific land use and hydrogeological characteristics can be effective in aquifers with a large spatial variability in groundwater quality. In all cases, selection of springs, pumping wells or observation wells requires evaluation of flow paths and characteristic travel times, and water sampled should be relatively young in order to give an indication of impacts from pressures being considered as part of the WFD characterisation and risk assessment process.

Monitoring networks may include a variety of types of the installations and facilities described above. Their characteristics for sampling groundwater are summarised in the following table. Decisions about types of sampling installations to be used can also have important implications for the cost of monitoring and some information about relative costs is given in the table.

Table 6: Summary of the characteristics of groundwater sampling facilities

Type of sampling point	**Character of discharge**	**Discrete vertical sampling points**	**Quantitative measurements**	**Hydraulic testing**	**Inert materials**	**Costs**			**Notes**
						Drilling	**Materials**	**Sampling**	
Existing groundwater sampling points									
Public supply borehole	Usually high and continuous	Integrates over screen interval	Usually disturbed by pumping	Data may exist	No	None	None	Very low	
Private supply borehole	Often low and intermittent	Integrates over screen interval, but may be shallow	Sometimes disturbed by pumping	Data may exist	No	None	None	Low	Purging may be problematic/time consuming for irregularly used boreholes
Irrigation borehole	High but may be intermittent or seasonal	Integrates over screen interval	Possible in non-pumping seasons	Data may exist	No	None	None	Low	Purging may be time consuming when boreholes not used
Dug well	Usually intermittent	No	Yes, usually	Unlikely	No	None	None	Low	Large storage in well, difficult to purge with sampling pump
Large springs	High and continuous	No	Yes, discharge	No	No materials	None	None	Low	May have large catchments and good in karst areas
Small springs	May be low and seasonal or irregular	No	Yes, discharge	No	No	None	None	None	May have shallow, vulnerable flow paths
Purpose-constructed observation or monitoring boreholes									
Single piezometer	Low and needs portable pump	One, usually a short screen near bottom	Yes	Yes	Yes	Moderate	Low	Moderate, but needs pump	
Cluster of single piezometers	Low and needs portable pump	Several distinct depths	Yes	Yes	Yes	Very high	High	High, needs pump	
Nest of piezometers in single borehole	Very low, needs portable pump	Two to five	Yes	Yes	Yes	High	High	High	
Multi-port sampling systems	Very low, needs specialist pump	Many	Some types	Some types	Yes	Moderate	High	High	Requires specialist techniques and expertise for installation and operations

ANNEX 4 - INITIAL GUIDANCE ON THE SELECTION OF DETERMINAND SUITES

SURVEILLANCE MONITORING

The following core determinands are mandatory:

- oxygen content (DO),
- pH-value,
- electrical conductivity (EC),
- nitrate, and
- ammonium.

In addition, the WFD requires that this core determinand list must be supplemented by parameters that are indicative of the impact of pressures identified through the characterisation and risk assessment process. It should be noted that chemical substances or indicators related to identified risks should be considered for the establishment of groundwater threshold values (quality standards) under the daughter Groundwater Directive, and surveillance and operational monitoring will represent key steps in this respect. This also means that monitoring should be carried out for all substances which characterise groundwater (groups of) bodies as being at risk.

Although not required by the WFD, the core list should also be supplemented by suites of inorganic parameters to provide data for QA purposes and information on the natural background level of groundwater, temperature and water level. It will also provide necessary information to support verification of the conceptual model/understanding of the groundwater body and contribute to improved confidence in the assessment of status.

Further generic indicator species may also be added to supplement the risk assessment process. These may include indicators of general industrial activity, e.g. TCE and PCE and urban areas, e.g. Zn and B. These parameters are however only necessary where a pressure has been identified that may give rise to potential impact at the groundwater body scale.

For surveillance monitoring it is therefore recommended that:

- The core suite will comprise DO, pH, EC, nitrate, ammonium, temperature, a suite of major and trace ions plus, where appropriate, selected indicators.
- Parameters indicative of the risks to and impacts on groundwater from pressures identified through the Annex II characterisation process where relevant taking into account the indicative list of pollutants identified in Annex VIII. At this stage it is very important to use the conceptual model. In order to identify each pressure influencing each sampling site, it is necessary to take into account of information provided by the conceptual model.
- Temperature, DO, EC, pH should be measured in the field (at the sampling point), while the other parameters should be measured/analysed in the laboratory. Additional field parameters may also be included as necessary, e.g. redox potential (Eh) and turbidity.
- It is not necessary to monitor each of the 33 priority substances mentioned in Annex X of the WFD. Among these parameters, those that should be included in the surveillance programme must be chosen on the basis of the characterisation and potential risks to groundwater and other associated receptors, e.g. surface waters.
- Consideration is also given to both emerging substances and those that have been phased out and are no longer used.

OPERATIONAL MONITORING

In addition to the core parameters, selective determinands will need to be monitored at specific locations, or across groundwater bodies, where the risk assessments carried out as part of the characterisation process of groundwater bodies indicate that they are at risk of failing to achieve relevant objectives.

As mentioned above, these determinands will have to be considered when establishing groundwater threshold value and the monitoring results used in the assessment of status classification.

The selection of parameters will be made on a case-by-case basis and be influenced by WFD characterisation work supplemented, where necessary, by other information including existing water quality data and local knowledge. The chemical monitoring suites must be reviewed on a regular basis to ensure that they provide representative information and data on groundwater quality and fully support the risk assessment process.

Broad land use/cover categories can be used as a basis for initial determinand selection. A careful analysis of the types of land use/cover and the nature and approximate amounts of chemicals being used should be made in cooperation with competent local bodies and be used for the identification of potential determinands. Further targeting and optimisation of determinand suites should be based on information from the characterisation process.

APPROACHES FOR THE SELECTION OF ADDITIONAL DETERMINANDS

The following approaches may be considered when selecting additional determinands for monitoring. An indicator representative of background industrial anthropogenic pressure may be included in monitoring programmes (e.g. hydrocarbons, organochlorides). For the selection of substances the following criteria can be considered. They will take into account the hydro-geological characteristics of the groundwater body and its interaction with surface water bodies and with connected terrestrial ecosystems. The criteria are:

- Ecotoxicological and toxicological properties of pollutants
- Intrinsic characteristics of pollutants
- Anthropogenic pressures
- Contamination pathways
- Quantitative aspects

Ecotoxicological and toxicological criteria: the prioritising of the substances should be based on the evaluation of the direct risk for aquatic organisms and the indirect risk for human health due to the consumption of drinking water, fresh water organisms and vegetables. The risk for the aquatic organisms due to the interaction with surface water bodies should be evaluated through the use of ecotoxicological data, when available, in particular, using acute and chronic bioassays for local aquatic organisms of different trophic levels.

Intrinsic characteristics of pollutants: The chemical-physical properties of chemicals, in particular organic chemicals, among which water solubility, relative density, persistence, as measured by soil and water degradation parameters, and the whole set of partition parameters, included soil adsorption coefficient and BCF, improve the knowledge of their environmental fate in surface and subsurface soil layers and water bodies. On this basis, a rough screening of mobile or potentially mobile and persistent molecules can be made, also by the application of screening indexed or more complex models which allow for estimating the groundwater pollution potential of chemicals and their tendency to distribute in environmental compartments. Chemical-physical and chemical-dynamic properties can be found in the scientific literature. For plant protection products and biocides, which have undergone a registration procedure, comprehensive sets of data including risk assessments for the active ingredients, as well as for relevant metabolites and degradation products, are contained in the respective registration dossier and are available to the competent authorities.

Anthropogenic pressures: The following non-exhaustive list of anthropogenic pressures could be taken into consideration when identifying determinands. The presence and significance of a pressure will be determined through the WFD risk assessment process. Some of the activities may also refer to old, disused infrastructure (industrial-municipal-agriculture).

- Agriculture, livestock breeding (fertilizer constituents, plant protection products and biocides and related breakdown products and metabolites, pollutants from sludge and manure spreading and pharmaceuticals (antibiotics, hormones, etc.).
- Industrial activities (polishing and degreasing of metal manufacturing, tissues, paints, dyes, detergents, galvanization, tannery, mining, hydrocarbon fuel extraction and fuel additives including production and use and sludge spreading)
- Municipal activities (management of sewage pipelines, management of recreational areas: fertilizers, plant protection products, biocides and related breakdown products and metabolites, management of urban sludge and waste.
- Waste disposal sites, dumps, landfills: leakage of the above mentioned categories
- Transport
- Groundwater overexploitation: salt content enrichment, concentration and abstraction of pollutants from neighbouring polluted waters

Contamination pathways:

- Leaching processes from diffuse sources
- Accidental spills, leakages due to point sources
- Polluted surface waters which feed aquifers
- Saltwater intrusion

- Atmospheric deposition

Quantitative aspects: When selecting additional determinands, high priority should be given to those substances with large total amounts used in the recharge zone of a groundwater body. Quantification of loads of pollutants, information on chemical production volumes, indirect evaluation through sales data etc.; collection of historical monitoring data which may confirm the environmental relevance of selected pollutants; availability and practicability of analytical methods.

CASE STUDY - NETHERLANDS

Background information
Title/Name of case study: Frequency of groundwater quality monitoring.
Type of case study: the Netherlands National Groundwater Quality Monitoring Network
Web-Link: http://www.rivm.nl/milieuStoffen/milieumeting/Meetnetten/lmg/index.jsp#tcm:4-587
Objective of case study The objective of this case study is to show that frequency of sampling of monitoring sites for groundwater quality is dependent on the overall monitoring strategy, the site characteristics and acquired experience in the course of monitoring.
Contribution to…
WFD focus: monitoring, groundwater quality
Specific contributions: sampling frequency, monitoring strategy, conceptual model

Characterisation

In principle, the Netherlands consist of one single sandy aquifer. This aquifer was divided into 20 GW-bodies based on the consideration of the hydrogeological situation, the status, protection and finally water management aspects. In the clay and peat areas the upper layers (about 3 m) are treated as separate groundwater bodies which are closely associated with surface water bodies.

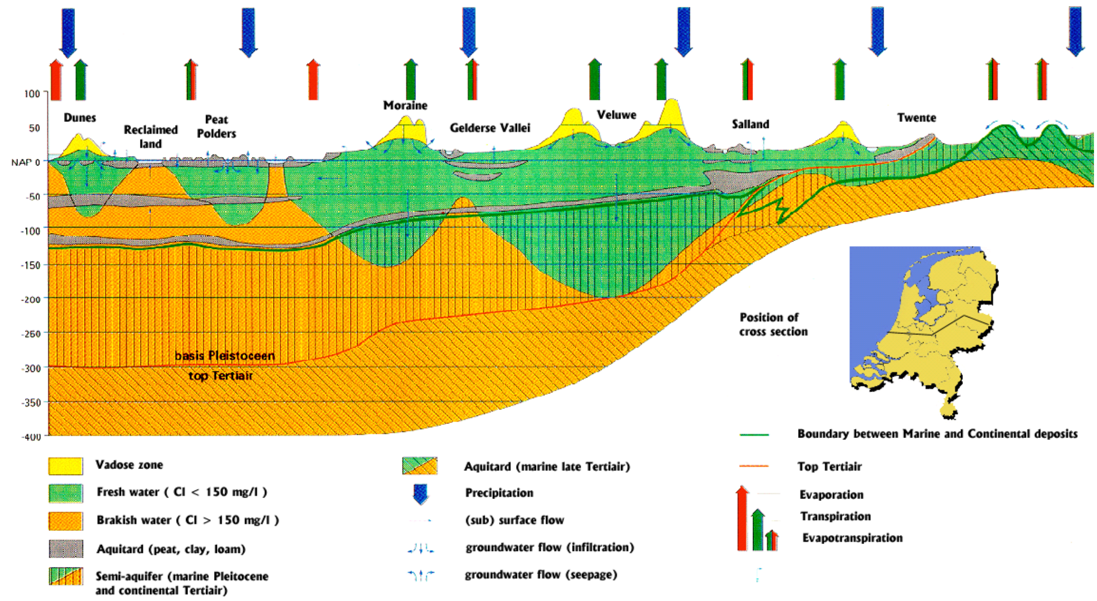


Figure 1: Schematic East-West cross section of the subsoil of the Netherlands. The subsoil is characterised by marine and continental deposits of mainly Pleistocene and late Tertiary origin (Source: Dufour, 1998).

The Netherlands National Groundwater Quality Monitoring Network (LMG), established between 1979 and 1984, comprises about 360 locations divided over the whole country (Van Duijvenbooden, 1987). The main criteria for site selection were type of soil, land use and hydrogeological state. At each location groundwater is sampled at depths of approximately 10 and 25 m below the surface level using special designed observation wells with screens of 2 m length. From 1984 to 1998 locations were sampled annually, results have been published by Reijnders et al., (1998), Fraters et al. (2004) and by Pebesma & De Kwaadsteniet (1997). After an evaluation of the network design in 1998 (Wever & Bronswijk, 1998), the frequency of sampling was decreased for certain combinations of soil type and depth. Shallow screens in sand regions are still sampled every year; shallow screens in other regions (clay and peat) are sampled every two years; deep screens are sampled every four years; shallow screens with high chloride concentrations (more than 1000 mg l^{-1} due to marine influence) are also measured every four years. Finally, well-screen combinations dominated by local conditions (e.g. nearby rivers and local sources of pollution) have been eliminated. In this way, the number of screens to be sampled every year has been reduced from 756 to about 350.

Experiences gained - Conclusions - Recommendations

The quality of groundwater in Dutch groundwater bodies shows a large variability in space (both in the horizontal and in depth) relative to the variability in time, even in the upper five meter of the groundwater, see Figure 1. A sampling frequency of once per year was established in the design phase of the network, based on a conceptual model of groundwater flow. Given the Dutch net yearly precipitation a net vertical infiltration rate of 1 m·a^{-1} was assumed, which yields minimum groundwater ages of about 10 and 25 years at the two monitoring depths. These ages were later confirmed by tritium measurements. A vertical transport velocity of 1 m a^{-1} and 2 m long screens yields a replacement rate of water around the screen every two years. Given this replacement rate, an annual monitoring frequency is sufficient for trend detection purposes. Over ten years of data showed that under certain hydrological and soil conditions the sampling frequency could be lowered from once a year to once every two or every four years without loss of information. After optimisation of the networks, a specific set of locations is used for *trend assessment* using a high sampling frequency, i.e. assessment of effects of measures. The complete sets of locations are used for *status assessment* using a measurement frequency of once every 4 years (Broers, 2002). In addition, frequencies might differ for different chemical parameters, for example, a lower frequency for metals that show a slower displacement in the soil environment.

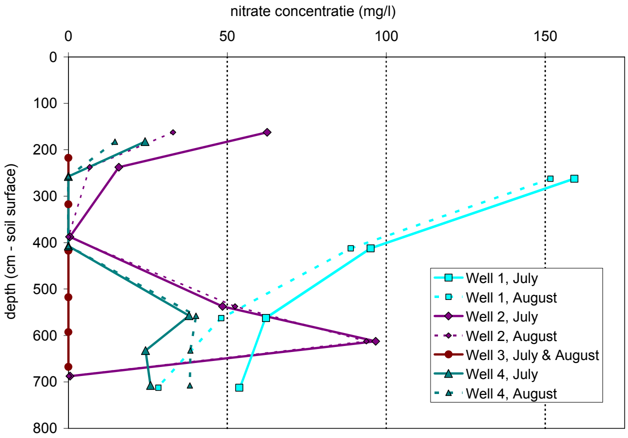


Figure 2: Nitrate concentration in upper five meter of groundwater in four multi-screen wells at one 40 ha dairy farm in the Netherlands. Wells with screens of 0.25 m length are sampled in July and August 2005 (RIVM, unpublished data).

The design and operation of a monitoring network is an iterative process. A conceptual model of transport velocities and an analysis of the sources of variances for the parameters of interest are a prerequisite for effective and efficient monitoring. It forms the basis for the determination of the number of sites, type of wells, number, type and depths of screens, and the frequency of sampling. All these aspects of the design have to be considered coherently.

Outlook - Next steps – Accessibility of results

Data are available at http://milntj34.rivm.nl/website/lmg_eng/viewer.htm;

Broers, H.P. (2002). Strategies for regional groundwater quality monitoring. Netherlands Geographical Studies no. 306, Ph.D. Thesis University of Utrecht, the Netherlands.

Dufour, F.C. (1998) Grondwater in Nederland; Onzichtbaar water waarop wij lopen. Geologie van Nederland deel 3. Delft, the Netherlands, Nederlands Instituut voor Toegepaste Geowetenschappen TNO [265p].

Fraters, B., Hotsma, P.H., Langenberg, V.T., Van Leeuwen, T.C., Mol, A.P.A., Olsthoorn, C.S.M., Schotten, C.G.J. & Willems, W.J. (2004) Agricultural practice and water quality in the Netherlands in the 1992-2002 period. Background information for the third EU Nitrates Directive Member States report. Bilthoven, the Netherlands, RIVM report no. 500003002 [178p].

Pebesma, E.J. & De Kwaadsteniet, J.W. (1997) Mapping groundwater quality in the Netherlands. Journal of Hydrology 200, 364-386.

Reijnders, H.F.R., Van Drecht, G., Prins, H.F. & Boumans, L.J.M. (1998) The quality of groundwater in the Netherlands. Journal of Hydrology, 207, 179-188.

Van Duijvenbooden, W. (1987) Groundwater quality monitoring networks: design and results. In: W. van Duijvenbooden & H.G. van Wageningh (eds.), Vulnerability of Soil and Groundwater to Pollutants. Proc. Intern. Conf., Noordwijk aan Zee, the Netherlands, 30 March – 3 April 1987, 179-191.

Wever D., Bronswijk J.J.B. (1998) Optimalisatie van het Landelijk Meetnet Grondwaterkwaliteit [Optimisation of the Dutch National Groundwater Quality Monitoring Network]. Bilthoven, the Netherlands, RIVM report nr.714851002, 27 p.

CASE STUDY - AUSTRIA

Background information
Title/Name of case study: National Water Quality Monitoring in Austria
Type of case study: National Water Quality Monitoring Network
Web-Link: http://gis.umweltbundesamt.at/austria/wasser/Default.faces
Objective of case study: Demonstrate the business rules of monitoring and the QA aspects
Contribution to…
WFD focus: Groundwater Quality Monitoring
Specific contributions Organisation, Procedure, Costs, Quality Assurance

Characterisation

In Austria standardised water quality monitoring based on legal provisions started in 1991. The monitoring programme covers groundwater in porous media, groundwater in karst and fractured (fissured) rock and running waters.

Water quality monitoring is carried out in periodical cycles for the whole of Austria. The main goals are to assess the current status of the Austrian waters on the basis of a sound and reliable database and to detect negative developments at an early stage. Based on this programme, measures can be introduced to reverse a negative development.

Groundwater sampling sites are distributed all over the groundwater areas. A distinction is made between groundwater in porous media and groundwater in karst and fractured rock. Regarding groundwater in porous media continuous groundwater bodies and discontinuous groundwater-bodies are distinguished. Continuous groundwater bodies can mainly be found in flat regions and valleys along rivers. Small, discontinuous groundwater bodies were grouped in so-called “groundwater regions“. Groundwater in karst (carbonate rock) and in fractured rock (crystalline rock) is distinguished due to hydrochemical criteria.

Experiences gained - Conclusions - Recommendations

Procedure / Business rules

The implementation of the Austrian Water Quality Monitoring Network is the shared responsibility of Federal and Provincial Authorities:

At the Federal level the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Department Water Management Register, is responsible for:

- the integrative assessment of data,
- the yearly publications of results,
- ensuring uniform procedures all over Austria, and
- covering the main part of costs.

The provincial governor is responsible for

- operational management (call for tender, tendering, inspection of contractors during sampling and analyses, quality check of received data, data delivery to the federal level),
- covering parts of the costs, and
- co-operation regarding elaboration and amendment of guidance papers.

Based on an agreement the Federal Environmental Agency is responsible for

- IT-development and data management,
- technical co-operations regarding analytics and data assessment,
- Reporting/writing the biannual reports in co-operation with the Federal Ministry for Agriculture, Forestry, Environment and Water Management.

Monitoring Cycle / Frequency / Parameter sets

The monitoring is a cyclic procedure of 6 years:

- One year initial investigation period (extended parameters) and
- five years period of repeated investigation (minimum requirement based on the results from the initial investigation period).

Groundwater is monitored four times a year and sometimes only twice a year in groundwater bodies without pollution.

The parameters monitored in groundwater and running waters are split into three sets comprising about 100 different parameters.

Call for tender

Usually the parameter sampling and analysis are executed by private accredited laboratories (EN 45000). The contract is awarded according to price and quality criteria ('principle of best cost/benefit offer') in order to get best quality at reasonable costs.

Tendering is done by Provincial Authorities based on groundwater bodies und parameter sets.

Budget / Financial distribution of monitoring costs

All costs for Water Quality Monitoring in Austria are covered by the public authorities. According to the Hydrography Act the Federal Authorities bear all costs concerning the monitoring network. The costs for sampling and analytics are met two-thirds by Federal and one-third by Provincial Authorities.

From 1990 up to 2005 in total 43 Million Euro were spent for the Water Quality Monitoring in Austria:

- 2.7 Million Euro for selection and establishing sampling sites and
- 2.2 to 3 Million Euro per year for sampling and analytics.

The mean costs for a groundwater sample (70 up to 100 parameters) are about 300 Euro.

Quality assurance

For best quality assurance of analytical results, various elements of quality assurance were introduced in the monitoring programme as there are:

- nationwide standardised tendering documents (declaration of analytical figures of merit in the offers);
- accredited laboratories;
- provision of key figures of the analytical procedures within the bidding files;
- standardised procedure (guidelines) including sampling methods
- laboratory control visits (inspection before awarding of contracts and during the monitoring periods);
- compulsory participation in sampling courses;
- compulsory participation in (international) round robin tests;
- control system (proficiency testing scheme for water analyses) in routine work with spiked samples – performed by the Institute for Agrobiotechnology (IFA-Tulln); and
- minimum requirements for limit of quantification and limit of detection.

Outlook - Next steps – Accessibility of results

The monitoring network is currently been adapted by end of 2005. The new monitoring network has to be operative by Dec 2006.

CASE STUDY - FINLAND, SWEDEN, NORWAY

Background information

Title/Name of case study: INFORM – **In**tercalibration of **F**enn**o**scandian **r**eference **m**onitoring of groundwater in Finland, Sweden and Norway

Type of case study: Regional study, organizations involved

Finland –	Finish Environment Institute, SYKE
	Geological Survey of Finland, GTK
Sweden –	Geological Survey of Sweden, SGU
Norway –	Geological Survey of Norway, NGU
	Norwegian Water Resources and Energy Directorate, NVE

Web-Link:

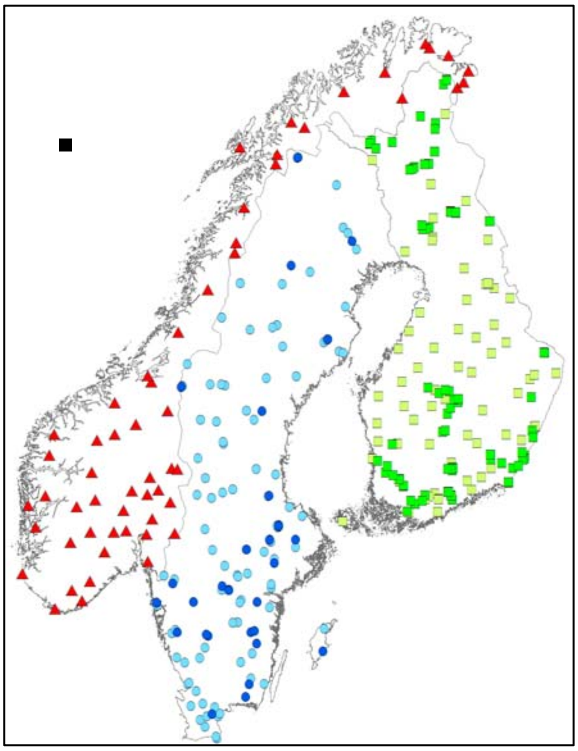
Objective of case study: The study will include an evaluation of monitoring system design and operation, of representativeness with regard to groundwater typology and other natural parameters, and of effectiveness and cost efficiency with the objective to recommend a common Fennoscandian reference network for groundwater monitoring

Contribution to…

WFD focus: reference monitoring, natural background levels, natural trends

Specific contributions: Fennoscandian aquifer typology, intercalibration of strategies, methods and networks, common Fennoscandian reference network

Characterisation:



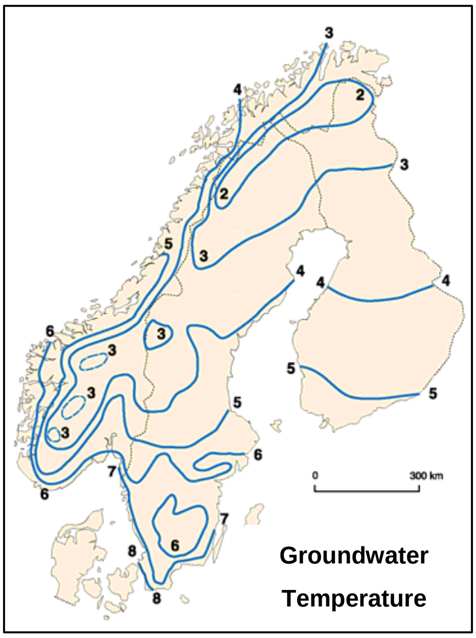
The combined networks for reference monitoring of groundwater in Finland, Sweden and Norway total about 230 stations, or 1 station per 4665 km^2. The responsible government agencies in these countries will carry out this joint project in 2006-7 with the following objectives:

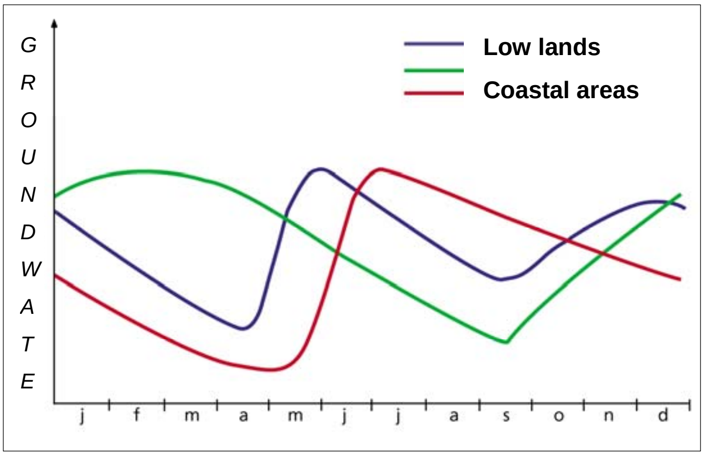
- Intercalibration of *system* design and operation for reference monitoring of groundwater in Finland, Sweden and Norway, incl. groundwater typology and representativeness of monitoring stations.
- Intercalibration of groundwater *quality* for reference monitoring in each of the three countries (e.g. comparability of water quality for groundwaters with comparable hydrogeological origin, interlaboratory comparison etc.).
- Producing a common dataset for reference groundwater quality in Finland, Sweden and Norway, for scientific analysis and for use in practical aspects related to the WFD (e.g. baseline values, monitoring transboundary aquifers, determination of threshold values etc.).
- Evaluation of, and recommendation for a common Fennoscandian network for reference ground-water monitoring related to the WFD, with the objective to produce a more effective and cost-efficient common network in comparison with the current three reference networks in Finland, Sweden and Norway.

Experiences gained - Conclusions – Recommendations:

With regard to groundwater, Finland, Sweden and Norway have been collaborating since 2002 on work carried out in each country for the implementation of the WFD, arising from a common basis in natural conditions, such as geology, climate and demography, and the wish to exchange experience both on a national level and with regard to the EU. In addition to WFD-related issues, the collaboration has generated scientific topics that warrant joint activities. The relevant topic of interest here is the variation in groundwater chemical composition across the three countries, both as a function of the bedrock geology and of the younger Quaternary geology.

Earlier collaboration has resulted in, e.g., a regional overview of groundwater temperature and of variations in groundwater level which is controlled by the recharge-discharge mechanism which in turn is highly dependent on climate.





Outlook - Next steps – Accessibility of results:

Project activities fall into two main categories – **A**, a documentation part and **B**, a data-collection part.

A - This work consists of an analysis of existing documentation for the design and operation for the monitoring system in each country, including

- the criteria for locating monitoring stations and for the density of stations, i.e., typology and representativeness,
- the content, methods and frequencies for collecting both quantitative and qualitative data,
- the method and exchangeability of data storage (databases),
- evaluation and selection of a common dataset for reference groundwater quality, following the completion of part B, and
- evaluation and recommendation of a common Fennoscandian network for reference groundwater monitoring related to the WFD.

B - This activity involves the collection and analysis of a timed batch of groundwater samples from all monitoring stations in each country, including one common batch of samples for intercalibration of laboratory analyses.

The project will publish its results in national reports, international publications and as digital maps showing results for groundwater quality data across the Fennoscandian region.

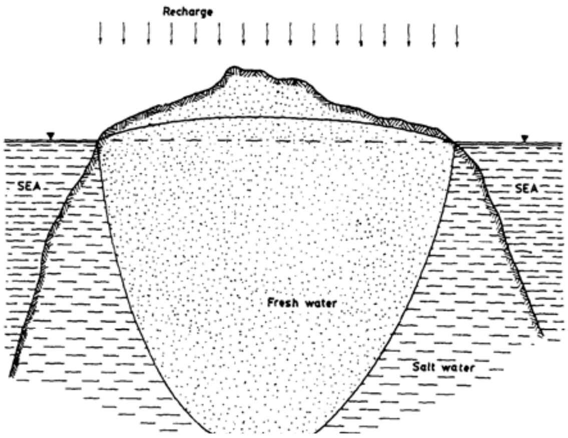
CASE STUDY - MALTA

Background information
Title/Name of case study: Monitoring for Quantitative Status in small islands
Type of case study: Testing the reliability of groundwater level as an indicator of groundwater volume
Web-Link: http://www.mra.org.mt/wfd_introduction.shtml
Objective of the case study: Investigating the utilization of groundwater levels as a metric for status determination
Contribution to…..
WFD focus: Groundwater Quantitative Status Monitoring
Specific Contributions: Best practice in quantitative status monitoring

Characterisation

The Malta Main Mean Sea Level Groundwater Body is sustained in the Lower Coralline Limestone aquifer and is in free contact with sea-water. This groundwater body extends over the whole southern and central parts of the island and is by far the major groundwater body in the Maltese islands, yielding an estimated 66 % of the total groundwater abstracted in the country.

The groundwater body can be compared to a lens shaped body of fresh-water floating on more saline water, having a convex piezometric surface and conversely a concave interface sloping towards the land. The thickness of the lens below sea level is roughly thirty-six times its piezometric height above sea level following closely the Ghyben-Herzberg model.



Scheme showing a Ghyben-Herzberg (floating) groundwater body in an island. It should be noted that the vertical dimensions are highly exaggerated relative to the horizontal dimensions. In fact if the situation in Malta is considered, for an island width of app. 13km, the lens reaches a maximum thickness of around 100m (Source: UNESCO)

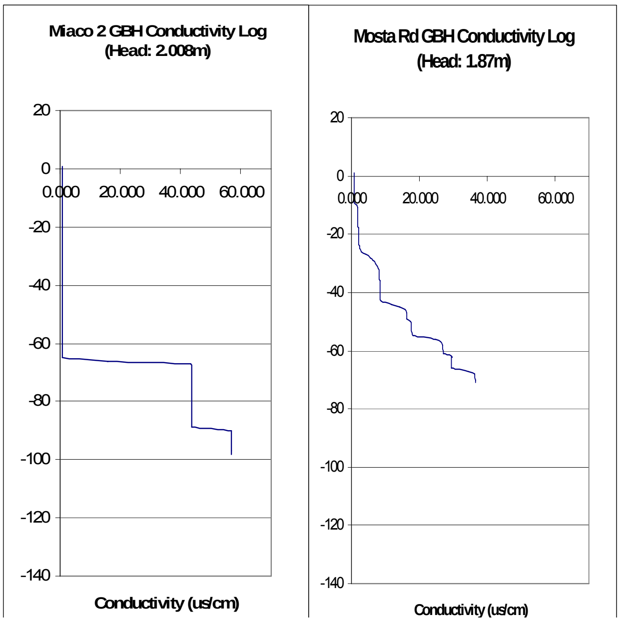
However, in reality, the underground interface that separates the freshwater from the saltwater is not a sharp boundary line. This interface is in fact a mixing zone, whose limits are generally defined by the 1 and 95 % sea water content, called the Transition Zone. The thickness of this zone depends both on the hydro-dynamic characteristics of the aquifer and the fresh and sea water fluctuations.

Experiences gained – Conclusions – Recommendations

The quantitative status of such a mean sea level–island–groundwater body is dependent not only on the hydraulic head but also on the vertical distribution of the chloride content throughout the body. The sole measurement of the piezometric head might therefore not be enough to effectively monitor status. This is particularly so in cases where the hydro-dynamic characteristics of the aquifer supporting the groundwater body favour the occurrence of a wide transition zone.

A pilot project was initiated in Malta involving five deep gauging boreholes in which conductivity logs were taken twice every year. The depth of these boreholes was such that it exceeded the theoretical position of the interface. The process involved taking conductivity readings with a probe at 1 m successive intervals down the borehole.

Reference is made to the results obtained from two of these boreholes, the Miaco 2 and Mosta Road Gauging Boreholes which are located in the southern and north/central regions of the island respecitvely. Both gauging boreholes register almost the same hydraulic head above mean sea level, which is 2.0 m for the Miaco 2 GBH and 1.9 m for the Mosta Road GBH. This data alone would imply that these two monitoring stations are representing regions of the groundwater body having the same quantitative status. However, the results from the conductivity logs indicate that the quantitative status is significantly different.



Conductivity Logs from Miaco 2 and Mosta Rd GBH

In the case of the Miaco 2 GBH; a sharp interface between fresh and salt water was encountered, and the depth of freshwater exceeded 60 m below mean sea level. On the otherhand, results from the Mosta Road GBH indicated that disturbance of the groundwater body has led to the formation of a transition zone, the thickness of which was estimated to exceed 40 m. The depth of freshwater in this case was in the region of 10 to 20 m below mean sea level.

These results indicate that the metric identified by the WFD for the determination of quantitative status may in such cases, where groundwater quantitative and qaulitative status are interlinked, be not sufficient for an effective assessment of status.

Outlook – Next steps – Accessibility of Results

Proposals are currently being formulated for the adaptation of groundwater monitoring in Malta in line with WFD requirements. In the case of sea level groundwater bodies, it is being proposed that, initially, a basic geometrically based water level monitoring network is established, in which groundwater level will be continually monitored. These monitoring stations will subsequently be deepened to enable the collection of quarterly groundwater conductivity profiles in all monitoring stations. It is planned that the basic network will be operational by December 2006; whilst the time-table for the subsequent upgrading of the network is still being formulated.

The monitoring proposals formulated by the MRA will be open to public consultation on the Authority's web-site. The final monitoring plan and an evaluation of its effectiveness following the first monitoring results will also be subsequently available on the same website.

CASE STUDY - NORTHWEST AND CENTRAL EUROPE

Background information

Title/Name of case study: Monitoring effectiveness of Nitrates Directives Action Programmes

Type of case study: regional study; organisations involved: environmental and agricultural institutes from Austria, Belgium, Denmark, Germany, Ireland, Sweden, the Netherlands, the United Kingdom

Web-Link: http://www.rivm.nl/bibliotheek/rapporten/500003007.html

Objective of case study

To show that monitoring of effectiveness of programmes of measures, as required by the WFD (Annex VII, B.2), needs special attention; for example by designing "early warning" monitoring programmes.

Contribution to…

WFD focus monitoring, programme of measures, environmental objectives

Specific contributions. effect monitoring, conceptual model, selection of sampling sites

Characterisation

The Water Framework Directive requires all Member States to make a plan of measures for each river basin, taking account of the characterisation and review of the environmental impact of activities, in order to achieve the WFD objectives. The first update of the river basin management plan (2015) shall also include an assessment of the progress made towards the achievement of the environmental objectives.

Operational monitoring, required to establish the chemical status and presence of long term anthropogenically induced trends in pollutants concentrations, can also be used to assess the effectiveness of programmes of measures. For the design of an operational programme for WFD monitoring experiences can be gained from existing Nitrate Directive monitoring programmes designed for effect monitoring.

The Nitrates Directive (91/767/EEC) requires all Members States to make Action Programmes for Nitrate Vulnerable zones and to monitor not only groundwater and surface water quality, but also the effectiveness of these Action Programmes. In several EU Member States special designed monitoring programmes are operational to monitor the effectiveness of the Nitrate Directive Action Programmes. In 2003 a workshop has been organised to exchange experiences and identify common goals, problems and solutions for improving monitoring programmes and, possibly, for improving comparability.

Experiences gained - Conclusions – Recommendations

When focusing on monitoring effects of measures on water quality we can evaluate the pros and cons of each of these possibilities. Three main factors have to be considered, these are:

1. the time between the implementation of the measure and the moment that a change in water quality will occur as a consequence of this measure, this we call the lag time;
2. the ability to distinguish between the effects of different measures, actions and/or sources of pollution, this we term resolution power;
3. the occurrence of interfering processes in soil or water system, for example, denitrification lowers the nitrate concentration during transport of water through the soil and/or the surface water system.

The table below gives an overview of the importance of these factors for each of the main monitoring possibilities (see Figure). It is evident that the closer to the source of pollution the shorter the time between measure and effect and the smaller the chances that other sources of system processes may influence water quality.

In studying the relationship between the effects of agriculture and water quality, collection of data should preferably be on the same scale for both agriculture and water quality.

The choice for a certain level of scale for effect monitoring depends, amongst others, on the scale used in existing monitoring networks and level of scale of data collection by regional and/or national authorities for other purposes.

The study made clear that water quality is not only influenced by agricultural practice but by other factors as well. Soil type, hydro(geo)logical characteristics of sediments or rocks, or of the surface differences in water quality between locations or in time. The type and structure of the farm, the educational level of the farmer, and whether the farmer has a successor or not are examples of "farm factors". These farm factors influence the way policy measures are implemented in farm practice.

Table: *Overview of the merits and demerits of different types of water quality monitoring for monitoring the effects of changes in agricultural practice.*

Type of monitor	Lag time	Resolution power	Importance of interfering processes
Soil moisture	Short	high	little
Tile drains	Short	high	little
Shallow groundwater	short – moderate	moderate – high	little – moderate
Deep groundwater	moderate – long	low – moderate	moderate – significant
Ditches & brooks	short – moderate	moderate	moderate
Regional & main waters	Long	low	significant

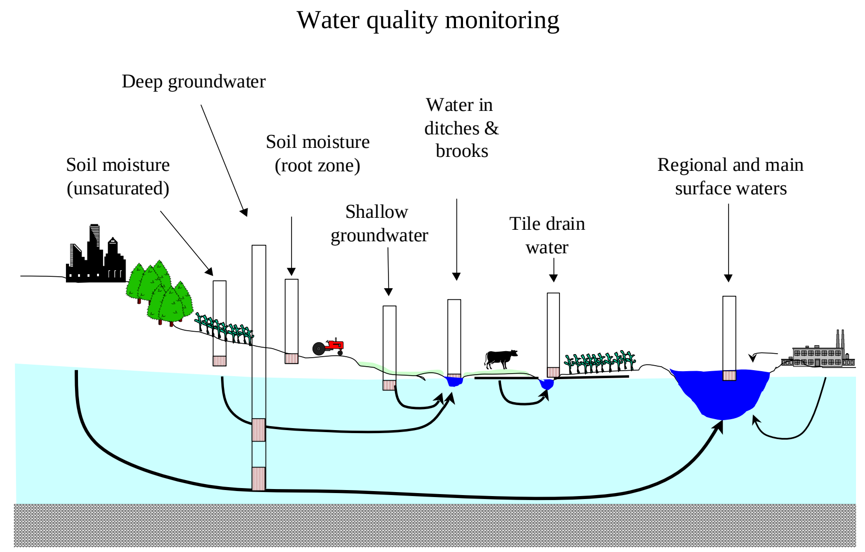


Figure: range of possibilities of water quality monitoring

Two different approaches − upscaling and interpolation − for describing the effect of Action Programmes on a national scale were defined. The upscaling approach uses the results of studies on the effects of change in agricultural practice on nitrate leaching (and water quality) on experimental sites (e.g. homogeneous plots or parcels). Numerical process models and data on agricultural practice covering national-scale change are used to upscale the experimental-site results. This allows Member States to describe the effect of the Action Programme on nitrate leaching and water quality on the national scale. The interpolation approach uses the results on monitoring agricultural practice and nitrate leaching (and water quality) for a random sample of locations, e.g. farms. Statistical models based on knowledge of processes and national-scale monitored changes in agricultural practice are used on the national scale to describe the effect of their Action Programmes on nitrate leaching and water quality.

Outlook - Next steps – Accessibility of results

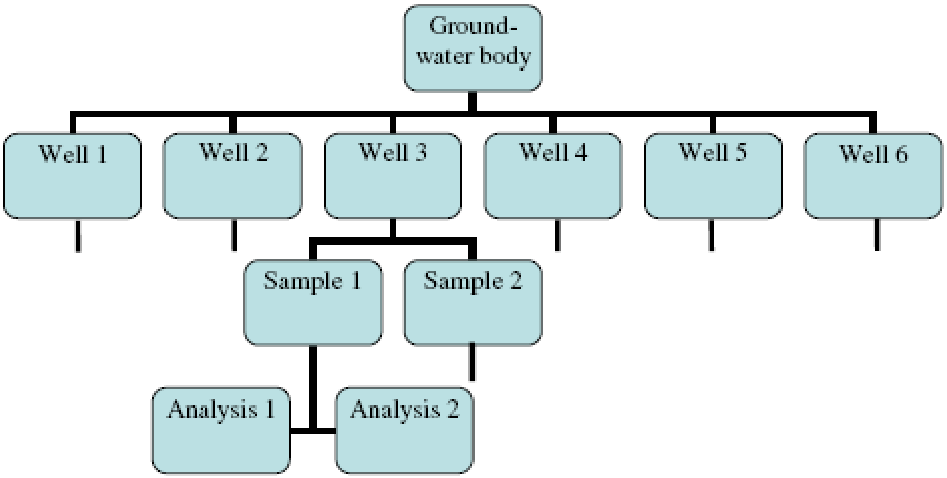
After the workshop effect monitoring programmes have been adapted and/or efforts have been increased, for example, in England and the Netherlands.

England: http://www.bluesky35.adas.co.uk/record/display_index.html?podlet_id=39&article_id=21

The Netherlands: http://www.rivm.nl/bibliotheek/rapporten/680100001.html (Dutch)

CASE STUDY - ÅRHUS COUNTY (DENMARK)

Background information
Title/Name of case study: Estimation of groundwater monitoring uncertainty
Type of case study: Local monitoring study as part of international guidance cooperation
Web-Link: http://www.samplersguide.com
Objective of case study: Demonstration of the use of simple methods for estimation of monitoring uncertainty and for monitoring quality control
Contribution to…
WFD focus: Groundwater quality monitoring
Specific contributions: Uncertainty from analysis, sampling and aquifer heterogeneity, methods for estimation of uncertainty, use of uncertainty estimates to identify points of improvement as well as fitness for purpose (compliance with set quality objectives)
Characterisation: A group of groundwater bodies that are an important drinking water resource for the city of Århus, the second largest city of Denmark, has through surveillance monitoring been identified as at risk for deterioration of the quality due to intensive drinking water abstraction. An operational monitoring program was established in order to control the trend in water quality development. The groundwater body is in glacial outwash sands with Miocene sands and clays below and glacial till above. The natural quality of the groundwater is anaerobic without nitrate, with sulphate and reduced iron, but without hydrogen sulphide and methane. One of the threats to the groundwater bodies is oxygen intrusion into the aquifer as the result of the water abstraction and concomitant groundwater table draw down. One groundwater body representing the group, 2 km x 2 km x 10 m, starting 20–30 m below the surface, was selected for the operational monitoring. In the operational monitoring planning, it was decided to use dissolved iron as a target parameter that would be a sensitive indicator of aquifer oxidation (decreasing iron concentration with increasing oxidation). It was further decided to aim at monitoring one well twice per year and the objective of the operational monitoring was set to having a 95 % probability of recognising a 20 % quality deterioration. This requires a measurement uncertainty including both sampling and analysis of not more than 10 % (comparison of two means each for two samples, 95 % confidence interval, two sided test) corresponding to an expanded measurement uncertainty of 20 %. To ensure the compliance of the monitoring program with this stated objective, a sampling validation study was initially conducted including all wells available and based upon the results from this, a routine sampling quality control program was set up for implementation with the monitoring program for the selected monitoring well.
Experiences gained - Conclusions – Recommendations: The empirical approach was selected as study design in order to provide estimates of heterogeneity in the groundwater body (between-target variation well to well or over time) and measurement uncertainty, split into sampling uncertainty and analytical uncertainty. The basic principle of the empirical approach is to apply replicate measurements. Sampling was done using the groundwater monitoring sampling protocol developed by the county. Analyses were performed at an independent, accredited (ISO 17025) laboratory using accredited methods subject to the required quality assurance and analytical quality control. Estimates of laboratory uncertainty and analytical detection limits were obtained from the laboratory quality control scheme and evaluated with the data from the monitoring validation and quality control. The objective of the validation study was to ensure that measurement uncertainty meeting the set quality objective could be obtained and to describe the components of uncertainty in order to identity points of improvement, if required. The validation study was set up with sampling of the 6 wells, two independent samplings per well and 2 sub-samples per sample analysed, see overleaf figure. The validation study thus included one sampling round with a total of 12 samples taken and 24 sub-samples sent for analysis.



The objective of the quality control programme for the operational monitoring was to ensure that measurement uncertainty did not increase over time during the monitoring. The quality control programme was set up after careful evaluation of the results from the validation study and was designed including duplicate sampling on one of the two annual sampling occasions of the monitoring programme.

The replicate data were treated using the range method (ISO 3085), see below table for results. The applied calculation methods are demonstrated in the guide on uncertainty from sampling, calculations are easily done using standard spread sheets, and an example can be downloaded from http://www.samplersguide.com. The data treatment provided estimates of analytical, sampling and total measurement uncertainty, in addition to the uncertainty due to heterogeneity (in space or time). Only random errors were included, whereas the occurrence of systematic sampling errors was not assessed quantitatively, but the consistency of the obtained results for different chemical parameters was used as a qualitative control of systematic errors.

Dissolved iron	**Expanded uncertainty, coverage factor 2**			**Between-target**
in groundwater	**Analysis**	**Sampling**	**Measurement**	**heterogeneity**
Validation	2.1 %	10 %	10 %	35 %[1]
Quality control			4.0 %	9.9 %[2]

[1)] In the validation study, between-target variability was between wells
[2)] In the quality control, between-target variability was between sampling occasions, first 6 sampling occasions included

The data show that the requirement for less than 20% expanded measurement uncertainty could be fulfilled for dissolved iron (sampling validation), and that the required measurement uncertainty was in reality achieved during the routine monitoring (sampling quality control). Furthermore, the data show that if an improvement of the certainty of monitoring was required, the obvious point of improvement would be increased monitoring density (between-target heterogeneity dominating).

Outlook - Next steps – Accessibility of results

In planning groundwater monitoring, fitness for purpose (monitoring uncertainty corresponding to set quality objectives) can be ascertained by a simple monitoring validation approach. If required, points of improvement of monitoring can be identified from the contributions to monitoring uncertainty (analysis, sampling, heterogeneity). With a simple and cost efficient quality control, it can be ascertained that the routine monitoring uncertainty remains as required for the purpose.

Considering the total costs of groundwater monitoring and the costs associated with decisions on measures taken from monitoring data, the costs of including an initial monitoring validation during planning and a subsequent monitoring quality control during routine monitoring seem justified.

The principles applied are described in the Eurachem/EUROLAB/CITAC/Nordtest Guide

“Estimation of measurement uncertainty arising from sampling”.

CASE STUDY - TEVERE, COLLI ALBANI (ITALY)

Background information

Title/Name of case study: Studies and management of a volcanic aquifer in an area subject to different pressures. Colli Albani volcanic structure (Lazio-central Italy)

Type of case study:

The case study is being conducted as part of phase II of the PRB testing activity and it is coordinated by the Tevere River Basin Authority with the support of the Italian Ministry of the Environment, the Italian National Institute of Health (ISS), the Italian National Environment Protection Agency and Technical Services (APAT), the Regional River Basin Authority of Lazio, ARPA Lazio (Regional Environment Agency), the National Research Council - Water Research Institute (Cnr Irsa), and the Department of Geological Sciences of "Roma3" University. Testing of the methodologies set up within the FP6 Bridge project will be carried out in the same area.

Web-Link: http://www.abtevere.it/prb_2/

Objective of case study:

The management of aquifers subject to intense overexploitation for household, agricultural and industrial uses requires specific and complex plan measures. The case study of the Colli Albani volcanic structure located in the south of the city of Rome has been given as an example. Other aspects of interest in this area are the presence of protected areas and dependent terrestrial and aquatic ecosystems. The identification of thresholds, especially in relation to quantitative aspects and natural background levels will be taken into account during the phase related to the Bridge project.

The scheme of this case study is as follows:

- description of the water circulation in the Colli Albani
- identification of the natural background levels
- key elements of the pressures and impacts analysis
- identification of areas that require specific protection
- safeguard measures
- analysis of existing monitoring activities
- steps needed for the monitoring network to comply with the WFD objectives

Contribution to…

WFD focus: monitoring, protected areas, risk assessment, programme of measures, volcanic aquifer, saline intrusion

Specific contributions: groundwater-surface water interaction, natural background levels, programme of measures

Characterisation:
The Colli Albani volcanic structure is situated south of the city of Rome. It is constituted by an isolated relief with a characteristic truncated cone shape that surmounts the Roman countryside with an altitude of 970 m asl. During the final phases of the volcanic activity, the top of the structure was subject to violent explosions, which created a vast caldera with a diameter of about 10 km. Today, two secondary craters, formed in a subsequent phase within the calderic ring, are filled by the Albano lake and Nemi lake.

This territory has an important value from a landscape, historical and cultural point of view and has been widely exploited since the Roman epoch. It comprises important natural protected areas of local, national and European interest.

The Colli Albani structure's water circulation develops in radial direction from the center to the periphery following complex patterns and it is characterized by a substantial interaction between groundwater and surface water circulation. The geological setting originated an aquifer in the central area, sustained by low permeability volcanic rocks and a basal aquifer, sustained by marine pre-volcanic clay deposits and contained in the more ancient volcanic rocks. Water circulates also through the lakes from the superior to the basal aquifer complexes. The characteristic springs in this system are linear springs that feed the perennial surface water circulation at the bottom of the riverbed. The water circulation was subdivided into four sectors delimited by potential levels, where it was possible to carry out water balance calculations.

Furthermore, some areas where the water enters into contact with the surfacing magma fluids from the later phases of the volcanic activity are characterized by the presence of thermal springs and water with particular chemical compositions.

In the last 50 years this area has been subject to growing pressures due to the expansion of urban settlements, scattered houses, industrial activity and agriculture (water-demanding crops). The water demand was mainly satisfied by groundwater abstraction from wells, facilitated by the development of drilling techniques and by the relative shallowness of the water.

Experiences gained - Conclusions - Recommendations

The first step was to carry out a hydrogeological study in order to allow the calculations to be made.

Hydrogeological balance calculations were carried out analyzing the spatial and temporal variability of precipitations and climatic conditions on a monthly basis, analyzing the effects of morphological, lithological, pedological conditions, vegetation and land use on runoff and evapotranspiration with elevated spatial detail, estimating the withdrawals.

The most important results of the hydrogeological study carried out on the Colli Albani aquifer showed how in the last years, also due to a decrease of rainfall, especially during the winter season, the base flow in surface watercourses dropped by 50%. In particular, the water level of Albano lake, which is in direct contact with the aquifer, dropped by about 2 m.

Considering that surface base flow is fundamental in sustaining aquatic ecosystems and that the flow of water bodies receiving wastewater discharge determines the quality status of water bodies, it is very important to maintain the base flow at a compatible level with the life of aquatic ecosystems and the achievement of good quality status.

Another issue that merits attention regards the ratio between estimated withdrawals and effective infiltration.

The balance units have different withdrawal/recharge ratios and can be considered as four water bodies.

For the purpose of the study a methodology was designed for the identification of sectors where the withdrawals and consequently the major critical situations are concentrated. This methodology is based on seven indexes regarding both causes (withdrawals) and effects (alterations to the aquifer's equilibrium), calculated spatially on a grid with 250 m wide cells.

The necessity emerged of urgent interventions through the application of safeguard measures that set rules for groundwater use on the basis of the different levels of attention that were detected.

Outlook - Next steps – Accessibility of results

An efficacious management of the water in the Colli Albani volcanic structure must be aimed at fulfilling general characteristics, such as the preservation of an acceptable level of equilibrium of the aquifers and specific objectives, such as the protection of particular areas.

In particular, regarding the quantitative aspects it is necessary to:

- verify the exploitation trends of the aquifer by measuring the piezometric levels
- verify the trends of the surface base flow through measures of peripheral watercourses
- verify the trends of intakes by means of rainfall and temperature measurements

regarding qualitative aspects, it is necessary to:

- define the basic and specific chemical parameters in particular conditions
- define the interaction between discharge water and freshwater in the perennial network
- define the suitability of lakes for bathing

CASE STUDY - EMILIA-ROMAGNA REGION (ITALY)

Background information

Title/Name of case study: Groundwater monitoring network of the Regione Emilia-Romagna (Italy).

Type of case study: Groundwater level and chemical monitoring network of the Regione Emilia-Romagna alluvial plain (part of the Po Plain - Italy). Regione Emilia-Romagna (Servizio Geologico, Sismico e dei Suoli; Servizio Tutela e Risanamento Risorsa Acqua); ARPA Regione Emilia-Romagna.

Web-Link: http://www.arpa.emr.it/acquarer/

Objective of case study: support of groundwater management

Contribution to…

WFD focus: Monitoring of groundwater. Presentation of groundwater status.

Specific contributions: Hydrogeological structure of the aquifer. Monitoring network features and optimising.

Characterisation:

Emilia-Romagna alluvial plain is 12,000 km² large, here is located a Pleistocene alluvial aquifer up to 700 m thickness. It is divided in three main hydrostratigraphical units, each one divided in four or five sub-units. Inside the units we recognise three different groundwater bodies (appenninic rivers alluvial fans, appenninic rivers alluvial plain, deltaic and alluvial river Po plain). According to the greatest quantitative and chemical features, the appenninic rivers alluvial fans could be considered as the priority groundwater bodies. Recharge areas are located in the southern margin, where all the aquifers are amalgamated and unconfined, toward north aquifers become multilayers and confined.

In Emilia-Romagna plain aquifer the groundwater monitoring network started in 1976 with level and electrical conductivity measures, the chemical measures started in 1988. Network is now composed by 575 wells (about 1–25 km²); 112 measure the quantity, 143 the quality and 320 measure both.

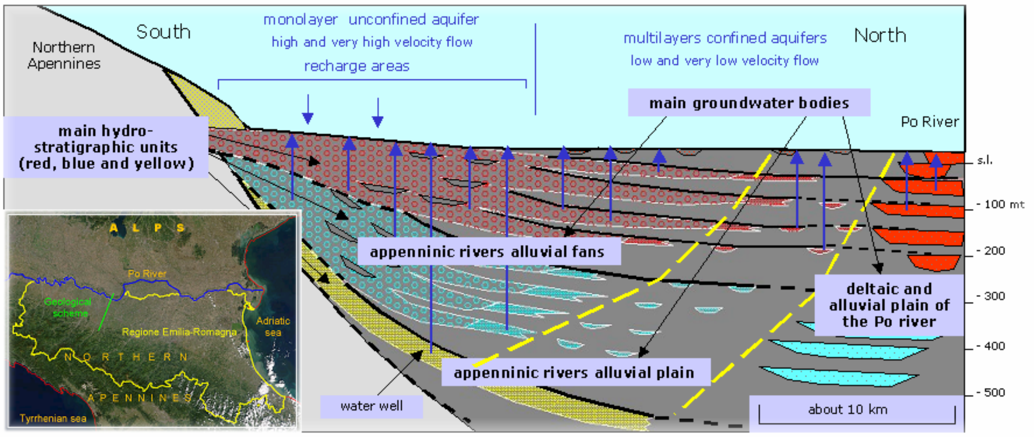


Figure 1: Schematic cross section and simplified conceptual model of the Emilia-Romagna alluvial plain aquifer.

Experiences gained – Conclusions - Recommendations

Monitoring network features

Main objective of the network. Classify groundwater according to Italian and European law. Verify the groundwater status. Define quantitative and qualitative capacity of the aquifer. Control the natural status of the aquifer.

Network design. In 1976 network started with a regular distribution of the monitoring wells. During time we reduced the density where no appreciable quantitative or chemical variations was clear, and we increased monitoring wells:

- where water level is low due to main withdrawal and near to the pumping station for drinking water;
- in the recharge areas, and where the piezometrical gradient is higher (ex. 6–8 ‰);
- where pollutants (first of all nitrates) are present, and in vulnerable areas;
- in priority groundwater bodies (alluvial fans), where we arrange wells along flow line to

consider chemical variations.

Therefore density of monitoring wells is higher in alluvial fans areas (1–15 km²) than in alluvial plain areas. In any case we adapted monitoring network to hydrogeological conceptual model in order to have information in each unit and in every groundwater bodies (see the figure 2 for the wells distribution). Depth of monitoring wells varies from 5 to 700 m (mean about 100 m).

Quantitative monitoring frequency. From 1976 to 1998 we took 4 measures per year. After statistical study of available data, we understood that 2 lecture per year are sufficient to realise multiyears trend. On the other hand, in case of high piezometrical gradient (strong withdrawal, nearness to river, recharge areas), 4 lectures per year are not sufficient to understand the situation. So from 1998 we have been continuing with 2 lecture per year on the great number of wells (400 about), and 12 lecture per year in the most stressed areas (on 30 monitoring wells).

Chemical monitoring frequency and type. Frequency is every six month. After a geostatistical approach we optimised the numbers of parameters to analyse. Now we have 4 wells groups, where related to their importance we analyse from 67 to 27 chemical and microbiological parameters.

Costs (level measures, sampling and analyses) in 2003 was about 550,000 Euro.

Groundwater status

From piezometrical trend value we calculated water deficit volume, as the volume of the water needed to achieve the equilibrium in the water balance aquifer. Therefore quantitative status is assigned considering value of the water deficit. Chemical status is assigned on the basis of the concentration of 7 main parameters and 33 additional parameters. Then we attributed groundwater status at each monitoring well by superposition of quantitative and chemical status data. The worse classes with biggest human impact (red and yellow dots in Figure 2) are located principally in the recharge alluvial fans areas. At the same time in the main alluvial fan areas are also present green dots, indicating good status, due to the high aquifer transmissivity and high dilution with clean fresh river water. Grey dots in Figure 2 represent particular conditions (no human impact, but poor chemical status due to natural condition), they are present in the northern side, where aquifers are extremely confined, groundwater velocity is reduced, and the exchange between groundwater and sediments is higher.

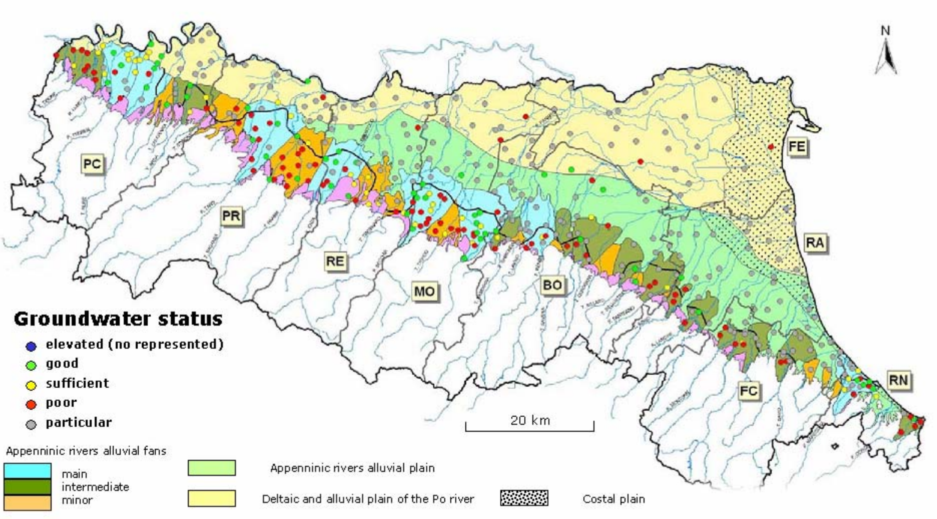


Figure2: Groundwater status taken from Water Plan (Piano di Tutela delle Acque) of the Regione Emilia-Romagna. Each dot represents a monitoring well.

Outlook - Accessibility of results

Data are available at http://www.arpa.emr.it/acquarer/ (Italian language), http://www.regione.emilia-romagna.it/geologia/ (Italian and English language), http://www.arpa.emr.it/ (Italian language)http://www.ermesambiente.it/ermesambiente/acque/servizio_acqua/ (Italian language), http://www.ermesambiente.it/PianoTutelaAcque/ (Italian language).

Next steps:

- Installation of 50 instruments for continuous groundwater level measurements.
- Identification of network for evaluation of the measure programmes.

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ESTRATEGIA COMÚN DE IMPLANTACIÓN DE LA DIRECTIVA MARCO DEL AGUA (2000/60/CE)

Documento Guía No. 16

Guía sobre aguas subterráneas en zonas protegidas para la captación de agua potable

Versión española
Dirección General del Agua
Agosto 2009

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ESTRATEGIA COMÚN PARA LA APLICACIÓN DE LA DIRECTIVA MARCO DEL AGUA (2000/60/CE)

Documento guía nº 16

Guía sobre aguas subterráneas en zonas protegidas para la captación de agua potable

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El presente documento técnico ha sido elaborado a través de un programa de colaboración en el que han participado la Comisión Europea, todos los Estados miembros, los países de la Adhesión, Noruega y otras partes interesadas y organizaciones no gubernamentales. El documento debe entenderse como la presentación de una posición de consenso informal sobre la mejor práctica aprobada por todas las partes asociadas. No obstante, el documento no representa necesariamente la posición oficial y formal de ninguna de las partes, por lo que los puntos de vista que en él se exponen no representan necesariamente aquéllos de la Comisión Europea.

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Nota.
La versión en español del documento original ha sido realizada por encargo y bajo la supervisión de la Dirección General del Agua del Ministerio de Medio Ambiente, y Medio Rural y Marino

Prólogo

Los Directores Generales del Agua de la Unión Europea (UE), los países de la Adhesión, los países candidatos y los países de la EFTA, han desarrollado conjuntamente una estrategia común para apoyar la aplicación de la Directiva 2000/60/CE, “por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas” (Directiva Marco del Agua). Esta estrategia tiene como principal objetivo permitir una aplicación coherente y uniforme de la Directiva. La atención se ha centrado en las cuestiones metodológicas relacionadas con una comprensión común de las repercusiones técnicas y científicas de dicha Directiva.

En particular, uno de los objetivos de la estrategia es el desarrollo de documentos guía, de carácter práctico y jurídicamente no vinculantes, sobre varios aspectos técnicos de la Directiva. Estos documentos guía van dirigidos a los expertos que, directa o indirectamente, son los responsables de aplicar la Directiva Marco del Agua en las demarcaciones hidrográficas. En consecuencia, se ha adaptado la estructura, la presentación y la terminología a las necesidades de estos expertos, y, en la medida de lo posible, se ha evitado la utilización de un lenguaje formal y legalista.

En este contexto, los Directores Generales del Agua elaboraron y adoptaron el documento guía *Identification of Water Bodies* en noviembre de 2002 (ECI[*], Documento guía nº 2). Este documento ofrece a los Estados miembros una comprensión común de la definición de masas de agua e indicaciones específicas de carácter práctico para su identificación de acuerdo con la Directiva Marco del Agua.

A modo de continuación y en el contexto del desarrollo de la nueva Directiva relativa a las aguas subterráneas, tal como establece la Directiva Marco del Agua en su artículo 17, los Estados miembros han expresado la necesidad de aclarar algunos aspectos relacionados con las aguas subterráneas en zonas protegidas y, en particular, en Zonas protegidas para el abastecimiento de agua potable (ZPAP). En este sentido, en 2004 se inició un proyecto para desarrollar un documento guía que completara el Documento guía nº 2 de la CIS, y se creó un grupo informal de redacción al amparo del Grupo de Trabajo sobre Aguas Subterráneas de la CIS (WG-C). El Reino Unido y la EUREAU (Unión Europea de Asociaciones Nacionales de Suministradores de Agua y Servicios de Aguas Residuales) han sido los coordinadores de dicho grupo de redacción, y en él han participado varios expertos procedentes de otros Estados miembros y de organizaciones interesadas.

Este documento guía es el resultado de los trabajos del grupo de redacción. Contiene la síntesis de los resultados de los debates celebrados desde diciembre de 2004. Está basado en las aportaciones y las reacciones de una amplia variedad de expertos y partes interesadas que han participado a lo largo de todo el procedimiento del desarrollo de la guía a través de reuniones, talleres, conferencias y medios electrónicos, sin que por ello resulten vinculados en modo alguno con el contenido del presente informe.

“Nosotros, los Directores Generales del Agua de la Unión Europea, Noruega, Suiza y los países que han solicitado la adhesión a la Unión Europea, hemos examinado el presente Documento guía y lo hemos respaldado en el transcurso de nuestra reunión informal bajo la Presidencia alemana en Dresde (18-19 de junio de 2007). Deseamos expresar nuestro agradecimiento a los participantes del Grupo de Trabajo C y, en particular, a los jefes del grupo de redacción, al Reino Unido y a la EUREAU por la elaboración de este documento de gran calidad. Creemos firmemente que éste y otros documentos guía elaborados en el marco de la Estrategia común para la aplicación de Directivas tendrán un papel destacado en el

[*] CIS: Common Implementation Strategy, Estrategia común para la Implantación

proceso de aplicación de la Directiva Marco del Agua y de la Directiva relativa a las aguas subterráneas, adoptada recientemente.

Esta guía es un documento vivo que necesitará aportaciones y mejoras continuas a medida que avanza la aplicación y crece la experiencia en todos los países de la Unión Europea y en otros países. Hemos acordado, no obstante, que este documento se haga público en su forma actual con el fin de presentarlo al gran público como la base para seguir avanzando en los esfuerzos de aplicación en curso. Asimismo, nos comprometemos a evaluar y a decidir sobre la necesidad de revisarlo a la luz de los avances científicos y técnicos, así como de las experiencias acumuladas en la aplicación de la Directiva Marco del Agua y de la nueva Directiva relativa a las aguas subterráneas."

MIEMBROS DEL GRUPO DE REDACCIÓN

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ÍNDICE

1. Objeto y alcance

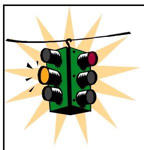
1.1 Introducción

Este documento guía explica las obligaciones de carácter normativo aplicables a las aguas subterráneas que se encuentran en zonas protegidas y, en particular, los requisitos para las Zonas protegidas para la captación de agua potable (en adelante, ZPAP) que establece el artículo 7 de la Directiva Marco del Agua (en adelante, DMA). No se incluyen aquí los requisitos recogidos en otras Directivas, en virtud de las cuales se designan las zonas protegidas. El documento explica asimismo la relación que existe entre los objetivos para las zonas protegidas y otros objetivos de la DMA. En particular, aclara los requisitos relativos a las ZPAP.

El presente documento debe leerse conjuntamente con otras de las guías de la ECI (estrategia común para la implantación, CIS en las siglas inglesas), tales como: la guía de carácter horizontal sobre la designación de masas de agua[1] y los documentos guía elaborados por el Grupo de Trabajo C de la ECI – Aguas subterráneas y, en particular, la guía de seguimiento de las aguas subterráneas[2].

1.2 Finalidad de la guía

- Contribuir a una visión común de las repercusiones técnicas y científicas de la DMA en lo que respecta a las zonas protegidas;
- Contribuir a que se formule en términos que sean comprensibles tanto para los organismos reguladores como para los que se vean afectados por la aplicación de la Directiva;
- En lo relativo a las exigencias de la DMA para las zonas protegidas, aclarar los aspectos relativos a las aguas subterráneas que no hayan sido tratados en otra parte, incidiendo especialmente en las exigencias para las ZPAP y los perímetros de protección asociados;
- Poner de relieve las cuestiones que puedan afectar a la gestión de acuíferos y masas de agua transfronterizos.



¡Atención! La metodología que propone esta guía deberá adaptarse a las circunstancias regionales y nacionales

El documento guía propone un enfoque pragmático global. Considerando la diversidad de circunstancias que se da en el territorio de la Unión Europea, los Estados miembros podrán aplicar las guías con flexibilidad, para responder a problemas que serán diversos en las distintas cuencas hidrográficas; por ello las guías deberán adaptarse a las circunstancias específicas de cada caso.

[1] CIS Guidance Document No. 2 on identification of water bodies, Comisión Europea, 2003
[2] CIS Guidance Document No. 15 on groundwater monitoring, Comisión Europea, 2006

2. Requisitos generales para zonas protegidas de la Directiva Marco del Agua

2.1 Zonas definidas con arreglo a la DMA

El artículo 4 de La DMA establece que los objetivos medioambientales de la Directiva se dividen en: objetivos para las aguas superficiales, para las aguas subterráneas y para las zonas protegidas. Los objetivos para las zonas protegidas son los que recoge la legislación comunitaria en virtud de la cual hayan sido establecidas dichas zonas, con el objetivo adicional de que "*Los Estados miembros habrán de lograr el cumplimiento de todas las normas y objetivos"* a más tardar en diciembre de 2015, a menos que se especifique de otro modo en el acto legislativo comunitario.

El anexo IV de la DMA define las zonas protegidas como:

1. zonas designadas para la captación de agua destinada al consumo humano con arreglo al artículo 7 de la DMA – Zonas protegidas de agua potable (ZPAP);
2. zonas designadas para la protección de especies acuáticas significativas desde un punto de vista económico;
3. masas de agua declaradas de uso recreativo, incluidas las zonas declaradas aguas de baño en el marco de la Directiva 76/160/CEE;
4. zonas sensibles en lo que a nutrientes respecta, incluidas las zonas declaradas vulnerables en virtud de la Directiva 91/676/CEE y las zonas declaradas sensibles en el marco de la Directiva 91/271/CEE; y
5. zonas designadas para la protección de hábitats o especies cuando el mantenimiento o la mejora del estado de las aguas constituya un factor importante de su protección, incluidos los puntos Natura 2000 pertinentes designados en el marco de la Directiva 92/43/CEE y la Directiva 79/409/CEE.

Respecto a las zonas protegidas para la captación de aguas subterráneas, exceptuando las ZPAP:

Los Estados miembros tendrán facultad discrecional respecto a su designación cuando:

- formen parte de una masa de agua subterránea;
- se extiendan sobre partes de dos o más masas de agua subterránea;
- incluyan zonas que no contengan en sí mismas aguas subterráneas o aguas superficiales, pero que comprendan hábitats o especies que dependen directamente de dichas aguas (p.ej. algunas zonas Natura 2000, que están protegidas); o
- coincidan con los límites de las masas de agua subterránea.

Dichas zonas figurarán designadas en los planes hidrológicos de cuenca.

La designación de ***ZPAP*** con arreglo a los artículos 6.2 y 7.1 de la DMA se presta a diferentes interpretaciones, las cuales han sido objeto de debate en el transcurso de la redacción del presente documento. Una primera interpretación es que las ZPAP podrán designarse como "zonas", mientras que la segunda interpretación es que deben designarse como masas de agua, como se recoge en el artículo 7.1. Esta divergencia de opiniones procede principalmente de las terminologías que a nivel interno utilizan los Estados miembros; es posible que éstos hayan percibido que el empleo de una terminología determinada tiene consecuencias en las medidas de protección. Estas pueden resumirse como sigue:

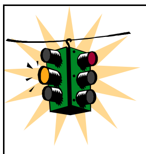
- En la primera interpretación, una ZPAP puede ser una zona que forme parte de una masa de agua subterránea, que se extienda a otras partes de dos o más masas de agua o que corresponda a los límites de la masa de agua subterránea. En este sentido, puede que no sean necesarios los perímetros de protección definidos en el artículo 7.3, además de la ZPAP. De hecho, las ZPAP se convierten en perímetros de protección en los que se centran las medidas.
- En la segunda interpretación, las ZPAP abarcan en su totalidad las masas de agua subterránea. Las medidas de protección necesarias podrán centrarse en el área circundante a los puntos reales de captación previstos (aunque no tienen por que limitarse solamente a dicha área), es decir, en los perímetros de protección que, por consiguiente, son similares a las ZPAP definidas en la primera interpretación.

Independientemente de la interpretación que se adopte, será aplicable el objetivo del artículo 7.3 de evitar el deterioro de su calidad y deberá otorgarse la protección necesaria a las zonas que estén en riesgo de sufrir un deterioro.

En el presente documento guía se ha adoptado la segunda interpretación como base de trabajo. Esto implica, en definitiva, que:

1. las ZPAP son las masas de agua en su conjunto;
2. las ZPAP comprenden las zonas de extracción de agua propiamente dichas (perímetros de protección) y otras zonas de captación potenciales;
3. las medidas de protección se centran en los perímetros de protección, normalmente ligados a los puntos de extracción de agua potable que estén en riesgo de sufrir un deterioro, lo cual no descarta otras medidas más amplias para toda la ZPAP, cuando un Estado miembro desee garantizar la protección, por ejemplo, de una zona que haya sido designada para la captación de agua en un futuro;
4. como especifica la nueva Directiva relativa a las aguas subterráneas, los perímetros de protección podrán incluir una masa de agua subterránea (es decir, una ZPAP), comprender partes de dos o más masas de agua o abarcar todo el territorio de un Estado miembro.

La designación de masas de agua subterránea (incluidas las masas de agua declaradas como ZPAP), que son unidades de gestión creadas para facilitar la consecución de los objetivos de la DMA, dependerá exclusivamente de la facultad discrecional de los Estados miembros. Los requisitos asociados a las ZPAP podrán ser una de las consideraciones para la designación de una masa de agua subterránea. Como se resalta más arriba, también podrán designarse **perímetros de protección** en los que centrar las medidas de protección necesarias para cumplir los objetivos del artículo 7 y de conformidad con el artículo 4.2.

	***¡Atención!* La terminología existente en los Estados miembros para la protección de zonas o áreas de captación de agua potable puede no concordar con la del artículo 7. En algunos Estados miembros, estas zonas son sinónimo de “perímetros de protección”. No será necesario modificar las designaciones existentes siempre que la relación con la terminología de la DMA sea inequívoca y se apliquen los objetivos y medidas de la DMA.**

2.2 Calendario para la consecución de los objetivos

La DMA establece en su artículo 4.1.c) que, para las zonas protegidas:

“Los Estados miembros habrán de lograr el cumplimiento de todas las normas y objetivos a más tardar quince años después de la entrada en vigor de la presente Directiva, a menos que se especifique otra cosa en el acto legislativo comunitario en virtud del cual haya sido establecida cada una de las zonas protegidas.”

Los objetivos y normas de otros actos de la legislación comunitaria quedan así integrados en los planes hidrológicos de cuenca con arreglo a la DMA.

La DMA introduce la fecha del 22 de diciembre de 2015 para alcanzar las normas y objetivos para la zona protegida, a menos que la legislación comunitaria en virtud de la cual haya sido establecida dicha zona protegida especifique una fecha alternativa.

2.3 Relación entre la zona protegida y otros objetivos de la DMA y de la nueva Directiva relativa a las aguas subterráneas

Los objetivos dirigidos a aplicar las medidas necesarias para evitar o limitar la entrada de contaminantes en las aguas subterráneas, recogidos en el artículo 4.1.b),i), y a invertir toda tendencia significativa y sostenida al aumento de la concentración de cualquier contaminante, con arreglo al artículo 4.1.b),iii), son aplicables a todas las aguas subterráneas. Los objetivos relativos al estado de las aguas, según se especifica en el artículo 4.1.b), i) y ii) de la DMA, son aplicables a las masas de agua subterránea. Los objetivos para zonas protegidas recogidos en el artículo 4.1.c) son aplicables a las zonas declaradas en virtud de las Directivas de referencia (es decir, aquellas que se han mencionado en el apartado 2.1).

Las normas y objetivos para las zonas protegidas difieren de los objetivos relativos al estado de las aguas. Las medidas encaminadas a cumplir los objetivos para una zona protegida podrán centrarse en dichas zonas protegidas, aunque sin limitarse necesariamente a las mismas. Las medidas para cumplir los objetivos relativos al estado de las aguas se aplicarán, en caso necesario, a toda la masa de agua subterránea.

La DMA establece en su artículo 4.2 que cuando sea aplicable a una masa de agua más de un objetivo, se utilice el más riguroso. Dentro de una zona protegida se aplicaría el objetivo más riguroso y, por ejemplo, aquél relativo al estado de las aguas. Aun cuando sea más riguroso, un objetivo para una zona protegida no será aplicable fuera de la zona protegida declarada.

Las exenciones y excepciones aplicables a cada uno de los objetivos medioambientales de la DMA, incluidos los objetivos para las zonas protegidas, serán sometidas a debate en el grupo de expertos de la ECI sobre Excepciones y, en este sentido, la ECI formulará recomendaciones claras en un Documento guía aparte.

De conformidad con el artículo 11 de la DMA, los Estados miembros velarán por que se establezca un programa de medidas con el fin de alcanzar los objetivos establecidos en el artículo 4, incluyendo los relativos a las zonas protegidas.

Por último, hay que mencionar que la nueva Directiva relativa a las aguas subterráneas, Directiva 2006/118 CE (en adelante, DAS), hace referencia a la necesidad de investigar con el fin de obtener mejores criterios relativos a la calidad y a la protección del ecosistema de las aguas subterráneas. Se pone así de relieve que las aguas subterráneas deben ser consideradas como un ecosistema, al tiempo que se reconoce que los conocimientos disponibles actualmente no son suficientes para establecer medidas claras de protección. De acuerdo con el considerando 20 de la Directiva, debe tenerse en cuenta la información adquirida a la hora de aplicar o revisar dicha Directiva, lo que significa que también deben actualizarse los documentos guía pertinentes.

2.4 Registros de zonas protegidas

La DMA establece en su artículo 6 que los Estados miembros velarán por que se establezca un registro de las zonas protegidas. El registro (o registros) se limitará a:

- *las zonas incluidas en cada demarcación hidrográfica….*

- *que hayan sido declaradas objeto de una protección especial <u>en virtud de una norma comunitaria específica</u>….*
- *para la <u>protección</u> de sus aguas superficiales o <u>subterráneas</u> o…*
- *para la conservación de los hábitats y las especies que dependen directamente del agua.*

Estos registros se completarán a más tardar el 22 de diciembre de 2004 y se revisarán y actualizarán regularmente. En el caso de las ZPAP que no hayan sido establecidas anteriormente en virtud de otros actos de la legislación, esto implica que deben haber sido establecidas antes de la fecha citada.

3. Aguas subterráneas en zonas protegidas para la captación de agua potable

3.1 Terminología

La DMA introduce en su artículo 7 algunos términos, aunque no los define. A continuación se ofrece orientación sobre los mismos:

- **captación de agua destinada al consumo humano**

A efectos del presente documento, son las aguas extraídas de una masa de agua subterránea cuyo destino sea para beber, cocinar, preparar alimentos o para otros fines domésticos. Asimismo, son todas las aguas utilizadas en empresas alimentarias para fines de fabricación, tratamiento, conservación o comercialización de productos o sustancias destinados al consumo humano, a menos que a las autoridades nacionales competentes les conste que la calidad de las aguas no puede afectar a la salubridad del producto alimenticio final.

Observación: Esta definición ha sido tomada de la Directiva sobre Agua Potable (98/83/CE). Incluye las aguas extraídas para el abastecimiento público y privado de agua potable, para su inclusión directa en productos alimenticios (por ej. en la fabricación de cerveza y el enlatado), pero no las aguas destinadas a usos indirectos como el riego por aspersión.

- **perímetro de protección (“safeguard zone”)**

Por regla general, es una zona situada dentro de una masa de agua subterránea (declarada ZPAP) que puede ser considerablemente más pequeña que dicha masa de agua, en la que se puedan centrar las medidas para impedir que se deteriore la calidad de las aguas subterráneas captadas para el consumo humano (véase apartado 3.4). En algunas circunstancias, por ejemplo en acuíferos kársticos, la extensión de los perímetros de protección puede ser la misma de la masa de agua subterránea o incluso mayor (véanse más detalles sobre los perímetros de protección en el apartado 3.7). Estos perímetros de protección pueden llegar a abarcar todo el territorio de un Estado miembro (considerando 15 de la Directiva 2006/118/CE).

3.2 Identificación y delimitación de las ZPAP

El artículo 7.1 establece que los Estados miembros especificarán dentro de cada demarcación hidrográfica:

“todas las masas de agua utilizadas para la captación de agua destinada al consumo humano que proporcionen un promedio de más de 10 m^3 diarios <u>o</u> que abastezcan a más de 50 personas, <u>y</u>

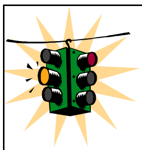
todas las masas de agua destinadas a tal uso en el futuro.”

En virtud de dicha disposición, así se designarán las masas completas de agua subterránea y así lo confirma el apartado 4 de la Referencia 1.

Observación: Como se ponía de relieve en el apartado 2.1, esto no significa que el objetivo mencionado en el artículo 7.3 de la DMA deba cumplirse en todos los puntos situados sobre una masa de agua subterránea, ni que deban aplicarse por igual medidas sobre toda la masa de agua (véanse apartados 3.4-3.8 de esta guía).

El enunciado *"un promedio [de más] de 10 m^3 diarios"* induce a pensar que la masa de agua en su conjunto debe poder proporcionar 10 m^3 diarios. La calificación alternativa, abastecer a más de 50 personas, confirma dicha interpretación (*Observación: este enunciado es similar al de la Directiva sobre Agua Potable (DAP), aunque el contexto en el que se utiliza es diferente*). Teniendo en cuenta las variaciones en el consumo y el tamaño de los hogares que existen en la Comunidad, estos límites son cercanos al abastecimiento de agua potable, procedente de la masa de agua subterránea, para entre 10 y 20 hogares.

La DMA no fija ningún límite respecto al tamaño que pueden tener las masas de agua subterránea – son unidades de gestión cuya designación es competencia de los Estados miembros, como se observa en la Referencia 1. No obstante, los requisitos administrativos con arreglo a la DMA, incluida la notificación, favorecen la creación de masas de agua subterránea o grupos de masas de agua subterránea de gran tamaño. Por lo general, estas masas de agua alcanzan muchas decenas y hasta muchos centenares de kilómetros cuadrados. La necesidad de proteger el agua potable es sólo uno de los numerosos factores entre los que habrá que elegir y que podrán ser tenidos en cuenta en la designación de masas de agua subterránea.



¡Atención! **De acuerdo con la DMA, puede que deban designarse como ZPAP muchas de las masas de agua subterránea de un Estado miembro. Esto no significa que sea necesario aplicar medidas de protección para cumplir los objetivos del artículo 7 a toda la extensión terrestre de dichas ZPAP. Podrán utilizarse los perímetros de protección para centrar las medidas a fin de proteger las aguas subterráneas que se extraen para el consumo humano y cumplir así los requisitos de los artículos 7.3 y 4.1.c).**

Las zonas de protección existentes (previas a la DMA) que hayan sido establecidas con arreglo a la legislación u orientaciones de los Estados miembros podrán ser similares a los perímetros de protección y podrían ser utilizadas para cumplir los objetivos del artículo 7.

Las exigencias de establecer masas de agua subterránea que estén "destinadas a tal uso en el futuro" con arreglo al artículo 7.1 y de crear un registro de dichas zonas de acuerdo con el anexo IV de la DMA, indican que los Estados miembros deben declarar dichas masas de agua como un recurso hídrico destinado al consumo humano en el futuro. Es posible que en la actualidad no exista dicho uso o que la captación total existente sea inferior a los límites mencionados anteriormente. Cuando, dentro de las perspectivas de planificación de la DMA, pueda preverse razonablemente dicho uso (tomando como base las propiedades hidrogeológicas del acuífero así como su uso potencial), las masas de agua subterránea deberán especificarse como destinadas a tal uso en el futuro.

3.3 Cumplimiento de los requisitos de la Directiva sobre Agua Potable (DAP)[3]

El artículo 7.2 de la DMA reza: *"además de cumplir los objetivos del artículo 4……los Estados miembros velarán por que, en el régimen de depuración de aguas que se aplique y*

[3] Directiva 98/83/CE del Consejo relativa a la calidad de las aguas destinadas al consumo humano.

de conformidad con la normativa comunitaria, el agua obtenida cumpla los requisitos de la Directiva 80/778/CEE, modificada por la Directiva 98/83/CE."

Observación: en la práctica, la Directiva 98/83/CE sustituye a la Directiva 80/778/CEE).

Esto confirma que:

- los objetivos del artículo 4 (es decir, el estado del agua, el objetivo de prevenir o limitar, aplicar la inversión de la tendencia y otros objetivos para las zonas protegidas) deberán cumplirse independientemente del cumplimiento del objetivo del artículo 7.2 ; y
- deberán cumplirse los requisitos de la Directiva sobre Agua Potable (DAP). Se incluye aquí el requisito general de garantizar que el agua esté libre de toda contaminación que pueda constituir un peligro para la salud humana **y** el requisito de cumplir las normas establecidas en la DAP en el punto de suministro a los consumidores (es decir, el grifo).

Observación: todas las demás referencias al cumplimiento de las normas de la DAP de esta guía, se interpretarán igual que el cumplimiento de estos dos requisitos.

No todas las captaciones de agua destinada al consumo humano están sujetas a la DAP. Tal como permite la propia Directiva, algunos Estados miembros han optado por eximir de su cumplimiento a fuentes **individuales** que proporcionan un promedio de menos de 10 m^3 diarios o que abastecen a menos de 50 personas; por ello, no todas las captaciones dentro de una ZPAP están sujetas al cumplimiento de la DAP y, por consiguiente, del artículo 7.2 de la DMA.

Observación: esta excepción de fuentes individuales es, de hecho, muy diferente de la aplicación del enunciado del artículo 7.1, descrito más arriba, que define qué masas de agua son ZPAP.

El punto de cumplimiento para el artículo 7.2 es el mismo que el mencionado en la DAP, es decir, el punto en el que se utiliza el agua potable para el consumo humano. En virtud de la legislación comunitaria, las normas de calidad mencionadas en la DAP no son aplicables al agua sin tratar captada de la masa de agua subterránea. No obstante, los Estados miembros podrán tener legislación propia sobre las normas de calidad aplicables a las aguas subterráneas sin tratar en tales circunstancias y, en la práctica, son numerosos los abastecimientos dentro de la UE en los que las aguas subterráneas se extraen y utilizan para el consumo humano sin ser sometidas a ningún tratamiento de purificación.

Los requisitos del artículo 7.2 no introducen ningún objetivo nuevo para los Estados miembros, y el calendario para el cumplimiento de los requisitos lo fija la Directiva sobre Agua Potable.

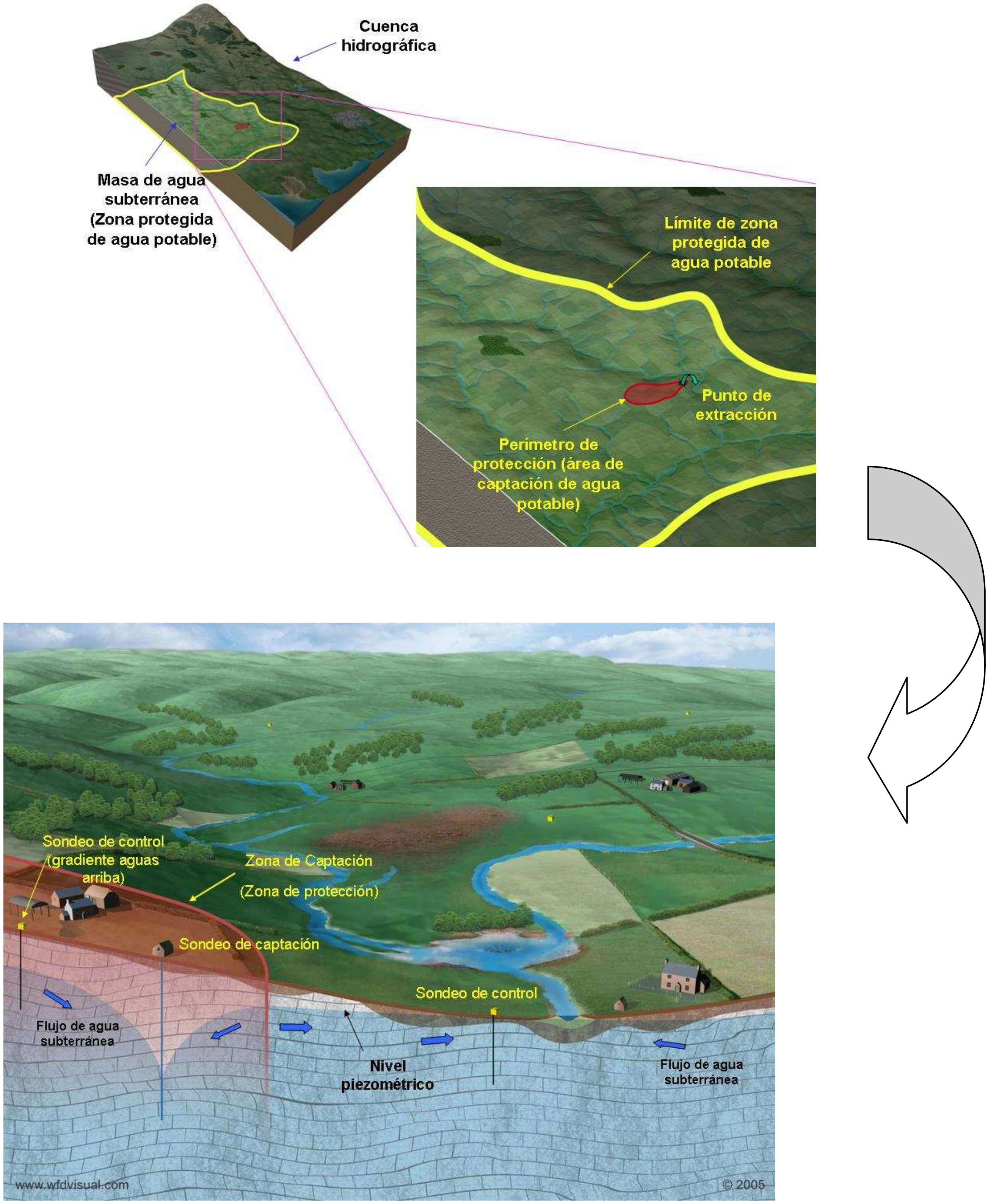


Figura 1: Posible relación entre una zona de aguas subterráneas protegida para la captación de agua potable y un perímetro de protección.

3.4 Protección necesaria y cómo evitar el deterioro

En virtud del **artículo 7.3** de la DMA, los Estados miembros velarán por la necesaria protección de las masas de agua subterránea especificadas como ZPAP *"con objeto de evitar el deterioro de su calidad, contribuyendo así a reducir el nivel del tratamiento de purificación necesario para la producción de agua potable. Los Estados miembros podrán establecer perímetros de protección para esas masas de agua."*

En la práctica, evitar el deterioro de la calidad de una masa de agua subterránea no necesariamente tendrá como resultado una reducción del nivel del tratamiento de purificación que pueda ser necesario para producir agua potable. Para reducir el tratamiento sería necesaria una mejora de la calidad. Existe, sin embargo, la clara intención de, al menos, evitar el deterioro de la calidad de las aguas subterráneas. En el mejor de los casos, la protección debería ser suficiente para que, con el paso del tiempo, pueda reducirse el tratamiento de purificación. La segunda frase del artículo 7.3 establece que los Estados miembros tendrán facultad discrecional para establecer perímetros de protección dentro de los cuales se centre la protección necesaria. En algunos Estados miembros, estos perímetros de protección se conocen comúnmente como "zonas de protección de captación de agua potable". Estas se tratan con mayor detenimiento en el apartado 3.8 y en el anexo 1.

¿Cuándo puede hablarse de deterioro significativo?

Serán necesarios valores de referencia sobre la calidad de las aguas subterráneas existente respecto de los cuales pueda evaluarse el deterioro. Estos valores podrán obtenerse de los datos existentes y de los programas de seguimiento creados con arreglo a la DMA, como se describe a continuación en el apartado 3.6. Habida cuenta de que un solo contaminante que exceda los niveles establecidos por las normas para el agua potable puede hacer necesario un tratamiento de purificación, cabe deducir que la evaluación del deterioro debe llevarse a cabo para parámetros individuales. Será necesario un valor de referencia para aquellos contaminantes que supongan un riesgo de deterioro, respecto al cual puedan evaluarse las tendencias en el futuro. El objetivo es prevenir el deterioro derivado de las presiones antropogénicas en cualquier contaminante que pueda necesitar un tratamiento adicional para cumplir las normas relativas al agua potable.

La figura 2 ilustra un caso en el que ya se ha instalado un tratamiento para corregir un problema existente de calidad del agua -cuyo origen puede estar relacionado con causas naturales o con la actividad humana-, de manera que se cumpla la norma sobre agua potable respecto al contaminante 1. Este tratamiento podría corregir asimismo un futuro deterioro en el contaminante 2. Sin embargo, este sistema oculta el hecho de que se ha producido un deterioro significativo de la calidad del agua sin tratar. El objetivo de prevenir el deterioro no se ha cumplido.

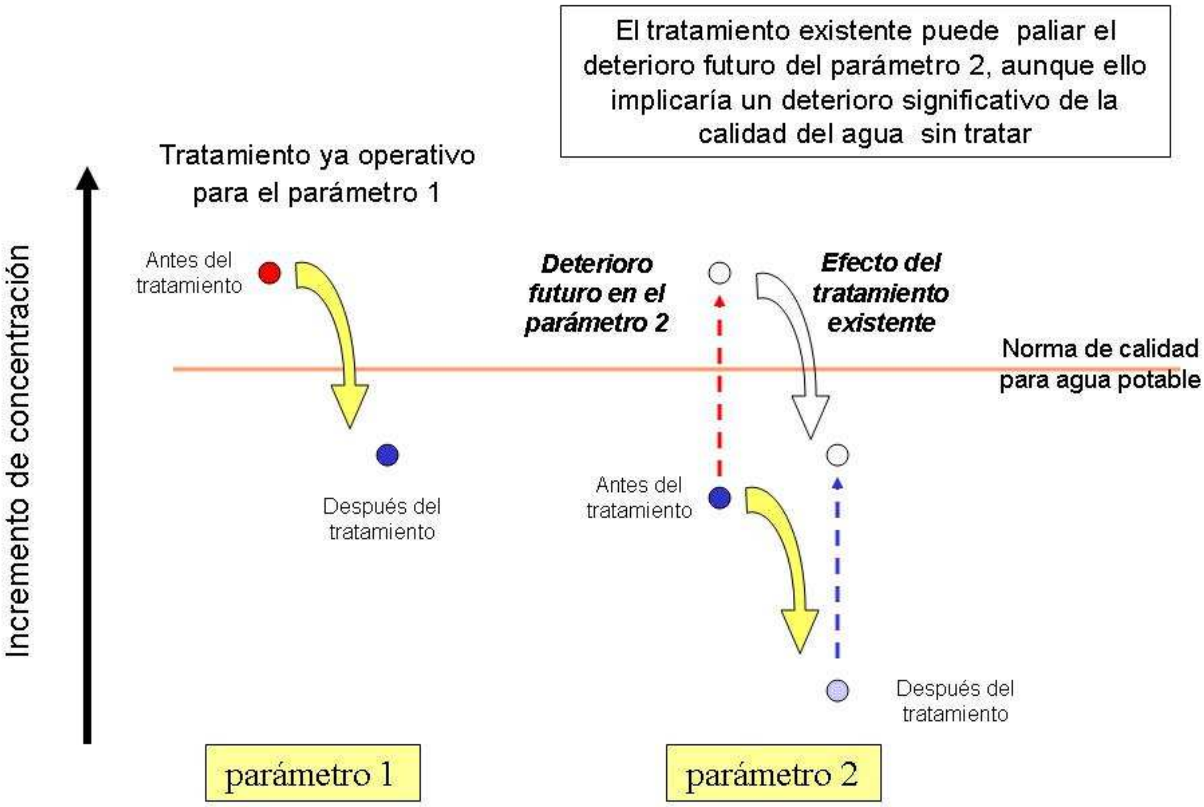


Figura 2: Deterioro significativo de la calidad de aguas subterráneas en una captación tras haberse instalado un tratamiento de purificación.

Mejoras de la calidad

La imposibilidad de abastecer a la población con agua salubre y limpia tiene consecuencias graves tanto para el abastecedor como para el consumidor de agua potable. En la práctica, una pequeña mejora de la calidad del agua sin tratar no reducirá necesariamente el nivel del tratamiento. Una vez que se haya instalado el tratamiento de purificación, es probable que sea necesaria una mejora sostenida de la calidad para infundir al abastecedor -y al consumidor- confianza suficiente de que dicho tratamiento ya no es necesario y puede abandonarse.

La DMA observa en su artículo 11.3.d) que las medidas básicas de un programa de medidas para una demarcación hidrográfica deben incluir:

"las medidas para cumplir lo dispuesto en el artículo 7, incluyendo las destinadas a preservar la calidad del agua con el fin de reducir el nivel del tratamiento de purificación necesario para la producción de agua potable"

A pesar de que esto indica claramente una aspiración a reducir el nivel del tratamiento, no supone en sí mismo la obligación absoluta a hacerlo.

El término "con objeto de evitar" del artículo 7.3 de la DMA indica que los Estados miembros deben intentar por todos los medios garantizar la protección necesaria de las aguas subterráneas. Sin embargo, es posible que a pesar de que lo intenten por todos los medios, no puedan evitar un deterioro de la calidad del agua debido a las influencias antropogénicas. Este caso puede darse cuando exista un desfase temporal entre la fuente de contaminación y cualquier impacto en un receptor, como consecuencia de la lentitud del flujo en el subsuelo. Es posible que la fuente de contaminación date de una fecha anterior a la DMA u otra legislación que exija su control, y que esta fuente no haya sido eliminada, sino que aún exista contaminación residual en las aguas subterráneas. Es posible asimismo que la tarea de eliminar la contaminación en las aguas subterráneas sea técnicamente inviable o que su coste sea desproporcionadamente oneroso.

En tales circunstancias no sería razonable esperar que los Estados miembros adoptaran nuevas medidas para proteger la captación de agua potable, una vez que todas las medidas viables ya han sido adoptadas. Aún podrá ser necesaria la instauración de tratamiento o de un nivel adicional del tratamiento para garantizar el abastecimiento continuado de agua potable y para cumplir los requisitos de la DAP.

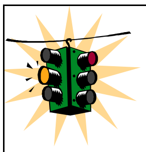
Cualquier otra opción – el cierre de la captación de agua potable – debería considerarse en sí misma como indicio del posible incumplimiento de los objetivos del artículo 7.3, pero únicamente cuando exista un deterioro de la calidad debido a los efectos antropogénicos. En muchos casos, el cierre de un punto de abastecimiento de agua potable puede no ser viable si no existe un abastecimiento alternativo; puede que el tratamiento de purificación resulte inevitable.

Protección necesaria

Es posible que no sea necesario aplicar por igual las medidas de protección a toda la masa de agua subterránea para cumplir los requisitos del artículo 7.3. La DMA prevé la utilización de perímetros de protección dentro de los cuales podrán centrarse las medidas adoptadas con este fin (apartado 3.8).

Los Estados miembros disponen de amplia libertad para designar y hacer operativos los perímetros de protección, pero, en principio, estas zonas deberán basarse en los riesgos, de manera que cualquier medida necesaria sea lo más eficaz posible para reducir el impacto de la actividad humana sobre la calidad de las aguas subterráneas que se extraen. La cartografía de vulnerabilidad y/o los métodos para calcular el tiempo de tránsito ya son utilizados en numerosos Estados miembros para designar las zonas con diferentes niveles de riesgo, en las que pueden centrarse medidas específicas de protección.

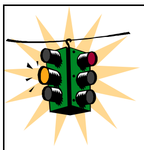
Observación: *existen propuestas, que están siendo objeto de debate, sobre la introducción de Planes de seguridad del agua en el marco de la DAP que incluyan procedimientos integrados que garanticen su calidad desde el punto de extracción hasta que llega al consumidor. En cuanto a su efecto, las propuestas son similares a los requisitos del artículo 7 de la DMA, aunque deben aclararse los vínculos que existan entre ambos*.

	***¡Atención!*** **Existe una relación potencial entre la identificación de una ZPAP y, en particular, la designación de perímetros de protección y las medidas de protección necesarias, por un lado, y los Planes de seguridad del agua propuestos en el marco de la Directiva sobre Agua Potable, por otro.**

Puntos de cumplimiento

Es necesario designar un punto de cumplimiento para valorar si se ha previsto la protección necesaria. Si este punto estuviera en el punto de utilización del usuario (el grifo), sería posible mezclar múltiples fuentes de agua de una extensa zona antes del suministro, ocultando así cualquier deterioro de la calidad de las aguas subterráneas y cualquier medida de protección inadecuada.

Sería asimismo poco práctico vigilar y evaluar el cumplimiento en todos los puntos dentro de la masa de agua subterránea. Puesto que el objetivo es evaluar el deterioro de la calidad del agua extraída, el punto de cumplimiento debe situarse en las inmediaciones del lugar de captación de las aguas subterráneas y antes de ser sometidas a cualquier tratamiento de purificación. Puede ser aceptable o inevitable una cierta cantidad de mezcla para compensar la calidad del agua sin tratar en un campo de pozos, debido a la naturaleza de la infraestructura utilizada para la extracción. Sin embargo, la mezcla de agua procedente de diferentes campos de pozos o lugares de producción podría ocultar alteraciones significativas y sostenidas de la calidad de las aguas subterráneas.



***¡Atención!* Los Estados miembros deben velar por que la vigilancia de la calidad del agua sin tratar sea representativa y suficiente para garantizar que se detectan las alteraciones significativas y sostenidas de la calidad de las aguas subterráneas causadas por las influencias antropogénicas, y que se toman las medidas oportunas al respecto. Los puntos de cumplimiento deben fijarse en los lugares adecuados para poder detectar dichas alteraciones.**

Aplicación a futuras captaciones

Cuando no se estén utilizando las aguas subterráneas para la captación de agua potable pero esté prevista su utilización en un futuro, resulta poco práctico evaluar si es necesario un tratamiento de purificación y cuál debe ser su nivel antes de efectuar las pruebas oportunas en el lugar de captación propuesto. Por consiguiente, se aconseja que se determine una base de referencia y el nivel del tratamiento necesario para corregir las influencias antropogénicas en el momento de instalar el abastecimiento previsto para la producción de agua potable y que se efectúen pruebas iniciales en ese momento. El cumplimiento con el objetivo reseñado en el artículo 7.3 debe evaluarse con respecto a esta base de referencia.

Interpretación resumida de los requisitos del artículo 7.3

Mediante la adopción de medidas de protección de las aguas subterráneas que sean técnicamente viables y proporcionadas, los Estados miembros velarán para que la calidad de las aguas subterráneas no experimente ningún deterioro en el punto de extracción para la producción de agua potable, para que no sea necesario incrementar el nivel del tratamiento de purificación.

Debe evaluarse el riesgo de deterioro para todos los parámetros individuales. Si se ha instalado tratamiento para un parámetro, no debe permitirse el deterioro de otros parámetros que también puedan controlarse con dicho tratamiento hasta el punto de que necesiten también tratamiento.

Puede existir un tratamiento de purificación instalado para corregir la mala calidad natural del agua y las alteraciones de su calidad causadas por la actividad humana. Los Estados miembros deben velar por la protección de las aguas subterráneas al objeto de infundir confianza suficiente a los suministradores (y consumidores) de agua potable en lo que respecta a que el nivel del tratamiento de purificación necesario para corregir las alteraciones antropogénicas de la calidad de las aguas subterráneas podrá reducirse con el tiempo y, en el mejor de los casos, eliminarse por completo. Esto puede conseguirse con medidas de protección de las aguas subterráneas (medidas que podrán aplicarse utilizando perímetros de protección) y con un seguimiento de la calidad de las aguas subterráneas sin tratar que demuestre las mejoras significativas y sostenidas (tendencias).

3.5 Calendario para el cumplimiento

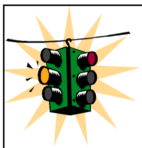
Como ya se ha mencionado, las ZPAP deberán haber sido identificadas e incluidas en un registro a más tardar el 22 de diciembre de 2004.

La DMA no fija en su artículo 7.3 ningún calendario explícito que indique el momento en que debe iniciarse una evaluación de cualquier deterioro de la calidad de las aguas subterráneas y para cuándo deberán estar implantadas las medidas de protección necesarias.

Cuando se disponga de datos suficientes sobre el seguimiento actual de la calidad de las aguas subterráneas, para definir un nivel de calidad que sirva de base de referencia para la evaluación del deterioro, se recomienda que el punto de partida se base en dichos datos, al objeto de prevenir un mayor deterioro de la calidad del que fija la base de referencia. No obstante, cuando los datos existentes no sean suficientes, la evaluación podrá esperar hasta que se disponga de datos suficientes obtenidos de los programas de seguimiento que establece la DMA.

En la práctica, la recogida de datos suficientes para disponer de una imagen coherente de la calidad natural del agua en una masa de agua subterránea y de las tendencias de su calidad en los puntos de extracción de agua para el consumo humano podrá llevar algún tiempo. Para poder determinar de una manera fiable un deterioro de la calidad del agua sin tratar con respecto a los valores establecidos en un inicio (de hecho, se tratará de una tendencia adversa significativa y sostenida) pueden ser necesarios varios años.

Lo expuesto anteriormente no implica que la protección necesaria de las ZPAP y los perímetros de protección no deban implantarse en una fase anterior. En la mayoría de los casos, las medidas de protección adoptarán la forma de medidas para prevenir o limitar las entradas de contaminantes en aguas subterráneas. Son de aplicación la actual Directiva sobre Aguas Subterráneas (80/68/CEE), al igual que la nueva Directiva sobre Aguas Subterráneas (2006/118/CE) y otros actos de la legislación comunitaria que contribuyen a la protección de estas aguas. Los Estados miembros deben haber implantado programas sustanciales para la protección de las aguas subterráneas ya operativos, al objeto de cumplir estos requisitos; dichos programas deben mantenerse y ampliarse para cumplir los requisitos recogidos en la DMA y la DAS. De conformidad con los artículos 11 y 13 de la DMA, cualquier medida complementaria necesaria deberá establecerse y ser incorporada en los planes de demarcación hidrográfica a más tardar en diciembre de 2008 y ser aplicada en su totalidad a más tardar en diciembre de 2012.

	***¡Atención!*** **Deben mantenerse los programas existentes de protección de las aguas subterráneas para prevenir el deterioro de su calidad, al tiempo que se recogen datos de seguimiento suficientes y se realizan evaluaciones de la calidad de referencia y de las tendencias.**

3.6 Seguimiento y evaluación

Es fundamental que el seguimiento de las ZPAP esté integrado en los programas operativos y de vigilancia de las aguas subterráneas que son necesarios con arreglo a lo establecido en el anexo V de la DMA. Los pormenores de los requisitos de seguimiento de las ZPAP se indican en la guía sobre el seguimiento de las aguas subterráneas[2]. No obstante, a continuación se indican algunos de los temas más importantes.

La DMA establece en su **artículo 7.1** que:

"Los Estados miembros efectuarán un seguimiento, de conformidad con el anexo V, de las masas de agua que proporcionen, de acuerdo con dicho anexo, un promedio de más de 100 m^3 diarios."

El valor umbral de 100 m^3 diarios debe interpretarse como la suma de todas las extracciones destinadas al consumo humano en la extensión total de la masa de agua subterránea.

De acuerdo con el **artículo 7.2,** deberán cumplirse los objetivos de la DAP para el agua obtenida que se destine al consumo humano. Para ello puede ser necesario tener en cuenta la serie de parámetros que son evaluados con arreglo a esta Directiva a fin de valorar si en dichos parámetros existe algún riesgo de deterioro.

Utilizando las referencias a "contaminantes" y "contaminación" y sus respectivas definiciones, la mayoría de los objetivos de la DMA son aplicables únicamente a sustancias, lo que excluye los parámetros biológicos. No obstante, el **artículo 7.3** no hace referencia a los contaminantes, sino que se refiere en cambio a la "calidad". (*Observación: ésta es la razón por la que en el texto se utiliza en inglés el término "contaminants" (contaminantes) en lugar de "pollutants" (agentes contaminantes), ya que incluye parámetros microbiológicos, así como sustancias químicas y radiactivas).*

Los Estados miembros deberán evaluar la necesidad de hacer un seguimiento de los parámetros adicionales en el agua sin tratar a los que se refiere la DAP, que tenga en cuenta cualquier posible riesgo de deterioro en dichos parámetros.

La presencia de nuevos contaminantes para los que no exista una norma oficial aplicable al agua potable, pero que pueden repercutir en la utilización de aguas subterráneas para consumo humano, puede exigir un seguimiento y una evaluación complementarios, una vez que el riesgo haya sido identificado.

Cuando exista un riesgo procedente de fuentes de contaminación antropogénicas, los parámetros que se vigilan en el agua tratada deberían vigilarse asimismo en el punto de extracción de las aguas subterráneas sin tratar. En principio, esto podrá incluir los parámetros químicos, radiológicos y microbiológicos que son objeto de seguimiento con arreglo a la DAP.

El programa de seguimiento de las ZPAP no requiere necesariamente la misma intensidad de vigilancia que la que establece la DAP. Se recomienda que para las extracciones que estén sujetas a la DAP se haga un seguimiento de las aguas subterráneas sin tratar para todos los parámetros indicados en la DAP al menos una vez cada seis meses (el ciclo de planificación de la DMA). En el caso de parámetros en los que exista un posible riesgo de deterioro, el seguimiento debe hacerse con mayor frecuencia y de conformidad con las recomendaciones expuestas en la guía sobre el seguimiento de las aguas subterráneas[2]. A tal efecto podrán agruparse las extracciones, siempre que el seguimiento siga siendo representativo.

A la hora de determinar el alcance y la frecuencia de cualquier seguimiento necesario se tendrán en cuenta los probables riesgos de contaminación, cualquier impacto real en las aguas subterráneas y de superficie que tenga su origen en la actividad humana y las características hidrogeológicas de la masa de agua subterránea[2]. Por ejemplo, para un conjunto de captaciones podría ser adecuado hacer un seguimiento en una que sea representativa del conjunto además del seguimiento en aquellas donde el riesgo sea mayor.

3.7 Evaluación del nivel del tratamiento de purificación necesario

El tratamiento de purificación para cumplir los requisitos que establece la DAP o cualquier otro requisito para el agua destinada al consumo humano podrá instalarse en una captación de agua potable para corregir el deterioro por sustancias de origen natural así como por impactos antropogénicos.

En la práctica puede resultar difícil atribuir a un contaminante concreto los niveles actuales de tratamiento y poder evaluar en qué medida el aumento del grado del tratamiento obedece únicamente al componente antropogénico de dicho contaminante. Esto es especialmente aplicable a las sustancias frecuentes en el medio natural -p.ej. cloro, sulfato o arsénico-. También es complejo evaluar los sistemas de tratamiento.

Dado lo expuesto más arriba y teniendo en cuenta que el artículo 7.3 hace hincapié en evitar el deterioro de la calidad de las aguas subterráneas, es aconsejable que los Estados miembros centren sus esfuerzos en averiguar si se han producido cambios significativos y sostenidos en la calidad de las aguas subterráneas sin tratar en la captación, tal como determinan los programas de seguimiento. Si no se han producido dichos cambios, es razonable asumir que no habrá que modificar el grado de tratamiento necesario.

Si existen tendencias significativas y sostenidas [al aumento de la contaminación] y el sistema de tratamiento ya está instalado, lo más probable en la mayoría de los casos es que cualquier deterioro adicional repercuta con el tiempo en el grado del tratamiento (véase más abajo). Debe evaluarse el posible deterioro en un futuro y sus repercusiones en el tratamiento cuando aún no se sobrepasen las normas sobre el agua potable y aún no se haya instalado el sistema de tratamiento.

Observación: en este contexto, un cambio significativo en la calidad de las aguas subterráneas sin tratar supondría un cambio en un parámetro individual, cuya consecuencia sería, en la actualidad o en un futuro previsible (p.ej. en uno o dos ciclos de planificación con arreglo a la DMA), la necesidad de tratamiento de purificación para alcanzar las condiciones propias del agua potable.

El impacto del grado de tratamiento en la captación sólo deberá evaluarse cuando existan pruebas de cambios significativos en la calidad del agua sin tratar que puedan ser atribuidos al impacto antropogénico. De este modo se reducirá al mínimo la recogida y evaluación de datos adicionales.

Para evaluar los cambios en el "grado" de tratamiento será necesario conocer el proceso de tratamiento (incluyendo en su caso para qué parámetros se instaló el sistema de tratamiento, su alcance y la utilización de materiales consumibles, como sustancias químicas).

Resulta difícil ofrecer orientación sólida sobre la cuestión de qué constituye un cambio en el grado de tratamiento, pero se insta a los Estados miembros a que, de una manera individualizada, tengan en cuenta los siguientes factores:

- Durante cuanto tiempo será necesario en su caso incrementar el tratamiento - ¿se trata de un incremento temporal o a largo plazo?
- ¿Cuál es la tendencia general en lo que respecta a la utilización del tratamiento *in situ*?
- ¿Se requieren nuevas instalaciones?
- ¿Los cambios en las instalaciones o en las sustancias químicas pretenden incrementar el tratamiento o sencillamente hacerlo más eficaz? Los cambios en el proceso de tratamiento pueden ser un reflejo de los avances tecnológicos y no un incremento del grado del tratamiento como tal.

- En caso de mezcla del agua de diferentes fuentes, ¿cuál es su finalidad? ¿Es un indicador de que se ha producido un cambio significativo y sostenido en la calidad del agua sin tratar dentro de la ZPAP?

Debe recopilarse información sobre la modificación, el cierre y el abandono de captaciones existentes de agua potable como consecuencia de la contaminación antropogénica, con el fin de poder utilizar dicha información para reforzar el sistema de seguimiento; por mucho empeño que se ponga en ello, puede que no siempre se consiga detectar los incidentes de contaminación. Estos datos podrán utilizarse asimismo para evaluar si las medidas de protección necesarias están siendo eficaces.

Cabe observar que los cambios en la calidad de las aguas subterráneas pueden ser inducidos no sólo directamente como resultado de las entradas de contaminantes, sino también por los efectos de las extracciones. Estos efectos también deberán tenerse en cuenta.

3.8 Perímetros de protección

Como se ha dicho antes, el artículo 7.3 indica que los Estados miembros podrán establecer perímetros de protección que contribuyan a cumplir el requisito de garantizar la protección necesaria de las ZPAP. El establecimiento de dichos perímetros dependerá, por consiguiente, de la facultad discrecional de los Estados miembros.

Los perímetros de protección pueden utilizarse como un medio práctico de enfocar las medidas de protección en los puntos de captación de agua para el consumo humano. Dados el tamaño y el alcance de la mayoría de las masas de agua subterránea, se recomienda esta opción para que, en su caso, las medidas de protección específicas puedan dirigirse de modo que tengan el mayor efecto posible – en este caso, proteger las zonas de recarga de las aguas subterráneas (zonas de captación) en los puntos (fuentes) en los que se extraen aguas subterráneas para el consumo humano.

De esto se deduce que la extensión de los perímetros de protección puede ser en muchos casos mucho más pequeña que las masas de agua subterránea y que dentro de una masa de agua subterránea pueden existir varias zonas de este tipo. Sin embargo, en determinadas circunstancias como en los acuíferos kársticos, los perímetros de protección pueden ser bastante más extensos, como reflejo de la velocidad del flujo y la vulnerabilidad extrema de las aguas subterráneas. Incluso puede ser necesario ampliar los perímetros de protección hasta más allá de los límites de la masa de agua subterránea para que incluyan también las masas de agua superficial asociadas “aguas arriba”, que consideren las zonas de captación para la producción de agua potable. Por último, los Estados miembros podrán decidir establecer perímetros de protección que cubran todo el territorio nacional para proteger el suministro de agua potable (considerando 15 de la Directiva 2006/118/CE).

La extensión del perímetro de protección podrá variar, por consiguiente, en función de:

- las propiedades hidrogeológicas del acuífero. Por ejemplo, en un acuífero muy poroso, la zona de captación para la producción de agua puede ser relativamente pequeña, mientras que en un acuífero de baja porosidad, la zona de captación puede ser muy extensa;
- el volumen de la extracción para consumo humano;
- el tipo de contaminante y las fuentes de contaminación que requieran medidas de protección. En principio, podrían ser necesarios perímetros de protección de mayor extensión para contaminantes persistentes que tengan su origen en fuentes difusas extensas, en contraposición con los contaminantes ya atenuados procedentes de pequeñas fuentes puntuales;

- si se tomó como base del perímetro de protección el tiempo de tránsito hasta el punto de extracción, o la extensión de la zona de "captura". En principio, las zonas de "captura" son más adecuadas para enfocar las medidas destinadas a corregir los contaminantes persistentes, mientras que el tiempo de tránsito es más adecuado para contaminantes ya atenuados;
- la vulnerabilidad de los acuíferos. Por ejemplo cuando existe una zona superior de terreno de baja permeabilidad, cerca del punto de extracción, la zona de "captura" puede ser extensa y las zonas de mayor riesgo pueden encontrarse a cierta distancia del punto de extracción, donde la vulnerabilidad a la contaminación procedente de la superficie es mayor.

Muchos Estados miembros ya utilizan zonas de protección para las aguas subterráneas con distintos fines, partiendo de los principios expuestos más arriba. En el anexo 1 se exponen estudios de casos que ilustran su designación y utilización. La mayoría de los planes se centran en las captaciones de agua potable y, en particular, en aquéllas desde las que se suministra agua a los consumidores con arreglo a la DAP. Estos planes podrían adaptarse fácilmente para fines de designación de los perímetros de protección a efectos del artículo 7.3 de la DMA. Las zonas kársticas o aquéllas en las que existan grandes fisuras podrán necesitar consideraciones adicionales y métodos especiales a la hora de decidir sobre la designación de los perímetros de protección.

En particular, cuando el volumen extraído es muy pequeño (por ejemplo, para abastecer a viviendas aisladas o propiedades individuales), puede resultar difícil mantener en un lugar concreto un registro de todos los abastecimientos de este tipo, y tal vez no resulte práctico establecer medidas de protección específicas para la captación. Asimismo, puede resultar innecesario establecer medidas de protección de las aguas subterráneas aplicables a toda la extensión de la masa. Por ejemplo, la imposición de medidas de cautela a toda la masa de agua subterránea para un contaminante ya atenuado, podría impedir el desarrollo de muchas actividades humanas corrientes, lo que puede resultar innecesario para mantener la calidad del agua extraída para consumo humano.

Cuando se trata de designar los perímetros de protección, se sugiere a los Estados miembros un enfoque basado en el riesgo, para garantizar una protección de las captaciones para el consumo humano que sea lo más rentable posible, y recalcar a las partes interesadas que la protección de las aguas subterráneas tiene especial importancia en dichas zonas de producción de agua potable. En el cuadro 1 se ofrece un ejemplo de un plan de este tipo. El objetivo es relacionar la designación del perímetro de protección, tanto con la presencia de captación de agua destinada al consumo humano como con su tipo y el riesgo que la actividad humana puede suponer para la captación de agua en cuestión.

Referencias

1. Common Implementation Strategy for the WFD – Identification of water bodies: horizontal guidance, CIS Guidance Document No. 2, enero de 2003.

2. Common Implementation Strategy for the WFD – Guidance on Groundwater Monitoring, CIS Guidance Document No. 15, diciembre de 2006.

3. Protecting Groundwater for Health. Managing the Quality of Drinking Water Sources. Publicación [en inglés] de la OMS/IWA (Asociación Internacional del Agua). 2006.

Cuadro 1: Ejemplo de un plan para designar perímetros de protección de captaciones individuales o grupos de captaciones a efectos del artículo 7.3 de la DMA

	Presiones antropogénicas	Seguimiento	Zonas y mediciones
Tipo 1 **Riesgo bajo** **Protección general**	Insignificantes, Por ej. designadas como no en riesgo durante la caracterización, baja densidad de población y de actividad humana en general.	Ningún seguimiento estratégico adicional. (Únicamente seguimiento operativo y control de vigilancia con arreglo a la DMA).	Zonas arbitrarias mínimas, por ej. medidas cautelares como códigos de buena práctica aplicados en un radio de 50 m en torno al punto de captación.
Tipo 2 **Riesgo moderado** **Protección cautelar**	Moderadas Por ej. la caracterización con arreglo a la DMA ha identificado riesgos, pero ninguna prueba de deterioro de la calidad de las aguas subterráneas.	Seguimiento de las fuentes de captación y posible seguimiento cautelar adicional dirigido a los riesgos identificados.	Considerar la posibilidad de establecer zonas en función del tiempo de tránsito y/o de las zonas de captura. Medidas cautelares adecuadas dirigidas a los riesgos identificados.
Tipo 3 **Riesgo alto** **Protección específica**	Altas Por ej. pruebas del deterioro de la calidad del agua.	Seguimiento específico en el perímetro de protección tanto de la captación como de las aguas subterráneas dentro de la zona. El seguimiento deberá diseñarse de modo que permita determinar la eficacia de las medidas.	Se recomienda calcular el tiempo de tránsito específico al lugar y/o zonas de captura. Medidas dentro de estas zonas específicas para atacar las fuentes de contaminación.

***Observación*: en todos los casos deberán tenerse en cuenta el volumen de captación y los riesgos dentro de la zona de captura/ tiempo de tránsito hasta la captación. Además, debe considerarse la vulnerabilidad del acuífero dentro de la zona.**

Anexo 1: Casos prácticos

ITALIA (Región de Emilia Romagna)

Identificación de zonas protegidas de aguas subterráneas y aplicación de medidas

Tipo de estudio: Cumplimiento de la normativa vigente en Italia

Enlaces de Internet:
http://www.camera.it/parlam/leggi/deleghe/testi/99152dl.htm
http://www.sogesid.it/allegati/accordo_conferenza_permanente_12_12_2002.pdf

Objetivo: protección y mejora de la calidad del agua potable

Referencia de la DMA: Protección de las aguas subterráneas para consumo humano.

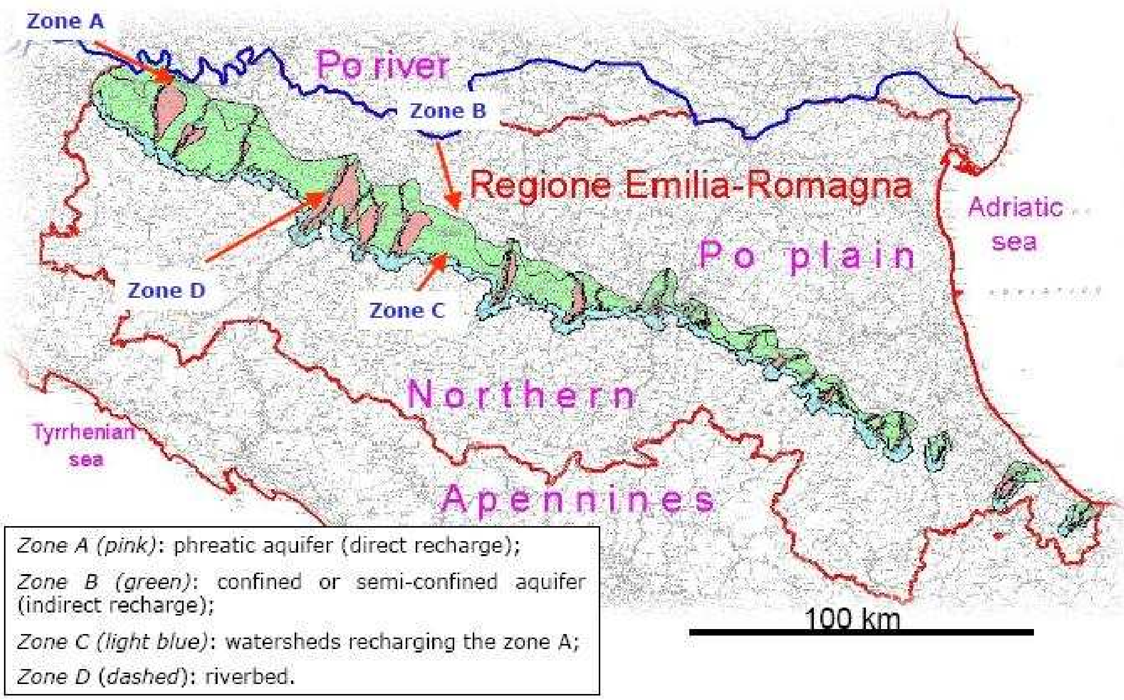
Contribuciones específicas: Definición de los perímetros de protección y de las zonas protegidas

Caracterización

La legislación italiana (D. Lgs. 152/99, art.21, apartado 1) establece que, para proteger y mejorar la calidad de los recursos de aguas subterráneas destinados al consumo humano, las Regiones (unidades administrativas italianas) especificarán perímetros de protección dentro de los cuales podrán aplicarse medidas y restricciones con objeto de garantizar la protección de las aguas subterráneas.

Los perímetros de protección se dividen en: 1. **"zona de protección absoluta"** (un área de 10 m de radio como mínimo en el entorno inmediato del punto de extracción); 2. **"zona respetada"** (el territorio que rodea la zona de protección absoluta, especificado por un tiempo de recorrido de entre 180 y 365 días, dependiendo de la vulnerabilidad y de las condiciones de peligro, o como mínimo de un radio de 200 m desde el punto de extracción); y 3. **"zonas de protección",** especificadas dentro de las zonas de recarga de las aguas subterráneas. La designación de zona de protección se basa en análisis hidrogeológicos, hidroquímicos e hidrológicos. También se tiene en cuenta la vulnerabilidad de la zona a la contaminación. Las zonas de protección se corresponden específicamente con toda la zona de recarga.

Las "zonas de protección absoluta" y las "zonas respetadas" ya están designadas en la mayoría de los casos, mientras que las Regiones establecen las zonas protegidas. En algunos casos, las zonas protegidas ya han sido designadas y son objeto de medidas de protección en vigor. La Región de Emilia Romagna ha designado las principales zonas protegidas de aguas subterráneas, que suponen más de 2.850 km^2 de los 22.000 km^2 (13%) que conforman el territorio de esta unidad administrativa, y está dividida en 4 subzonas que presentan características diferentes (Fig.1).



Zona A (de color rosa): acuífero freático (recarga directa);
Zona B (de color verde): acuífero confinado o semiconfinado (recarga indirecta);
Zona C (de color celeste): márgenes del río que recargan la zona A;
Zona D (rayada): lecho del río.
Figura 1: Zonas protegidas para la producción de agua potable en Emilia Romagna.

La llanura aluvial del río Po se extiende en la parte septentrional de la Región Emilia Romagna sobre más de 12.000 km². En esta llanura se han designado tres masas de agua subterránea diferentes, entre las que los “conos de deyección de los ríos de los Apeninos” podrían considerarse como las masas de agua subterránea prioritarias en lo que respecta a sus características químicas y cuantitativas. Las zonas de recarga están situadas a lo largo del margen meridional, donde los acuíferos son libres; hacia el norte, se convierten en acuíferos multicapa y confinados (Fig.2).

Las zonas protegidas para la producción de agua potable han sido especificadas en las zonas de recarga, como muestran la Fig.1 y el corte transversal esquemático de la Fig. 2. Las zonas de protección se extienden hasta más allá de los límites de la masa de agua subterránea e incluyen, aguas arriba, las cuencas impermeables de los conos que indirectamente pueden contribuir a la recarga de los acuíferos (zona C en la Fig.1).

Medidas de protección aplicadas

Las medidas de protección, organizadas en un Plan Regional, varían en función de las características de cada zona dentro de las áreas protegidas (A, B, C, D en la Fig.1). Dichas medidas van dirigidas a las actividades agrícolas y ganaderas (aplicación de estiércol y utilización de fertilizantes y pesticidas), explotación de canteras, urbanización (alcantarillados, impermeabilización), actividades industriales (también en relación con aspectos cuantitativos) y ubicación de vertederos. Las actividades peligrosas que guarden alguna relación con la calidad del agua deben ser autorizadas específicamente. Las medidas y normas han sido objeto de debate y de modificaciones a través de procesos participativos en los que han intervenido las partes interesadas públicas y privadas (compañías de abastecimiento de agua, asociaciones agrícolas, representantes de los sectores industriales y organizaciones de defensa del medio ambiente, entre otros).

Se han seleccionado indicadores de contaminación (p.ej. NO_3) y se han emprendido actividades de seguimiento en las zonas protegidas para comprobar la eficacia de las medidas adoptadas. Se ha previsto la posibilidad de introducir medidas correctoras durante la ejecución del Plan. Los órganos de administración están designando nuevas zonas protegidas para la producción de agua potable en la Región para las masas de agua subterránea de menor importancia.
Resultados obtenidos – Conclusiones – Recomendaciones La participación activa de las partes interesadas en la definición de las medidas y restricciones que deben adoptarse ha sido un componte esencial en la aplicación de zonas protegidas y ha propiciado una aceptación generalizada del Plan.
Accesibilidad a los resultados http://www.regione.emilia-romagna.it/geologia/ (en italiano e inglés) http://www.ermesambiente.it/PianoTutelaAcque/ (en italiano) **Siguientes pasos:** Otras Regiones de Italia están aplicando actualmente la normativa nacional y están designando zonas para la protección de las aguas subterráneas para el consumo humano. Las medidas que deberán aplicarse y los procedimientos de designación son competencias que han sido transferidas a las Regiones, mientras que los criterios generales y los objetivos son aquellos que establece la legislación nacional.

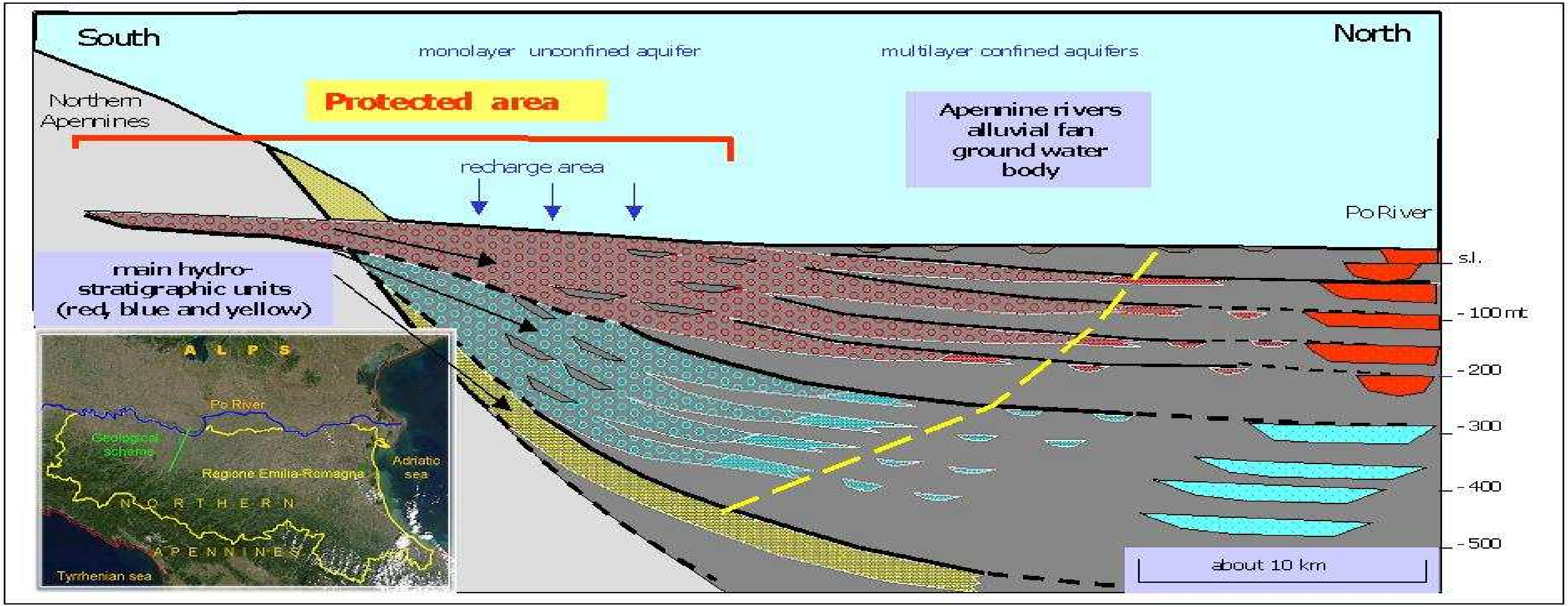


Figura 2: Mapa de ubicación y corte transversal esquemático de los acuíferos, en el que se indican las zonas protegidas para la masa de agua subterránea del "cono de deyección de los ríos de los Apeninos".

PORTUGAL Zonas de protección de las fuentes y medidas en torno al suministro público de agua en Golegã

Tipo de estudio: Especificación de las zonas de protección de aguas subterráneas y cumplimiento de las medidas.

Enlace de Internet: http://snirh.inag.pt/snirh.php?main_id=1&item=3.4&objlink=&objrede=

Objetivo: – indicar cómo se cumple la legislación portuguesa en materia de protección de la calidad del agua potable y la gestión del abastecimiento de aguas subterráneas en dos pozos situados en Golegã

Referencia de la DMA : Protección de las aguas subterráneas destinadas al consumo humano, seguimiento de las aguas subterráneas

Contribuciones específicas: garantía de la calidad de las aguas subterráneas, zonas de protección

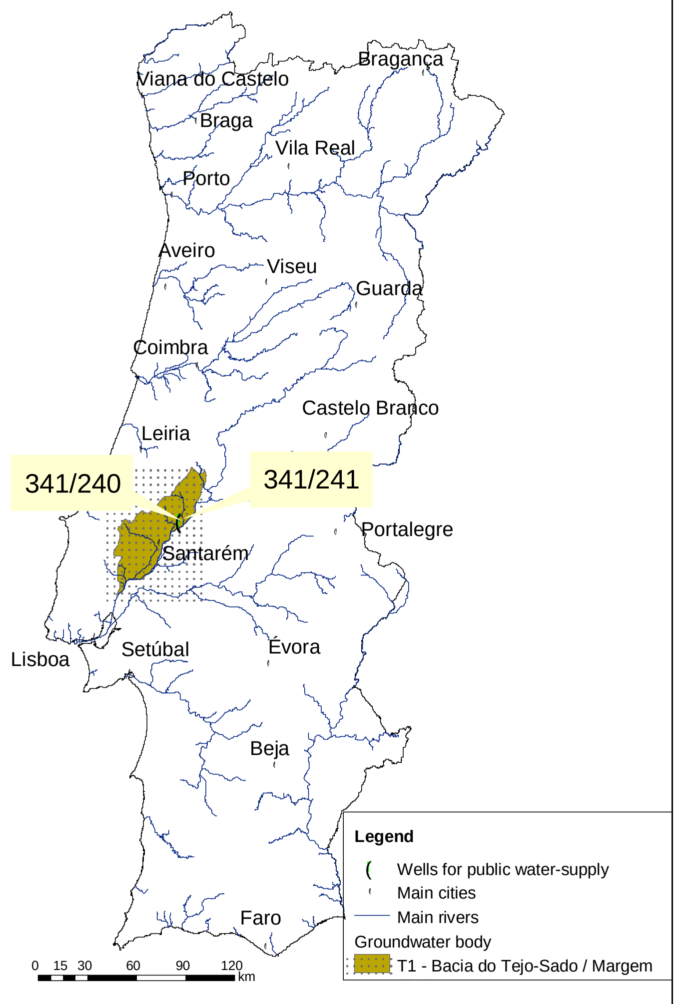
Caracterización

En el sistema de acuíferos porosos denominado “Bacia do Tejo-Sado / Margem Direita” existen dos pozos, identificados con el código nacional 341/240 (JK1) y 341/241 (JK2). Este es un sistema de acuíferos confinado y lo conforman arenisca alternada con arcilla. Los pozos JK1 y JK2 tienen una profundidad de 226,5 m y de 230,5 m respectivamente.

El flujo local de las aguas subterráneas discurre en dirección NNO hacia SSE. Esto significa que, **para tener en cuenta una posible expansión del cono**, las zonas de protección intermedias y exteriores deben tener una forma elíptica, desarrollada a lo largo de la dirección opuesta a la del flujo de las aguas subterráneas. La zona interior tiene forma poligonal.

En este caso se utilizó un método sencillo (Jacobs & Bear) para definir las zonas de protección de fuentes, principalmente la zona intermedia y la exterior. Deben conocerse la **transmisividad** (T), el caudal de bombeo (Q), el tiempo de residencia (t) (t=50 días en la zona intermedia y t=3500 días en la zona exterior), el espesor saturado (b), la porosidad efectiva (m_e) y el **gradiente hidráulico** (i). El tiempo de recorrido (t_R) se calcula mediante la fórmula:

$$t_R = \frac{2T^2 i^2}{m_e Q b} t$$

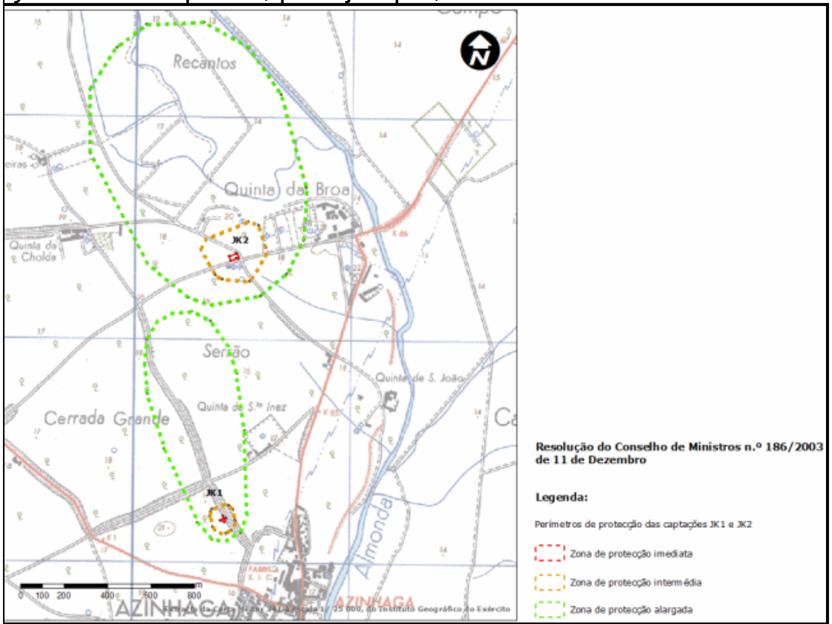


La zona interior, de forma poligonal, ya había sido definida por la autoridad competente para el suministro de aguas subterráneas. Se decidió mantenerla porque quedó demostrado que era una zona suficiente para proteger los pozos.

Las tres zonas de protección de las fuentes han sido designadas tal y como muestra el croquis *infra*: la línea roja marca la zona de protección interior; la de color naranja marca la zona intermedia y la verde, la zona exterior. La extensión para el pozo JK1 es como sigue; zona interior: 263 m^2, zona intermedia: 0,01 km^2, y zona exterior: 0,34 km^2; para el pozo JK2, zona interior: 780 m^2, zona intermedia: 0,06 km^2, y zona exterior: 0,95 km^2.

Una vez designadas las zonas, fue necesario establecer qué actividades o instalaciones debían quedar restringidas dentro de las diferentes zonas de protección para evitar la contaminación.

Para cada zona de protección, la norma portuguesa establece en su artículo 6 qué actividades o instalaciones están prohibidas o restringidas. En este sentido, en la zona interior están prohibidas todas las actividades o instalaciones, excepto aquellas destinadas a proteger el pozo. Ha sido necesario instalar un vallado. En la zona intermedia están prohibidos, por ejemplo, los desguaces, las fosas sépticas y las instalaciones aeronáuticas. La utilización de pesticidas persistentes y móviles, las carreteras, los ferrocarriles, las depuradoras, los cementerios solamente podrán darse dentro de esta zona de protección cuando se demuestre que no suponen ningún peligro de contaminación de las aguas subterráneas. En la zona exterior están prohibidos los vertederos, las fosas sépticas y las industrias químicas. Los lagos y los nuevos pozos, por ejemplo, han sido acondicionados.



Estos dos pozos pertenecen al Programa nacional de control de vigilancia. Cada seis meses se toman muestras de agua sin tratar. Se lleva un seguimiento de 48 parámetros diferentes.

Resultados obtenidos - Conclusiones - Recomendaciones

Las aguas subterráneas constituyen un recurso natural muy importante en Portugal porque de ellas se obtiene casi el 60% del abastecimiento de agua potable. La protección de su calidad y de su cantidad es una prioridad. Una de las estrategias utilizadas para proteger las aguas subterráneas para el suministro público de agua es la designación de zonas de protección de fuentes. Este marco es muy importante y debe integrarse en los programas de seguimiento y otras prácticas preventivas para conservar la buena calidad de las aguas subterráneas.

Accesibilidad a los resultados

Todos los datos están disponibles en la siguiente dirección de Internet: http://snirh.inag.pt/snirh.php?main_id=2&item=1.1&objlink=&objrede= (en portugués)

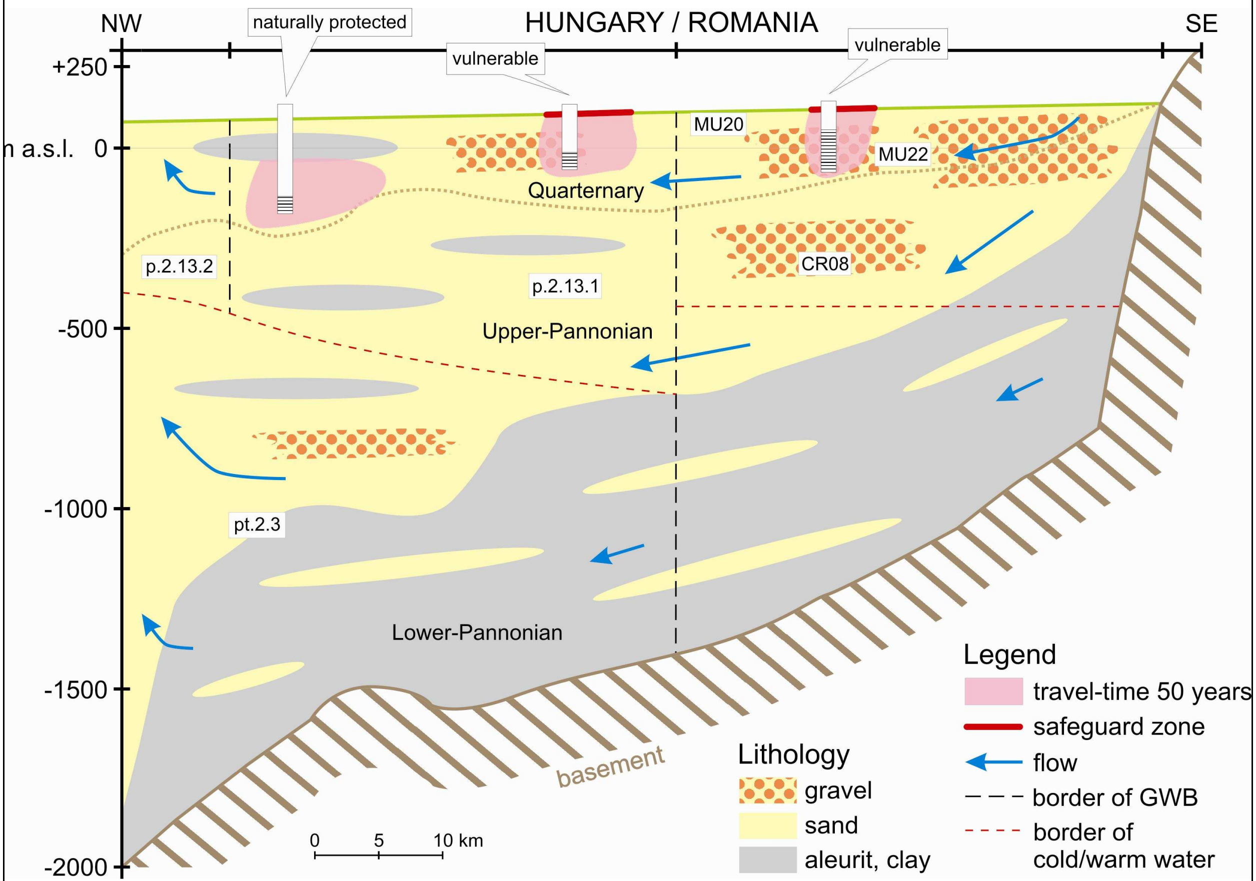
HUNGRÍA/RUMANÍA: Masas de agua subterránea transfronterizas - sistema de acuíferos multicapa del río Maros/Mureş

Información general
Título del estudio: Grupo de conos aluviales de las masas de agua subterránea transfronterizas – sistema de acuíferos porosos multicapa del río Maros/Mureş
Tipo de estudio: Ejemplo de protección de las aguas en las masas de agua subterránea transfronterizas entre Hungría y Rumanía (subregión – llanura aluvial del Maros/Mures: en parte central de la Llanura Occidental rumana y la parte sudoriental de la Gran Llanura húngara).
Enlaces de Internet: www.euvki.hu, www.inhga.ro, www.icpdr.org
Información general: El grupo de conos aluviales de las masas de agua subterránea del Mureş/Maros ha sido designado como una importante masa de agua subterránea transfronteriza en la cuenca del Danubio. Los conos aluviales del río Maros/Mures, donde los depósitos se remontan hasta el Mioceno, se extienden a ambos lados de la frontera húngaro-rumana. Es un importante recurso de agua potable para ambos países. Algunos de los abastecimientos de agua potable afrontan problemas de calidad considerables que se deben al alto contenido natural de arsénico, hierro, manganeso y amonio de estas aguas, especialmente en el lado húngaro. La masa de agua superior de Rumanía, y las aguas subterráneas poco profundas en la parte húngara son vulnerables a los contaminantes que se originan en la superficie.
Referencia de la DMA: Perímetros de protección de agua potable, zonas protegidas, masa de agua transfronteriza.
Contribuciones específicas: Designación de los perímetros de protección, protección de las fuentes de agua potable.
Caracterización: La cuenca, que comprende la parte sudoriental de la Gran Llanura húngara, se ha rellenado con más de 2000 m de sedimentos que datan de diferentes épocas. El enfoque húngaro para designar las masas de agua separa verticalmente el sistema de acuíferos multicapa con arreglo a las diferencias de temperatura (isoterma: HU 30 ºC, RO 23 30 ºC). Por consiguiente, la parte fría de las capas de la Alta Panonia y el Pleistoceno están unificadas verticalmente en Hungría, pero divididas horizontalmente por el característico flujo hacia abajo y de transición (Figura 1 - p.2.13.1) que las separa de la parte superior (p.2.13.2). En el lado rumano han sido designadas tres masas de agua, tomando como base la antigüedad de los estratos que separan el Alto Pleistoceno - Holoceno (MU20) del Bajo Pleistoceno – Pleistoceno Medio (MU22). La masa de agua subterránea MU20 alcanza una profundidad de 30 m, mientras que la MU22 se sitúa entre 30 y 150 m de profundidad, con su máximo espesor situado en la frontera. Debajo de la masa de agua subterránea MU22 existe otra masa de agua subterránea, la Arad-Oradea-Satu Mare (CR08), que data de la era Alta Panonia, contiene agua fría y se ha desarrollado a una profundidad de entre 150 y 400 m. Esta cuenca de agua subterránea es confinada, de tipo poroso permeable y la conforman arcilla y marga, con finas capas intermedias de arena, arenas arcillosas, con escasos guijarros o arenisca. Esta masa de agua ha sido explotada sobre todo en la cuenca del río Crişuri y su gestión ha sido asignada al Régimen de Aguas del Crişuri.

Las masas de agua se caracterizan desde el punto de vista litológico por guijarros, arenas y capas intermedias arcillosas, pero la parte superior y oriental es considerablemente más gruesa y su permeabilidad es mayor. La capa de cobertura está compuesta principalmente por entre 3 y 5 m de légamo arenoso y arcilla.

El acuífero superior es libre, mientras que los inferiores son confinados. El nivel freático en Hungría se sitúa a apenas 2-4 m por debajo de la superficie. La dirección principal del flujo de las aguas subterráneas va desde la zona de recarga hacia las zonas de descarga, o lo que es lo mismo, del ESE hacia el ONO. En condiciones naturales (sin extracción de aguas subterráneas), la principal zona de recarga se sitúa en Rumanía, por lo que el flujo lateral al otro lado de la frontera es un elemento importante del régimen de aguas de la parte húngara.

Figura 1: Corte transversal a través del grupo de conos aluviales del Maros/Mureş

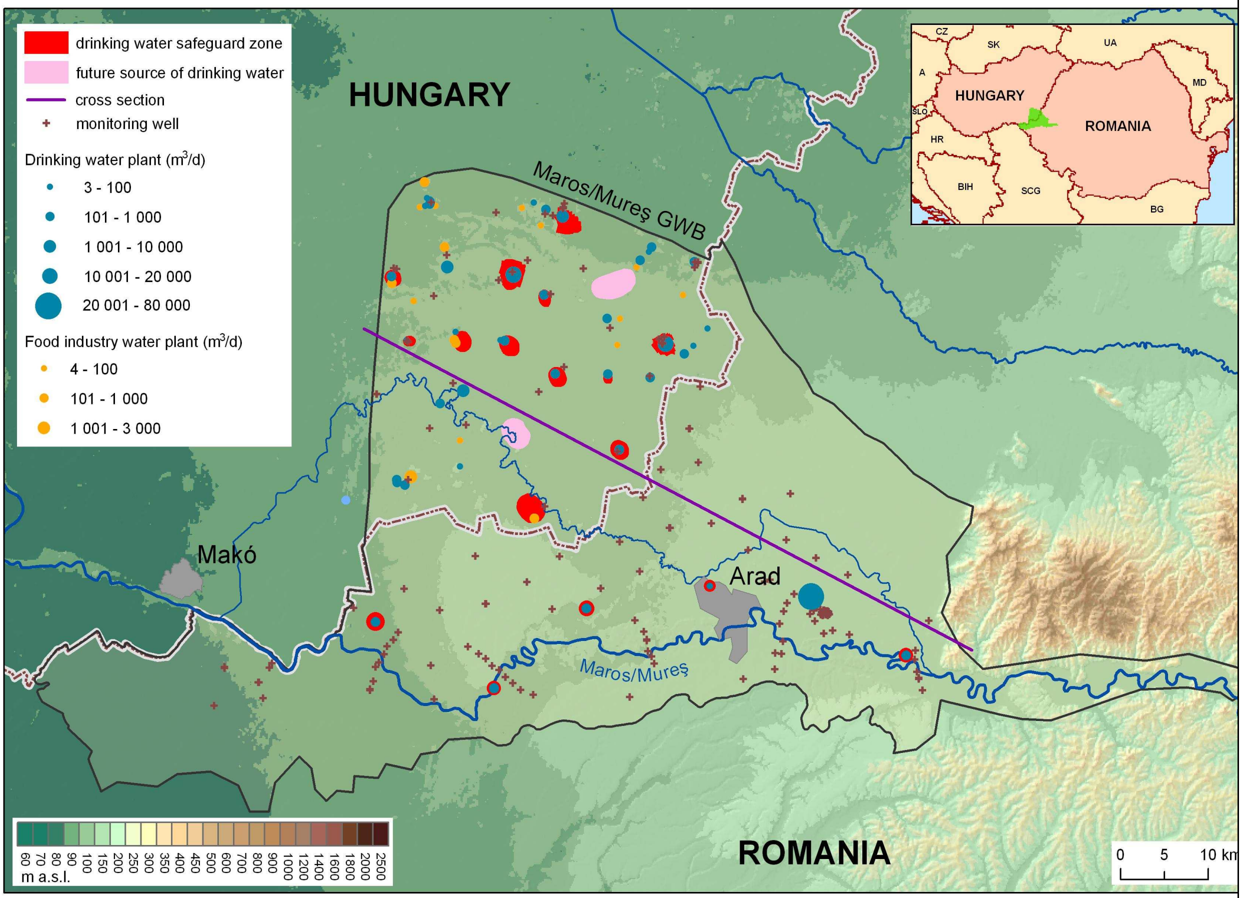


Resultados obtenidos - Conclusiones - Recomendaciones

En Hungría, el abastecimiento de agua potable depende casi por completo (96%) de los recursos de aguas superficiales. La legislación exige la protección de todas las fuentes de agua potable, con independencia de si están siendo explotadas o han sido designadas para su uso en el futuro. La metodología que se sigue para designar los perímetros de protección se basa en el Decreto Gubernamental nº 123/1997. (VII.18.). Los límites de los perímetros de protección se determinan con arreglo a las condiciones hidrológicas e hidrogeológicas, y la extensión de las zonas protegidas se basan en el factor tiempo de recorrido. Los tiempos de recorrido utilizados para las distintas zonas son como sigue: 20 días para la zona interior, medio año para la zona exterior y entre 5 y 50 años para las zonas hidrogeológicas protegidas. Estos perímetros de protección se establecen en las zonas de intersección.

La gestión del agua persigue designar perímetros de protección y evaluar un plan a la medida para restringir los usos del suelo y demás medidas necesarias para cada fuente vulnerable de agua potable. Como resultado de una investigación a escala nacional, todas las fuentes de agua potable han sido divididas entre grupos en los que existe protección natural y grupos vulnerables. Se considera que una fuente es vulnerable cuando la contaminación pueda llegar hasta ella en menos de 50 años. El modelo hidrogeológico es objeto de controles mediante el análisis químico de las aguas subterráneas, especialmente en lo que respecta a contaminantes de origen humano, p.ej. nitrato, pesticidas, hidrocarburos clorados, etc. Además se mide el contenido de tritio (3H). La detección de tritio significa que la edad del agua será de menos de 50 años, lo que significa que las aguas subterráneas son vulnerables.

En Rumanía, la designación de zonas de protección sanitaria y zonas de protección hidrogeológica se lleva a cabo de conformidad con la Decisión Gubernamental nº 930/2005. Las zonas de protección sanitaria tienen en cuenta un tiempo de recorrido de 20 días de una partícula de agua supuestamente contaminada desde el límite de la zona hasta el punto de extracción de agua, en el caso de una zona sujeta a un régimen riguroso, y un tiempo de recorrido de 50 días en el caso de una zona sujeta a un régimen de restricción. La designación de zona de protección hidrogeológica tiene en cuenta criterios geológicos y geomorfológicos.



Estos métodos cumplen los requisitos que la DMA recoge en sus artículos 6 y 7. En el caso de las fuentes vulnerables deben establecerse perímetros de protección que garanticen la protección necesaria de las fuentes de agua potable. La zona protegida de agua potable equivale a la extensión completa de todos los diferentes perímetros de protección. Las medidas no van encaminadas necesariamente a salvaguardar los recursos que ya cuentan con protección natural (acuíferos profundos), a los que no se les designa una zona protegida.

El seguimiento de la zona protegida de agua potable se efectúa en los pozos (de extracción y seguimiento).

En esta región se extraen de las aguas subterráneas unos 63 millones de m^3 de agua potable al año. La mitad de los recursos de agua potable son vulnerables. Las zonas de protección de agua potable abarcan cerca del 2% de la extensión total del cono fluvial del Maros/Mureş (4.038 km^2).

Accesibilidad a los resultados

Los organismos regionales responsables de los regímenes de aguas y el medio ambiente permiten el acceso a los resultados de las investigaciones que se llevan a cabo en cada una de las distintas instalaciones de abastecimiento de agua (solamente en húngaro). En Rumanía se puede acceder a estos datos en el Instituto Nacional de Hidrología y Gestión del Agua, así como en la Dirección General de Aguas del Mureş.

Siguientes pasos

En ambos países se está aplicando un programa nacional para la protección de fuentes de agua potable. El proceso de designación concluirá en 2009.

De conformidad con el nuevo acuerdo bilateral firmado en 2005, se elaborará un modelo hidrogeológico conjunto del cono aluvial del Maros/Mureş, para evaluar el régimen hídrico y obtener una base sólida para la gestión integral de las aguas subterráneas. Se están negociando las actividades necesarias para hacer un seguimiento bilateral.

ALEMANIA (zona de Lingen) Designación y utilización de perímetros de protección

Tipo de estudio: Redefinición de perímetros de protección en los alrededores de un campo de pozos de extracción
Objetivo: Protección y mejora de la calidad del agua potable
Referencia de la DMA: Protección de las aguas subterráneas para consumo humano.
Contribuciones específicas: Designación de perímetros de protección y zonas protegidas

Descripción

La ciudad de Lingen (57.000 habitantes) está situada a orillas del río Ems, a 30 km de la frontera neerlandesa, a una altitud de entre 20 y 65 m sobre el nivel del mar. Una parte considerable del agua potable que necesita la ciudad proviene de dos instalaciones de abastecimiento de agua. Dichas instalaciones tienen un derecho de extracción de 2,5 millones de m³ anuales. La más antigua de estas instalaciones se encuentra relativamente cerca del centro urbano y está rodeada de zonas de viviendas. A pesar de esta utilización del suelo y de la vulnerabilidad relativamente alta del acuífero, la calidad de las aguas subterráneas que se extraen es muy buena. Salvo la eliminación de hierro, no es necesario ningún otro tratamiento de purificación para garantizar la calidad del agua potable. Esto se debe principalmente a que la zona de captación goza de protección desde hace más de 30 años gracias al establecimiento de perímetros de protección del agua potable.

En 2003 se iniciaron amplias investigaciones hidrogeológicas con el fin de revisar y adaptar los perímetros de protección existentes. Las investigaciones han tenido como resultado el establecimiento y calibrado de un modelo tridimensional del flujo y del transporte transitorios de las aguas subterráneas. Utilizando el modelo como herramienta de gestión, el objetivo consistía en establecer nuevos perímetros de protección tomando como base las orientaciones DVGW W101 que utilizan las autoridades alemanas. De acuerdo con estas directrices debían establecerse tres perímetros de protección:

- Zona I: en las inmediaciones de los pozos de extracción (en un diámetro de 10 m)
- Zona II: Perímetro de protección más próximo (tiempo de recorrido de 50 días)
- Zona III: Perímetro de protección más amplio

La geología de Lingen la conforman arenas cuaternarias de 30 m de espesor, intercaladas con capas de légamo y arcilla, que crean una separación del acuífero en dos partes más o menos independientes, aunque existen orificios de comunicación (*hydraulic windows*) en varios puntos, que permiten una conexión limitada entre ambos. El acuífero inferior se utiliza como fuente para pozos de agua potable.

Al sureste de Lingen, la cuenca de captación está marcada por un saliente formado por depósitos glaciales, característico de las tierras bajas del norte de Alemania (Fig. 2). Las corrientes de aguas subterráneas desde este saliente siguen una dirección noroccidental hacia los pozos de extracción (Fig. 1). Para la cuenca de captación más amplia se estableció un modelo detallado tridimensional del flujo de elementos finitos en las aguas subterráneas.

Las mediciones de la corriente del agua superficial indican que existe un cierto grado de interacción entre las masas de agua superficial y el acuífero subyacente. Por ello el modelo incorpora asimismo las fugas desde los pequeños arroyos y ensenadas que van a parar al acuífero.

Tras haber calibrado con éxito el modelo, fue posible determinar la designación hidrogeológica de la cuenca hidrográfica a través de varias simulaciones (Fig. 3). La visualización del modelo de flujo simulado facilitó esta labor (Fig. 4).

La línea de demarcación del perímetro de protección más próximo, Zona II, se determinó utilizando el enfoque de modelo de transporte inverso (Fig. 5). Aquí se simula la migración de trazadores virtuales con respecto a la dirección del flujo durante un período de 50 días. El límite exterior, desde el que – con un 95% de probabilidades – el trazador puede llegar hasta los pozos de extracción en un intervalo de tiempo limitado, sirve como indicación para la designación del Perímetro de protección más próximo, zona II.

Medidas de protección aplicadas

Toda la zona protegida ha sido finalmente planificada tomando como base la cuenca hidrográfica y utilizando puntos de referencia, carreteras y lindes de propiedades (Fig. 6). Las restricciones de uso, definidas individualmente, en relación con, p.ej. obras de construcción, uso comercial y agrícola, están sujetas a las condiciones estipuladas localmente y están incorporadas en las directrices para la explotación de la zona protegida específica para la captación de agua.

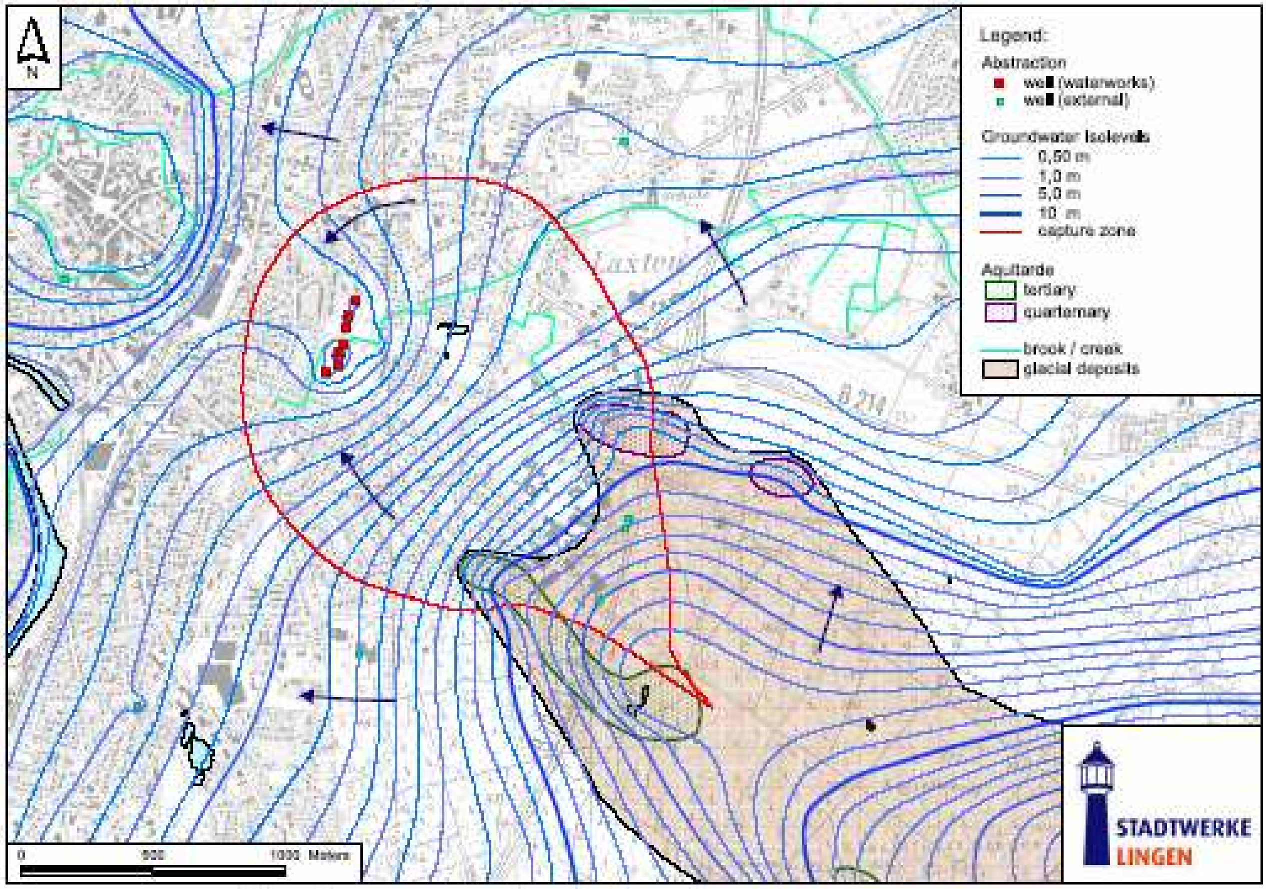


Figura 1: Nivel freático observado con delimitación hidrogeológica de la cuenca de captación

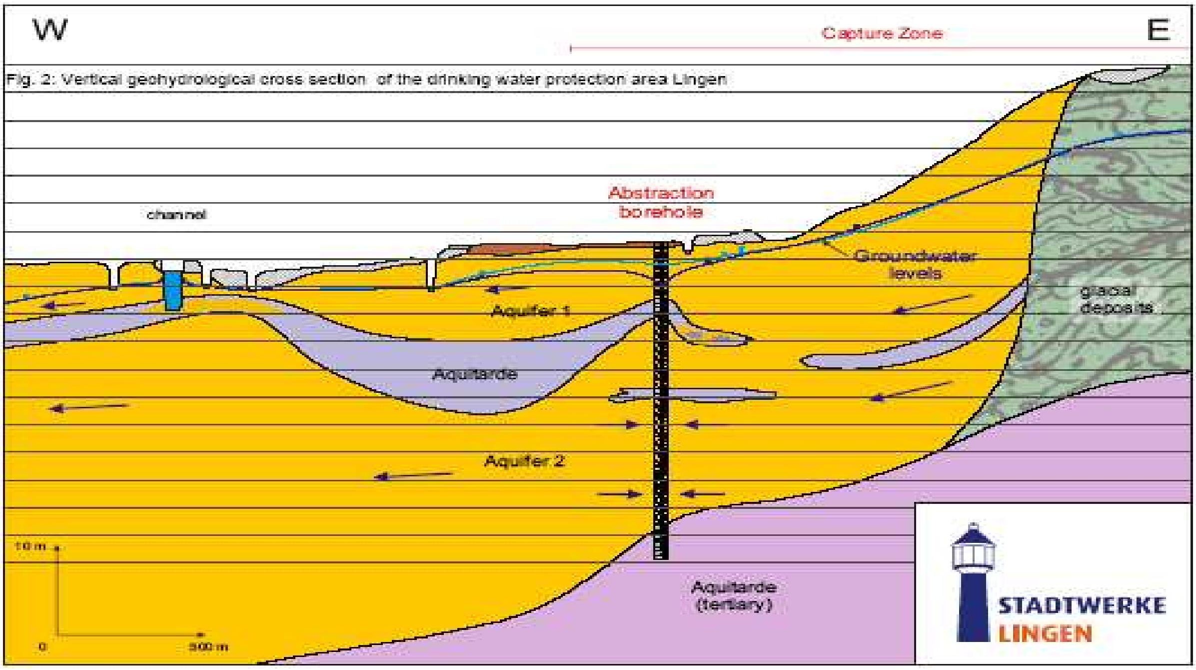


Figura 2: Corte hidrogeológico transversal de la zona de Lingen

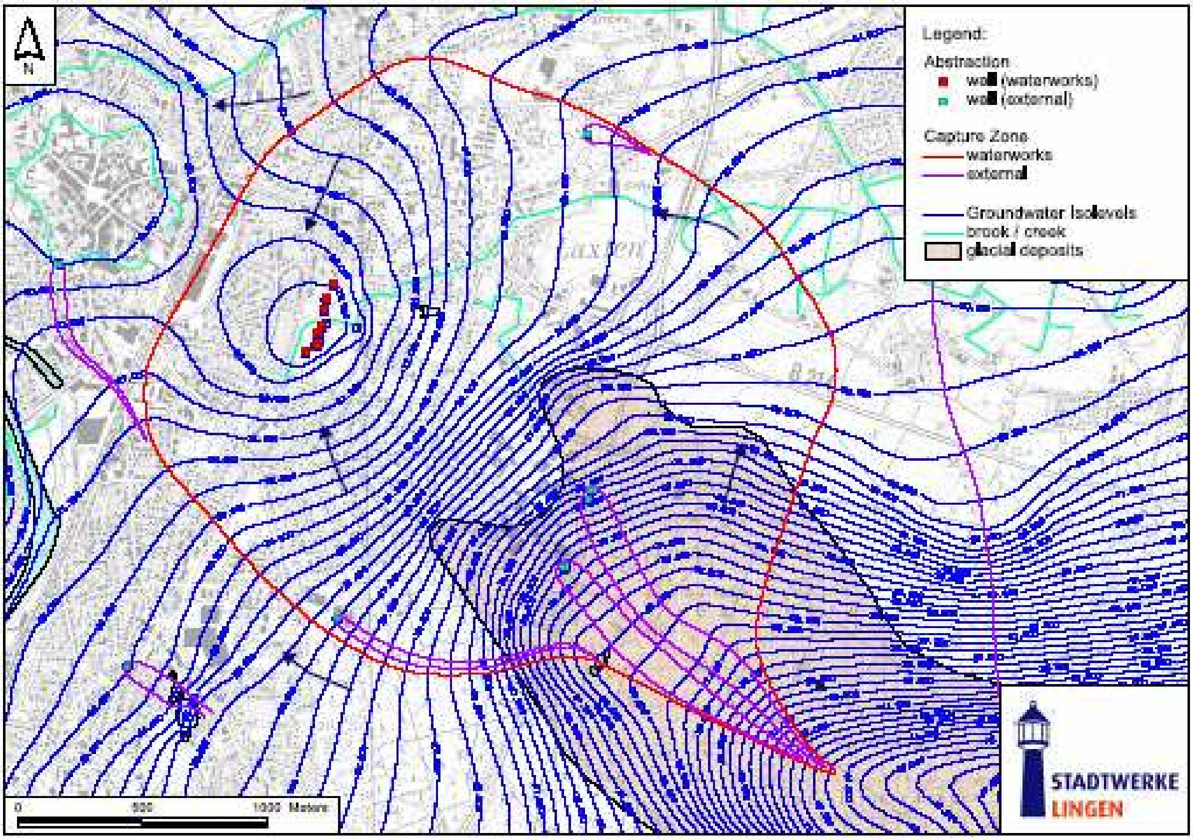


Figura 3 : Niveles piezométricos simulados, para los que se ha tomado como base una extracción de 1,5 Mm^3 anuales

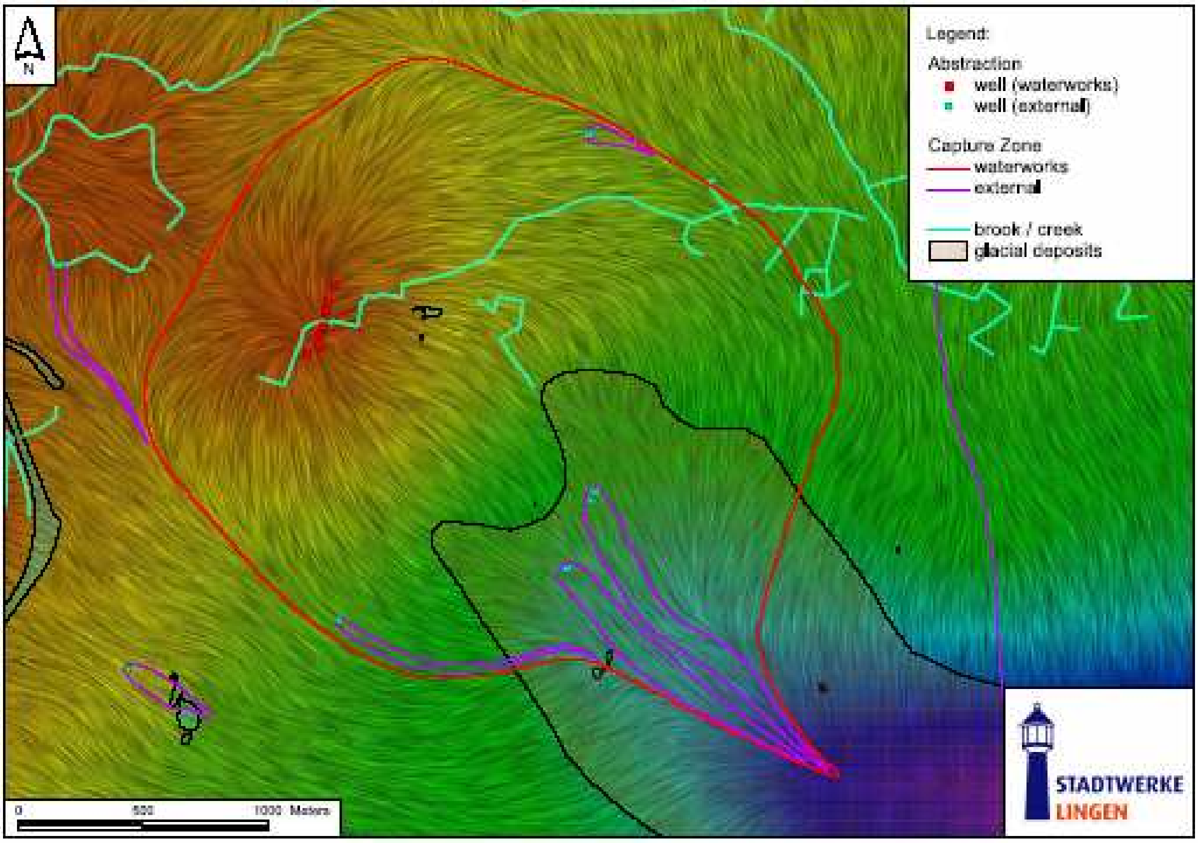


Figura 4: Visualización del modelo de flujo simulado

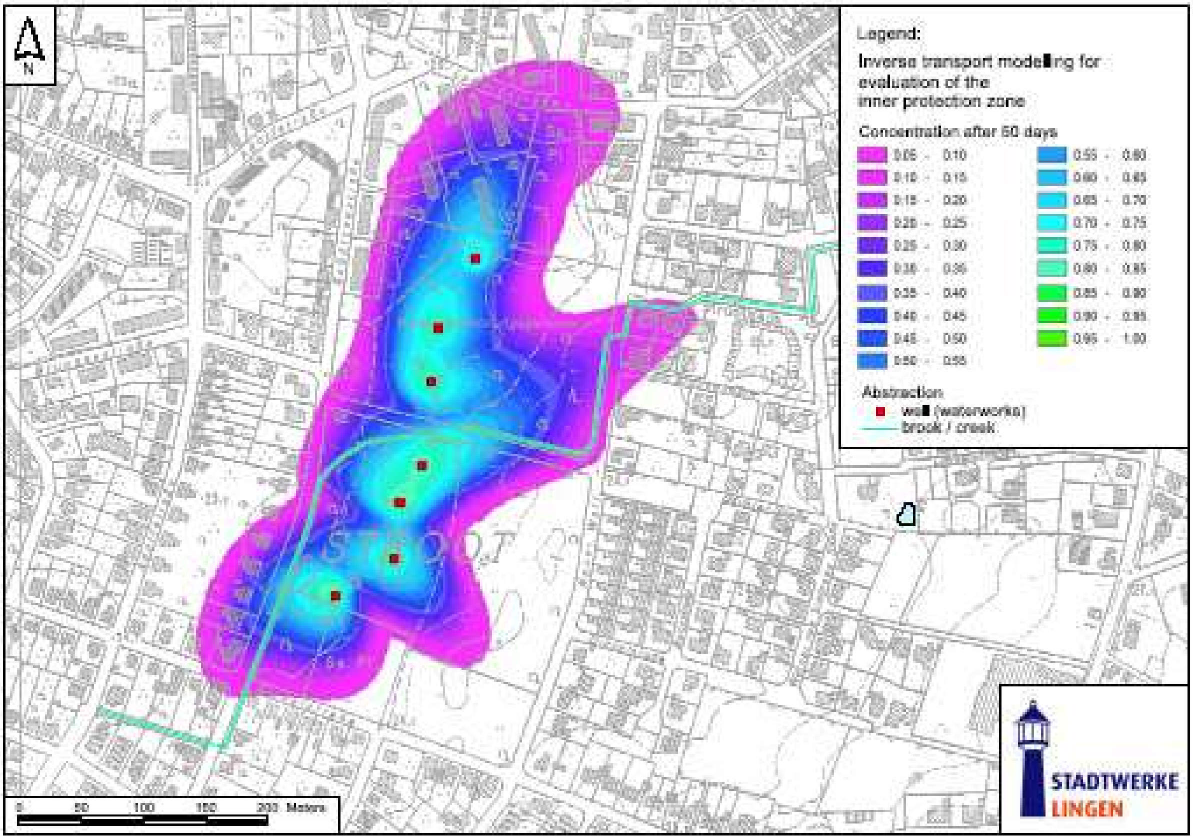


Figura 5: Modelo de transporte inverso para evaluar el Perímetro de protección II (50 días)

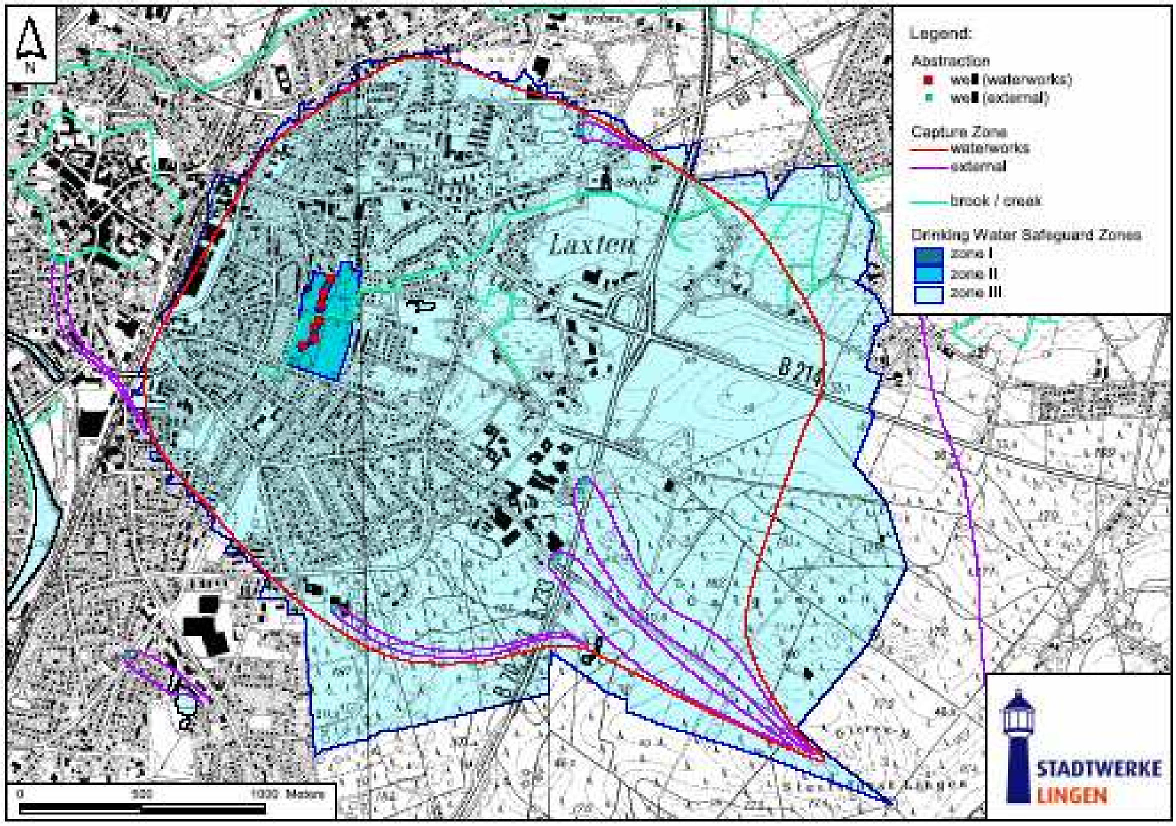


Figura 6 : Perímetros de protección definitivos para las instalaciones de abastecimiento de agua

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ESTRATEGIA COMÚN DE IMPLANTACIÓN DE LA DIRECTIVA MARCO DEL AGUA (2000/60/CE)

Documento Guía No. 17

Guía sobre prevención o limitación de las entradas directas e indirectas en el contexto de la Directiva sobre aguas subterráneas 2006/118/CE

Versión española
Dirección General del Agua
Agosto 2009

COMISIÓN EUROPEA

medio ambiente

ESTRATEGIA COMÚN DE IMPLANTACIÓN DE LA DIRECTIVA MARCO DEL AGUA (2000/60/CE)

Documento guía Nº 17

GUÍA SOBRE PREVENCIÓN O LIMITACIÓN DE LAS ENTRADAS DIRECTAS E INDIRECTAS EN EL CONTEXTO DE LA DIRECTIVA SOBRE AGUAS SUBTERRÁNEAS 2006/118/CE

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Nota.

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Prólogo

Los Directores Generales del Agua de la Unión Europea (UE), los países de la Adhesión, los países candidatos y los países de la EFTA, han desarrollado conjuntamente una estrategia común para la implantación (ECI) de la Directiva 2000/60/CE, *"por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas"* (Directiva Marco del Agua). Esta estrategia tiene como principal objetivo contribuir a una aplicación coherente y uniforme de la Directiva. La atención se ha centrado en las cuestiones metodológicas relacionadas con una comprensión común de las repercusiones técnicas y científicas de dicha aplicación.

En particular, uno de los objetivos de la estrategia es el desarrollo de documentos guía, de carácter práctico y jurídicamente no vinculantes, sobre varios aspectos técnicos de la Directiva. Estos documentos guía van dirigidos a los expertos que, directa o indirectamente, son los responsables de aplicar la Directiva Marco del Agua en las demarcaciones hidrográficas. En consecuencia, se ha adaptado la estructura, la presentación y la terminología a las necesidades de estos expertos, y, en la medida de lo posible, se ha evitado la utilización de un lenguaje formal y legalista.

En este contexto se elaboró un documento guía sobre "Análisis de Presiones e Impactos", aprobado por los Directores Generales del Agua en noviembre de 2002 (CIS Guidance Document nr. 3). Dicha guía sirve de referencia a los Estados miembros durante el proceso de análisis de presiones e impactos para la caracterización de las masas de agua subterránea, en el marco del desarrollo de los planes hidrológicos de cuenca requeridos por la Directiva Marco del Agua.

A modo de continuación y en el ámbito de aplicación de la nueva Directiva relativa a protección de las aguas subterráneas contra la contaminación y el deterioro, elaborada en cumplimiento del mandato del artículo 17 de la Directiva Marco del Agua, los Estados miembros han manifestado la necesidad de aclarar algunos aspectos relacionados con la evaluación del riesgo y con las medidas relativas a las "entradas ("inputs") directas e indirectas de contaminantes" en las aguas subterráneas. En 2004 se puso en marcha un proyecto para redactar un documento guía que complementase al anteriormente reseñado, y con ese objetivo se estableció un grupo de redacción (WG- C) bajo la supervisión del Grupo de Trabajo sobre Aguas Subterráneas de la Estrategia Común de Implantación. El grupo de redacción ha desarrollado su tarea bajo la coordinación de organizaciones de grupos interesados del sector industrial y de Países Bajos y con la participación de expertos de otros Estados miembros y de representantes de partes interesadas.

Este documento guía es el resultado de los trabajos de este grupo y contiene la síntesis de los resultados de los debates celebrados desde diciembre de 2004. Está basado en las aportaciones y las reacciones de una amplia variedad de expertos y partes interesadas que han participado en su elaboración a través de reuniones, talleres, conferencias y medios electrónicos, sin que por ello resulten vinculados en modo alguno con el contenido del presente informe.

"Nosotros, los Directores Generales del Agua de la Unión Europea, Noruega, Suiza y los países que han solicitado la adhesión a la Unión Europea, hemos examinado y aprobado el presente Documento guía en el transcurso de nuestra reunión informal bajo la Presidencia alemana (Dresden, 18-19 de junio de 2007). Deseamos expresar nuestro agradecimiento a los miembros del Grupo de Trabajo C y, en particular, a los responsables del grupo de redacción por la elaboración de este documento de gran calidad.

Creemos firmemente que éste y otros documentos guía elaborados en el marco de la Estrategia Común de Implantación tendrán un papel destacado en el proceso de implantación de la Directiva Marco del Agua y de la Directiva sobre la protección de las aguas subterráneas contra la contaminación y el deterioro.

Esta guía es un documento vivo que precisará de aportaciones y mejoras a medida que se procede a su aplicación y crece la experiencia en todos los países de la Unión Europea y en otros países. Hemos acordado, no obstante, que este documento se haga público en su forma actual con el fin de presentarlo al gran público como la base para seguir avanzando en su puesta en práctica.

Asimismo, nos comprometemos a evaluar y a decidir sobre la necesidad de revisarlo a la luz de los avances científicos y técnicos, así como de las experiencias acumuladas en la aplicación de la Directiva Marco del Agua y de la Directiva sobre la protección de las aguas subterráneas".

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1 OBJETIVOS Y ALCANCE

1.1 Introducción

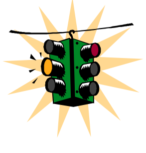
Las aguas subterráneas constituyen un recurso natural importante: si se deteriora, su restauración puede resultar difícil y costosa. En aras de la sostenibilidad, y por razones de carácter medioambiental y económico, parece apropiado disponer de un marco normativo para su protección eficaz que sea acorde con el principio de precaución y con el de “quien contamina, paga”. Este marco viene establecido en gran medida por la Directiva 2000/60/CE, de 23 de octubre, por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas (Directiva Marco del Agua, DMA) que incorpora disposiciones contenidas en la Directiva 80/68/CEE, de 17 de diciembre de 1979, relativa a la protección de las aguas subterráneas, aunque su alcance es mucho mayor. Esta última directiva quedará derogada en 2013 y será reforzada y reemplazada por la Directiva 2006/118/CE, de 12 de diciembre, relativa a la protección de las aguas subterráneas contra la contaminación y el deterioro (DAS). Este marco normativo complementa asimismo otros aspectos de la legislación comunitaria relativos a medidas de protección de las aguas subterráneas, como la Directiva relativa a los nitratos y la Directiva relativa a la comercialización de productos fitosanitarios.

1.2 Objeto

Esta guía pretende servir de orientación para la aplicación de la DMA en lo relativo a las obligaciones de prevención o limitación de la entrada de contaminantes en las aguas subterráneas, tal y como especifica la DAS. La guía explica la relación que existe entre los objetivos de prevención o limitación y otros objetivos de la DMA y, en particular, aclara los requisitos relativos a las entradas directas o indirectas de contaminantes.

El documento debe leerse conjuntamente con las guías del Grupo de trabajo C sobre aguas subterráneas (WG C) de la Estrategia Común de Implantación (ECI) de la DMA, en particular la guía sobre el seguimiento de las aguas subterráneas[1].

La DMA brinda a los Estados miembros flexibilidad para que tengan en cuenta las circunstancias locales a la hora de establecer los criterios para valorar el buen estado químico del agua y cumplir los otros requisitos de la Directiva, incluidos los objetivos de prevenir o limitar la entrada de contaminantes en las aguas subterráneas. Estas circunstancias locales pueden incluir modos diferentes de enfocar la normativa y la protección medioambiental entre los distintos Estados miembros. En este sentido, el presente documento guía no tiene el propósito de recomendar medidas específicas que puedan adoptarse para prevenir o limitar las entradas de contaminantes en las aguas subterráneas, sino que se centra, en primer lugar, en explicar las definiciones y los requisitos contenidos en la DMA para que todos los Estados miembros entiendan por igual aquello que se les exige; y, en segundo lugar, ofrece ejemplos de cómo pueden cumplirse dichos requisitos. Se han incluido figuras y gráficos que explican, de la manera más precisa y completa posible, procedimientos, criterios, decisiones y otra información pertinentes. Debe tenerse presente, sin embargo, que no es posible incluir todas las situaciones específicas ni instrucciones pormenorizadas en estas presentaciones esquemáticas. No obstante, con la inclusión de estos esquemas se pretende facilitar información visual que permita la rápida comprensión de los aspectos clave de la DMA y la DAS sobre los temas tratados.



¡Atención! La metodología que propone esta guía deberá adaptarse a las circunstancias regionales y nacionales

La guía propone un enfoque pragmático global. Dada la diversidad de las circunstancias en la Unión Europea, los Estados miembros podrán aplicar la guía con flexibilidad para responder a los distintos problemas de las cuencas hidrográficas, subcuencas o masas de agua subterránea. Así pues, la guía se adaptará a las circunstancias específicas de cada caso.

[1] CIS Guidance Document No. 15 on Groundwater Monitoring. Diciembre de 2006.

1.3 Alcance

Esta guía forma parte de una serie de documentos que explican y analizan las disposiciones normativas de la DMA y de la DAS. Cada uno de ellos se centra en un aspecto diferente de las aguas subterráneas, -seguimiento[1], aguas subterráneas en áreas protegidas para la captación de agua potable[2] de acuerdo con la DMA, aplicación del término "entradas directas e indirectas", evaluación del estado químico y tendencias-, y en una metodología común para el establecimiento de valores umbral relativos a las aguas subterráneas.

En la práctica, estos diferentes requisitos están estrechamente relacionados entre sí y, en ocasiones, pueden solaparse. Cada documento guía tendrá su máxima utilidad en relación con un requisito específico de una directiva que, a menudo, sólo es pertinente en una parte concreta del sistema de aguas subterráneas. La figura 1 describe las partes del sistema de aguas subterráneas mencionado en las diferentes guías. En la figura se diferencian tres "áreas" principales de las aguas subterráneas, denominadas GWI, GWII y GWIII, para ilustrar el centro de atención principal de cada guía. No obstante, las áreas se solapan, dependiendo de las circunstancias locales y de los puntos específicos de atención -p.ej. en un área protegida las entradas pueden producirse en la zona no saturada, o, en caso de contaminación histórica, en la zona saturada-.

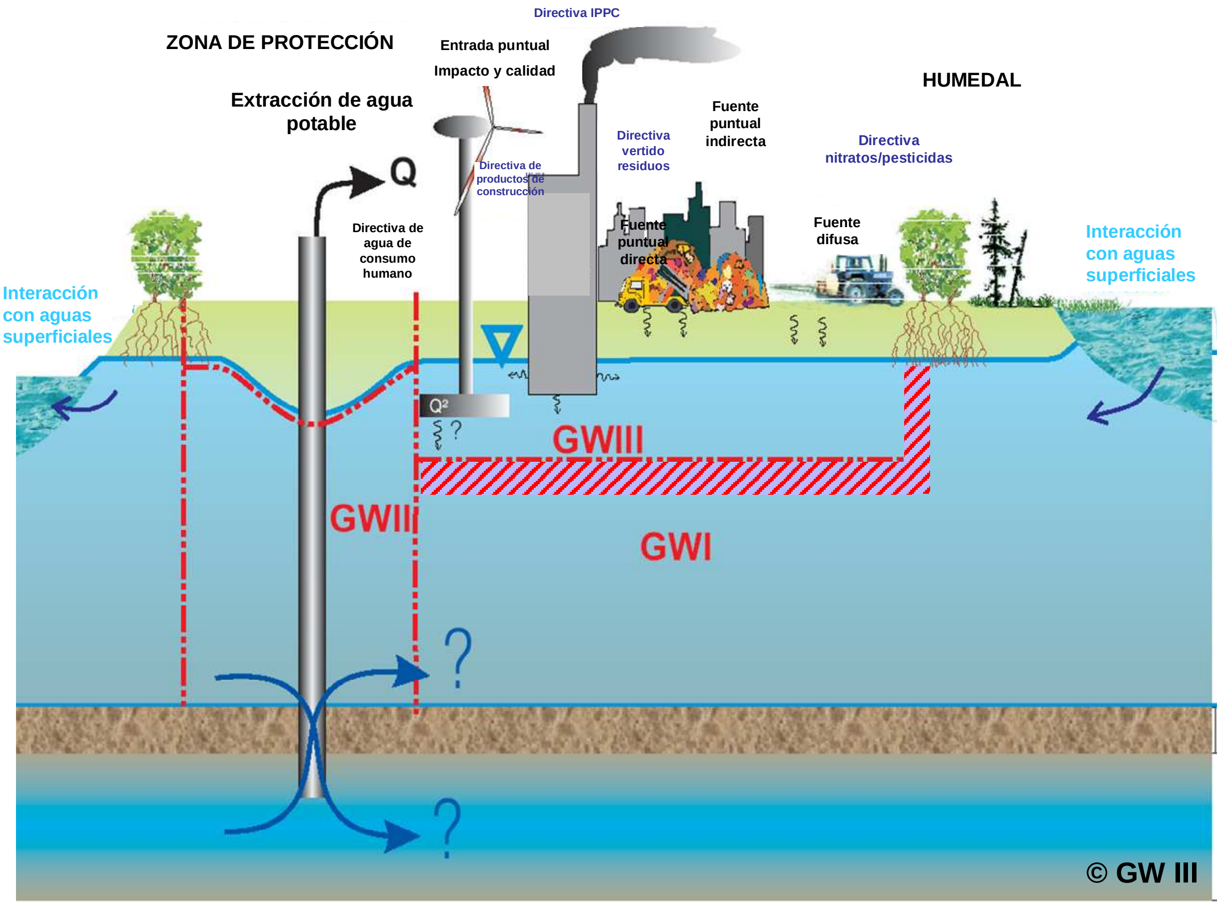
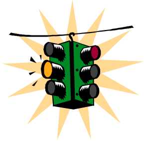


Figura 1: Enfoque de los diferentes documentos guía en el ámbito del sistema de aguas subterráneas (GWI-GWIII). Puede haber solapamiento de zonas y puntos de atención. GWI se refiere principalmente a "seguimiento", "estado químico y tendencias" y "valores umbral"; GWII trata principalmente de las "áreas protegidas" -p. ej. áreas protegidas de agua potable-; mientras que GWIII está relacionada principalmente con las "entradas directas o indirectas".

[2] CIS Guidance Document Nº. 16 on Groundwater in Drinking Water Protected Areas, July 2007.

La guía ofrece orientación sobre las entradas directas o indirectas de contaminantes en las aguas subterráneas. Las entradas pueden tener origen y formas diferentes. Por ejemplo, las entradas de carácter difuso pueden tener su origen en áreas urbanas o agrícolas, o en fuentes puntuales procedentes de la actividad industrial.



¡Atención! El alcance de los documentos guía puede solaparse

En ocasiones, para una situación determinada puede haber más de un documento guía pertinente. Es el caso de la entrada de contaminantes desde una fuente puntual directa, con el impacto correspondiente en la captación de agua potable o en un humedal.

2 ANTECEDENTES

2.1 Directiva relativa a las aguas subterráneas (80/68/CEE)

La Directiva 80/68/CEE relativa a las aguas subterráneas, en vigor hasta 2013, establece que los Estados miembros adoptarán las medidas necesarias, incluido un sistema de autorización especial, para *impedir* el vertido de sustancias de la “lista I” en las aguas subterráneas y *limitar* el vertido de sustancias de la lista II en las aguas subterráneas a fin de evitar su contaminación. Las listas I y II, recogidas en un anexo de la directiva, constan cada una de ellas de distintos grupos de sustancias. La lista I contiene sustancias de origen antropogénico, así como otras sustancias presentes en el medio natural, cuya introducción directa o indirecta en las aguas subterráneas por actividades antropogénicas supone riesgos relativamente altos para el medio ambiente, mientras que la entrada de sustancias de la lista II presenta riesgos relativamente moderados para el medio ambiente. El significado de “impedir o evitar” y “limitar” y también de “vertido directo” y “vertido indirecto” se trata más adelante en el presente documento.

2.2 Directiva Marco del Agua (2000/60/CE)

La DMA amplía los controles a las entradas de todos los contaminantes en las aguas subterráneas y establece objetivos medioambientales adicionales para las aguas subterráneas. A efectos de esta guía, las disposiciones más importantes son:

- Artículo 4.1,b),i), que establece que los Estados miembros habrán de aplicar las medidas necesarias para evitar o limitar la entrada de contaminantes en las aguas subterráneas. Este objetivo de evitar o limitar la entrada de contaminantes en las aguas subterráneas fue introducido en la DMA para garantizar la continuidad del sistema de protección de las aguas subterráneas que establece la Directiva 80/68/CEE a partir de su derogación en 2013;
- Artículo 4.1,b),ii), que establece que los Estados miembros habrán de proteger, mejorar y regenerar todas las masas de agua subterránea, con objeto de alcanzar un buen estado de las mismas, de conformidad con lo dispuesto en el anexo V de la DMA;
- Artículo 4.1.b),iii), que establece que los Estados miembros habrán de aplicar las medidas necesarias para invertir toda tendencia significativa y sostenida al aumento de la concentración de cualquier contaminante debida a las repercusiones de la actividad humana; y
- Artículo 11.3.j), que introduce la prohibición de *todos* los vertidos *directos* de contaminantes en las aguas subterráneas (sin perjuicio de determinadas excepciones). El artículo 2.32) define “vertido directo” como el vertido de contaminantes en el agua subterránea sin atravesar el suelo o el subsuelo. Véase asimismo el apartado 3.3 del presente documento guía.

2.3 Directiva sobre la protección de las aguas subterráneas (2006/118/CE)

La nueva Directiva sobre las aguas subterráneas incluye criterios para valorar el buen estado químico de las aguas subterráneas, así como para determinar las tendencias significativas o sostenidas al aumento y los puntos de partida para la inversión de la tendencia. Otro elemento que también se incluye es un marco para hacer operativo el objetivo de “evitar o limitar” que establece la DMA. En él se aclara cuáles son las sustancias cuya entrada en las aguas subterráneas deberá evitarse y cuáles limitarse, así como las excepciones al cumplimiento de este objetivo de evitar o limitar.

De conformidad con el artículo 22.2 de la DMA, la Directiva 80/68/CEE quedará derogada en diciembre de 2013, pero el nivel de protección que establece esta Directiva debe mantenerse y reforzarse en virtud de la DMA y la DAS.

2.4 Relación entre el objetivo de prevenir y limitar y los valores umbral

El objetivo de "prevenir o limitar" en la DMA y en la DAS protege las aguas subterráneas contra las entradas inaceptables de contaminantes. La protección abarca un amplio conjunto de receptores e incluye la contaminación a escala local.

Esto contrasta con los requisitos de buen estado químico, ya que la evaluación en este último caso se efectúa para la totalidad de la masa de agua subterránea. En la mayoría de las ocasiones, se tratará de un área bastante extensa. La evaluación se lleva a cabo en cada período del plan de cuenca y supone una revisión del estado de las masas de agua subterránea cada seis años. Esta evaluación determina si la masa de agua subterránea cumple con las condiciones de buen estado químico estipuladas en las DMA/DAS. La definición de ese buen estado se refiere solamente a algunos receptores y a circunstancias específicas, y no se traduce necesariamente en la protección de la calidad a escala local.

Para que se produzca una afección a un receptor, una entrada de contaminante debe desplazarse físicamente en el sistema de aguas subterráneas. Ese movimiento varía en función de las características físicas y químicas de los estratos geológicos. Y, más importante, el contaminante puede estar sujeto a procesos de dilución y atenuación en el trayecto hacia el receptor. En consecuencia, muchas entradas sólo tienen efectos localizados. Dichas entradas pueden producir una contaminación localizada, pero su efecto puede ser leve o nulo en los receptores reseñados en la definición del buen estado químico. Si se considera lo estipulado en las DMA/DAS, es muy posible que se produzca una contaminación de alcance espacial limitado en una masa de agua subterránea que se encuentre en buen estado químico. Sin embargo, cuanto mayor es la extensión de la contaminación, mayor será la probabilidad de que la masa se encuentre en mal estado químico. La contaminación localizada debería ser investigada –y suprimida en caso necesario- mediante la adopción de medidas de prevención o limitación.

En principio, las medidas de prevención o limitación constituyen la primera línea de defensa en la prevención de entradas inaceptables de contaminantes en las aguas subterráneas, consiguiendo así evitar la contaminación. La aplicación efectiva del objetivo de prevenir o limitar mediante medidas de carácter normativo debería asegurar la protección de la calidad de las aguas subterráneas. Dichas medidas pueden consistir en permisos, regulaciones de carácter vinculante o códigos de buena práctica para el control de actividades específicas en el uso del suelo. Las condiciones de los permisos y/o "valores límite" pueden utilizarse para asegurar que no se producen entradas inaceptables de contaminantes en las aguas subterráneas. Prescindiendo del tiempo necesario para que las entradas producidas en el pasado lleguen a degradarse o dispersarse, si todos los requisitos de prevenir y limitar se cumplieran en la totalidad de la masa de agua subterránea, la masa estaría en buen estado. El objetivo de prevenir o limitar y los requisitos de buen estado son así complementarios y, conjuntamente, proporcionan un marco efectivo para la protección de las aguas subterráneas en la Unión Europea.

Aunque los valores umbral que deben establecerse de conformidad con el artículo 3 de la DAS servirán para la evaluación del buen estado químico, esos valores, junto con el régimen de cumplimiento asociado, no serán frecuentemente apropiados para cumplir con los requisitos más estrictos del objetivo de prevenir y limitar.

Resulta conveniente resumir en este punto los diferentes propósitos y funciones de los valores límite y los valores umbral en la protección de las aguas subterráneas:

1. Escala de aplicación

   Los valores umbral establecidos para cumplir con los requisitos de los artículos 3 y 4 de la DAS no se aplican necesariamente en los mismos puntos de cumplimiento (PdC) que los valores límite reseñados en esta guía. La evaluación del estado se efectúa en las estaciones de la red de seguimiento o de la red operativa, que están distribuidos a lo largo de la masa de agua de agua subterránea. Las entradas se evalúan localmente en la proximidad de la fuente, en los puntos de seguimiento de la red diseñada para prevenir o limitar, y pueden ser reales o virtuales.

Con ello se consigue una protección más inmediata y completa del agua subterránea. Debe reseñarse que, en algunos casos, el punto de seguimiento de la red de prevención utilizado para evaluar la aceptabilidad de la entrada puede ser una estación de la red operativa donde se evalúa el estado, en cuyo caso el valor umbral constituye un valor límite apropiado.

2. Lugar de aplicación

   Debe utilizarse un valor umbral único en la totalidad de la masa, pero pueden utilizarse distintos valores límite en los distintos PdC. Además, los valores umbral sólo se aplican para las masas de agua subterránea, mientras que los valores límite sirven para cumplir con el objetivo de prevenir o limitar en las aguas subterráneas. Por ejemplo, el agua contenida en una terraza discontinua formada por gravas, o el agua "colgada" en una turbera situada sobre unas arcillas con bolos, son aguas subterráneas, y las entradas de contaminantes deben ser prevenidas o limitadas para asegurar que no se produce la contaminación de ningún receptor. Sin embargo, ninguno de esos depósitos geológicos es una unidad de gestión y, por tanto, masa de agua subterránea. No son objeto por ello de evaluación sobre el buen estado y no precisan de una designación de valores umbral.

2.5 Otras disposiciones pertinentes de la legislación comunitaria

Existen otras normas de la legislación comunitaria que garantizan cierto nivel de protección de las aguas subterráneas o facilitan información de referencia relativa a su protección. A continuación se citan las más importantes:

- Directiva relativa a la contaminación por nitratos (91/676/CEE). Contiene disposiciones sobre la designación de zonas vulnerables y sobre la actuación de los Estados miembros cuando la cantidad de nitrato que contienen las aguas subterráneas sobrepase o pueda sobrepasar el límite de 50 mg/l;
- Directiva Hábitats (92/43/CEE). Protege indirectamente las aguas subterráneas, en particular su estado cuantitativo. El requisito de mantener los hábitats que se nutren de aguas subterráneas implica la protección del flujo de aguas subterráneas en estas zonas;
- Directiva 91/414/CEE relativa a los productos fitosanitarios. Regula la autorización de la comercialización de productos fitosanitarios sobre la base de valoraciones exhaustivas de los riesgos para la salud humana y el medio ambiente. En lo que respecta a las aguas subterráneas, no se concederán autorizaciones cuando los usos que deben autorizarse sobrepasen (o pudieran sobrepasar) las concentraciones máximas admisibles de sustancias activas y metabolitos pertinentes, productos de degradación o de reacción, según lo establecido en la Directiva 80/778/CEE sobre el agua potable, sustituida por la Directiva 98/83/CE.
- Directiva sobre Biocidas (98/8/CEE), relativa a la autorización y comercialización para el uso de biocidas, similar a la Directiva 91/414/CEE,
- Directiva 91/271/CEE sobre el tratamiento de las aguas residuales urbanas. Tiene como objetivo proteger el medio ambiente de los efectos adversos de los vertidos de aguas residuales urbanas y de las aguas residuales procedentes de determinados sectores industriales. Esta Directiva es indirectamente pertinente para las aguas subterráneas (protección de las aguas subterráneas receptoras frente a aguas residuales que puedan estar contaminadas procedentes de fuentes de agua dulce).
- Directiva 96/61/CE relativa a la prevención y al control integrados de la contaminación (IPPC). Establece controles en la autorización de emplazamientos, con objeto de prevenir o reducir las emisiones al aire, al agua y al suelo procedentes de una serie de actividades recogidas en el anexo I de la Directiva.
- Directiva 99/31/CEE relativa al vertido de residuos. Su objetivo es establecer medidas, procedimientos y orientación para prevenir o reducir, en la medida de lo posible, las repercusiones negativas en el medio ambiente, incluidas las aguas subterráneas.
- Directiva 86/278/CEE sobre los lodos de depuradora. Intenta promover la utilización de los lodos de depuradora en agricultura y regular su utilización de tal manera que se eviten los efectos nocivos en el suelo, la vegetación, los animales y el ser humano.
- Directiva 89/106/CEE sobre los productos de construcción. Se centra en la conformidad de los productos de la construcción, teniendo en cuenta los posibles riesgos para el medio ambiente acuático, en particular el vertido de sustancias peligrosas a las aguas.

- Directiva 2006/21/CE sobre la gestión de los residuos de industrias extractivas. Instrumento jurídico independiente que exige minimizar los efectos para las aguas subterráneas derivados de los desechos de las industrias extractivas.
- Reglamento 1907/2006/CE relativo al registro, la evaluación, la autorización y la restricción de las sustancias y preparados químicos (REACH), por el que se crea la Agencia Europea de Sustancias y Preparados Químicos y se modifica la Directiva 1999/45/CE. Este Reglamento crea una estructura para la evaluación de las sustancias que se comercializan en el mercado de la UE y para facilitar información adecuada, entre otros, a los usuarios y las autoridades. Este Reglamento se basa en el principio de que corresponde a los fabricantes, importadores y usuarios intermedios garantizar que fabrican, comercializan o utilizan dichas sustancias de manera que no pongan en peligro la salud humana o el medio ambiente. Sus disposiciones están respaldadas por el principio de precaución. La evaluación de sustancias que deben hacer los fabricantes y otros organismos pertinentes incluye la protección de las aguas subterráneas. REACH deja amplio margen para la DMA y la DAS y para que las autoridades competentes evalúen las sustancias (como tales o contenidas en productos) con respecto a la protección del agua en general o en situaciones específicas.
- Directiva 2004/35/CE sobre responsabilidad medioambiental. Crea un dispositivo para prevenir y reparar la contaminación de aguas subterráneas.
- Directiva 80/778/CEE relativa a la calidad de las aguas destinadas al consumo humano, sustituida por la Directiva 98/83/CE. El objetivo de esta directiva es proteger la salud humana frente a los efectos nocivos de cualquier tipo de contaminación del agua destinada al consumo humano, garantizando su salubridad y su pureza.
- Directiva sobre la protección del suelo: La propuesta de directiva se centra en la protección del suelo frente a los procesos de degradación -sin incluir las aguas subterráneas- y a las amenazas –p.ej., la erosión, o el sellado, que deberán limitarse; deberán redactarse planes de acción y se adoptarán medidas cuando sea necesario. Comprende asimismo la contaminación del suelo, incluida la prevención, la detección de contaminación y la restauración o recuperación. Se limitará la introducción de sustancias peligrosas en el suelo (artículo 9).

La legislación mencionada anteriormente está recogida, en su mayoría, en la parte A del Anexo VI de la DMA como parte de las “medidas básicas” que los Estados miembros deben aplicar para lograr los objetivos de la DMA. Por consiguiente, dichas directivas son complementarias de la DMA, y sus requisitos deberán seguir cumpliéndose. Si los requisitos que establecen estas directivas en vigor no son por si solos suficientes para alcanzar los objetivos de la DMA, los Estados miembros aplicarán medidas complementarias.

2.6 Calendario para el cumplimiento de los objetivos de la DMA

A diferencia del logro del buen estado químico de las masas de agua, la DMA no establece plazos específicos para el cumplimiento de los objetivos en materia de prevención o limitación recogidos en el artículo 4 y complementados por el artículo 6 de la DAS. No obstante, el artículo 11 de la DMA estipula que, a más tardar en diciembre de 2009, los Estados miembros velarán por que se establezca para cada demarcación hidrográfica un programa de medidas con el fin de alcanzar los objetivos establecidos en esa directiva. Estos programas de medidas incluirán medidas para controlar los vertidos desde fuentes puntuales que puedan causar contaminación, medidas para prevenir o controlar la entrada de contaminantes procedentes de fuentes difusas que puedan generar contaminación, y la prohibición de efectuar vertidos directos de contaminantes en aguas subterráneas, sujeta a determinadas excepciones. Para poder determinar cuáles son las medidas necesarias es preciso conocer las presiones (entradas de contaminantes en aguas subterráneas), su impacto, cómo evitar o limitar dichas presiones y el coste de las medidas de prevención o limitación.

Estos programas de medidas deberán incluirse en los planes hidrológicos de cuenca, que también deberán presentarse a más tardar en diciembre de 2009.

2.7 Normativa de ámbito estatal

La DMA, la DAS y otras directivas de la EU establecen que los Estados miembros designarán las autoridades competentes que desempeñarán los cometidos y obligaciones estipulados. Las autoridades competentes establecerán definiciones del buen estado de las aguas superficiales y subterráneas, los métodos para evaluar el estado de las masas de agua, los valores umbral, los planes hidrológicos de cuenca, la concesión de licencias y otras medidas que puedan afectar a la entrada de contaminantes en las aguas.

Este requisito de designación de las autoridades estatales y de otras autoridades competentes significa que no es posible limitarse a describir las medidas generales que deben aplicarse respecto a actividades y productos que puedan provocar una entrada en las aguas subterráneas. Uno de los principales cometidos de las autoridades competentes es tener en cuenta las condiciones locales a la hora de especificar los criterios o, incluso, prohibir actividades o productos que puedan originar la contaminación de las aguas superficiales y subterráneas.

3 PRINCIPIOS GENERALES

Este capítulo trata sobre los principios fundamentales relativos a las “entradas”. Qué es “contaminación”, qué son “entradas” -directas o indirectas-, qué debe entenderse por “evitar o impedir” y “limitar”, y cómo pueden abordarse las entradas. La subdivisión en “entradas directas” y “entradas indirectas” se basa principalmente en las importantes diferencias en el modo de considerar las sustancias “peligrosas” -relacionadas principalmente con “evitar”- y las “no peligrosas” -vinculadas principalmente a “limitar”-.

3.1 ¿Qué es contaminación?

La finalidad de los objetivos de “evitar o limitar” que establecen la DMA y la DAS es prevenir la contaminación. En consecuencia, las autoridades competentes de los Estados miembros deben tener una comprensión clara de la base sobre la que se evalúa la “contaminación”. Para que exista contaminación, debe existir un efecto nocivo real o probable de la actividad humana en un receptor determinado.

La Directiva relativa a las aguas subterráneas (80/68/CEE), actualmente en vigor, define la contaminación como “…*el vertido de sustancias o de energía efectuado por el hombre, directa o indirectamente, en las aguas subterráneas y que tenga consecuencias que puedan poner en peligro la salud humana o el abastecimiento de agua, dañar los recursos vivos y el sistema ecológico acuático o perjudicar otros usos legítimos de las aguas.”*

La DMA y, en consecuencia, también la DAS, adoptan una definición más amplia de contaminación, a saber: “...*la introducción directa o indirecta, como consecuencia de la actividad humana, de sustancias o calor en la atmósfera, el agua o el suelo, que puedan ser perjudiciales para la salud humana o para la calidad de los ecosistemas acuáticos, o de los ecosistemas terrestres que dependan directamente de ecosistemas acuáticos, y que causen daños a los bienes materiales o deterioren o dificulten el disfrute y otros usos legítimos del medio ambiente*” (artículo 2.33) de la DMA). La DMA, por consiguiente, amplía los controles a todos los contaminantes (todas las sustancias que puedan causar contaminación, incluidas las sustancias radiactivas así como el dióxido de carbono o el agua calentada procedente de refrigeración), y no se limita al medio de las aguas subterráneas. La DMA no menciona los agentes microbiológicos.

La DMA define sustancias peligrosas como “*las sustancias o grupos de sustancias que son tóxicas, persistentes y pueden causar bioacumulación, así como otras sustancias o grupos de sustancias que entrañan un nivel de riesgo análogo*” (artículo 2.29). La DAS establece la necesidad de prevenir las entradas de estas sustancias en las aguas subterráneas (artículo 6.1,a). Se considerará que se han producido daños cuando los vertidos contengan sustancias peligrosas en cantidades apreciables que superen las concentraciones de fondo existentes de manera natural en las aguas subterráneas receptoras. El artículo 6.3 establece, sin embargo, excepciones a las entradas de contaminantes en determinadas circunstancias. En el caso de nuevos vertidos -p.ej. procedentes de un vertedero o de excavaciones para drenaje- no podrá tenerse en cuenta la dilución de estas sustancias por el flujo de aguas subterráneas a menos que esté cubierta por las excepciones, ni tampoco podrá alegarse que dichas sustancias pueden entrar en las aguas subterráneas porque éstas ya estaban contaminadas. En lugares en los que exista contaminación histórica del suelo y donde ya hayan penetrado sustancias peligrosas en aguas subterráneas, se considerará que ya se ha producido contaminación.

Las sustancias consideradas “no peligrosas” pueden, sin embargo, causar contaminación y producir efectos nocivos, dependiendo de cuál sea su concentración en las aguas subterráneas. En lo que respecta a estas sustancias, su mera entrada en aguas subterráneas o un ligero deterioro de la calidad de éstas no se considerará contaminación. La contaminación se producirá únicamente cuando la entrada o el deterioro estén relacionados con un efecto en un receptor. En este sentido, deberán tenerse en cuenta, junto con las aguas subterráneas, todos los receptores en el punto de entrada y “aguas abajo en la dirección del flujo subterráneo”. El término “receptor” se entenderá en su contexto más amplio, para que incluya no solamente los usos existentes de las aguas subterráneas, sino también todos los futuros usos y funciones plausibles a que podrían destinarse las aguas subterráneas, así como las propias aguas subterráneas. El término “usos” incluye la extracción de aguas subterráneas mediante bombeo y los receptores pasivos de aguas subterráneas como las fuentes, los ríos o los humedales.

3.2 ¿Qué son entradas?

La DMA no define el término “entrada” (“input”), utilizado en el contexto de evitar o limitar las entradas de contaminantes en las aguas subterráneas (artículo 4.1,b),i)). La DAS, por su parte, define “entrada de contaminantes en las aguas subterráneas” como “*la introducción directa o indirecta de contaminantes en las aguas subterráneas, como resultado de la actividad humana*”.

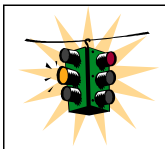
El término entrada es claramente diferente de vertido, utilizado en la Directiva 80/68/CEE, en el sentido de que abarca todos los contaminantes que entran en las aguas subterráneas, y no se limita a los casos de eliminación deliberada. Esto significa que el término entrada abarca un conjunto más amplio de hipótesis y situaciones, en los que las sustancias penetran en el subsuelo.

Las entradas pueden proceder de una fuente puntual, cuando se trata de un vertido/emisión/instalación único, o de fuentes de carácter difuso, derivadas de numerosas pérdidas o emisiones. La distinción entre ambas radica en el número de entradas y su magnitud.

Algunas de las actividades que pueden originar entradas son:

- En la industria: accidentes, derrames, fugas, almacenamiento, eliminación de residuos y vertederos.
- Actividades de gestión de residuos.
- En el tráfico: gases de escape, pérdidas de aceite o gasolina, abrasión de neumáticos, accidentes con pérdida de aceite, gasolina o carga; u otras partículas.
- Otros: materiales de construcción utilizados sobre o dentro del suelo -hormigón, pinturas-; instalaciones de almacenamiento y de aprovisionamiento de carburante, ya sean para uso particular o comercial -depósitos, estaciones de servicio-; campos de tiro; sistemas de evacuación de aguas residuales; almacenamiento de dióxido de carbono; entrada de agua de refrigeración en centrales geotérmicas.

Las entradas de carácter difuso se producen principalmente en explotaciones agrícolas, en suelos que contengan contaminantes procedentes de la precipitación atmosférica como consecuencia de las emisiones a la atmósfera procedentes de la industria, el tráfico, los incendios, etc., y en zonas “desarrolladas”, como grandes núcleos urbanos.

	***¡Atención! Una entrada es, por consiguiente:*** *cualquier introducción de una sustancia en las aguas subterráneas procedente de una actividad, ya sea accidental o deliberada, de una fuente puntual o difusa, que provoque la transferencia de un contaminante a las aguas subterráneas.*

Es necesario controlar las entradas en las aguas subterráneas porque pueden:

1. causar contaminación;
2. provocar o mantener un mal ***estado*** *q*uímico de la masa de agua subterránea;
3. tener como resultado ***tendencias*** significativas y sostenidas al aumento de la contaminación.

Por ello, la DMA establece el objetivo de evitar o limitar la entrada de contaminantes en las aguas subterráneas (véase capítulo 3.4) y la DAS introduce en su artículo 6 disposiciones complementarias.

3.3 Entradas directas e indirectas

Las entradas directas pueden identificarse mediante una de las siguientes propiedades:

- No se integran en el flujo en la zona no saturada del acuífero;
- La fuente de contaminación se sitúa en la zona saturada o afecta directamente a la zona saturada (masa de agua subterránea, MAS);
- Las fluctuaciones estacionales de la superficie piezométrica hacen que la fuente de contaminación entre ocasionalmente en contacto directo con las aguas subterráneas.

Estas tres situaciones se representan en la figura 2.

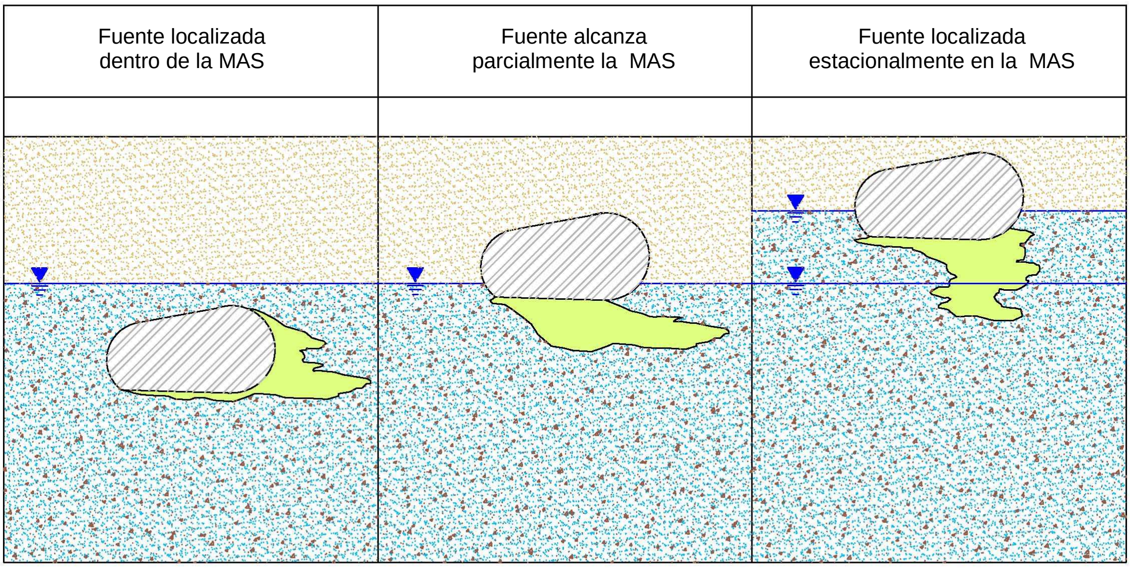


Figura 2: Entradas directas. La sección ovalada y sombreada, que representa una entrada, puede situarse permanentemente, en su totalidad o en parte, en la zona saturada, o puede situarse periódicamente en la zona saturada, cuando el nivel piezométrico asciende hasta la sección ovalada.

Las entradas indirectas se caracterizan por la incorporación a las aguas subterráneas tras haberse filtrado a través del suelo o el subsuelo (figura 3).

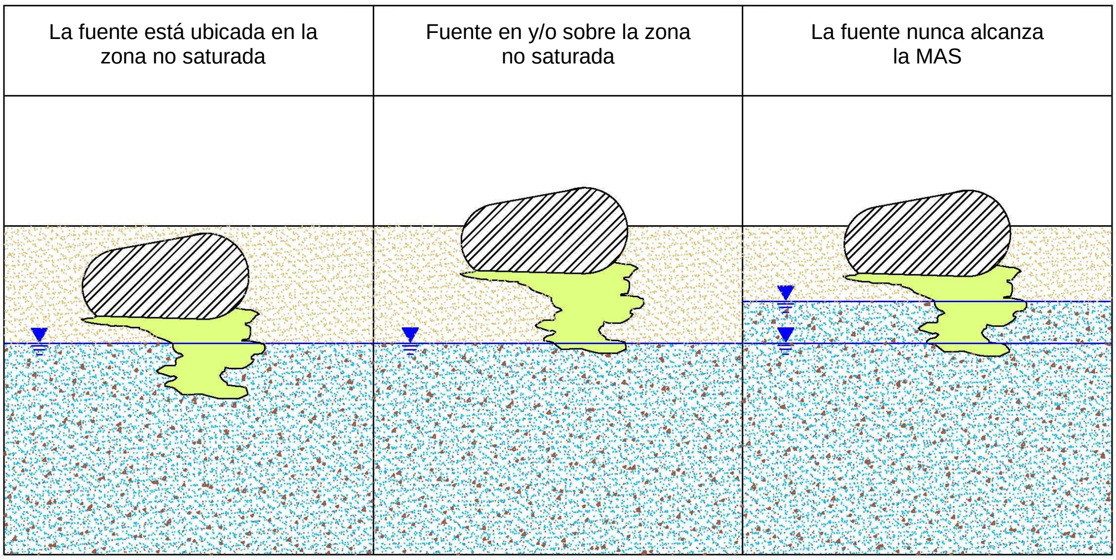


Figura 3: Entradas indirectas. La sección ovalada y sombreada, que representa una entrada, se sitúa permanentemente y en su totalidad por encima de la zona saturada, incluso en períodos de ascenso del el nivel piezométrico.

El anexo 1 ofrece algunos ejemplos de distintos tipos de entradas directas e indirectas.

3.4 ¿Qué se entiende por prevenir o limitar?

Según la DAS, las sustancias cuya entrada en aguas subterráneas hay que *prevenir o evitar* son aquéllas que los Estados miembros hayan identificado como *peligrosas* (Artículo 6.1,a)). En la identificación de tales sustancias, los Estados miembros tendrán en cuenta las sustancias peligrosas pertenecientes a las familias o grupos de contaminantes enumerados en los puntos 1 a 6 del Anexo VIII de la Directiva 2000/60/CE, así como las sustancias pertenecientes a las familias o grupos de contaminantes enumerados en los puntos 7 a 9 de dicho anexo, cuando se considere que son peligrosas. Las sustancias cuya entrada en aguas subterráneas hay que *limitar* de manera que no causen contaminación comprenden todos los demás contaminantes.

En el contexto de la DMA se entiende por "sustancias peligrosas" las sustancias o grupos de sustancias que son tóxicas, persistentes y pueden causar bioacumulación, así como otras sustancias o grupos de sustancias que entrañan un nivel de riesgo análogo. La DMA no define los criterios para designar una sustancia como tóxica, persistente y que puede causar bioacumulación. Los criterios para la definición de "peligrosa" se exponen, por ejemplo, en las Guías técnicas[3] adoptadas en la UE para apoyar la evaluación de riesgos de las sustancias. Podrán aplicarse estos criterios o cualquier otro procedimiento de evaluación adecuado por parte de los Estados miembros. Por consiguiente, no todas las sustancias incluidas en los puntos 1 a 9 del Anexo VIII de la DMA pueden clasificarse como "peligrosas". Obsérvese que al vincular las sustancias peligrosas a la cláusula de prevención, y todos los demás contaminantes a la cláusula de limitación, la DAS se aparta del planteamiento de las listas 1 y 2 de la Directiva 80/68/CEE. De hecho, de conformidad

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[3] Guía técnica de apoyo a la Directiva 93/67/CEE de la Comisión por la que se fijan los principios de evaluación del riesgo de las sustancias objeto de nueva notificación, al Reglamento (CE) nº 1488/94 de la Comisión por el que se establecen los principios de evaluación del riesgo de las sustancias existentes, y a la Directiva 98/8/CE del Parlamento Europeo y del Consejo relativa a la comercialización de biocidas. (http://ecb.jrc.it/home.php?CONTENU=/Technical-Guidance-Document/sommaire.php). Véase también http://ecb.jrc.it.

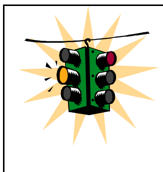
con esta directiva, los Estados miembros adoptarán las medidas necesarias para evitar que las sustancias de la lista 1 entren en las aguas subterráneas, mientras que deberá limitarse la entrada de sustancias de la lista 2 para evitar la contaminación.

La ampliación de los controles de los contaminantes adoptada por la DMA, según se ha mencionado anteriormente, se ve ahora atenuada por la serie de excepciones que introduce la DAS (artículo 6.3). En realidad, no es técnicamente viable evitar todas las entradas de sustancias peligrosas, y algunas pequeñas entradas son insignificantes desde el punto de vista ambiental, por lo que no suponen riesgo de deterioro de las aguas subterráneas. Sin estas excepciones, el requisito de “prevenir” implicaría una tarea onerosa y, en ocasiones, inviable. Cada excepción es aplicable al objetivo de “prevenir y limitar” -tanto sustancias peligrosas como no peligrosas-, pero no invalidará otros requisitos más estrictos recogidos en otras normas comunitarias. Estas excepciones se detallan en el apartado 5.3.

“Prevenir" una entrada en las aguas subterráneas significa adoptar todas las medidas que se consideren necesarias y razonables para evitar la entrada de sustancias peligrosas en las aguas subterráneas y evitar un incremento significativo de la concentración en las aguas subterráneas, incluso a escala local. "Razonable" significa técnicamente viable, sin que entrañe costes desproporcionados. La definición de “costes desproporcionados” dependerá de las circunstancias locales.

A la hora de considerar la necesidad de adoptar medidas para prevenir la entrada *indirecta* de una sustancia peligrosa en las aguas subterráneas, podrá tenerse en cuenta la atenuación -fijación, degradación- de la sustancia en la *zona no saturada*. A tal efecto, se tendrán en cuenta todos los procesos geológicos, hidrogeoquímicos y biológicos, incluidos los cambios en la superficie piezométrica en un lugar determinado. Los procesos en la *zona saturada* no son pertinentes para evaluar las entradas de sustancias peligrosas, puesto que, como se reseña anteriormente, hay que evitar la entrada de estas sustancias en la zona saturada. Los procesos en la zona saturada son pertinentes únicamente cuando las sustancias peligrosas ya estén presentes en dicha zona (contaminación histórica). Los procesos ya no podrán evitar la entrada -puesto que ésta ya se ha producido-, pero son pertinentes para determinar las medidas necesarias -restauración, aislamiento, etc.- encaminadas a impedir que la contaminación se propague a través de las aguas subterráneas. Esto está relacionado con la disposición recogida en el artículo 5.5 de la DAS, que establece la necesidad de evaluar el impacto de los penachos de contaminación y de adoptar las medidas adecuadas.

En muchos casos no es posible evitar por completo la entrada de sustancias que ya están presentes en el medio ambiente -en la atmósfera, aguas superficiales, el suelo y en las obras de construcción- en las aguas subterráneas. Sin embargo, de conformidad con la DMA, la contaminación del medio ambiente por sustancias peligrosas podría ser objeto de una prevención más absoluta mediante la prohibición o eliminación gradual de determinadas prácticas o su prohibición/eliminación gradual total. Antes de poder tomar la decisión de prohibir/eliminar gradualmente, será necesario comprobar si es posible aplicar medidas razonables para evitar la entrada en las aguas subterráneas.

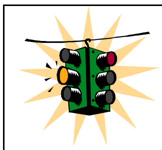
	***¡Atención! Prevenir o evitar la entrada en aguas subterráneas significa:*** *Que no debe producirse un incremento significativo de la concentración de contaminantes en las aguas subterráneas, ni siquiera a escala local. Deberán adoptarse todas las medidas que se estimen necesarias y razonables para evitar la entrada de sustancias peligrosas en las aguas subterráneas. Los Estados miembros podrán, bajo determinadas condiciones, eximir entradas de estas medidas, como se estipula en el artículo 6.3 de la DAS (véase apartado 5.3).*

La *limitación* es aplicable a todos los contaminantes no peligrosos. El artículo 6.1 de la DAS establece que los Estados miembros aplicarán las medidas necesarias para limitar las entradas en aguas subterráneas de manera que se garantice que tales entradas no causen deterioro del estado o tendencias significativas y sostenidas al aumento de las concentraciones de contaminantes en las aguas subterráneas.

Observación: aunque en el artículo 6.1 <u>deterioro</u> no se refiere específicamente al <u>estado</u>, el artículo 1 de la DAS así lo especifica de forma clara, y la Comisión Europea lo confirma como la interpretación correcta.

Aunque el artículo 6.1 de la DAS no lo especifica, se desprende claramente del resto de la Directiva que debe aplicarse el requisito de “limitar” para evitar la *contaminación*. Esto es necesario para mantener el nivel actual de protección de las aguas subterráneas amparado por la Directiva 80/68/CEE, cuando ésta sea derogada en diciembre de 2013.

A diferencia de la disposición relativa a “prevenir”, “limitar” significa que podrá permitirse un cierto incremento de la concentración por encima de los niveles de referencia de sustancias que pueden estar presente de manera natural, siempre que no cause el deterioro o una tendencia significativa y sostenida al aumento de las concentraciones de contaminantes (artículo 6.1,b) de la DAS). Asimismo, la DMA establece que la entrada no deberá entrañar una tendencia significativa y sostenida al aumento ni causar el deterioro del buen estado químico de las aguas. La DAS define “tendencia significativa y sostenida al aumento” como cualquier aumento significativo desde el punto de vista estadístico y medioambiental de la concentración de un contaminante, grupo de contaminantes o indicador de contaminación en las aguas subterráneas para el que se haya determinado la necesidad de una inversión de la tendencia, de conformidad con el artículo 5 (la guía nº 18 sobre estado y tendencias contiene un desarrollo más elaborado del tema). Los requisitos que establece la DAS de que las entradas no produzcan tendencias significativas al aumento y/o el deterioro del estado garantizan que las aguas subterráneas inalteradas y relativamente no contaminadas seguirán estando protegidas.



¡Atención! Limitar una entrada en aguas subterráneas significa:

Adoptar todas las medidas necesarias para prevenir la contaminación, al objeto de garantizar que:

1. *no se deteriora su estado; y*
2. *no se produce ninguna tendencia significativa y sostenida al aumento de las concentraciones de contaminantes en aguas subterráneas.*

La limitación de las entradas para prevenir la contaminación garantizará el mantenimiento de la concentración de sustancias por debajo del nivel en que pueda causar daños a un receptor o sobrepasar las concentraciones máximas admisibles y/o los niveles de calidad pertinentes de las aguas subterráneas.

Los Estados miembros podrán, bajo determinadas condiciones, eximir de estas medidas algunas entradas, de conformidad con el artículo 6.3) de la DAS. Para permitir dichas excepciones, los gestores de aguas subterráneas locales y las partes interesadas deberán presentar los oportunos argumentos. Los argumentos se describirán con transparencia, y el lugar idóneo para su exposición podrían ser los planes hidrológicos de cuenca (véase apartado 5.3).

A la hora de considerar qué medidas serían necesarias para limitar una entrada (véase la explicación de las medidas en el capítulo 5), también pueden tenerse en cuenta los procesos que producirán una atenuación en la zona no saturada así como en la zona *saturada*. En estos procesos se incluye la fijación de partículas al suelo, la degradación o la dilución, de manera que los receptores no sufran ningún daño ni se produzca una tendencia significativa y sostenida al aumento de la concentración. Deberá tenerse en cuenta asimismo la posibilidad de que la sustancia se transforme en una sustancia peligrosa. Si esto ocurriera, deberá *impedirse* que la sustancia entre en las aguas subterráneas.

3.5 Enfoque basado en el receptor frente al enfoque basado en compartimentos

Algunos Estados miembros difieren en su modo de gestionar la protección de las aguas subterráneas, aún cumpliendo los requisitos de la legislación comunitaria. Uno de los enfoques utilizados es el “basado en el receptor”, cuando los receptores que se tienen en cuenta al valorar si una entrada podría causar contaminación son todos los usos de las aguas subterráneas -los activos, p.ej. las extracciones, así como los pasivos, p.ej. las descargas de las fuentes en ríos y humedales-. Este enfoque es aplicable a aquellas sustancias que deben limitarse en aguas subterráneas. Respecto a las sustancias peligrosas, cuya entrada en las aguas subterráneas deberá evitarse, el receptor son las propias aguas subterráneas.

El enfoque alternativo es el “basado en compartimentos”, es decir cuando el receptor es el “compartimento” de aguas subterráneas en su conjunto[*], cualquiera que sea su utilización, y constituye el objeto de la protección. Este enfoque se aplica por igual, cualesquiera que sean las sustancias que intervengan. Son las propias aguas subterráneas las que hay que proteger de la contaminación.

3.6 Modelo conceptual

Para determinar si se ha producido o se producirá contaminación, es necesario desarrollar un modelo conceptual y conocer todas las relaciones entre fuentes, vías de propagación y receptores dentro de su enclave hidrogeológico más amplio (capítulo 3.6). Las consideraciones fundamentales son:

1. la naturaleza física y química del vertido o de la fuente de contaminación instalación o parte contaminada del subsuelo;
2. las características físicas y químicas del acuífero;
3. los procesos del subsuelo, p.ej. la dilución y degradación, que actúan sobre el contaminante a medida que éste desciende hacia la superficie piezométrica o se desplaza en la zona saturada;
4. el emplazamiento de todos los receptores y sus relaciones con el flujo de aguas subterráneas; y
5. las normas de calidad de las aguas que se aplican a los receptores y que permiten medir el daño, así como los criterios para el ecosistema de las aguas subterráneas.

El modelo conceptual constituye, por consiguiente, la esquematización de los procesos hidrodinámicos, hidroquímicos y biológicos fundamentales que actúan en una masa de agua subterránea. Esta caracterización es fundamental para comprender los procesos físicos, químicos y biológicos básicos que influyen en la calidad de las aguas subterráneas. Puesto que a menudo los contaminantes se desplazan a través de la zona no saturada hasta llegar a las aguas subterráneas, también deben incluirse, en su caso, los procesos que actúan sobre los contaminantes en la zona no saturada.

La esquematización del sistema y la cuantificación del proceso son partes necesarias del modelo conceptual, que permite determinar la calidad de referencia y cualquier variación de de la misma, y constituye una base fiable para futuras decisiones. Con respecto a las entradas directas e indirectas, el modelo conceptual es una pieza fundamental en la valoración básica de los mecanismos de atenuación que determinan el impacto de las entradas y la calidad de las aguas subterráneas.

Existen documentos guía sobre modelos conceptuales en inglés[4] y alemán[5].

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[*] la acepción de “compartimento” es equivalente a acuífero o a masa.

[4] UK Environment Agency, 2001

[5] FH, DGG, 2002a, 2002b

4 CÓMO EVALUAR LAS ENTRADAS

4.1 Puntos de cumplimiento

Para evaluar si un vertido potencialmente contaminante es permisible, o determinar el nivel de limpieza necesario para el tratamiento de una contaminación histórica, es necesario establecer indicadores de evaluación de cumplimiento (véase recuadro) en uno o varios puntos de cumplimiento.

Los puntos de cumplimiento pueden ser de dos tipos:

1) Un punto teórico en un modelo que permita calcular una concentración de vertidos aceptable o el grado necesario de restauración de un lugar contaminado;

2) Un punto de seguimiento físico -p.ej. un sondeo de observación- que permita evaluar el cumplimiento de un permiso o de un régimen de restauración.

Un punto de cumplimiento puede estar ubicado, bien en el propio receptor, o bien en un punto situado entre el receptor y la fuente de contaminación; esto último podría ser necesario o más deseable por motivos prácticos. Cuando el punto de cumplimiento se sitúa entre el receptor y la fuente en cuestión, los valores de cumplimiento se basan en los efectos previstos de dilución y atenuación/degradación en el receptor “aguas abajo”.

A efectos de esta Guía, se pueden identificar cuatro puntos de cumplimiento (PdC) diferentes:

- PdC 0: situado en la base de la fuente en la zona no saturada, tanto en el caso de fuentes puntuales como de fuentes difusas. La finalidad del PdC 0 es poder evaluar si se produce contaminación, cuáles son los contaminantes y si podrían afectar a las aguas subterráneas;
- PdC 1: se sitúa en el punto más alto de la entrada en las aguas subterráneas -p.ej. en el caso de entradas indirectas, en la supeficie piezométrica, y en el caso de entradas directas, en el PdC 0- y sirve para verificar si los contaminantes alcanzan las aguas subterráneas. Si se trata de una entrada directa, el PdC 0 es el mismo que el PdC 1. Su función es, sin embargo, diferente, puesto que en el PdC 1 se tiene en cuenta principalmente la concentración real en las propias aguas subterráneas, mientras que en el PdC 0 se examinan principalmente las propiedades de la fuente, como se explicaba anteriormente;
- PdC 2: se sitúa “aguas abajo”de la entrada, entre el PdC 1 y el receptor. La finalidad de este punto de cumplimiento es servir de alerta temprana cuando el receptor pueda resultar afectado. También se utiliza durante el proceso de evaluación de riesgo para pronosticar el impacto potencial de la entrada. El PdC 2 puede situarse tanto en el sentido horizontal de dispersión como en el vertical;
- PdC 3: se utiliza para controlar si las aguas subterráneas alcanzan la calidad deseada y para vigilar el impacto en el receptor. Si una evaluación de riesgo indica que el contaminante sobrepasará el valor de cumplimiento en este PdC, es probable que la entrada provoque contaminación. Deberán efectuarse controles para eliminar este impacto o, de lo contrario, no debe permitirse la actividad.

Deben definirse las especificaciones en PdC 0, PdC 1 y/o PdC 2 para evitar que se sobrepasen los valores de cumplimiento en PdC 3.

Valores de cumplimiento y valores límite

Un **valor de cumplimiento** para una sustancia es la concentración y el régimen de cumplimiento asociado que, cuando no sea superado en el punto de cumplimiento, prevendrá la contaminación. ***Se mide en el punto de seguimiento de "prevención/limitación" (PdC 1, 2 ó 3).***

Un valor de cumplimiento sirve así de referencia para impedir que se sobrepase una norma medioambiental en un receptor. Los valores de cumplimiento suelen estar relacionados con la protección de los usos del agua, como el abastecimiento de agua para el consumo humano o el entorno natural de aguas superficiales. No deben, sin embargo, utilizarse automáticamente valores de otros regímenes legislativos -normas de calidad del agua potable o normas de calidad ambiental- sin antes tomar en consideración su pertinencia, en particular cuando el régimen de cumplimiento es diferente. La utilización inadecuada de dichas normas puede derivar en un exceso o en una falta de protección de los recursos hídricos subterráneos.

Los valores de cumplimiento son diferentes de los "valores límite" en cuanto al lugar de establecimiento y aplicación.

Un **valor límite** para una sustancia es la concentración y el régimen de cumplimiento asociado que, no siendo superado en la fuente, prevendrá la emisión inaceptable de un contaminante a las aguas subterráneas. ***Se mide en la fuente, es decir, en el punto de emisión (PdC 0).***

Los valores límite pueden expresarse como concentraciones o como carga contaminante aceptable. Pueden utilizarse como referencia para una autorización o servir como objetivo de recuperación en suelos contaminados.

Ejemplos.

1. Utilización o reutilización de materiales de construcción

Pueden definirse valores límites fijos para la emisión de sustancias procedentes de los materiales en el PdC 0. Estos valores pueden ser establecidos por los órganos competentes de conformidad con el correspondiente procedimiento de aprobación de los materiales de construcción –en caso de que exista como tal- o mediante la correspondiente disposición vinculante de carácter general. Si se ha confirmado en modelos de simulación y con base en experiencias anteriores que los lixiviados nunca producirán la superación de los valores máximos pertinentes -por ejemplo en un zona protegida para abastecimiento de de agua potable-, por lo general no será necesario designar puntos de vigilancia específicos. En caso contrario, los valores de cumplimiento podrán ser definidos en los puntos virtuales PdC 1, PdC 2 y/o PdC3 a fin de efectuar el seguimiento de las entradas y prevenir la contaminación.

2. Utilización de estiércol.

A los agricultores les resulta más práctico controlar los efectos de la utilización de estiércol mediante un seguimiento, por ejemplo, a un metro por debajo del nivel piezométrico (PdC 2). Si las aguas subterráneas descargan directamente en aguas superficiales -p.ej. en acequias- próximas a las tierras de labranza, podrá designarse un PdC 3 en los puntos de descarga en aguas superficiales. Los valores de cumplimiento pueden establecerse en cualquiera de estos PdC.

Respecto de las entradas históricas -p.ej. suelos contaminados o accidentes/derrames/pérdidas- en las que ya se ha producido la contaminación de las aguas subterráneas, incluidas sustancias peligrosas, la evaluación de las entradas debería determinar la necesidad de medidas paliativas adecuadas y su alcance para dicha situación. La ubicación de los puntos de cumplimiento seguirá siendo la misma.

Los PdC reseñados se muestran en la figura 4.

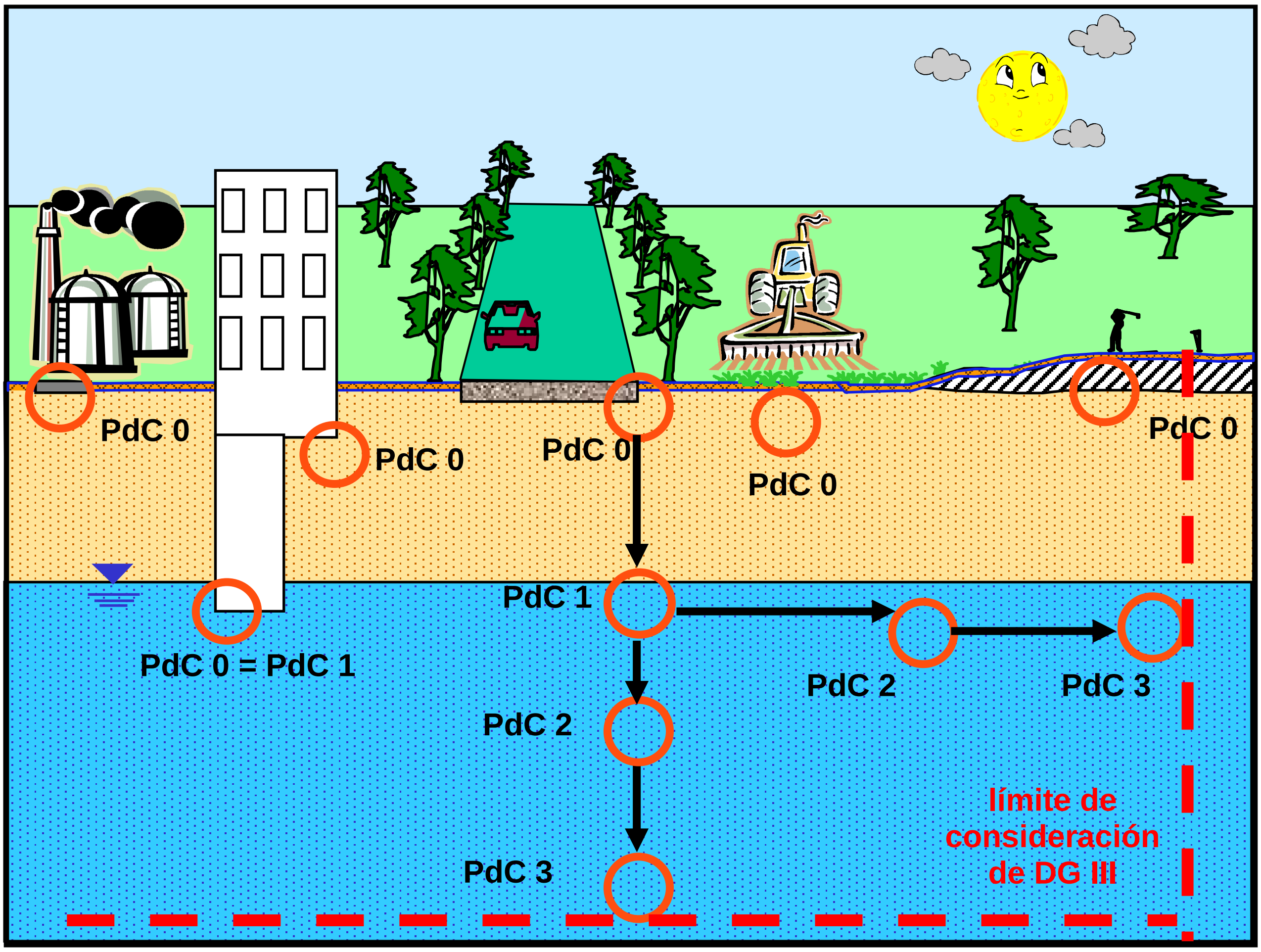

Figura 4: Puntos de cumplimiento (PdC)

Lo que sigue a continuación es un esbozo de las necesidades potenciales de datos para el PdC 0, para lo que se utilizarán los ejemplos de la figura 4. El primer PdC 0 de la izquierda está situado bajo una fábrica. El tipo de datos que podrían ser necesarios son:

- un inventario de las sustancias presentes en el suelo, en bidones, en depósitos, en camiones o en las tuberías, y que podrían llegar hasta el suelo debido a derrames, fugas, accidentes o vertidos previstos;
- sus propiedades: peligrosidad, comportamiento físico-químico -propensión a la degradación, evaporación, etc.-;
- las características de la mezcla total de sustancias y sus reacciones mutuas, -p.ej. la influencia que determina el p^H del suelo, el transporte por carbono orgánico disuelto (COD), la competencia entre sorbción y transporte de diferentes sustancias, etc.; y
- la probabilidad de que dichas sustancias penetren en el suelo -¿superficies selladas? ¿drenaje?-.

Si los cimientos de una edificación alcanzan las aguas subterráneas, la evaluación en un PdC 0 precisará de un inventario de las sustancias presentes en el material de cimentación, sus propiedades y su potencial de migrar desde el material hasta las aguas subterráneas. Cuando los materiales de construcción estén situados en la zona no saturada, las evaluaciones en el PdC 0 tendrán en cuenta asimismo la migración de sustancias desde el material, pero no incluirán la entrada en las aguas subterráneas, puesto que la migración a través de la zona no saturada es un paso que se evalúa en el PdC 1.

En vertederos, depósitos de suelos contaminados, residuos mineros, etc., el PdC 0 debe situarse en la interfaz entre la barrera de protección artificial, si la hubiera, y en el subsuelo.

En el caso de aplicación de sustancias para uso agrícola -plaguicidas, fertilizantes minerales, estiércol-, es prácticamente seguro que se producirá una ligera penetración de estas sustancias en el terreno debido a factores como la estructura abierta del suelo. En consecuencia, el PdC 0 debe situarse a una profundidad determinada, por lo general de un metro, donde puede considerarse que la presencia de las sustancias potencialmente contaminantes es un indicio de su potencial de adentrarse en el acuífero.

El tipo de entrada y las características hidrológicas, físicas y químicas del suelo y subsuelo en cuestión determinarán qué contaminantes cabe prever en la zona de interés, incluidos los productos de degradación.

En el anexo 2 se incluyen otros diagramas del emplazamiento de los PdC en diferentes tipos de acuíferos y en diferentes situaciones.

4.2 Directrices sobre la elección de receptores y puntos de cumplimiento

Las entradas procedentes de actividades presentes o previstas en el futuro o las derivadas de la presencia de suelos históricamente contaminados o derrames/accidentes/pérdidas, etc., deben ser objeto de tratamientos diferentes. En los siguientes apartados se exponen orientaciones al respecto.

4.2.1 Actividades previstas.

Como ya se mencionado anteriormente, deberá evitarse que los vertidos, emisiones y pérdidas que contengan sustancias peligrosas provoquen la entrada de estas sustancias en las aguas subterráneas. El receptor son las propias aguas subterráneas, por lo que todas las propuestas relativas a las sustancias peligrosas deben evaluarse en el PdC 1 (superficie piezométrica).

En lo que respecta a actividades previstas en las que intervienen sustancias no peligrosas, la evaluación deberá garantizar que las sustancias no sobrepasen los niveles aceptables de concentración en las aguas subterráneas, de manera que no se produzca contaminación ni una tendencia significativa y sostenida al aumento. Su cumplimiento debe evaluarse en el PdC 3, dependiendo del receptor; en el PdC 2 se definirán los valores de cumplimiento con arreglo a las características del acuífero, los contaminantes, los procesos en el suelo y las aguas subterráneas, asegurando así el cumplimiento en el PdC 3.

4.2.2 Entradas en lugares históricamente contaminados.

La limpieza de dichos lugares debe enfocarse de tal manera que se prevenga la entrada de cualquier sustancia peligrosa en las aguas subterráneas –PdC 0 y PdC 1-, a menos que sea aplicable alguna de las excepciones descritas en el artículo 6.3,a)-f) o que una evaluación del riesgo y del coste-beneficio demuestre que dicha prevención no es factible.

Cuando ya se haya producido la contaminación de las aguas subterráneas, la necesidad de restauración y su alcance, en lo que respecta a sustancias no peligrosas, vendrán determinados por los receptores que pudieran sufrir o hayan sufrido daños. El principal objetivo de la estrategia de restauración será prevenir que se produzca la contaminación o reducir el riesgo de que ésta se extienda por la expansión del penacho (artículo 5.5). La evaluación deberá efectuarse en PdC 2 y PdC 3.

Una vez emprendida la restauración adecuada, el resultado será, en muchos casos, un punto final estable en el que no se producirán nuevas entradas en aguas subterráneas. Podría, sin embargo, quedar aún un penacho de contaminación, porque a menudo es demasiado costoso o técnicamente no factible limpiar por completo las aguas subterráneas hasta restaurarlas a su estado inalterado. En tales circunstancias, no sería razonable exigir la adopción de medidas complementarias para eliminar por completo la contaminación; además, así lo permiten las excepciones a la prevención o limitación recogidas en el artículo 6.3 de la DAS (véase apartado 5.3). Esta acción requerirá de una justificación que resulte satisfactoria a los órganos competentes. Además, deberá efectuarse una evaluación de tendencias adicional del penacho contaminante remanente.

Las nuevas actividades previstas en lugares de contaminación histórica -p.ej. un depósito de petróleo ubicado sobre suelos contaminados en el pasado debido a fugas en tuberías e instalaciones industriales-, deberían diseñarse y ser objeto de mantenimiento de manera que no se produzca una nueva contaminación, teniendo en cuenta todos los requisitos sobre prevención y limitación reseñados en la DAS. Cualquier nueva entrada autorizada no debería impedir la futura mejora de la calidad de las aguas.

4.2.3 Limitaciones físicas en la ubicación de los puntos de cumplimiento.

Es posible que la decisión de situar un receptor en un punto más alejado de la vía de propagación de las aguas subterráneas del que se describe más arriba, se justifique en un momento dado por factores como los usos actuales y futuros del suelo, la propiedad de la tierra, la topografía o las limitaciones al desarrollo futuro de aguas subterráneas. Evidentemente, la escala es un factor a considerar. La duración de los efectos de un pequeño vertido puntual podría ser considerablemente menor que la de un vertedero o una zona industrial extensa, cuyo impacto podría prolongarse durante muchas décadas. La cautela deberá ser inevitablemente mayor en la elaboración de hipótesis sobre cuestiones como la propiedad de la tierra, en impactos importantes y a largo plazo.

4.3 Evaluación de nuevas actividades

A la hora de evaluar si son aceptables nuevas actividades que podrían originar entradas, es decir si se cumplen los requisitos que establece la DMA, habrá que responder a varias preguntas sobre cada una de las sustancias en cuestión, a saber:

- ¿Está contemplada la actividad en alguna de las excepciones existentes recogidas en el artículo 6 de la DAS o está prevista una excepción, p.ej. si la entrada es tan pequeña que puede descartarse cualquier peligro actual o futuro de deterioro de la calidad de las aguas subterráneas receptoras?
- ¿Es una entrada directa o indirecta?
- ¿Es una sustancia peligrosa o no peligrosa?
- ¿Es posible crear controles suficientes para evitar que la sustancia entre en aguas subterráneas o para limitar su efecto?

El diagrama de flujo de la figura 5 recoge de manera esquemática el procedimiento para efectuar dicha evaluación.

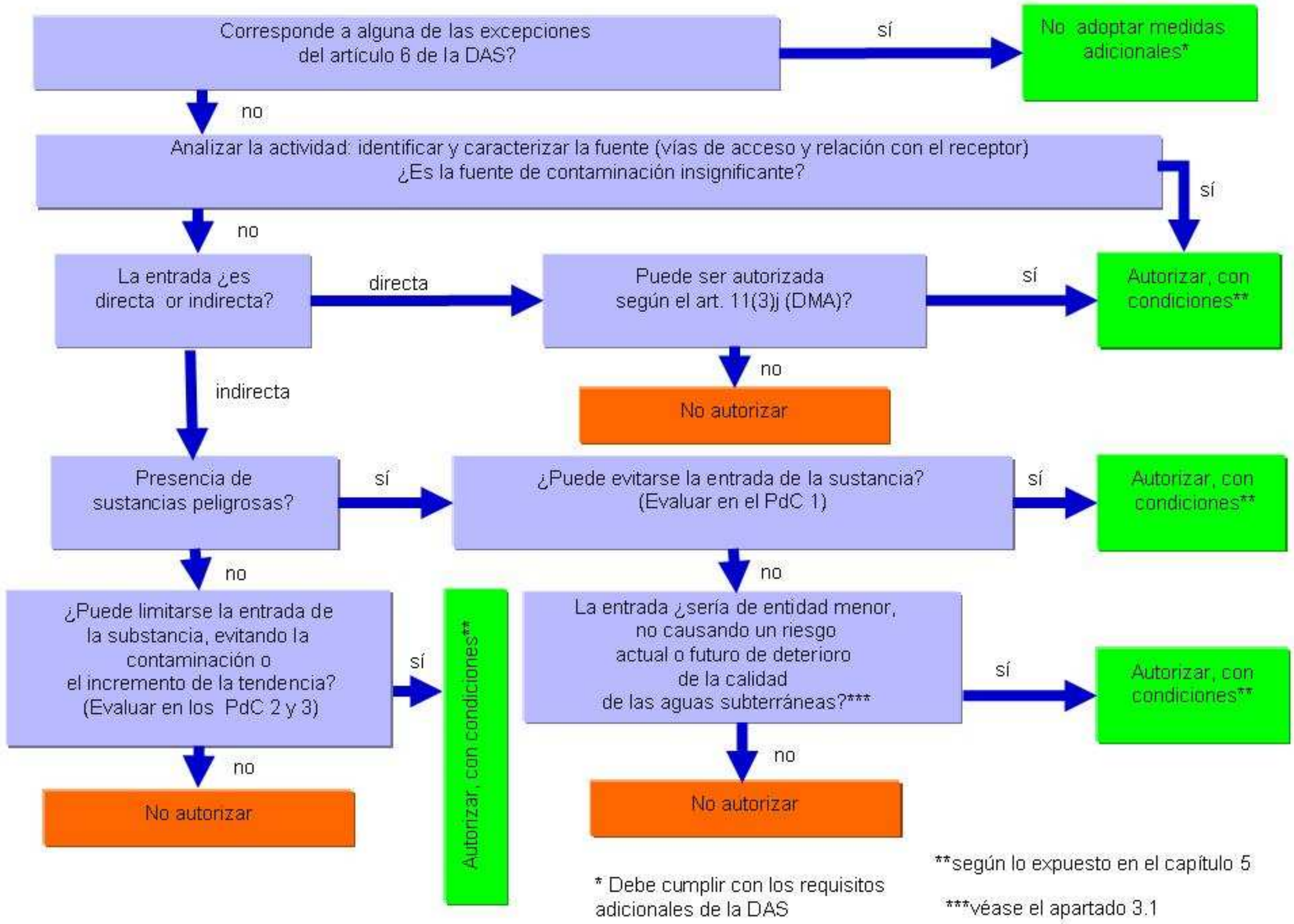

Figura 5: Evaluación de nuevas actividades

4.4 Evaluación de las fuentes de contaminación existentes

Cuando se haya puesto fin a la actividad que provocó la entrada y exista contaminación en las aguas subterráneas, o contaminación en el suelo que pueda contaminar las aguas subterráneas, carece de importancia que la entrada sea directa o indirecta. Habrá que evaluar si la contaminación ya ha alcanzado las aguas subterráneas, y qué nivel de limpieza será necesario. El procedimiento de evaluación se describe de forma esquemática en la figura 6. .

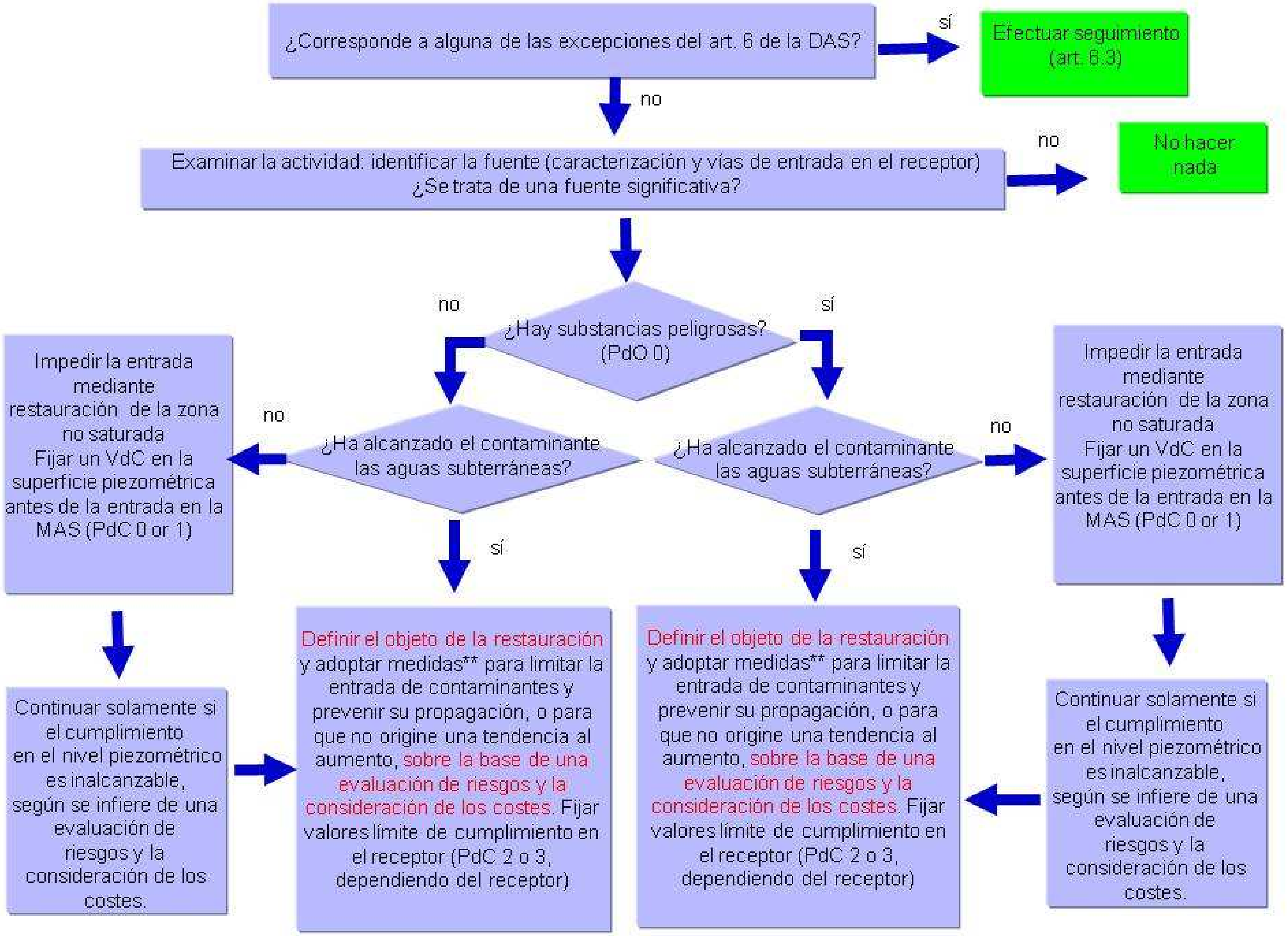

Figura 6: Evaluación de fuentes de contaminación existentes

4.5 Seguimiento preventivo de las entradas

El seguimiento al que se refiere esta guía es complementario al descrito en el documento guía nº 15 sobre seguimiento de las aguas subterráneas[1]. Dicho documento ofrece orientación sobre el establecimiento de los programas de seguimiento de las aguas subterráneas que exige la DMA, y se centra principalmente en las redes de control de vigilancia y de control operativo[6], es decir, el seguimiento estratégico necesario para caracterizar las masas de agua subterránea y determinar su estado.

Las medidas de planificación, ejecución y control para prevenir o limitar las entradas directas o indirectas requieren un modelo conceptual fiable (capítulo 3.6). La elaboración de este modelo puede requerir una estrategia de seguimiento más específica que aquélla necesaria para el seguimiento del estado de las masas de agua, porque deberá aportar información detallada sobre las interacciones del sistema. Estos puntos de seguimiento podrán formar parte más tarde del seguimiento relativo a la prevención y limitación de las entradas.

4.5.1 Finalidad del seguimiento de carácter preventivo

El seguimiento de la calidad de las aguas subterráneas es necesario para evaluar la eficacia de las medidas introducidas para prevenir o limitar las entradas de contaminantes y garantizar que no se ha producido o no se producirá contaminación y/o un deterioro del estado de las aguas subterráneas como resultado de las entradas. Aunque los programas de control de vigilancia y de control operativo van a contribuir de manera significativa a este fin, pueden ser necesarios programas de seguimiento específicos complementarios, que estén enfocados hacia las presiones desde fuentes puntuales y difusas. Este tipo de seguimiento es distinto del seguimiento estratégico -de vigilancia y operativo-, efectuado a escala de masa de agua subterránea. Véase, para más información, la citada guía sobre el seguimiento. El seguimiento de carácter preventivo debe basarse en un modelo o conocimiento conceptual del sistema de las aguas subterráneas correspondiente y en la interrelación de las entradas directas e indirectas con dicho sistema (véanse apartados anteriores).

Con este seguimiento preventivo se pretende principalmente garantizar el cumplimiento acorde con las condiciones del lugar o zona objeto de análisis y con las autorizaciones en los casos de actividades reguladas, o contribuir a la caracterización de impactos específicos en dicho lugar y elaborar y evaluar programas de acción correctora. Debe proporcionar información suficiente para evaluar si las entradas no tienen un impacto inaceptable en las aguas subterráneas. La aceptabilidad de las entradas viene determinada por la naturaleza de la sustancia, el tipo de entrada y si produce contaminación, con arreglo a la definición de la DMA, tal como se ha explicado en apartados anteriores.

4.5.2 Diseño de la red de seguimiento preventivo

En muchos casos, la necesidad de un seguimiento preventivo y su alcance vendrán determinados por la normativa vigente en materia de autorizaciones y medidas de recuperación de suelos contaminados. A diferencia del seguimiento estratégico a gran escala, este tipo de seguimiento suele situarse en un área reducida de la masa de agua subterránea. El seguimiento preventivo

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- [6]Una **red de control de vigilancia** para: a) complementar y validar el procedimiento de evaluación de impacto; b) facilitar información para su utilización en la evaluación de las tendencias prolongadas como consecuencia de modificaciones de las condiciones naturales y de la actividad antropogénica, y c) determinar, conjuntamente con la evaluación de riesgo, si es necesario un seguimiento operativo. (Véase asimismo la guía de seguimiento de las aguas subterráneas, capítulo 2).
- Una **red de control operativo** para: a) determinar el estado químico de todas las masas o grupos de masas de agua subterránea respecto de las cuales se haya establecido riesgo; y b) determinar la presencia de cualquier tendencia prolongada al aumento de la concentración de cualquier contaminante. (Véase asimismo la guía de seguimiento de las aguas subterráneas, capítulo 2).
- **Seguimiento para prevenir y limitar:** su principal finalidad es garantizar el cumplimiento de las condiciones en el lugar y de las autorizaciones en el caso de actividades reguladas o de una investigación específica al lugar, es decir un control del cumplimiento, o para caracterizar los impactos específicos en el lugar y diseñar y evaluar programas de acción correctora, es decir, un control de investigación. (Véase asimismo la guía de seguimiento de las aguas subterráneas, capítulo 6).

siempre requiere una planificación caso por caso, que determine los parámetros, la frecuencia y la ubicación de los puntos de seguimiento.

A la hora de diseñar programas de seguimiento preventivo deberán tenerse en cuenta los siguientes aspectos:

- Seguimiento de una concentración cero (seguimiento aguas arriba y/o de referencia): Podría ser necesario informar sobre la situación inalterada/de referencia en el subsuelo antes de emprender una nueva actividad o aguas arriba de una fuente de contaminación existente;
- Los intervalos del seguimiento (frecuencia de muestreos) dependerán de evolución de los contaminantes conocidos –condiciones de flujo y transporte- y de sus productos de degradación;
- Las características técnicas de la construcción de las estaciones de seguimiento, y la profundidad a la que se efectúa el seguimiento en cada una, dependerán de la naturaleza de la entrada -p.ej. LNAPL/DNAPL[7]- y de las fluctuaciones estacionales del nivel del agua subterránea;
- Los métodos de muestreo, la conservación de las muestras y el método de análisis dependerán de la naturaleza de la entrada y de la concentración de contaminantes prevista;
- Los parámetros objeto del seguimiento en cada estación servirán para identificar el tipo de contaminante(s) y su impacto previsto. Podrían utilizarse posibles parámetros indicadores -oxidación-reducción, p^H, conductividad eléctrica, temperatura, sales disueltas- para simplificar las tareas de seguimiento;
- El coste-beneficio derivado de la comparación entre el número de estaciones de seguimiento y el nivel de información obtenido;

La configuración de la red de seguimiento va a depender de la definición de los puntos de cumplimiento que, a su vez, están condicionados en gran medida por las características de la masa de agua subterránea descritas en el modelo conceptual (capítulo 3.5) y por los requisitos de carácter normativo.

5 MEDIDAS Y EXCEPCIONES PARA PREVENIR O LIMITAR LAS ENTRADAS EN AGUAS SUBTERRÁNEAS

Este apartado tiene por objeto explicar los requisitos necesarios para que puedan adoptarse las medidas pertinentes para alcanzar los objetivos de "prevenir o limitar" las entradas en las aguas subterráneas previstos en la DMA y la DAS. Se describen asimismo las diferencias que existen entre estos nuevos requisitos y el sistema que establece la directiva en vigor relativa a las aguas subterráneas (80/68/CEE).

La Directiva 80/68/CEE será sustituida por la DMA en 2013, y el sistema que establece la primera se mantendrá y será reforzado en el marco de la DAS. El artículo 11 de la DMA establece que a más tardar en 2009 se establecerán programas de medidas, y que todas las medidas estarán operativas a más tardar en diciembre de 2012.

Esto supone que los permisos/licencias/autorizaciones concedidos deberán ajustarse a los requisitos que establece la DMA a más tardar el 22 de diciembre de 2012. Para poder lograrlo, será necesario un período de revisión de los permisos existentes a fin de garantizar que todas las medidas de prevención o limitación se ajusten a la DMA a más tardar el 22 de diciembre de 2012 y, por consiguiente, estén en conformidad asimismo con el nuevo sistema que establece la DAS antes de diciembre de 2013, fecha en que la directiva 80/68/CEE será derogada.

De conformidad con el artículo 11 de la directiva 80/68/CEE, "Las autorizaciones mencionadas en los artículos 4 y 5 sólo se concederán por un período limitado; las mismas serán reexaminadas al menos cada cuatro años. Se podrán prorrogar, modificar o revocar." Por consiguiente, a partir de

[7] LNAPL: líquido ligero de fase no acuosa; DNAPL: líquido denso de fase no acuosa

2009 este proceso de revisión de las autorizaciones existentes debe tener en cuenta el nuevo sistema de las directivas DMA y DAS, de manera que las autorizaciones que se renueven se ajusten plenamente al nuevo sistema a partir del 22 de diciembre de 2012.

De conformidad con el artículo 7 de la DAS, los nuevos permisos/licencias/autorizaciones que se concedan a partir del 16 de enero de 2009, al amparo de los artículos 4 y 5 de la directiva 80/86/CEE, deben tener en cuenta los requisitos que establece la DAS en sus artículos 3, 4 y 5.

Cabe reseñar por ello que, como resultado del paso del antiguo al nuevo sistema, podría ser necesario modificar las condiciones para la concesión de los permisos y/o los procedimientos de gestión. Por consiguiente, deberá actuarse durante este período de transición de una manera práctica y eficaz.

Resulta así evidente que deberán aplicarse los requisitos que establece la DMA y los sistemas de “prevenir o limitar” que establece la DAS antes de la derogación de la Directiva 80/68/CEE.

5.1 “Medidas básicas” que estipula la DMA

El artículo 4.1,b),i) de la DMA establece que “los Estados miembros habrán de aplicar las medidas necesarias para evitar o limitar la entrada de contaminantes en las aguas subterráneas”. El artículo 11 de la DMA establece que los Estados miembros velarán por que se establezca un programa de medidas con el fin de alcanzar los objetivos establecidos en el artículo 4, incluidos los objetivos de evitar o limitar las entradas en aguas subterráneas.

Se entenderá por medidas aquellos procesos y controles que deberán implantarse para alcanzar los objetivos medioambientales fijados para las masas de agua, incluida la prevención o limitación de las entradas de contaminantes en aguas subterráneas. En este apartado se pretende describir e interpretar los requisitos mínimos de las “medidas básicas” establecidas en el artículo 11.3, en lo que se refiere a evitar o limitar las entradas. Estas “medidas básicas” son las medidas mínimas que deberán incluirse en el programa de medidas en el marco de los planes hidrológicos de cuenca. Existen asimismo “medidas complementarias” que podrán adoptarse si se consideran necesario, pero este documento no trata sobre ellas.

Los apartados pertinentes son los siguientes (las letras de los apartados corresponden a las del artículo 11.3 de la DMA):

a) *las medidas necesarias para cumplir la normativa comunitaria sobre protección de las aguas, incluidas las medidas exigidas en virtud de los actos legislativos especificados en el artículo 10 y en la parte A del anexo VI;*

En el preámbulo de la DMA se hace referencia a un enfoque combinado en el considerando (40): “En relación con la prevención y el control de la contaminación, la política comunitaria de aguas debe basarse en un enfoque combinado a partir del control de la contaminación en la fuente mediante la fijación de valores límite de emisión y de normas de calidad medioambiental.”

El artículo 2.36) especifica que el “planteamiento combinado” significa el control de vertidos y emisiones en aguas superficiales de acuerdo con el enfoque expuesto en el artículo 10”. Este artículo 10 establece que los Estados miembros velarán por la aplicación de la legislación vigente para garantizar un planteamiento combinado para controlar las fuentes puntuales y difusas que pudieran originar vertidos en aguas superficiales. Esto debe lograrse mediante la creación de controles de emisión basados en las mejores técnicas disponibles, fijando valores límite de emisión pertinentes y, en el caso de impactos derivados de entradas difusas, siguiendo la mejor práctica medioambiental expuesta en la legislación comunitaria pertinente. Se incluyen aquí la directiva PCIC, relativa a la prevención y al control integrados de la contaminación, la directiva relativa al tratamiento de aguas residuales urbanas y la directiva relativa a los nitratos, aunque sin restringirse a las mismas.

El artículo 10 no hace referencia directa a las entradas en aguas subterráneas, pero sí a la aplicación de las directivas en vigor para reducir y/o eliminar los vertidos en aguas superficiales, lo que podrá suponer también en el control indirecto de las entradas en aguas subterráneas.

La parte A del anexo VI enumera las directivas cuyos requisitos deberán incluirse en los programas de medidas y que, por consiguiente, son complementarias para lograr los objetivos que establece la DMA.

Las principales directivas pertinentes para evitar o limitar las entradas de contaminantes en aguas subterráneas recogidas en el anexo VI son:

- La Directiva relativa a la comercialización de productos fitosanitarios, que establece un sistema de aprobación del uso de plaguicidas. En lo que respecta a la consideración de los efectos en aguas subterráneas, uno de los principios uniformes para la evaluación de los productos (anexo VI de la Directiva 91/414/CEE que es la Directiva 97/57/CEE) establece que debe procurarse que en las aguas subterráneas no se sobrepase la norma sobre agua potable de 0,1 mg/L de cualquier plaguicida, reproducida de la Directiva 98/83/CE. Mediante la aplicación de este principio, cada vez que se aprueben nuevos plaguicidas, se protegen, en cierto modo, las aguas subterráneas. Sin embargo, de la experiencia acumulada en toda Europa se desprende que, a veces, los plaguicidas aprobados penetran en el terreno hasta alcanzar las aguas subterráneas, incluso cuando se ha aplicado la mejor práctica, por lo que se precisaría de medidas adicionales para garantizar que los plaguicidas no llegan a las aguas subterráneas. Estas medidas podrían ser aquéllas expuestas en la parte restante del artículo 11.3, incluida la autorización previa de la utilización de los productos (véase la definición de los productos en el artículo 11.3,g) de la Directiva relativa a la comercialización de productos fitosanitarios);
- La Directiva relativa a los nitratos, que contiene disposiciones sobre la designación de zonas vulnerables y sobre la acción de los Estados miembros cuando la concentración de nitrato que contienen las aguas subterráneas sobrepasa o es probable que sobrepase 50 mg/L. Estos planes de acción se refieren únicamente al control de nitratos procedentes de actividades agrícolas y, por consiguiente, serán necesarias medidas complementarias para corregir las entradas procedentes de fuentes no agrarias;
- La Directiva relativa al tratamiento de aguas residuales urbanas, que indirectamente protege las aguas subterráneas al establecer que los núcleos urbanos de más de 2000 viviendas deberán estar conectados a una red de alcantarillado, en lugar de verter las aguas residuales al terreno o a las aguas superficiales.

d) *las medidas para cumplir lo dispuesto en el artículo 7, incluyendo las destinadas a preservar la calidad del agua con el fin de reducir el nivel del tratamiento de purificación necesario para la producción de agua potable;*

La interpretación de los requisitos del artículo 7 se puede encontrar en el documento guía nº 16 sobre zonas protegidas para la producción de agua potable[2]. Para cumplir con lo dispuesto en el artículo 7, lo más adecuado será probablemente que las medidas se centren en los “perímetros de protección” en el entorno de los puntos de captación de agua potable antes del tratamiento. Los controles podrán incluir restricciones o prohibiciones de la utilización de determinadas sustancias peligrosas en estas zonas o restringir la explotación y utilización del suelo a las actividades de bajo riesgo que los órganos competentes consideren apropiadas.

f) *medidas de control, con inclusión de un requisito de autorización previa, de la recarga artificial o el aumento de masas de agua subterránea. El agua que se utilice podrá obtenerse de cualquier agua superficial o subterránea, siempre que el uso de la fuente no comprometa la consecución de los objetivos medioambientales establecidos para la fuente o la masa de agua recargada o aumentada. Dichos controles se revisarán periódicamente y, cuando proceda, se actualizarán.*

Es un requisito que los Estados miembros dispongan de un sistema de concesión de autorizaciones o permisos para los sistemas de recarga artificial o aumento de acuíferos. Se trata de un control y una disposición similares a los que ya existen en la Directiva 80/68/CEE.

g) *para los vertidos de fuente puntual que puedan causar contaminación, un requisito de regulación previa, como la prohibición de la entrada de contaminantes en el agua, o el requisito de autorización previa, o de registro basado en normas generales de carácter vinculante, que establezca controles de emisión para los contaminantes de que se trate, incluyendo controles con arreglo a lo dispuesto en los artículos 10 y 16. Dichos controles se revisarán periódicamente y, cuando proceda, se actualizarán.*

Éste es un requisito para regular las entradas desde fuentes puntuales, una regulación que puede adoptar la forma de:

- prohibiciones, si la evaluación del impacto de la fuente puntual demuestra que, por ejemplo, no puede controlarse adecuadamente el riesgo de entrada de sustancias peligrosas en aguas subterráneas;
- autorizaciones, para garantizar que existen medidas preventivas de carácter técnico para cumplir los objetivos de “evitar o limitar”; o
- elaboración de normas generales de carácter vinculante, que cubran las actividades consideradas de bajo riesgo para las aguas subterráneas.

El artículo 11.3,g) no contiene ninguna restricción sobre los tipos de actividades o las sustancias que cubre esta medida. Este artículo ofrece mayor protección que el sistema de investigación y autorización previas que establece la Directiva 80/68/CEE, en la medida en que la DMA amplía estos controles a todos los contaminantes, y no se limita a las sustancias que figuran en las listas I y II de la Directiva 80/68/CEE. Por consiguiente, este requisito abarca todos los sistemas de autorización existentes y podría ser necesario desarrollar sistemas complementarios para controlar las sustancias adicionales que incluye la DMA. Desaparece el requisito de la Directiva 80/68/CEE de conceder autorizaciones únicamente por un plazo limitado, y aunque se podrá revisar la eficacia de estas autorizaciones, desaparece el calendario fijo para efectuar dichas revisiones. Lógicamente, la revisión deberá hacerse al menos una vez cada seis años en el marco de la revisión de los planes hidrológicos de cuenca, porque los programas de medidas están contenidos en dichos planes.

Además de incluir más sustancias, la DMA también establece un planteamiento más flexible que el formulado por la Directiva 80/68/CEE. Otorga a los Estados miembros la capacidad de crear normas y códigos de buenas prácticas reconocidos por la ley aplicables a sectores industriales de bajo riesgo. Se dispone así de la facultad discrecional para utilizarlos como alternativa a la autorización de actividades individuales.

Los artículos 10 y 16 de la DMA, a los que hace referencia el artículo 11.3,g), tienen como principal objetivo la protección de las aguas superficiales.

h) *para fuentes difusas que puedan generar contaminación, medidas para evitar o controlar la entrada de contaminantes; los controles podrán consistir en un requisito de reglamentación previa, como la prohibición de la entrada de contaminantes en el agua, el requisito de autorización previa o el de registro basado en normas generales de carácter vinculante, cuando este requisito no esté establecido de otra forma en la legislación comunitaria. Dichos controles se revisarán periódicamente y, cuando proceda, se actualizarán.*

Se trata de un requisito similar al del párrafo g), aunque es aplicable a entradas difusas que no sean fuentes puntuales. Esta medida de protección es más específica y clara que las que establece la Directiva 80/68/CEE, que se refiere a un sistema de autorización previa para las acciones de “eliminación o de depósito con fines de eliminación dichas sustancias”, lo cual resulta ineficaz en el caso de contaminación difusa. No especifica cuáles son las medidas adecuadas que deben adoptarse para evitar o limitar los vertidos indirectos de las sustancias enumeradas procedentes de otras actividades.

Las medidas adoptadas en este caso para controlar adecuadamente las entradas difusas serán aplicables sobre un área más amplia y a mayor escala que aquéllas para fuentes puntuales. Las medidas más eficaces son probablemente medidas de control tales como normas generales de carácter vinculante y códigos de buena práctica reconocidos por ley.

El artículo 11.3,j) contiene una prohibición específica relativa a las aguas subterráneas, así como excepciones a esta disposición, cuestiones que se tratan en el apartado siguiente.

5.2 Prohibición de vertidos directos en aguas subterráneas

La DMA incluye una prohibición específica relativa a las entradas en las aguas subterráneas. La medida básica contenida en el artículo 11.3,j) es la prohibición de todos los vertidos directos de contaminantes en las aguas subterráneas. Difiere de la Directiva 80/60/CEE, que exige la prohibición de todos los vertidos directos de las sustancias de la lista I, es decir, solamente las sustancias más peligrosas.

Esto significa que la DMA es más estricta que el sistema actualmente en vigor porque, en principio, dicha prohibición incluirá en el futuro todos los vertidos directos. La consecuencia es que los Estados miembros deberán garantizar, mediante un proceso de revisión, que las prácticas existentes se ajustan a esta nueva exigencia.

La DAS no establece por escrito ninguna prohibición similar a las “entradas”. Como ha quedado dicho en el presente documento, el término “entradas” comprende todos los contaminantes que entran en las aguas subterráneas, y no se limita a las eliminaciones deliberadas. Por ello se considera que la prohibición que establece el artículo 11.3,j) de la DMA debe ser aplicable a todas las entradas directas en aguas subterráneas.

El artículo 11.3,j) de la DMA contiene asimismo una serie de excepciones/disposiciones relativas a esta prohibición sobre las que trata el apartado siguiente. La DMA no establece ninguna prohibición específica relativa a las *entradas indirectas*. La DAS, sin embargo, prohíbe mediante su cláusula de prevención en el artículo 6.1,a) y sin perjuicio de las excepciones, todas las entradas, directas o indirectas, de sustancias que las autoridades competentes consideren peligrosas para las aguas subterráneas, mediante la aplicación de la cláusula de prevención del artículo 6.1a), sujeta a excepciones.

5.3 Excepciones

Salvo las disposiciones relativas a los vertidos directos, la DMA no contiene ninguna excepción explícita a la exigencia de evitar o limitar las entradas de contaminantes en las aguas subterráneas. Sin embargo, la DAS incluye excepciones, recogidas en su artículo 6.3.

Las excepciones que figuran en la DAS sustituirán a aquellas que recoge actualmente la Directiva 80/68/CEE. En la tabla que sigue se hace una comparación de las excepciones en ambas directivas. La DAS contiene más excepciones que la Directiva 80/68/CEE. La única excepción de la Directiva 80/68/CEE que se mantiene es la denominada disposición *de minimis* (letra b) en la tabla A). Debe reconocerse que las excepciones que establece la Directiva 80/68/CEE son excepciones a la propia directiva. Las excepciones presentadas en la DAS son excepciones solamente al apartado 1 del artículo 6, es decir a las exigencias de “prevenir o limitar”, y no a la directiva en su conjunto, cuyo alcance es mucho mayor que el de la Directiva 80/68/CEE.

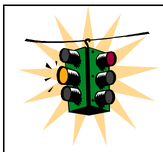
Tabla A: Excepciones incluidas en la DAS(2006) y en la Directiva 80/68/CEE

DAS - Artículo 6.3	**Directiva 80/68/CEE – Artículo 2**
Las entradas de contaminantes que: (a) sean resultado de vertidos directos autorizados de conformidad con la letra j) del apartado 3 del artículo 11 de la Directiva 2000/60/CE; (b) según las autoridades competentes, sean tan reducidas en cantidad y concentración, que excluyan todo peligro actual o futuro de deterioro de la calidad del agua subterránea receptora; (c) sean consecuencia de accidentes o circunstancias excepcionales de origen natural imposibles de prever, evitar o paliar; (d) sean resultado de una recarga artificial o aumento autorizados de	(a) los vertidos de efluentes domésticos que provengan de viviendas aisladas, no conectadas a una red de alcantarillado y situadas fuera de las zonas de protección de captación de agua destinada al consumo humano; (b) los vertidos respecto de los cuales la autoridad competente del Estado miembro afectado hubiere comprobado que contienen sustancias de las listas I o II en cantidad y concentración lo suficientemente pequeñas como para excluir cualquier riesgo de deterioro,

DAS - Artículo 6.3	Directiva 80/68/CEE – Artículo 2
conformidad con la letra f) del apartado 3 del artículo 11 de la Directiva 2000/60/CE;	presente o futuro, de la calidad de las aguas subterráneas receptoras;
(e) según las autoridades competentes, no sean técnicamente viables para prevenir o limitar sin la utilización de: (i) medidas que aumentarían los riesgos para la salud humana o la calidad del medio ambiente en su conjunto, o (ii) medidas con un coste desproporcionado para eliminar cantidades de contaminantes o para controlar su infiltración en suelos o subsuelos contaminados; o	(c) los vertidos de materias que contengan sustancias radiactivas.
(f) sean el resultado de actuaciones en las aguas superficiales con el objeto, entre otros, de paliar los efectos de inundaciones y sequías, así como para la gestión de las aguas y de los cursos de agua, incluidos los de ámbito internacional. Dichas actividades, que incluirán por ejemplo el corte, el dragado, el traslado y el almacenamiento de los sedimentos presentes en las aguas superficiales, se llevarán a cabo con arreglo a normas generales vinculantes, y, cuando sean aplicables, con permisos y autorizaciones concedidos sobre la base de las normas que hayan desarrollado al respecto los Estados miembros, siempre que esas entradas no pongan en peligro la consecución de los objetivos medioambientales que se hayan fijado para las masas de agua correspondientes a tenor de la letra b) del apartado 1 del artículo 4, de la Directiva 2000/60/CE.	

5.4 Ejemplos de excepciones

A continuación se citan textualmente las excepciones, seguidas de una explicación y de algunos ejemplos.



¡Atención!

Los ejemplos que figuran a continuación no constituyen una lista exhaustiva ni tampoco deben entenderse como los casos de excepciones más comunes.

El artículo 11.3,j) de la DMA, que comprende la prohibición general de vertidos directos, contiene asimismo una serie de excepciones en las que, en determinadas circunstancias, se permitirán los vertidos directos, siempre que hayan sido autorizados con condiciones o que se realicen con arreglo a las normas generales vinculantes desarrolladas para un determinado sector de actividad o industrial. Estas autorizaciones deben garantizar que no ponen en peligro la consecución de los objetivos medioambientales fijados para la masa de agua subterránea. Estas disposiciones son las siguientes:

1. *Los Estados miembros podrán autorizar la reinyección en el mismo acuífero de aguas utilizadas con fines geotérmicos.*

También podrán autorizar, indicando las condiciones para ello:

2. *la inyección de aguas que contengan sustancias resultantes de las operaciones de exploración y extracción de hidrocarburos o actividades mineras, así como la inyección de aguas por razones técnicas en formaciones geológicas de las que se hayan extraído hidrocarburos u otras sustancias, o en formaciones geológicas que por razones naturales no sean apropiadas, de manera permanente, para otros fines. Tales inyecciones no contendrán sustancias distintas de las resultantes de las operaciones antedichas,*
3. *la reinyección de aguas subterráneas bombeadas procedentes de minas y canteras o asociadas a la construcción o al mantenimiento de obras de ingeniería civil,*

4. *la inyección de gas natural o de gas licuado de petróleo (GLP) con fines de almacenamiento en formaciones geológicas que por razones naturales no sean apropiadas, de manera permanente, para otros fines,*
5. *la inyección de gas natural o de gas licuado de petróleo (GLP) con fines de almacenamiento en otras formaciones geológicas en las que haya necesidad imperiosa de garantizar el abastecimiento de gas y cuando la inyección se haga de manera que se evite cualquier riesgo actual o futuro de deterioro de la calidad de todas las aguas subterráneas receptoras.*
6. *obras de construcción, ingeniería civil y edificación y actividades similares sobre o dentro del terreno que esté en contacto con aguas subterráneas. A dicho efecto, los Estados miembros podrán determinar que dichas actividades se traten como si hubieran sido autorizadas siempre y cuando se lleven a cabo de conformidad con las normas generales de carácter vinculante establecidas por los Estados miembros relativas a dichas actividades,*
7. *vertidos de pequeñas cantidades de sustancias con fines científicos para la caracterización, protección o restauración de las masas de agua limitadas a la cantidad estrictamente necesaria para los fines en cuestión.*

Aunque la mayoría de las actividades descritas en los puntos 1 a 7 son autoexplicativas, hay descripciones generales, como “inyección de aguas por razones técnicas...”, (véase el punto 2 precedente), que podrían precisar de una explicación. Un ejemplo concreto es la inyección de salmuera, resultante de la desalación de aguas subterráneas salobres mediante la filtración a través de una membrana. La salmuera se reinyecta en un acuífero salino de mayor profundidad no utilizado. Situando debidamente los puntos de extracción y de reinyección puede expandirse la porción de una masa de agua que contiene agua dulce y agua salobre que puede ser utilizada de manera sostenible para la producción de agua potable. Mediante la filtración a través de una membrana sin sustancias adicionales, la actividad cumple la condición que establece la disposición 2): “Tales inyecciones no contendrán sustancias distintas de las resultantes de las operaciones antedichas”.

La excepción 6) incluye la condición previa de que las actividades se lleven a cabo de conformidad con las normas generales de carácter vinculante establecidas por los Estados miembros. Una de las finalidades de estas normas será la de prevenir la utilización de materiales de construcción y auxiliares o técnicas que causen filtraciones inaceptables de sustancias contaminantes en las aguas subterráneas. A pesar de que la excepción se refiere a “actividades”, es evidente que incluye también la *presencia* de materiales de construcción autorizados que entren en contacto con las aguas subterráneas una vez finalizada la obra.

Los Estados miembros podrán eximir, de conformidad con el artículo 6.3 de la DAS, las entradas con determinadas características de los requisitos de “prevenir y limitar”, sin perjuicio de otros requisitos más estrictos recogidos en otros actos de la legislación comunitaria. Las entradas exentas se enumeran en las letras a) a f).

a) las entradas que sean *el resultado de vertidos directos autorizados de conformidad con la letra j) del apartado 3 del artículo 11 de la Directiva 2000/60/CE;*

Esta disposición garantiza la coherencia de la DAS con el artículo 11.3,j) de la DMA que se describe más arriba.

b) las entradas que *las autoridades competentes consideren que son tan pequeñas en cantidad y concentración que no suponen ningún peligro actual o futuro de deterioro de la calidad de las aguas subterráneas receptoras;*

La Directiva 80/68/CEE incluía una disposición *de minimis* similar. Reconoce que existen pequeñas entradas respecto a las cuales las medidas de prevención o limitación no son razonables porque el efecto de dichas entradas en la calidad de las aguas subterráneas sería poco significativo o nulo si no se controlara la actividad. A pesar de que la excepción relativa a “los vertidos de efluentes domésticos que provengan de las viviendas aisladas, no conectadas a una red de alcantarillado” que establece la Directiva 80/68/CEE no está contemplada en la DAS, el caso de una vivienda aislada o un asentamiento muy pequeño cuyo efecto sea poco significativo seguirá estando exento de conformidad con la disposición *de minimis*.

La disposición *de minimis* podrá aplicarse asimismo a las entradas residuales de poca importancia procedentes de vertederos. Los vertederos han de cumplir ciertos requisitos encaminados a minimizar las filtraciones. Con el paso del tiempo podrá producirse un pequeño flujo de contaminantes hasta alcanzar las aguas subterráneas, pero si el impacto se evalúa como poco significativo -p.ej. mediante modelos de simulación- y se confirma mediante un seguimiento, será aplicable la excepción.

En general, la excepción se refiere también a entradas residuales de menor relevancia procedentes de materiales de construcción que hayan sido autorizadas por la autoridad competente para determinadas aplicaciones. Por lo general resulta materialmente imposible prevenir por completo los flujos de carácter difuso procedentes de los materiales de construcción en las aguas subterráneas circundantes. Entre los componentes del material puede haber sustancias consideradas peligrosas. No obstante, la autorización del material de construcción supone que las filtraciones previstas “sean tan reducidas en cantidad y concentración, que excluyan todo peligro actual o futuro de deterioro de la calidad del agua subterránea receptora”. Autorizar la utilización de tales materiales es también la finalidad de la excepción 6 con arreglo al artículo 11.3,j) de la DMA, mencionada más arriba.

c) las entradas que *sean consecuencia de accidentes o circunstancias excepcionales de origen natural imposibles de prever, evitar o paliar;*

El texto no especifica si se refiere a accidentes de origen natural o accidentes en general -p.ej. los accidentes durante el transporte terrestre de sustancias químicas-. Es razonable, sin embargo, suponer que la excepción no sea aplicable a los accidentes que causen contaminación que hubieran podido evitarse mediante la eliminación con un coste razonable.

Podrían considerarse como circunstancias excepcionales de origen natural inundaciones, sequías, incendios forestales, terremotos y erupciones volcánicas. El alcance del requisito de “prevenir y limitar” excluye, evidentemente, los efectos naturales que se producen con independencia de la actividad humana. No obstante, si pudieran preverse dichas circunstancias -p.ej. inundaciones o terremotos-, deberían adoptarse medidas preventivas, a menos que los efectos sean de poca importancia o que dichas medidas no sean viables por los motivos expuestos en las excepciones b) y e).

Las inundaciones pueden provocar la contaminación de las aguas subterráneas, en particular cuando afectan a instalaciones, como vertederos o lugares de almacenamiento y manipulación de sustancias químicas. El efecto directo es la contaminación de las aguas superficiales, pero la contaminación puede llegar con el tiempo hasta las aguas subterráneas mediante la filtración de las aguas superficiales en el suelo o la deposición de suelo contaminado, desde donde los contaminantes pueden filtrarse hasta las aguas subterráneas. La aplicabilidad o no de la excepción c) dependerá de la valoración que se haga respecto a si razonablemente podrían haberse adoptado medidas para evitar estos accidentes o paliar sus consecuencias. En principio, los accidentes deben prevenirse mediante construcciones seguras o restricciones en zonas inundables o, en caso de inundaciones, mediante sistemas de alerta y protocolos. La aplicación de tales medidas debe formar parte del programa de medidas al que se hace referencia en el artículo 6.1 de la DAS y en el artículo 11 de la DMA. Un razonamiento similar es aplicable a los accidentes de gran alcance, como los que pueden causar los terremotos.

d) las entradas que *sean resultado de una recarga artificial o aumento autorizados de conformidad con la letra f) del apartado 3 del artículo 11 de la Directiva 2000/60/CE;*

El artículo 6.3,d) de la DAS establece de manera explícita la coherencia entre el artículo 6 de la DAS y el artículo 11.3 de la DMA, reseñado en el apartado 5.1

La disposición que establece el artículo 11.3,f) de la DMA es clara y no requiere explicación. La recarga artificial o el aumento se denominan asimismo "infiltración artificial".

e) entradas que *según las autoridades competentes, no sean técnicamente viables para prevenir o limitar sin la utilización de:*

i) medidas que aumentarían los riesgos para la salud humana o la calidad del medio ambiente en su conjunto; o

ii) medidas con un coste desproporcionado para eliminar cantidades de contaminantes o para controlar su infiltración en suelos o subsuelos contaminados;

Un ejemplo de "medidas que aumentarían los riesgos para la salud humana o la calidad del medio ambiente en su conjunto" podría ser el tratamiento de suelo contaminado mediante trabajos de excavación que alteraran las capas impermeables del suelo, que protegen las aguas subterráneas profundas que se utilizan para la producción de agua potable.

Puede ocurrir que en algunos casos el suelo contaminado o los sedimentos produzcan una entrada de contaminantes en aguas subterráneas que sea significativa -al menos a escala local-, por lo que no será aplicable la excepción b); sin embargo, la restauración (recuperación) completa causaría más daños que beneficios al medio ambiente. Dicha restauración puede, por ejemplo, causar ruido que perturbe la vida silvestre, puede necesitar cantidades desproporcionadas de energía u otros recursos, etc. En algunos casos serán posibles otras soluciones que garanticen una restauración parcial. Es posible que en algunos casos la restauración de sedimentos contaminados depositados en el fondo de aguas superficiales no sea posible sin que se produzca una “resuspensión” considerable del material contaminado, lo que originaría daños ecológicos o sería perjudicial para la calidad del agua de baño o para la utilización de aguas superficiales para la producción de agua potable. Podría ser conveniente aplicar una técnica de restauración más cuidadosa, pero si su coste fuera desproporcionado, sería aplicable la excepción ii). En general, la restauración/recuperación de suelos contaminados o de sedimentos que entrañe unos costes desproporcionadamente altos en comparación con el beneficio medioambiental sería un motivo para la excepción ii). Lo que debe entenderse por "desproporcionado” se determinará mediante evaluaciones individualizadas que, de conformidad con el artículo 14 de la DMA, deberán hacerse con la participación de todas las partes interesadas y sobre las que se informará con transparencia.

f) las entradas que *sean el resultado de actuaciones en las aguas superficiales con el objeto, entre otros, de paliar los efectos de inundaciones y sequías, así como para la gestión de las aguas y de los cursos de agua, incluidos los de ámbito internacional. Dichas actividades, que incluirán por ejemplo el corte, el dragado, el traslado y el almacenamiento de los sedimentos presentes en las aguas superficiales, se llevarán a cabo con arreglo a normas generales vinculantes, y, cuando sean aplicables, con permisos y autorizaciones concedidos sobre la base de las normas que hayan desarrollado al respecto los Estados miembros, siempre que esas entradas no pongan en peligro la consecución de los objetivos medioambientales que se hayan fijado para las masas de agua correspondientes a tenor de la letra b) del apartado 1 del artículo 4, de la Directiva 2000/60/CE.*

Otros ejemplos en los que es aplicable esta disposición son el mantenimiento de la profundidad del canal fluvial para embarcaciones, y la excavación de un canal adyacente en la llanura de inundación de un río para reforzar la protección contra las inundaciones. Estas actividades generan grandes cantidades de sedimento o suelo que deberán depositarse en algún lugar. El material podría utilizarse, por ejemplo, en la construcción de diques. Otra solución sostenible y rentable es el depósito en excavaciones profundas para extracción de arena o grava dentro o en las inmediaciones del sistema fluvial. Estas excavaciones se llenan de agua, pero debido a su gran profundidad creada de manera artificial no forman un hábitat ecológico natural. La mayoría de los sedimentos están contaminados en cierta medida. La concentración de sedimentos muy esparcidos en la zona de la excavación reducirá probablemente la entrada global de contaminantes en las aguas superficiales y subterráneas, así como la exposición del medio ambiente a la contaminación. No obstante, podría producirse un flujo local de contaminantes en las aguas subterráneas. Éste podría ser un motivo para la excepción b) -poco significativo-; sin embargo, la excepción f) permite un planteamiento basado en la aplicación de normas generales de carácter vinculante. Dichas normas deberían evitar que las obras como las expuestas anteriormente tuvieran un efecto significativo en la calidad de las aguas subterráneas. Cuando una obra se ajusta a dichas normas generales, ello debería significar que el órgano competente ha considerado que el flujo potencial de contaminantes en aguas subterráneas es lo suficientemente pequeño como para no poner en peligro el logro de los objetivos medioambientales establecidos con arreglo a la DMA para las masas de agua subterránea en cuestión. Aunque puede aducirse que el depósito de suelo o sedimentos estaría permitido, asimismo de conformidad con la excepción e), ii), la excepción f) hace una referencia más clara a los casos como los que aquí se describen.

5.5 Condiciones para la aplicación de excepciones

El considerando 18 de la DAS reza: *"En determinadas circunstancias, los Estados miembros deben autorizar la concesión de excepciones a las medidas destinadas a impedir o limitar la entrada de contaminantes en las aguas subterráneas. Toda excepción debe basarse en criterios transparentes y justificarse en los planes hidrológicos de cuenca."* El artículo 6, 3) de la DAS define las actividades o situaciones específicas que pueden estar exentas bajo determinadas condiciones. Por tanto, para eximir una entrada de la exigencia de prevenir o limitar, el órgano competente debe, en primer lugar, decidir si es aplicable alguna de las descripciones recogidas en el artículo 6.3. Los criterios para tomar dicha decisión deben ser transparentes y deberán facilitarse los pormenores pertinentes en el plan hidrológico de cuenca. Para dilucidar si es aplicable una o más de las excepciones recogidas en el artículo 6, 3), deberá describirse la actividad o el incidente causante de la entrada que debe eximirse de las medidas. Evidentemente, en el caso de actividades o incidentes que tengan un carácter similar, bastará con una la mera descripción general en el plan hidrológico, o una referencia a otro documento que contenga dicha descripción. Esto es aplicable, por ejemplo, a las actividades que se ajusten a las normas vinculantes desarrolladas a tal efecto.

El artículo 6.4 de la DAS establece que para poder llevar a cabo la notificación a la Comisión, previa solicitud de ésta, las autoridades competentes deben realizar un inventario de las excepciones. El artículo 6.4 no especifica el nivel de detalle que debe contener el inventario ni tampoco exige que el propio inventario forme parte del plan de cuenca. El inventario podría ser un anexo del plan, que incluya todos los argumentos relacionados con las excepciones o que haga referencia a otros documentos que contengan dichos argumentos. Otra posibilidad sería que el plan de cuenca indicara dónde puede encontrarse el inventario. Es poco razonable mantener un inventario de cada excepción individual con una descripción detallada, especialmente cuando se trata de entradas que se producen con frecuencia y que proceden de obras de construcción o fosas sépticas. Por lo tanto convendría desarrollar soluciones prácticas para la elaboración de dichos inventarios; en caso de existir normativa o códigos de buena práctica para autorizar la utilización de materiales de construcción con el fin de garantizar que la entrada residual sea aceptable, es decir, que pueda quedar exenta, podría bastar con incluir en el inventario la correspondiente la norma general vinculante.

Según la última frase del artículo 6.3 de la DAS, las exenciones sólo podrán otorgarse previa comprobación por las autoridades competentes de los Estados miembros de que se realiza el seguimiento de las masas de agua subterránea implicadas, a tenor del punto 2.4.2 del Anexo V de la Directiva 2000/60/CE, u otro seguimiento pertinente. El seguimiento, de conformidad con el punto 2.4.2 del Anexo V de la DMA, sobre el que se trata en la guía de seguimiento de las aguas subterráneas, probablemente no establezca mediciones lo suficientemente detalladas para determinar los efectos de los casos individuales en los que se aplican exenciones. Las autoridades competentes deben decidir sobre la necesidad de un seguimiento adicional para verificar que es aceptable la evaluación, subyacente a la conclusión, de los efectos de una entrada exenta; por ejemplo, en el caso de un material de construcción que haya sido autorizado para utilizarlo en el suelo o en aguas subterráneas a pesar de contener una sustancia peligrosa, la autorización implica que la filtración se considera de poca importancia. Naturalmente no es necesario hacer un seguimiento de la calidad de las aguas subterráneas en todos los lugares en que se deposite el material. Bastará con los tests del material presentados para obtener la autorización. Es posible que otros tipos de entradas dispersas candidatas a la excepción deban ser objeto de seguimiento en varios puntos representativos.

El artículo 6.3 comienza con la condición "Sin perjuicio de cualquier requisito más estricto establecido en otros actos de la legislación comunitaria". La aplicación de una exención, por ejemplo, no debería tener efectos adversos sobre una zona Natura 2000 ni en la producción de agua potable. Si desde el lugar en cuestión se produce una escorrentía subterránea hacia otros lugares en los que otros actos de la legislación comunitaria establecen objetivos más estrictos, debe demostrarse que aún así, se prevé la consecución de los objetivos citados. Dichos razonamientos podrán requerir una evaluación experta de los gestores de las aguas subterráneas y de las partes interesadas -las partes interesadas deben participar, de conformidad con el artículo 14 de la DMA sobre participación pública-.

5.6 Cómo desarrollar las medidas

El desarrollo de medidas, esquematizado en la figura 7, se basa en las características de la entrada (capítulo 3.2 y 3.3), y en el tipo de actividad (capítulo 4.3 y 4.4). Esto constituye la base para comprobar si es aplicable una de las exenciones de la DAS (capítulo 5.3 y 5.5). En ambos casos, -nuevas actividades y fuentes existentes-, debe tenerse en cuenta el planteamiento del punto de cumplimiento (PdC, capítulo 4.1), a fin de evaluar el impacto de esas actividades y determinar las acciones necesarias para asegurar que se alcanza el objetivo de prevenir y limitar de la DMA.

Respecto a nuevas actividades, la figura 5 ofrece asesoramiento detallado sobre cómo proceder. Para las fuentes existentes, el planteamiento del PdC conduce a un desarrollo por etapas de las medidas necesarias para prevenir o limitar la entrada de contaminantes en aguas subterráneas. Comienza con el seguimiento y establece líneas de actuación concretas en caso de que deban adoptarse medidas más rigurosas específicas al lugar. La concepción de las medidas citadas debe basarse en una evaluación de los riesgos para el receptor/compartimento (capítulo 3.5) siguiendo el proceso descrito en la figura 6.

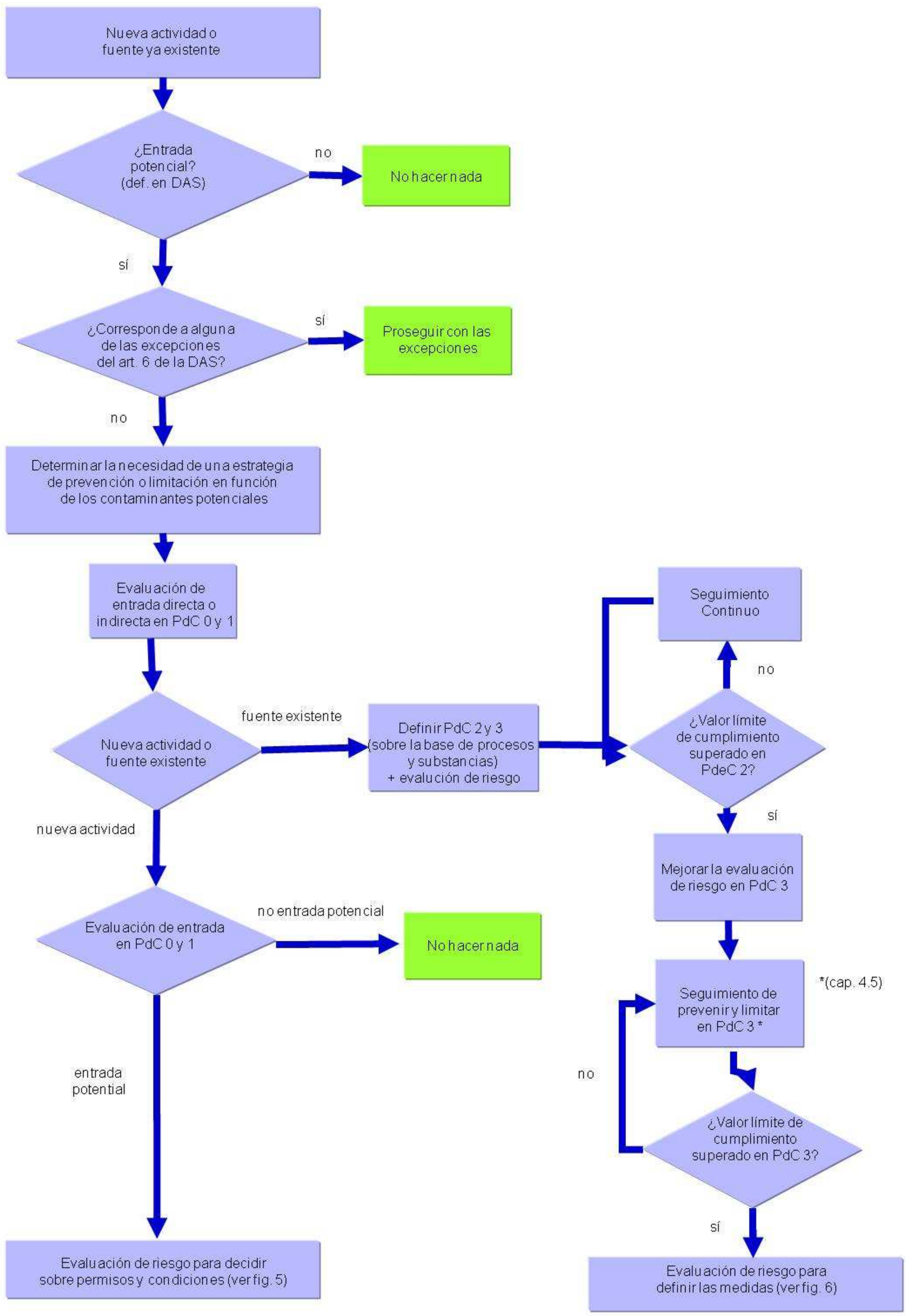


Figura 7: Esquema de cómo llegar hasta las medidas

Anexos

Anexo 1 Ejemplos de entradas

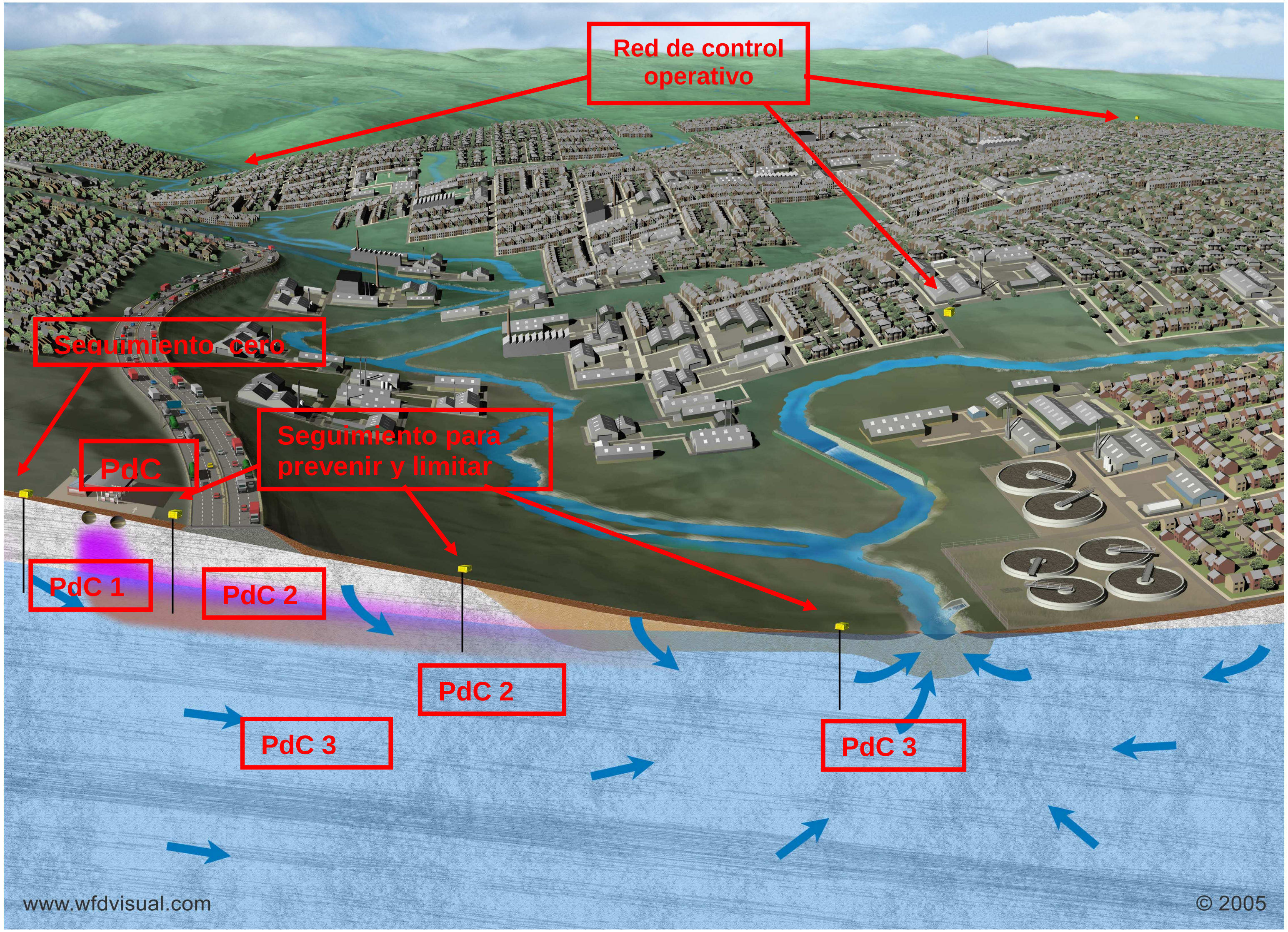
	Tipos de fuentes y entradas	Ejemplos	Tipo de entrada habitual :directa o indirecta	Propiedades de las entradas	Tipo de fuente: puntual o difusa (*)
1	Fuentes puntuales; vertidos líquidos a través de conducciones	- Infiltración desde estación depuradora de aguas residuales industriales - Fosa séptica-infiltración desde el sistema - Infiltración de agua de lluvia desde tejados, carreteras, etc.	- Indirecta o directa - Indirecta - Indirecta	Entrada continua	puntual
2	Lixiviado de materiales sólidos	- Materiales de construcción - Vertederos - Madera tratada - Objetos metálicos	Todas: Indirectas o directas	Entrada única (**); Disminución habitual del lixiviado con el paso del tiempo	puntual
3	Difusión	- Plaguicidas - Estiércol, Fertilizantes, Compost - Lodos de aguas residuales - Tratamiento antihielo en carreteras	Todas: Indirectas	Entrada de repetición periódica	difusa
4	Infiltración	- Recarga artificial - Para abastecimiento de agua potable - Para almacenamiento de energía - Fugas desde balsas para almacenamiento de residuos líquidos, etc. - Inyección/eliminación de fluidos derivados de la producción de petróleo y gas	- Directa o indirecta - Directa o indirecta - Directa - Directa o indirecta - Directa	- Entrada continua - Entrada continua - Entrada continua - Entrada continua o fortuita - Entrada continua	puntual
5	Entradas atmosféricas	- (Antiguas) industrias locales - Accidentes industriales - Por la calidad del aire en general	Todas: Indirectas	-Entrada continua -Entrada fortuita -Entrada continua	difusa
6	Contaminación existente en el suelo y en aguas subterráneas	- Zona de suelo contaminado - Gran extensión de suelo contaminado - Zona de aguas subterráneas contaminadas - Gran extensión de aguas subterráneas contaminadas	Todas: Directas o indirectas	Acción única (**); lenta propagación habitual a las aguas subterráneas y a través de éstas.	-puntual -difusa -puntual -difusa
7	Fugas por accidentes	- Depósitos, tuberías, perforaciones petrolíferas, - Sistemas de almacenamiento de energía	Todas: Directas o indirectas	Acción única (**); Propagación lenta o rápida	puntual

Observaciones

(*) varias fuentes puntuales en una misma zona pueden constituir una fuente difusa, cuando se las considera conjuntamente.

(**) única = cada entrada es una acción única. No obstante, es posible repetir la acción en el mismo lugar con materiales iguales o distintos que puedan liberar sustancias. En tales casos puede tratarse como una entrada de tipo continuo en dicho lugar.

Anexo 2 : Ejemplos del concepto PdC



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ESTRATEGIA COMÚN DE IMPLANTACIÓN DE LA DIRECTIVA MARCO DEL AGUA (2000/60/CE)

Documento Guía No. 18

GUÍA SOBRE EL ESTADO DE LAS AGUAS SUBTERRÁNEAS Y LA EVALUACIÓN DE TENDENCIAS

Versión española
Dirección General del Agua
Agosto 2009

COMISIÓN EUROPEA

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Prólogo

Los Directores Generales del Agua de la Unión Europea (UE), los países de la Adhesión, los países candidatos y los países de la EFTA, han desarrollado conjuntamente una estrategia común para la implantación (ECI) de la Directiva 2000/60/CE, *“por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas”* (Directiva Marco del Agua). Esta estrategia tiene como principal objetivo contribuir a una aplicación coherente y uniforme de la Directiva. La atención se ha centrado en las cuestiones metodológicas relacionadas con una comprensión común de las repercusiones técnicas y científicas de dicha aplicación.

En particular, uno de los objetivos de la estrategia es el desarrollo de documentos guía, de carácter práctico y jurídicamente no vinculantes, sobre varios aspectos técnicos de la Directiva. Estos documentos guía van dirigidos a los expertos que, directa o indirectamente, son los responsables de aplicar la Directiva Marco del Agua en las demarcaciones hidrográficas. En consecuencia, se ha adaptado la estructura, la presentación y la terminología a las necesidades de estos expertos, y, en la medida de lo posible, se ha evitado la utilización de un lenguaje formal y legalista.

En este contexto, los Directores Generales del Agua elaboraron y aprobaron una serie de documentos guía relativos a las aguas subterráneas. Dichos documentos deben servir de referencia a los Estados miembros en temas tales como identificación de masas de agua –documento guía nº 2- análisis de presiones e impactos –documento guía nº 3-, y seguimiento (“monitoring”) –documento guía nº 7-, en el marco del desarrollo de los Planes Hidrológicos de Cuenca.

A modo de continuación y en el ámbito de aplicación de la nueva Directiva relativa a las aguas subterráneas (Directiva 2006/118/CE), elaborada en cumplimiento del mandato del artículo 17 de la Directiva Marco del Agua, los Estados miembros han manifestado la necesidad de aclarar algunos aspectos relacionados con las aguas subterráneas. En respuesta a dicha solicitud se redactaron nuevos documentos que ampliaban la serie, relativos a aspectos cubiertos por ambas directivas, concretamente sobre seguimiento de las aguas subterráneas –documento guía nº 15-, zonas protegidas para el abastecimiento de agua potable –documento guía nº 16-, y prevención de entradas directas e indirectas de contaminantes –documento guía nº 17-. Como complemento a estos tres documentos guía se tomó la decisión de redactar recomendaciones sobre el estado de las aguas subterráneas y la evaluación de tendencias de contaminantes, sobre la base de la experiencia y mejora del conocimiento adquiridas en el proyecto BRIDGE, referente a criterios de referencia para la identificación de valores umbral en las aguas subterráneas y financiado bajo el 6º Programa Marco, y en el desarrollo del Informe Técnico sobre aspectos estadísticos de la identificación de tendencias en la contaminación de las aguas subterráneas y de la agregación de los resultados del seguimiento (2001). Con dicho objetivo se estableció un grupo de trabajo dependiente del Grupo de Trabajo WG-C de la ECI sobre aguas subterráneas. Este grupo de trabajo ha sido coordinado por Austria, Francia, Reino Unido y EuroGeoSurveys, y ha contado con la participación de expertos procedentes de otros Estados miembros y de organizaciones de grupos interesados.

El presente documento guía es el resultado de los trabajos de este grupo y contiene la síntesis de los resultados de los debates celebrados desde diciembre de 2004. Está basado en las aportaciones y las reacciones de una amplia variedad de expertos y partes interesadas que han participado en su elaboración a través de reuniones, talleres, conferencias y medios electrónicos, sin que por ello resulten vinculados en modo alguno con el contenido del presente informe.

“Nosotros, los Directores Generales del Agua de la Unión Europea, Noruega, Suiza y los países que han solicitado la adhesión a la Unión Europea, hemos examinado y aprobado el presente Documento guía en el transcurso de nuestra reunión informal bajo la Presidencia francesa (París, 24-25 de noviembre de 2008). Deseamos expresar nuestro agradecimiento a los miembros del Grupo de Trabajo C y, en particular, a los responsables del grupo de redacción por la elaboración de este documento de gran calidad.

Creemos firmemente que éste y otros documentos guía elaborados en el marco de la Estrategia Común de Implantación tendrán un papel destacado en el proceso de implantación de la Directiva Marco del Agua y de la Directiva relativa a las aguas subterráneas.

El presente documento guía es un documento vivo que necesitará aportaciones y mejoras continuas a medida que avanza la aplicación y crece la experiencia en todos los países de la Unión Europea y en otros países. Hemos acordado, no obstante, que este documento se haga público en su forma actual con el fin de presentarlo al gran público como la base para seguir avanzando en los esfuerzos de aplicación en curso.

Asimismo, nos comprometemos a evaluar y a decidir sobre la necesidad de revisarlo a la luz de los avances científicos y técnicos, así como de las experiencias acumuladas en la aplicación de la Directiva Marco del Agua y de la Directiva relativa a las aguas subterráneas."

MIEMBROS DEL GRUPO DE REDACCIÓN

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Manuel SAPIANO	Malta Resources Authority (Malta)
Martin SKRIVER	Danish Ministry of the Environment (Denmark)
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Manuel VARELA	Ministerio de Medio Ambiente, y Medio Rural y Marino (España)
Wilko VERWEIJ	RIVM (The Netherlands)
Rüdiger WOLTER	Federal Environmental Agency (Germany)

ABREVIATURAS UTILIZADAS

ECI Estrategia Común de Implantación	CIS Common Implementation Strategy
DAP Directiva de aguas potables	DWD Drinking Water Directive
DAS Directiva de aguas subterráneas (2006/118/CE)	GWD Groundwater Directive (2006/118/EC)
DMA Directiva Marco del Agua (2000/60/CE)	WFD Water Framework Directive (2000/60/EC)
ETDAS Ecosistemas terrestres dependientes de aguas subterráneas	GWDTE Groundwater Dependent Terrestrial Ecosystems
LC Límite de cuantificación	LOQ Limit of Quantification
MAS masa de agua subterránea o grupo de masas	GWB Groundwater Body or group of bodies of groundwater
NC Norma de calidad para las aguas subterráneas	GW-QS Groundwater Quality Standard
NCA Norma de calidad ambiental	EQS Environmental Quality Standard
PC Punto de cumplimiento	POC Point of Compliance
PHC Plan Hidrológico de Cuenca	RBMP River Basin Management Plan
VC Valor de cumplimiento	CV Compliance Value
VP Valor paramétrico (norma de calidad para aguas potables)	DWS Drinking Water Standard
VU Valor umbral	TV Threshold Value
ZPAP Zonas protegidas para la captación de agua potable	DWPA Drinking Water Protected Areas

INDICE

LA ESTRATEGIA COMÚN DE IMPLANTACIÓN (ECI) DE LA DIRECTIVA MARCO DEL AGUA

La Directiva Marco del Agua (2000/60/CE)[1] (DMA) es una norma jurídica de ámbito comunitario que establece, *inter alia*, objetivos de “buen estado” para todas las aguas de Europa. La DMA requiere una gestión sostenible e integrada de las demarcaciones hidrográficas incluyendo objetivos vinculantes, plazos claramente establecidos y un programa global de medidas basadas en análisis científicos, técnicos y económicos, que incluya la información y la consulta del público. Desde la fecha de adopción de la DMA se puso de manifiesto el reto que supondría lograr su aplicación con éxito para todos los países, instituciones y partes interesadas.

Para afrontar los retos de modo cooperativo y coordinado, los Estados miembros, Noruega y la Comisión Europea (CE) acordaron establecer una Estrategia Común de Implantación (ECI, CIS en las siglas inglesas) de la Directiva Marco del Agua. Además, los Directores Generales del Agua subrayaron la necesidad de implicar a los actores interesados, a las ONG y a la comunidad investigadora en este proceso conjunto, y de asegurar la participación de los países candidatos.

En la primera fase de la ECI se redactaron una serie de documentos guía, cuya aplicación práctica se sometió a prueba en cuencas hidrográficas piloto europeas en 2003 y 2004. En el Programa de Trabajo 2005/2006, los cuatro Grupos de Trabajo -Estado ecológico, Gestión Integrada de Cuencas Hidrográficas, Aguas Subterráneas e Informes (Reporting)- han seguido ocupándose de las cuestiones clave para la implantación. Además, los nuevos grupos de trabajo -DMA y Agricultura, Sistemas de Información Geográfica y Seguimiento del estado químico- están compartiendo sus experiencias en este ámbito, y una nueva red de cuencas hidrográficas piloto está apoyando las actividades técnicas de todos los grupos de trabajo.

El Grupo de Trabajo sobre aguas subterráneas (WG C) de la ECI desarrolla actualmente la tercera fase de los trabajos (2007-2009)[2], centrada en la aplicación de la nueva Directiva sobre aguas subterráneas y en los elementos relativos a las aguas subterráneas dentro de la DMA, junto con los principios de la ECI. En particular, el objetivo principal del WG C de cara a la preparación del primer Plan Hidrológico de Cuenca (PHC) es el desarrollo de una metodología común para el establecimiento de valores umbral para las aguas subterráneas y un documento guía sobre el estado del cumplimiento y la evaluación de las tendencias. Más adelante se centrará la atención en las mejores prácticas relacionadas con programas de medidas y recomendaciones para la evaluación y la gestión integrada de riesgos relativos a las aguas subterráneas, incluyendo modelos conceptuales.

Simultáneamente a este trabajo, la Actividad de Seguimiento Químico (CMA en sus siglas en inglés) se ha centrado en desarrollar una guía sobre el seguimiento del estado químico. Esto ha dado como resultado un proyecto de directiva de la CE sobre las especificaciones técnicas de los análisis químicos y el seguimiento del estado de las aguas[3]. Incluye las aguas superficiales y las aguas subterráneas. En la preparación de esta guía se han tenido en cuenta las nuevas especificaciones.

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[1] Directiva 2000/60/CE del Parlamento Europeo y del Consejo de 23 de octubre de 2000 por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas (DO L 327, 22/12/2000, p. 1) modificada por la Decisión del Parlamento Europeo y del Consejo 2455/2001/CE (DO L 331, 15/12/2001, p.1).

[2] Mandato del Grupo de Trabajo sobre Aguas Subterráneas. Estrategia común de implantación de la Directiva marco del Agua. Programa de Trabajo 2007-2009 (2006).

[3] Proyecto de directiva de la Comisión de (día, mes, 2009) que establece, de conformidad con la Directiva 2000/60/CE del Parlamento europeo y del Consejo, especificaciones técnicas para el análisis químico y el seguimiento del estado de las aguas. (Directiva QA/QC) 10575/08 ENV 365.

1 OBJETIVOS Y ALCANCE

Esta guía se ha redactado como respuesta a un mandato del Grupo de Trabajo de Aguas Subterráneas de la DMA -WG C-, que se concreta en el desarrollo de guías prácticas y especificaciones técnicas para la determinación de valores umbral y para la evaluación del estado del cumplimiento. El documento se basa en las guías de la DMA y las complementa[4]. Esencialmente se centra en los requisitos de la DMA y de la nueva Directiva de Aguas Subterráneas[5] (DAS), y en especial en las obligaciones contenidas en el Anexo V de la DMA y en los artículos 3 y 4 y los Anexos II y III de la DAS.

La DMA y la DAS requieren a los Estados miembros la identificación de las tendencias de las concentraciones de contaminantes, y la evaluación de esas tendencias para determinar en qué medida son significativas para el medio ambiente. Cuando existan tendencias significativas al aumento deben invertirse mediante la aplicación de programas de medidas que garanticen que no se incumplan en el futuro los objetivos medioambientales. El punto de partida establecido en la DAS para la inversión de la tendencia coincide con el momento en que la concentración del contaminante alcanza un porcentaje del valor umbral o norma de calidad (75% por defecto).

Este documento constituye una guía práctica para el cumplimiento de cada uno de los requisitos descritos anteriormente. Así:

- establece una metodología para la determinación de los valores umbral;
- establece criterios para la evaluación del estado químico y del estado cuantitativo;
- establece un método para la identificación de tendencias significativas desde el punto de vista medioambiental;
- reitera los requisitos de la DMA en materia de información;
- aporta ejemplos en forma de casos prácticos que ilustran la aplicación de la guía en los Estados miembros.

Durante la redacción de esta guía se han tenido en cuenta los resultados de distintos proyectos de I+D así como el contenido de otras guías publicadas anteriormente. En cuanto a los valores umbral para las aguas subterráneas, el método que se describe en este documento se basa en los resultados del proyecto BRIDGE[6]. Para la evaluación del estado químico se han consultado las especificaciones técnicas relativas al análisis químico y al seguimiento del estado de las aguas, que ha desarrollado la Actividad de Seguimiento Químico (CMA, en sus siglas en inglés) de la UE, así como la Directiva de la Comisión[7] sobre la materia. En cuanto a la evaluación de las tendencias y la inversión de las tendencias, se ha prestado una atención especial al Informe Técnico elaborado por el grupo de trabajo 2.8 de la Estrategia Común de Implementación de la DMA[8] .

El objetivo de este trabajo es proporcionar un enfoque práctico que apoye a los Estados miembros en la aplicación y la consecución de los requisitos de la DMA y de la DAS. El documento es fruto de numerosas consultas con expertos en aguas subterráneas de toda Europa, y representa un enfoque

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[4] Guidance Document No. 17 Preventing or Limiting Direct and Indirect Inputs (2007)
Guidance Document No. 16 Groundwater in Drinking Water Protected Areas (2007)
Guidance Document No. 15 Groundwater Monitoring (2007)
Guidance Document No. 7: Monitoring under the Water Framework Directive – WG 2.7 Monitoring (2003);
Guidance Document No. 3: Analysis of Impacts and Pressures – Working Group 2.1 IMPRESS (2003)
Guidance Document No. 2 Identification of Water Bodies (2003);
Informe Técnico Nº. 1: Statistical aspects of the identification of groundwater pollution trends and aggregation of monitoring results – WG 2.8 Statistics (2001);
Chemical Monitoring Activity;
Technical report No. 3: Groundwater Monitoring (workshop report 25th June 2004);
EC Monitoring Guidance for the Nitrates Directive;
EUROWATERNET Guidelines (Technical Report Nr. 7, EEA 1999);
Guidelines on monitoring and assessment of transboundary groundwaters (UN-ECE).

[5] Directiva 2006/118/CE del Parlamento Europeo y del Consejo de 12 de diciembre de 2006, relativa a la protección de las aguas subterráneas frente a la contaminación y el deterioro

[6] Müller *et al*. (2006)

[7] Proyecto de Directiva de la Comisión de (día, mes, 2009) que establece, de conformidad con la Directiva 2000/60/CE del Parlamento europeo y el Consejo, especificaciones técnicas para el análisis químico y el seguimiento del estado de las aguas. 10575/08 ENV 365

[8] Technical Report No 1: Aspectos estadísticos de la identificación de las tendencias de contaminación de las aguas subterráneas e agregación de los resultados del control – WG 2.8 Estadísticas (2001)

basado en las mejores prácticas del momento. La guía no tiene carácter jurídicamente vinculante y los Estados miembros son libres de adaptar las directrices que aquí se presentan, a la luz de las características de las masas de agua subterránea, y/o las estrategias y normativas nacionales o regionales para la gestión de las aguas subterráneas. Asimismo, es justo reconocer que la experiencia puede aportar mejoras a las metodologías propuestas.

2 PRINCIPIOS GENERALES

2.1 Modelos conceptuales

Para la aplicación de la DMA y la DAS, y para la gestión eficaz de las aguas subterráneas, se requiere una comprensión clara de las condiciones medioambientales necesarias para el logro de los objetivos medioambientales, y del modo en que éstas pueden verse afectadas por la actividad humana. Esta comprensión se apoya en el desarrollo de un **modelo conceptual o comprensión conceptual** del sistema de aguas subterráneas, en el que se definen el esquema general de las condiciones de flujo y de transporte, y el de las características hidrogeoquímicas. Los modelos conceptuales no son necesariamente modelos numéricos, y constituyen una comprensión de las relaciones funcionales en el sistema geológico e hidrogeológico objeto de estudio. No obstante, pueden utilizarse los modelos numéricos para apoyar o confirmar algunos elementos del modelo conceptual, cuando proceda.

No sólo la evaluación de riesgo, sino también el seguimiento, deben basarse en principio en un modelo conceptual del sistema de aguas subterráneas. Los datos obtenidos en los programas de seguimiento de la DMA deben utilizarse para verificar, validar y afinar los modelos conceptuales. La información sobre los tiempos de tránsito, caudal, velocidad de transporte y/o distribución de edades de las aguas subterráneas puede ser también una aportación útil para el diseño del modelo conceptual, así como para su validación.

Una masa de agua subterránea es tridimensional. Por ello, la concentración de contaminantes y los niveles de referencia de las sustancias presentes de modo natural pueden experimentar variaciones significativas en dirección vertical y lateral. Esto debe tenerse en cuenta cuando se establezcan valores umbral así como en el procedimiento de evaluación del estado y de las tendencias.

La importancia de los modelos conceptuales se describe ya en otra guía de la CIS[9]. El capítulo 3.1 de la guía “Groundwater Monitoring”[10] formula los principios y las relaciones del modelo conceptual con el programa de seguimiento. En el mandato del grupo de trabajo WG C se incluye el desarrollo de criterios y procedimientos adicionales sobre modelos conceptuales. Los modelos conceptuales se consideran actualmente como un instrumento fundamental para apoyar la aplicación de todas las disposiciones de las directivas DMA y DAS en materia de aguas subterráneas.

2.1.1 Modelos conceptuales y establecimiento de valores umbral

El anexo II.A de la DAS formula las siguientes orientaciones para la determinación de valores umbral:

- los valores umbral deberían basarse en el alcance de las interacciones entre las aguas subterráneas y los ecosistemas acuáticos y ecosistemas terrestres dependientes,
- los valores umbral deberían partir de los usos legítimos actuales o potenciales (a saber, abastecimiento de agua potable, regadío, etc.) o en las funciones de las aguas subterráneas,
- la asignación de valores umbral debería incluir a todos los contaminantes que caracterizan las masas de agua subterránea como masas en riesgo de no cumplir los objetivos del artículo 4 de la DMA,
- los valores umbral deberían basarse en las características hidrogeológicas de la masa de agua subterránea, incluida la información sobre las concentraciones de referencia derivadas de los procesos naturales hidrogeológicos e hidrogeoquímicos,
- la determinación de los valores umbral debería tener en cuenta el origen de los contaminantes, su posible existencia natural, su toxicología y tendencia a la dispersión, su persistencia y potencial de bioacumulación,
- la determinación de los valores umbral debería tener en cuenta la calidad de los datos y la precisión de las determinaciones analíticas.

La multiplicidad de aspectos que deben tenerse en cuenta para establecer valores umbral explica la necesidad de utilizar modelos conceptuales de flujo subterráneo y de características hidroquímicas de la masa de agua subterránea.

[9] Guidance Document No. 3: Analysis of Impacts and Pressures – WG 2.1 IMPRESS (2003)
Guidance Document No. 7: Monitoring Under the Water Framework Directive – WG 2.7 Seguimiento (2003);

[10] Guidance Document Nº 15: Groundwater Monitoring (2007)

2.1.2 Modelos conceptuales y evaluación del estado

En cada fase del procedimiento de evaluación del estado es importante considerar los resultados de la evaluación de riesgo, el análisis de presiones -por ej. el uso del suelo-, la vulnerabilidad de los acuíferos y los resultados del seguimiento.

Para la evaluación del estado químico de las aguas subterráneas, la DAS considera el modelo conceptual de una masa de agua subterránea como un componente integral y hace referencia al mismo en puntos específicos:

- el anexo III, 3, propone apoyar, en caso de necesidad, la evaluación de estado por medio de estimaciones de concentraciones basadas en un modelo conceptual.
- el anexo III, 4, afirma que junto con los datos objeto de seguimiento, un modelo conceptual adecuado debería permitir a los Estados miembros evaluar si el estado químico es bueno.

El modelo conceptual también desempeña un papel importante en la evaluación del estado cuantitativo, sirviendo de ayuda para la evaluación del impacto de los cambios en el nivel piezométrico en la masa de agua subterránea, en el nivel de las aguas superficiales y en su caudal, y en los ecosistemas dependientes de las aguas subterráneas.

2.1.3 Modelos conceptuales y evaluación de tendencias

Para evaluar las tendencias y la inversión de tendencias, el papel que desempeña el modelo conceptual es clave en las circunstancias siguientes:

- cuando se consideran las características temporales físicas y químicas, incluyendo las condiciones de flujo de las aguas subterráneas, las tasas de recarga y el tiempo de percolación a través del suelo o del subsuelo.
- cuando se decide la ubicación de los puntos de control y la frecuencia de medidas, para proporcionar la información necesaria que garantice que las tendencias significativas al aumento puedan distinguirse de las variaciones naturales con un nivel adecuado de confianza y precisión.
- cuando se establecen los puntos de partida para la inversión de tendencias que difieran del 75% de la norma de calidad de las aguas subterráneas o del valor umbral, que dependerán de las características del acuífero y de la capacidad para impedir del modo más rentable que se produzca cualquier cambio que perjudique seriamente la calidad de las aguas subterráneas.

2.2 Ecosistemas terrestres dependientes, pertinentes para la evaluación del estado y las tendencias

De conformidad con la definición establecida en la guía sobre humedales[11] en la página 22, los ecosistemas terrestres pertinentes que deben considerarse en la evaluación del estado de las aguas subterráneas y el establecimiento de valores umbral son los enclaves Natura 2000 que dependen directamente de las aguas subterráneas y otros ecosistemas terrestres dependientes de las aguas subterráneas -ETDAS, GWDTE en sus siglas en inglés- cuyo valor ecológico y socio-económico sea suficiente para que el perjuicio que produzcan en ellos las alteraciones del agua subterránea pueda ser considerado como significativo, en función de su gravedad.

2.3 Concentraciones de sustancias presentes de forma natural. Niveles de referencia

El considerando 10 de la DAS establece que "*Las disposiciones relativas al estado químico de las aguas subterráneas no se aplican a las situaciones en que se dan niveles naturales elevados de sustancias o iones, o de sus indicadores, contenidos en una masa de aguas subterránea o en masas asociadas de aguas superficiales, debidos a condiciones hidrogeológicas específicas no incluidas en la definición de "contaminación"*.

De conformidad con el artículo 2.5 de la DAS, "nivel de referencia" es "*la concentración de una sustancia o el valor de un indicador en una masa de agua subterránea correspondiente a condiciones no sometidas a alteraciones antropogénicas o sometidas a alteraciones mínimas, en relación con condiciones inalteradas";*

Los niveles de referencia pueden ser muy elevados[12] para algunos parámetros y algunos tipos de aguas subterráneas, por lo que es fundamental que el primer paso de la evaluación del estado y de las tendencias consista en su identificación. Además, tal como señala la DAS (anexo II.A.1.d), "*Al establecer los valores umbral, los Estados miembros atenderán a […]: las características hidrogeológicas, incluida la información sobre niveles de referencia."*

Como han puesto de manifiesto los proyectos BaseLine y BRIDGE[13], en Europa existen condiciones hidrogeológicas e hidroquímicas muy variadas. Los niveles de referencia son el resultado de varios factores, como las interacciones entre el agua y la roca, los procesos químicos y biológicos en la zona no saturada, el tiempo de permanencia, la lluvia, las relaciones con otros acuíferos (transferencias). Por este motivo, cada masa de agua subterránea es diferente y posee una composición química natural única. Además, es frecuente que dentro de una masa de agua subterránea se observen variaciones espaciales de los niveles de referencia. Con todo, es posible definir la horquilla de valores para cada parámetro y para cada tipo de acuífero.

Para la identificación de los niveles de referencia, los Estados miembros son libres de aplicar su propio enfoque, dependiendo de los estudios existentes y los modelos conceptuales de las aguas subterráneas. El proyecto BRIDGE ofrece una metodología para el cálculo de los niveles de referencia que puede aplicarse a todas las sustancias, tanto aquellas de origen puramente antropogénico –derivado de la actividad humana- como las que ocurren tanto de modo natural como derivadas de la actividad humana. Cuando los conocimientos existentes sean demasiado escasos, se propone un enfoque sencillo que utiliza tipologías de acuíferos como punto de partida para el establecimiento de los niveles de referencia.[14]

2.4 Concentraciones por debajo del límite de cuantificación

El tratamiento de los valores que están por debajo del límite de cuantificación (LC) requiere una atención especial cuando se comparan los datos dentro de una zona o en un plazo de tiempo. La DAS establece procedimientos específicos para la evaluación del estado químico y para la evaluación de las tendencias y de la inversión de la tendencia.

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[11] Guidance Document No. 12: The Role of Wetlands in the Water Framework Directive (2003)

[12] Pauwels *et al* (2006)

[13] Edmunds *et* Shand (2003); Pauwels *et al*., (2006)

[14] Müller *et al* (2006)

Del mismo modo, deberían tenerse en cuenta y aplicarse las disposiciones de la Directiva de la Comisión QA/QC, en particular el artículo 5.[15]

2.4.1 Evaluación del estado químico

Para la evaluación del estado químico, se recomienda que todas los valores registrados inferiores al límite de cuantificación se sustituyan por valores iguales a la mitad del LC (LC/2) excepto para los plaguicidas totales, de conformidad con el artículo 5 del Proyecto de Decisión de la Comisión QA/QC. Para los plaguicidas totales, la nota al pie (2) del anexo I de la DAS especifica que: *Se entiende por "total" la suma de todos los plaguicidas concretos detectados y cuantificados* […]" lo que significa que al calcular la suma sólo deben considerarse las concentraciones cuantificadas, y no los valores por debajo del límite de cuantificación.

2.4.2 Evaluación de tendencias

En la evaluación de tendencias, las concentraciones de parámetros individuales inferiores al LC deberían sustituirse por la mitad del valor del LC más elevado registrado en la serie temporal que sea objeto del análisis (anexo IV A, 2d) de la masa de agua subterránea. Este requisito reconoce que los límites de cuantificación pueden variar a lo largo del tiempo y pueden producir sesgos en la evaluación de tendencias.

La excepción es "plaguicidas totales", en cuya evaluación solo deberían considerarse concentraciones cuantificadas, porque el uso de la norma de sustitución podría dar lugar a un sesgo. Así pues, "plaguicidas totales" debe ser la suma de todos los plaguicidas individuales, incluyendo los metabolitos pertinentes, los productos de degradación y de reacción que se detecten y cuantifiquen (anexo I de la DAS, 1 (nota al pie)).

Además de los requisitos anteriores, para no introducir tendencias artificiales, todos los valores inferiores al LC más elevado deberían sustituirse por ese LC/2. Si las series temporales son suficientemente largas, los Estados miembros deberían decidir si suprimen los datos antiguos -datos consecutivos antiguos y no mediciones separadas dentro de la serie temporal- que presenten LC elevados. Esto garantizaría que se sustituyera por los LC/2 más altos un número inferior de datos medidos, para no perder de este modo información valiosa.

Si en una serie temporal la proporción de valores inferiores al LC es elevada, se puede producir un sesgo importante en la evaluación. En esta situación, no debería llevarse a cabo el test de tendencia si se considera que la influencia de los valores por debajo del LC es demasiado significativa[16].

***Nota:** En el futuro tal vez puedan utilizarse concentraciones por debajo del LC en la evaluación de tendencias. No obstante, estos datos no están disponibles en muchos casos, y se considera que su uso rutinario plantea dificultades. A la luz de los progresos científicos y técnicos del futuro, la DAS puede ser objeto de modificaciones, de conformidad con el artículo 8.*

2.5 Informes (Reporting)

El anexo V de la DMA y la DAS especifican cómo tienen que informar los Estados miembros en los planes hidrológicos de cuenca sobre el estado químico y cuantitativo y las tendencias. La información que debe figurar en los informes es la siguiente:

- valores umbral y un resumen de la metodología utilizada para determinarlos. Esto debe tener en cuenta los requisitos del artículo 3.5 y del anexo II Parte C de la DAS. El establecimiento de valores umbral de las aguas subterráneas debe considerar como mínimo la lista de sustancias que figura en el anexo II Parte B de la DAS.
- los resultados del estado químico y la metodología utilizada para clasificar las masas de agua subterránea de conformidad con el anexo V 2.5 de la DMA.

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[15] Proyecto de Directiva de la Comisión de (día, mes, 2009) que establece, de conformidad con la Directiva 2000/60/CE del Parlamento europeo y el Consejo, especificaciones técnicas para el análisis químico y el seguimiento del estado de las aguas (Directiva QA/QC) 10575/08 ENV 365.

[16] Technical Report No. 1: Aspectos estadísticos de la identificación de las tendencias a la contaminación de las aguas subterráneas y agregación de los resultados del seguimiento – WG 2.8 Estadísticas (2001)

- los resultados de la evaluación de tendencias y de la inversión de la tendencia y la metodología utilizada, de conformidad con el artículo 5.4, 5.5 y el anexo IV, Parte A, punto 3, de la DAS. El anexo V 2.4.5 exige que figure en los mapas que presentan el estado químico de la masa de agua subterránea la indicación de las tendencias y la inversión de la tendencia con sus códigos de color.

Todos los requisitos en materia de informes se consideran dentro de la serie de "*Reporting Sheets*", que desarrolló el grupo de trabajo D (Informes, Reporting en su acepción en inglés). Los informes sobre el primer plan hidrológico de cuenca deben presentarse en 2010.

Para las masas de agua transfronterizas se solicita información sobre las medidas adoptadas para coordinar el establecimiento de los valores umbral, la evaluación de estado y la evaluación de tendencias para las aguas subterráneas transfronterizas.

2.5.1 Valores umbral de las aguas subterráneas

Los Estados miembros pueden establecer varios valores umbral para cada MAS y/o cada parámetro, dependiendo de los receptores que estén en riesgo (aguas superficiales, ETDAS, usos…)

Tal como exige el artículo 3.5 de la DAS, los valores umbral deben establecerse por primera vez el 22 de diciembre de 2008, y publicarse en los planes hidrológicos de cuenca. De conformidad con el anexo II Parte C de la DAS, los Estados miembros realizarán un resumen del modo en que han llevado a cabo el procedimiento establecido en la Parte A del anexo II de la DAS, incluyendo, cuando resulte factible:

- información sobre el número de masas o grupos de masas de agua subterránea caracterizadas en riesgo, y sobre los contaminantes e indicadores de contaminación que contribuyen a tal clasificación;
- relación entre las masas de agua subterránea y las aguas superficiales asociadas o los ecosistemas terrestres directamente dependientes (ETDAS);
- valores umbral (VU) para cada parámetro e indicador de los contaminantes que contribuyen a la clasificación de riesgo y nivel al que se aplican los VU -masa de agua subterránea, demarcación hidrográfica, parte de la demarcación hidrográfica internacional, territorio del Estado miembro-;
- relación entre los valores umbral y niveles de referencia para los parámetros presentes de forma natural; y
- relación entre los valores umbral y los objetivos de calidad medioambiental y otras normas.

Los Estados miembros proporcionarán la información y los valores respectivos -valores umbral medioambientales y/o valores umbral de uso, dependiendo de los receptores-, de conformidad con las respectivas "*Reporting Sheets*" de la DMA.

2.5.2 Estado de la masa de agua subterránea

De conformidad con el anexo V de la DMA, los Estados miembros deben proporcionar mapas con códigos de colores en los planes hidrológicos de cuenca, que muestren el estado cuantitativo y químico para cada MAS. El color verde indica un buen estado y el color rojo indica un mal estado.

El anexo III.5 de la DMA establece que los Estados miembros no sólo deben elaborar mapas de conformidad con las secciones 2.4.5 y 2.5 del anexo V de la DMA sino que "…*además indicarán en esos mapas todos los puntos de control en los que se han excedido las normas de calidad para las aguas subterráneas y/o los valores umbral, siempre que sea pertinente y factible*."

Conviene reseñar que no todos los valores umbral son relevantes en todos los puntos de control, dependiendo de los receptores y de su ubicación en la MAS. Se propone por ello indicar en el mapa sólo los puntos de control en los que se ha superado el valor umbral pertinente más estricto, sin necesidad de incluir aquellos puntos de control en los que no se haya determinado un valor umbral, o el valor umbral no se haya excedido.

Este procedimiento estaría en consonancia la DAS, que dispone que *"se indiquen los casos en los que se ha superado… siempre que resulte pertinente y factible"*, y dirigiría la atención hacia los problemas específicos de cada masa de agua subterránea.

De acuerdo con el artículo 4.4 de la DAS, debe publicarse en los planes hidrológicos de cuenca un resumen de la evaluación del estado químico de las aguas subterráneas. Este resumen debe incluir una explicación sobre cómo la evaluación final se refiere a los incumplimientos de las normas de calidad de las aguas subterráneas o de los valores umbral registrados en las diferentes estaciones de control.

2.5.3 Evaluación de tendencias

De conformidad con el anexo V, 2.5 y 2.4.5, los resultados de la evaluación de tendencias y de la inversión de la tendencia deben reflejarse en un mapa. Las MAS que experimentan una tendencia significativa y sostenida al aumento de las concentraciones de cualquier contaminante como resultado del impacto de la actividad humana, deben indicarse en el mapa con un punto negro. Cuando se ha logrado la inversión de una tendencia ascendente debe indicarse mediante un punto azul.

Tal como establece el artículo 5(4) de la DAS, y de conformidad con el artículo 13 de la DMA y el artículo 5(5) de la DAS, el resumen que los Estados miembros deben publicar en los PHC debe indicar asimismo:

- de qué modo ha contribuido la evaluación de tendencias en los puntos de control dentro de una masa o de un grupo de masas de agua subterránea a identificar que las masas citadas están sujetas a una tendencia significativa y sostenida al aumento o a una inversión de esa tendencia; y
- la justificación de los puntos de partida definidos para la aplicación de las medidas de inversión de la tendencia, y
- cuando proceda, los resultados de la evaluación de los impactos de los penachos existentes, en particular la verificación por medio de evaluaciones de tendencia adicionales, de que los penachos existentes de suelos contaminados no se extienden, no deterioran el estado químico de las masas de agua subterránea y no presentan un riesgo para la salud humana y el medio ambiente.

3 EVALUACIÓN DEL ESTADO

De conformidad con la DAS, la evaluación del estado sólo debe llevarse a cabo en masas de agua subterránea que se hayan identificado como masas en riesgo y en relación con el receptor y cada uno de los contaminantes que contribuyen a esa caracterización de la masa de agua subterránea (anexo III, 1). Las MAS que no están en riesgo se clasifican automáticamente como masas en buen estado.

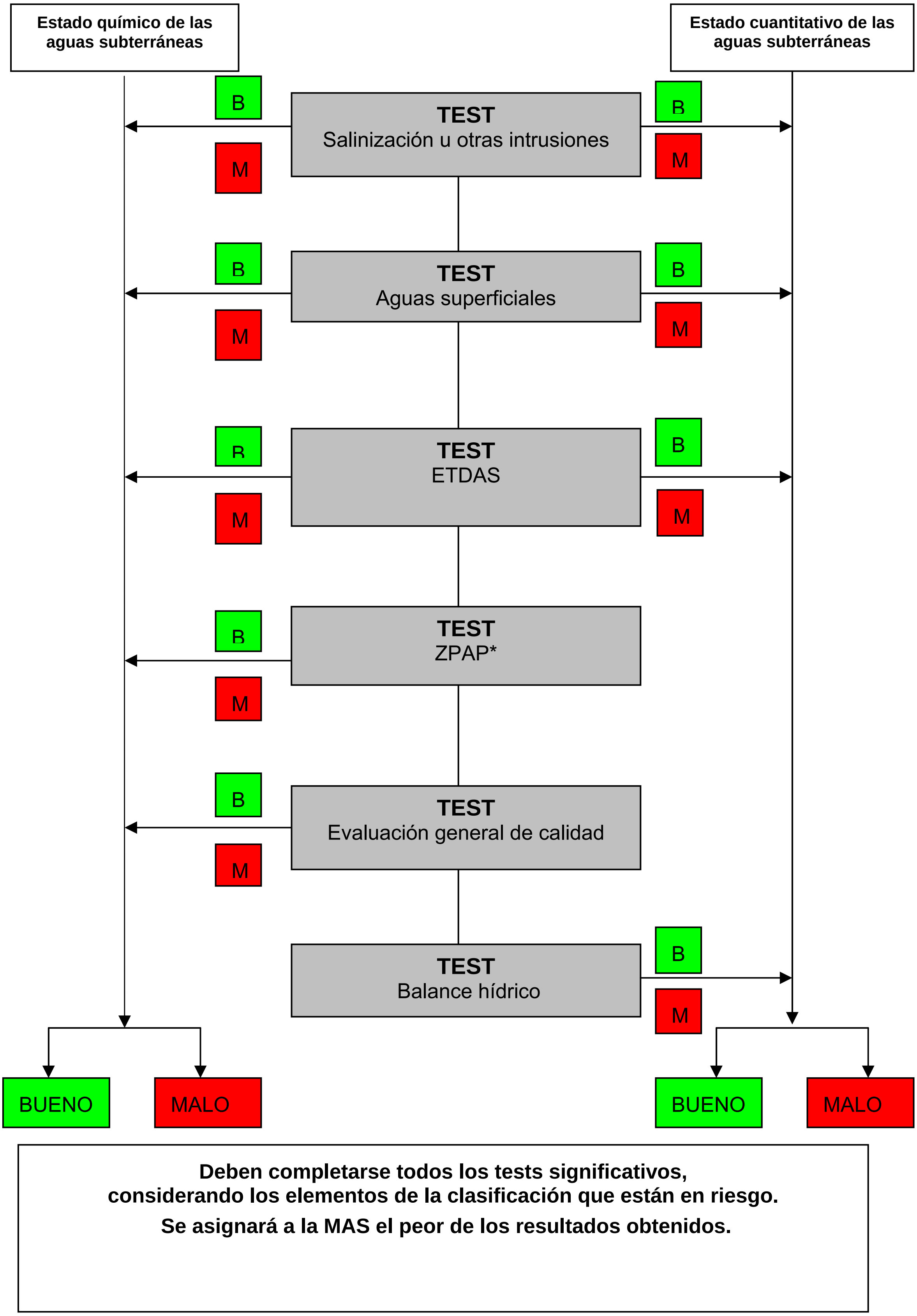
La evaluación del estado se lleva a cabo utilizando los datos de control operativo y de vigilancia disponibles recogidos durante el periodo del PHC. Debe producirse al final del PHC, para que permita evaluar la eficacia de los programas de medidas adoptados previamente.

El mapa que muestra los resultados de la evaluación del estado de las aguas subterráneas es parte integral del PHC. El proyecto de PHC se somete a participación pública un año antes de ser operativo, por lo que se recomienda que se realice una evaluación del estado antes de la publicación del proyecto de PHC para que puedan incluirse los resultados/mapas.

3.1 Tests de clasificación

Alcanzar un buen estado de las aguas subterráneas implica el cumplimiento de una serie de condiciones que se definen en las directivas DMA y DAS. Para evaluar si esas condiciones se cumplen, se ha desarrollado una serie de tests de clasificación para el estado cuantitativo y químico, que se ilustran en la Figura 1. Existen cinco tests químicos y cuatro cuantitativos con algunos elementos comunes a los dos tipos de evaluaciones. Cada uno de los tests, considerando los elementos de clasificación que estén en riesgo, debe llevarse a cabo de modo independiente y los resultados combinados deben aportar una evaluación global del estado químico y cuantitativo de la masa de agua subterránea (véase el capítulo 4.4 y la figura 4).

El peor resultado en la clasificación resultante de los tests químicos se establece como el estado químico global de la masa de agua subterránea, y el peor resultado de clasificación de los tests cuantitativos se establece como el estado cuantitativo global de la masa de agua subterránea. Si alguno de los tests da como resultado un mal estado químico o cuantitativo entonces la clasificación general de la masa será mala. Todos los tests pertinentes deben llevarse a cabo en todas las masas de agua subterránea. El proceso de evaluación del estado no debe detenerse aunque el resultado de uno de los tests indique el mal estado de la masa de agua subterránea.



* ZPAP: Zonas protegidas para la captación de agua potable

Figura 1: Procedimiento global para los tests de clasificación para la evaluación del estado de las aguas subterráneas

3.2 Evaluación de riesgo frente a evaluación de estado

Debe diferenciarse claramente la validación del análisis de presiones e impactos -evaluación del riesgo- del artículo 5 de la DMA al comienzo del ciclo de un PHC, de la evaluación del estado de una masa de agua subterránea al final del ciclo de un PHC -evaluación del cumplimiento-.

Al principio de cada ciclo, la evaluación del riesgo tiene en cuenta las presiones y los impactos, y lleva a cabo una estimación del estado en el que se encontrará la MAS al final del ciclo. Esta estimación se convalida con los datos de control recientes procedentes del control de vigilancia y con cualquier otra evaluación de tendencia que se considere adecuada. Si no puede confirmarse que una masa de agua subterránea estará en buen estado al final de un ciclo PHC, será necesaria una caracterización adicional, así como el establecimiento de valores umbral, seguimiento operativo y un programa de medidas.

Los valores umbral y los programas de medidas están sujetos a informes dentro del PHC. Al final de cada PHC, deberá llevarse a cabo una clasificación del estado para evaluar si la masa de agua subterránea se halla en buen estado y el programa de medidas ha sido efectivo.

Es posible que las dos evaluaciones -evaluación del riesgo y evaluación del estado- se lleven a cabo prácticamente a la vez, pero son procesos paralelos separados; la evaluación del riesgo se centra en el futuro, hacia el final del próximo ciclo del PHC, y la evaluación del estado es retroactiva, referida a los resultados obtenidos durante el último ciclo del PHC (véase la figura 2).

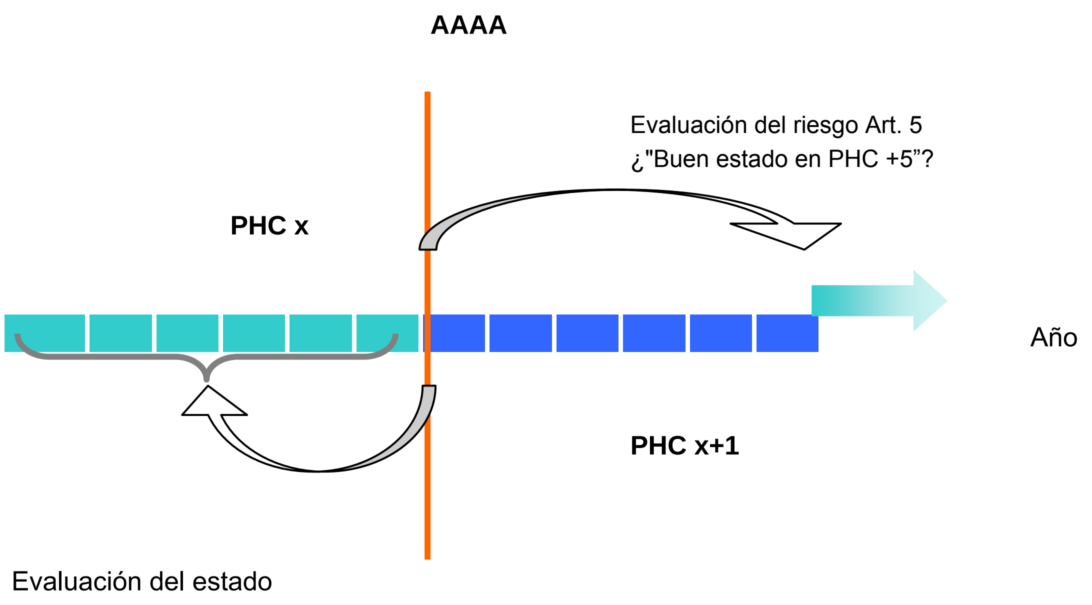


Figura 2. La evaluación de riesgo se centra en el futuro, mientras que la evaluación del estado se basa en los resultados anteriores.

3.3 Confianza en la evaluación

De conformidad con el anexo V 2.4.1 de la DMA *"[…] En el plan se ofrecerá una apreciación del nivel de fiabilidad y precisión de los resultados obtenidos mediante los programas de control."*

4 EVALUACIÓN DEL ESTADO QUÍMICO

4.1 Definición de buen estado químico y fundamentos legales

La definición del estado químico figura en el anexo V 2.3.2 de la DMA. Se alcanza un buen estado químico de las aguas subterráneas cuando:

"*La composición química de la masa de agua subterránea es tal que las concentraciones de contaminantes:*

- *como se especifica más adelante, no muestran los efectos de la salinización o de otras intrusiones,*
- *no exceden las normas de calidad aplicables según otros actos de la legislación comunitaria, de conformidad con el artículo 17 de la DMA*[17]
- *su naturaleza no es tal que pueda producir la imposibilidad de lograr los objetivos ambientales especificados de conformidad con el artículo 4 para las aguas superficiales asociadas ni ninguna disminución significativa de la calidad ecológica o química de estas masas ni ningún daño significativo a los ecosistemas terrestres que dependen directamente de la masa de agua subterránea.*

Los cambios en la conductividad no indican que exista salinización ni ninguna otra intrusión en la masa de agua subterránea".

La DAS reitera que la evaluación del estado químico debe llevarse a cabo para todas las masas de agua subterránea que estén en riesgo de no cumplir los objetivos del artículo 4 de la DMA, en relación con cada uno de los contaminantes que contribuyen a esa caracterización de la masa de agua subterránea (anexo III, 1 de la DAS). Esto se aplica a aquellas MAS que se identificaron en 2004 como masas en riesgo, de conformidad con los requisitos del artículo 5 de la DMA, así como cualquier otra que se identificara con posterioridad a raíz del trabajo de actualización de la evaluación de riesgo utilizando los nuevos datos de seguimiento. El artículo 4(2) de la DAS dispone que una masa de agua subterránea o un grupo de masas tiene un buen estado químico cuando:

- cumple las condiciones del anexo V 2.3.2 de la DMA,
- no excede ningún valor umbral (artículo 3 y anexo II de la DAS) ni norma de calidad (anexo I de la DAS) en ninguno de los puntos de control, o
- aunque ha excedido el valor umbral o la norma de calidad en alguno de los puntos de control, se ha demostrado mediante investigaciones adecuadas (anexo 3 de la DAS) que:
    - i. las concentraciones de contaminantes no presentan un riesgo medioambiental significativo, teniendo en cuenta, cuando proceda, el alcance de la masa de agua subterránea que se ve afectada;
    - ii. se cumplen las demás condiciones para un buen estado que figuran en el anexo V 2.3.2 (DMA), con arreglo al párrafo 4 del anexo III de la DAS;
    - iii. no hay deterioro de la calidad de las aguas para consumo humano (ZPAP) de conformidad con el párrafo 4 del anexo III de la DAS; y
    - iv. no hay deterioro significativo de la capacidad de la masa para atender los diferentes usos.

El anexo V, 2.4.5 de la DMA estipula las especificaciones siguientes para el procedimiento de evaluación del estado químico de las aguas subterráneas:

"Al evaluar el estado, los resultados de cada punto de control en una masa de agua subterránea se globalizarán para la totalidad de la masa. Sin perjuicio de las Directivas correspondientes, para que una masa de agua subterránea alcance un buen estado, en lo referente a los parámetros químicos para los que se han fijado normas de calidad medioambiental en la legislación comunitaria:

– *se calculará el valor promedio de los resultados del control obtenidos en cada punto de la masa o grupo de masas, y*

[17] Esto corresponde al requisito de la DMA que condujo a la adopción de la DAS

– *de acuerdo con el artículo 17, dichos valores promedio se utilizarán para demostrar la conformidad con el buen estado químico de las aguas subterráneas […]"*

La DAS dispone a continuación que de conformidad con el anexo III 2 c): *"Los Estados miembros deberán tener en cuenta […] c) cualquier otra información relevante, incluida una comparación de la concentración media anual de los contaminantes pertinentes en un punto de control con las normas de calidad de las aguas subterráneas […] y con los valores umbral […]."*

De conformidad con el anexo III, 3 de la DAS, en cuanto a i) y a iv) los Estados miembros efectuarán una estimación de la porción de la masa de agua subterránea cuya concentración media anual de un contaminante supera la norma de calidad o el valor umbral.

En lo relativo a ii) e iii), los Estados miembros evaluarán:

- el impacto de los contaminantes sobre la masa de agua subterránea
- la cantidad y las concentraciones de contaminantes que se están transfiriendo o pueden transferirse desde la masa de agua subterránea hacia las aguas superficiales asociadas o los ecosistemas terrestres directamente dependientes, y los posibles impactos resultantes
- el alcance de toda posible salinización o intrusión de otro tipo en la masa de agua subterránea
- los riesgos derivados de los contaminantes en la masa de agua subterránea para la calidad del agua captada o que pueda ser captada para el consumo humano

Los tests de clasificación química que se indican en esta guía se derivan de los requisitos mencionados con anterioridad.

4.2 Elementos de la evaluación del estado químico

En la evaluación del estado químico de las aguas subterráneas deben considerarse los siguientes elementos:

- **los criterios** para la evaluación del estado químico de las aguas subterráneas -*normas de calidad y valores umbral-* que se describen con detalle en la sección 4.3.
- la necesidad de **agregación** de los datos
- **el alcance** del incumplimiento de las normas de calidad o de los valores umbral
- **la localización** de los puntos donde se han superado las normas de calidad o los valores umbral
- **la confianza** en la evaluación

4.2.1 Agregación de los datos

Como se ha reseñado anteriormente, varios artículos y anexos de las Directivas DMA y DAS hacen referencia a la agregación de los datos. Se trata de la evaluación de los siguientes aspectos:

- los riesgos ambientales significativos derivados de los contaminantes presentes en una masa de agua subterránea,
- que no exista deterioro significativo de los diferentes usos,
- la disminución de la calidad ecológica y química de las masas de aguas superficiales asociadas,
- los daños a las ETDAS,
- que no haya deterioro de las aguas para el consumo humano.

Se propone adoptar la norma de considerar los datos de control recogidos en los dos últimos años, lo que posibilita el cálculo de un valor medio aunque solo se realice una medición al año. Puede elegirse un periodo medio más largo -hasta de 6 años- cuando el modelo conceptual y los datos de control indiquen que es necesario evitar la influencia de las variaciones de calidad a corto plazo, que no indican la repercusión real de las presiones.

4.2.2 Alcance del incumplimiento de las normas de calidad o de los valores umbral

De conformidad con el artículo 4 de la DAS, una masa de agua subterránea está en buen estado cuando no se superan las normas de calidad o los valores umbral en ninguna de las estaciones de control. En el caso de que se haya excedido una norma de calidad o valor umbral en una o varias estaciones de control, es necesaria una investigación adecuada que integre de manera apropiada los datos de control, para efectuar una estimación del alcance en la MAS -en términos de volumen o porción de territorio- cuya concentración media aritmética de un contaminante supera la norma de calidad o el valor umbral. Se trata de evaluar:

- los riesgos medioambientales significativos producidos por los contaminantes presentes en toda la masa de agua subterránea
- que no exista un deterioro significativo de los usos humanos,
- la salinización y otras intrusiones.

Para que la investigación o investigaciones adecuadas se desarrollen satisfactoriamente, podrán utilizarse datos adicionales, para afinar el modelo conceptual y/o valorar el alcance del citado incumplimiento.

4.2.3 Situación de los puntos donde se han superado las normas de calidad o los valores umbral

Algunos de los criterios para la evaluación del estado también se basan en la evaluación del impacto a escala local, que puede no ser representativo de las condiciones que se dan en toda la masa de agua subterránea. En esos casos, la ubicación de los puntos donde se han excedido las normas de calidad o los valores umbral será pertinente para determinar si se han cumplido las condiciones para un buen estado. Esto hace referencia a la evaluación de:

- la disminución de la calidad ecológica y química de las masas de agua superficial asociadas,
- los daños a los ETDAS,
- la salinización y otras intrusiones,
- el que no exista deterioro del agua para consumo humano.

En lo relativo a la protección de los ecosistemas terrestres y acuáticos dependientes, los Estados miembros evaluarán, cuando sea necesario y pertinente, las cantidades y las concentraciones de los contaminantes que se estén transfiriendo o puedan transferirse desde la masa de agua subterránea a las aguas superficiales asociadas o ETDAS [anexo III, 4 b)] y el posible impacto de los contaminantes transferidos [anexo III, 4 c)].

La evaluación de toda salinización o intrusión de otro tipo en la masa de agua subterránea está vinculada a la identificación de las zonas en las que existe presión producida por la captación de agua, y con los efectos que aparecen en los puntos de control, en relación con las tendencias al aumento de las concentraciones de contaminantes pertinentes y los impactos significativos en los puntos de captación.

4.3 Normas de calidad y valores umbral de las aguas subterráneas

4.3.1 Fundamentos y requisitos específicos

El artículo 3 de la DAS establece los criterios para la evaluación del estado químico de las aguas subterráneas:

“1. A efectos de la evaluación del estado químico de una masa de agua subterránea [….] los Estados miembros utilizarán los criterios siguientes:

(a) las *normas de calidad de las aguas subterráneas recogidas en el Anexo I;*

(b) Los valores umbral que establezcan los Estados miembros de conformidad con el procedimiento descrito en la parte A del Anexo II […]”.

Además, entre los criterios de evaluación del estado químico se incluye una investigación adecuada cada vez que se haya excedido una norma de calidad de las aguas subterráneas o un valor umbral, tal como se establece en el Anexo III de la Directiva de aguas subterráneas.

Las normas de calidad de las aguas subterráneas se refieren a nitratos y plaguicidas. Los valores para las normas citadas se muestran en la tabla 1.

Tabla 1. Normas de calidad de las aguas subterráneas (DAS, anexo I).

Contaminante	***Norma de calidad***
Nitratos	50 mg/L
Sustancias activas de los plaguicidas, incluyendo los metabolitos relevantes y los productos de degradación y de reacción	0.1µg/L 0.5 µg/L (total)

No obstante, si estas normas no son adecuadas para el logro de los objetivos medioambientales enunciados en el artículo 4 de la DMA, es decir, si se observa que el estado químico y/o el estado ecológico de las aguas superficiales asociadas y/o los ecosistemas terrestres asociados han sufrido algún daño real o potencial, deben aplicarse valores más exigentes[18]. Estos nuevos valores se transforman en valores umbral y el procedimiento para su definición se atiene a los requisitos del artículo 3 y del Anexo II de la DAS y a las especificaciones descritas en este documento.

El artículo 3.1.b de la DAS exige a los Estados miembros la determinación de valores umbral con respecto a otros parámetros pertinentes que están generando un riesgo de incumplimiento de los objetivos del artículo 4 de la DMA. Tal como se define en el artículo 2.2, los valores umbral en cuestión se convertirán en normas de calidad definidas por los Estados miembros. Estas normas deben fijarse a la escala más adecuada -nacional, por demarcación hidrográfica, o por masa de agua subterránea- y deben utilizarse en la evaluación del buen estado químico. Los Estados miembros deben tener en cuenta como mínimo la lista de sustancias del anexo II.B que son:

- Sustancias, o iones, o indicadores, que pueden estar presentes de modo natural y/o como resultado de las actividades humanas: As, Cd, Pb, Hg, NH_4^+, Cl^-, SO_4^{2-}
- Sustancias sintéticas artificiales: tricloroetileno, tetracloroetileno
- Parámetros indicativos de salinización o de otras intrusiones: conductividad o Cl^- y SO_4^{2-}, a elección de los Estados miembros.

Nota*:* "Teniendo en cuenta…" no significa que la determinación de valores umbral para todos los parámetros del anexo II.B sea obligatoria. Es obligatorio asignar valores umbral para otras sustancias/parámetros que no están en la lista, pero que contribuyen a que la masa de agua subterránea esté en riesgo.

Criterios para la determinación de valores umbral

Según el Anexo II.A de la DAS, *"la determinación de valores umbral debería basarse en:*

a) el alcance de las interacciones entre las aguas subterráneas y los ecosistemas acuáticos y ecosistemas terrestres dependientes;

b) la interferencia con usos o funciones existentes o futuros de las aguas subterráneas;

[…]

c) Las características hidrogeológicas, incluida la información sobre niveles de referencia".

Asimismo, según el Anexo II.A de la DAS *"se establecerán valores umbral de tal modo que […] ello indique el riesgo de que no se estén cumpliendo algunas de las condiciones para el buen estado químico del agua subterránea mencionadas en los incisos ii), iii) y iv) de la letra c) del apartado 2 del artículo 4".* Este requisito se refiere a los aspectos siguientes:

- la definición de buen estado químico del agua subterránea (DMA, anexo V, sección 2.3.2). Véase la sección 4.1 de este documento.

- las áreas protegidas utilizadas para la captación de agua potable (artículo 7 de la DMA),

- la capacidad de la masa de agua subterránea de soportar usos humanos.

Basándose en estos elementos, la determinación de valores umbral debe considerar dos tipos de criterios:

[18] Un ejemplo típico es cuando se demuestra que la existencia de nitratos en valores inferiores a 50 mg/L en las aguas subterráneas es causa de eutrofización en una masa de agua superficial asociada, lo cual justifica el establecimiento de un valor umbral más bajo para los nitratos.

- *criterios medioambientales*
  - valores umbral cuyo fin es la protección de los ecosistemas acuáticos asociados y de los ecosistemas terrestres dependientes,
- *criterios de uso*
  - valores umbral cuyo fin es la protección de las zonas protegidas para la captación de agua potable (ZPAP), y
  - otros usos legítimos de las aguas subterráneas: cultivos, regadío, industria, etc. Solamente deben tenerse en cuenta los usos localizados en una porción significativa de la masa de agua subterránea en relación a la superficie total o al volumen total de la misma.

Nota: Estos criterios consideran el nivel mínimo de protección del receptor de conformidad con los requisitos de la DAS. Los Estados miembros pueden optar adicionalmente por considerar que "las aguas subterráneas" son una función legítima a proteger por derecho propio y establecer valores umbral con este fin. No obstante, es obvio que no están obligados a hacerlo.

Escala para el establecimiento de valores umbral

Dependiendo del tipo de contaminante y de las concentraciones registradas, los Estados miembros pueden establecer valores umbral a distintas escalas: masa de agua subterránea o grupo de masas de agua subterránea, demarcación hidrográfica, o a escala estatal (articulo 3.2). La masa de agua subterránea es la escala más pequeña permitida para la determinación de valores umbral.

Por ejemplo, cuando un contaminante tal como el tricloroetileno se detecta con mucha frecuencia en valores muy bajos, los Estados miembros pueden establecer un valor umbral de ámbito estatal, a condición de no poner en peligro el logro de los objetivos medioambientales. Alternativamente, cuando se trata de parámetros para los cuales las concentraciones naturales varían de un tipo de masa de agua subterránea a otro -As, Cl, SO_4^{2-}, NH_4^+ y metales[19] -, se recomienda encarecidamente que los valores umbral se definan en el ámbito de la masa de agua subterránea.

Aspectos transfronterizos

Los Estados miembros que comparten masas de agua transfronterizas velarán por que la determinación de valores umbral se someta a la coordinación entre los Estados miembros afectados (artículo 3.3 de la DAS).

Para las masas de aguas subterráneas compartidas entre uno o más Estados miembros y uno o más Estados que no son miembros, el Estado(s) afectado(s) se comprometerán a que los valores umbral se determinen de modo coordinado con los Estados afectados que no sean miembros (artículo 3.4 de la DAS).

Calendario y revisión

Los Estados miembros deben establecer valores umbral por primera vez el 22 de diciembre de 2008 (artículo 3.5 de la DAS), y publicarlos en el primer PHC a más tardar el 22 de diciembre de 2009 (artículo 13 de la DMA).

No obstante, la determinación de valores umbral es un proceso abierto, y los Estados miembros podrán añadir, retirar o reintroducir valores umbral para cualquier sustancia siempre que sea necesario (artículo 3.6 de la DAS). Los cambios estarán en función de la disponibilidad de "nueva información" sobre los parámetros basada en los nuevos conocimientos y comprensión científica. Estos cambios deben comunicarse en el contexto de la revisión periódica de los PHC.

Asimismo, los Estados miembros podrán retirar un valor umbral de la lista cuando la masa de agua subterránea afectada deje de estar en riesgo para el parámetro en cuestión.

4.3.2 Relación entre los valores umbral (artículo 3) y el objetivo de "evitar o limitar" (artículo 6)

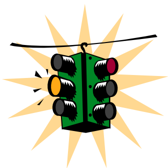
El objetivo de 'evitar o limitar' presente en la DMA y la DAS, protege a todas las aguas subterráneas frente a entradas inaceptables de contaminantes. Evitar o limitar la entrada de contaminantes en las

[19] Pauwels *et al* (2006)

aguas subterráneas protege a una gama amplia de receptores y preserva a las aguas subterráneas de la contaminación de ámbito local.

Los requisitos en materia de buen estado químico son diferentes. La evaluación del buen estado químico se lleva a cabo sobre **toda la masa de agua subterránea,** lo que en muchos casos implica una zona extensa. La evaluación se lleva a cabo una vez en cada periodo del PHC, es decir, cada seis años, y aporta información sobre el estado actual de las masas de agua subterránea. Esta evaluación nos dice si esa masa de agua subterránea se atiene a la definición de buen estado químico formulada en la DMA/DAS. Esta definición se limita únicamente a unos pocos receptores y a circunstancias específicas. Alcanzar un buen estado químico no siempre protege la calidad de las aguas subterráneas en el ámbito local.

La entrada de un contaminante debe desplazarse físicamente a lo largo del sistema de agua subterránea para afectar a un receptor. Este movimiento varía dependiendo de las características físicas y químicas de los estratos geológicos. Y, lo que es más importante, el contaminante puede estar sometido a dilución y atenuación durante el tránsito en el acuífero hacia un receptor. Por este motivo, muchas entradas sólo tienen efectos localizados. Estas entradas pueden desencadenar una contaminación localizada de las aguas subterráneas, aunque no afectan al estado de la masa de agua subterránea cuando su impacto sobre los receptores recogidos en la definición de buen estado químico de las aguas subterráneas es leve o nulo. De conformidad con la DMA/DAS, una masa de agua subterránea que se encuentre en un buen estado químico puede sufrir contaminación localizada. **No obstante, cuanto más extendida está la contaminación, más aumenta la posibilidad de que la masa de agua subterránea no se encuentre en buen estado. En caso de que exista una contaminación localizada de este tipo, los Estados miembros deben llevar a cabo investigaciones y adoptar medidas para limitar la contaminación, aunque el estado global de la masa de agua subterránea sea bueno. Estas medidas deberán adaptarse a lo dispuesto en el artículo 6 de la DAS (evitar y limitar entradas).**



¡Atención! En principio, las medidas para evitar o limitar son la primera línea de defensa para impedir entradas inaceptables de contaminantes a todas las aguas subterráneas y evitar con ello la contaminación. La aplicación efectiva del objetivo de ‘evitar o limitar’ por medio de la reglamentación existente debería garantizar la protección de la calidad de las aguas subterráneas. Esta reglamentación puede consistir en permisos, normas generales vinculantes o códigos de buenas prácticas para el control de actividades específicas en la superficie. Las condiciones de las permisos y/o los “valores límite” pueden utilizarse para garantizar que no se produzca ninguna entrada inaceptable de contaminantes en las aguas subterráneas. Es necesario un cierto tiempo para permitir que se degrade o se disperse el legado histórico de vertidos anteriores. Pero aparte de este hecho, si en todos los puntos de una masa de agua se cumplieran todos los requisitos de evitar y limitar, su estado químico sería bueno. **Así pues, los requisitos de ‘evitar o limitar’ y los requisitos de estado son complementarios, y utilizados conjuntamente proporcionan un marco efectivo para la protección de las aguas subterráneas en toda la Unión Europea. (ver la Guía CIS N°17[20]).**

Los valores umbral que se describen en esta guía ayudarán a evaluar el buen estado químico, aunque muchas veces estos valores -y el régimen de cumplimiento que va a asociado a ellos- no serán apropiados para cumplir los requisitos del objetivo de evitar o limitar. Esto se debe a que no protegen las aguas subterráneas de la contaminación a escala local.

El Documento guía sobre “Entradas directas e indirectas” (“*Direct and Indirect Inputs”*) contiene más información sobre el modo de aplicar el objetivo de ‘evitar o limitar’; no obstante, parece conveniente resumir aquí los distintos fines y funciones de los valores límite y los valores umbral en la protección de las aguas subterráneas:

[20] Guidance Document No. 17 Preventing or Limiting Direct and Indirect Inputs (2007)

1. Definiciones

   Valor Umbral. Definido previamente en este documento. Los valores umbral se fijan para la protección de los receptores y para garantizar que se cumple con los requisitos de buen estado químico.

   Valor Criterio. Es la concentración de un contaminante, sin tomar en consideración concentraciones naturales de referencia, que, en caso de que sea superada, puede resultar en el incumplimiento del respectivo criterio de buen estado.

   Valor Límite. Es un valor de concentración y su régimen de cumplimiento asociado que, si no se exceden en la fuente, evitarán un vertido inaceptable a las aguas subterráneas. Son ejemplos de valores límite una concentración o carga inaceptables incorporadas como condición en una autorización o un objetivo de recuperación para suelos contaminados. Se mide en la fuente, es decir en el punto de vertido.

   Valor de Cumplimiento. Es la concentración y el régimen de cumplimiento asociado que impiden la contaminación siempre que no se superen en el punto de cumplimiento (PC). Se mide en el punto de control de prevención/limitación.

   Tanto los valores límite como los valores de cumplimiento se fijan para proteger la calidad de las aguas subterráneas en el ámbito local, en el contexto del objetivo de "evitar o limitar".

2. Escala de aplicación

   Los valores umbral que se determinan para cumplir los requisitos de los artículos 3 y 4 de la DAS no se aplican necesariamente en los mismos puntos de cumplimiento como valores de cumplimiento, que se describen en el Documento guía respectivo[20]. La evaluación del estado se lleva a cabo en estaciones de control de la red de control operativo, que están distribuidos por la masa de agua subterránea. Las entradas se evalúan localmente en la fuente de entrada de los puntos de control de evitar/limitar, que pueden ser reales o virtuales. Esto aporta una protección más inmediata y global de las "aguas subterráneas propiamente dichas" como receptor. Cabe destacar que, en algunos casos, el punto de control de evitar/limitar utilizado para evaluar el grado de aceptabilidad de la entrada, puede ser también un punto de control operativo que permite evaluar el estado, en cuyo caso el valor umbral será un valor de cumplimiento apropiado.

3. Localización de la aplicación

   Los valores umbral se aplican sólo a las masas de agua subterránea, mientras que los "valores de cumplimiento" establecidos para apoyar los objetivos de "evitar o limitar" se aplican a todas las aguas subterráneas. Pueden aplicarse valores de cumplimiento diferentes en diferentes puntos de cumplimiento. Por ejemplo, tanto el agua de depósitos de gravas de terrazas fluviales discontinuas, como el agua colgada sobre niveles de arcillas glaciares, es agua subterránea, y deben evitarse o limitarse las entradas de contaminantes para garantizar que no se produzca contaminación en ninguno de los receptores. No obstante, ninguno de estos depósitos geológicos son unidades de gestión y por ello tampoco son masas de agua subterránea. Por ello, su estado no tiene que clasificarse como bueno o malo, y no tienen que establecerse valores umbral para ellos.

4.3.3 Metodología general para la determinación de valores umbral

La metodología general para la determinación de los valores umbral en una masa de agua subterránea se resume en la figura 3.

Como se señala en la sección 4.3.1, cuando se determinen los valores umbral, deberán considerarse dos tipos de criterios: criterios medioambientales y criterios de uso.

Los Estados miembros establecerán el valor umbral medioambiental utilizando una comparación entre los niveles de referencia (NR) y el valor criterio (VC). El valor criterio es una concentración de un contaminante, que sin tener en cuenta ninguna concentración natural de referencia, en caso de ser superada puede resultar en el incumplimiento de uno o más de los criterios de buen estado. Los VC deben tener en cuenta la evaluación de riesgo y las funciones de las aguas subterráneas.

Cuando se comparan los niveles de referencia con los valores criterio pueden surgir dos situaciones:

- Caso 1: El NR es menor que el VCi. En ese caso, los Estados miembros definirán los valores umbral según sus estrategias nacionales y una evaluación de riesgo, permitiendo que se establezca un valor umbral por encima del nivel de referencia, siempre que pueda justificarse claramente.

- Caso 2: El NR es mayor que el VCi. En ese caso, el valor umbral debe ser igual al nivel de referencia.

No obstante, para integrar el concepto de desarrollo sostenible y permitir el desarrollo de actividades económicas -especialmente las actividades existentes-, los Estados miembros pueden considerar un *pequeño* añadido a los niveles de referencia que representa un grado aceptable de influencia humana, siempre que se considere que no daña la protección de los receptores pertinentes. Una concentración admisible de este tipo consideraría el requisito de "limitar las entradas" de contaminantes no peligrosos de conformidad con el artículo 6 de la DAS y también persigue evitar problemas no deseados en la verificación de cumplimiento, provocados por un gran número de pozos que presentan pequeñas desviaciones sin importancia de los valores umbral. Considerando que a menudo el criterio para la evaluación de los niveles de referencia será el percentil 90, se supone que al menos el 10% de los pozos de observación superarían lo permitido si el valor umbral se fijara exactamente en la concentración del nivel de referencia. Esto conduciría obligatoriamente a una 'investigación adecuada' de todas las masas de agua subterránea que se encontraran en el caso 2, algo que se ha considerado imposible de gestionar.

Los Estados miembros deben definir la concentración adicional admisible utilizando un procedimiento de evaluación de riesgos. En particular se recomienda que se tenga en cuenta la vulnerabilidad o susceptibilidad de la MAS, incluyendo las propiedades biogeoquímicas del suelo y las propiedades de los contaminantes. Una evaluación de este tipo dependerá del nivel de conocimiento y de la confianza en los modelos conceptuales. Cabe señalar que los Estados miembros pueden actualizar los valores umbral, de conformidad con las indicaciones formuladas en el capítulo 4.3.1 de esta guía. Así pues, puede que sea necesario ajustar la "concentración adicional admisible" como consecuencia de los cambios en los valores umbral teniendo en cuenta la información nueva, es decir, como resultado de los proyectos de investigación.

Además de consideraciones de tipo socio-económico, un valor umbral que contenga una cierta concentración que excede del nivel de referencia puede ser aceptable por motivos prácticos, entre otros la armonización con otras directivas, como la directiva sobre nitratos, la directiva de aguas potables o la directiva relativa a normas de calidad ambiental (2008/105/CE). No obstante, en todos los casos el valor umbral final **debe** proteger a todos los receptores, tanto los diferentes usos humanos como el estado ecológico de las aguas superficiales y los ETDAS. Además, la protección de las aguas subterráneas está garantizada también por la consecución de los objetivos del artículo 5 y 6 de la DAS. Estos exigen que los Estados miembros inviertan las tendencias significativas al aumento de los contaminantes y que limiten o impidan las entradas de contaminantes en las aguas subterráneas[21].

[21] Guidance Document No. 17 Preventing or Limiting Direct and Indirect Inputs (2007)

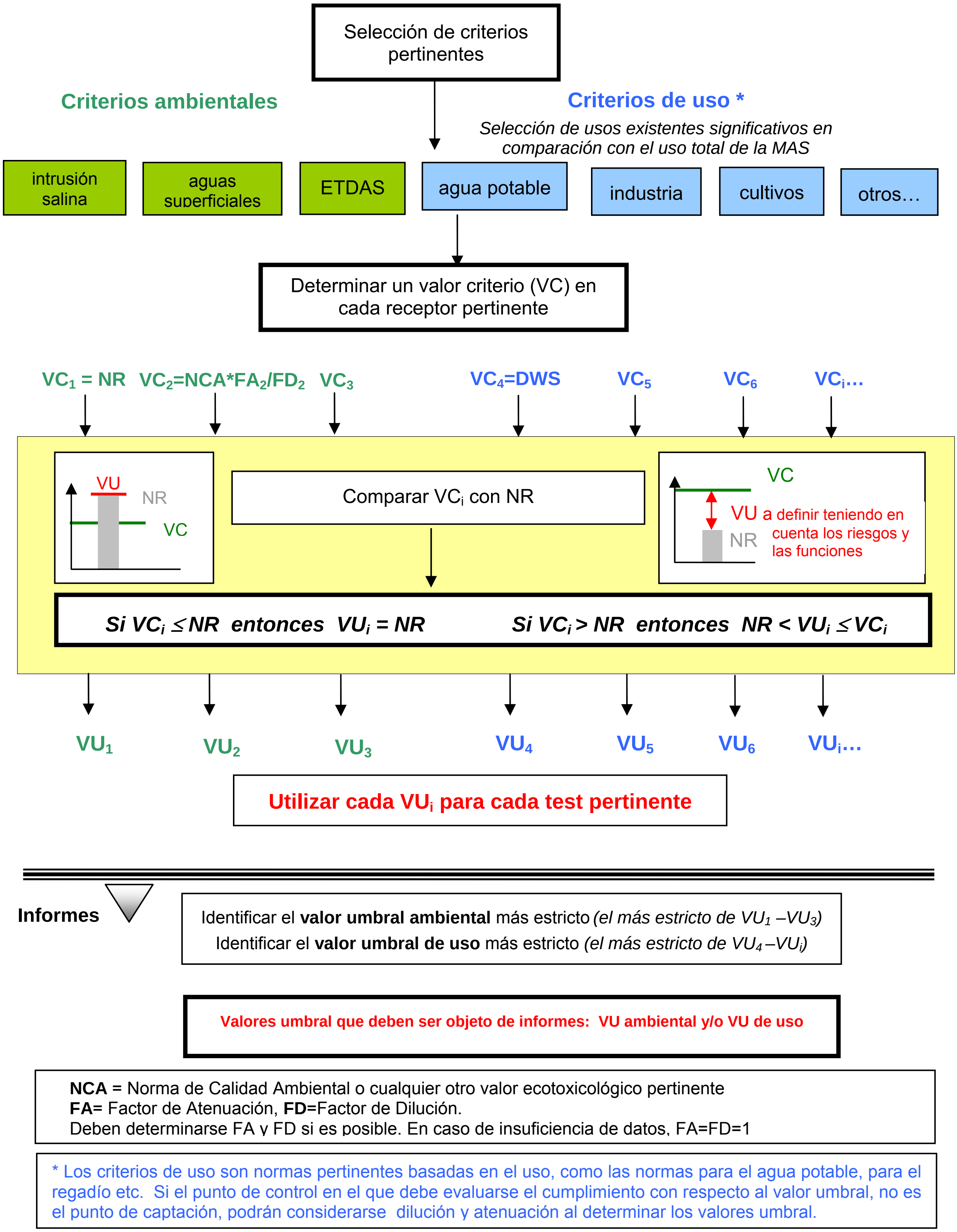


Figura 3: Metodología general para la determinación de valores umbral para las aguas subterráneas.

Determinación de los valores umbral para ecosistemas acuáticos asociados y ecosistemas terrestres dependientes

Cuando existe interrelación entre las aguas subterráneas y las aguas superficiales, y especialmente cuando las aguas superficiales o los ecosistemas terrestres dependientes son alimentados por agua subterránea, los valores criterio que sean relevantes para la protección de las aguas superficiales asociadas o los ETDAS se determinarán utilizando normas de calidad medioambiental (NCA) para las aguas superficiales o cualquier otro valor eco-toxicológico pertinente. Para las sustancias prioritarias y demás contaminantes reseñados en la directiva relativa a las “Normas de Calidad Medioambiental en el ámbito de la política de aguas” (Directiva 2008/105/CE) pueden utilizarse los valores establecidos en este texto. Puede aplicarse asimismo cualquier otra NCA establecida por un Estado miembro a escala local o estatal, por ejemplo, a partir de los resultados de tests de ecotoxicidad de organismos acuáticos.

La concentración de un parámetro varía según se trate de un acuífero o de un río. Por ello, puede aplicarse un factor de dilución (FD) o un factor de atenuación (FA) para determinar el valor adecuado para ese criterio.

Los factores de atenuación y dilución se calcularán dependiendo del nivel de conocimiento de la interacción entre el agua subterránea y el agua superficial, el modelo conceptual, y considerando la situación de los puntos de control en el sistema de aguas subterráneas en relación al receptor. (Véanse, en el anexo 1, principios generales de aplicación de los factores de dilución y de atenuación). Los Estados miembros podrán establecer libremente los valores de FD y de FA para cada masa de agua subterránea de acuerdo con su propio enfoque y conocimientos. Pueden utilizarse asimismo las propuestas del proyecto BRIDGE para el cálculo de FD y FA.[22]

Por lo tanto, el valor adecuado asignado a este criterio es igual a:

VC = NCA* FA/ FD.

La dilución y la atenuación **no** deberán incluirse cuando el control tiene lugar en el receptor.

En este caso:

$FD=FA=1 * NCA_{agua\ superficial}$.

Nota: El cálculo del factor de dilución y el factor de atenuación exige una buena comprensión del sistema de aguas subterráneas y de la interacción entre agua subterránea y agua superficial. Cuando no exista un conocimiento suficiente, puede ocurrir que los factores de dilución y/o de atenuación no puedan utilizarse. En este caso, puede recurrirse en primera instancia al enfoque de precaución; a saber, VC=NCA.

En las recomendaciones anteriores, basadas en los resultados del proyecto BRIDGE, se considera que el factor de atenuación FA es <1. Si un Estado miembro ya ha definido algunas masas de agua subterránea, y si la definición de esos factores de atenuación difiere ligeramente -por ej. FA>1-, la ecuación citada puede adaptarse. Ciertamente, la determinación del valor umbral debería basarse en los conocimientos existentes a escala nacional.

Determinación de los valores umbral para usos existentes

Cuando la masa de agua subterránea tiene otros usos aparte de apoyar la química y la ecología de las aguas superficiales, como por ejemplo, el abastecimiento de agua potable, el riego de cultivos o el apoyo a la industria alimenticia, entonces deben apoyarse dichos “usos existentes” de conformidad con las DMA y DAS. Para hacer efectivo este apoyo, deberán definirse los valores criterio según proceda. Por ejemplo, solo tendrán que determinarse y considerarse los VU si la superficie o volumen total de la zona contaminada está poniendo dichos “usos existentes” en riesgo, y si se trata de un riesgo “significativo” comparado con la superficie o volumen total de la masa de agua subterránea. En el caso del abastecimiento de agua potable, deberán considerarse las normas sobre el agua potable –VP, valor paramétrico, norma de calidad para aguas potables, DWS en las siglas en inglés- cuando se establezcan los valores para el criterio en cuestión. Para otros usos como regadíos e industria se recomienda un enfoque caso por caso.

Si el punto de control donde debe evaluarse el cumplimiento del valor umbral no es el punto de captación, puede ser conveniente tener en cuenta también la dilución y la atenuación cuando se

[22] (Müller *et al*., 2006).

efectúa la determinación de los valores umbral y los valores criterio para los usos del agua (véase el anexo 1), decisión que deben tomar los Estados miembros.

No obstante, es conveniente reiterar que el régimen de cumplimiento para las ZPAP no sólo consiste en comprobar si se han excedido los valores umbral, sino que también se basa en verificar que no será necesario un mayor aumento de las medidas de tratamiento del agua, tal como exige el artículo 7.3 de la DMA.

Determinación del valor para "salinización u otras intrusiones"

El valor umbral pertinente para la salinización u otras intrusiones será el nivel de referencia para los parámetros clave, puesto que es el valor medioambiental más adecuado que se puede usar cuando se examina si se ha producido alguna intrusión provocada por las actividades humanas.

4.4 Procedimiento para evaluar el buen estado químico

Dependiendo de los resultados de la evaluación de riesgo, deberán llevarse a cabo varios tests para evaluar el estado químico de las aguas subterráneas. Según los objetivos de las Directivas DMA y DAS, los criterios principales que deben considerarse en los tests son:

- Criterios medioambientales. Entre ellos se encuentran:
  – protección de las aguas superficiales asociadas (relacionadas)
  – protección de los ecosistemas terrestres dependientes de las aguas subterráneas
  – protección de las masas de agua subterránea frente a la salinización u otras intrusiones
- Criterios de uso. Entre ellos están:
  – protección del agua potable en las ZPAP
  – protección de otros usos existentes: regadío de cultivos, industria….

Cada test de clasificación considera elementos específicos del estado químico tal como se ha descrito en el capítulo 4.2. y se resume en la tabla 2. En cada uno de los apartados siguientes se describe en detalle cada test de clasificación y se hace referencia a los elementos individuales de los tests.

Tabla 2: Resumen de los tests de clasificación y de los elementos de verificación de estado

Elemento para la clasificación	Test de clasificación	Elementos del test			
		Agregación de los datos	Alcance	Localización	Confianza
No hay deterioro significativo de los usos humanos. Artículo 4(2)(c) (iv) DAS	Evaluación general del estado químico de toda la masa de agua subterránea.	✓	✓		✓
Los contaminantes presentes en toda la extensión de la masa de agua subterránea no suponen un riesgo ambiental significativo. Artículo 4(2)(c) (i) y Anexo III 3 de la DAS.	Evaluación general del estado químico de toda la masa de agua subterránea.	✓	✓		✓
Ausencia de salinización u otras Intrusiones. Anexo V 2.3.2 de la DMA.	Salinización u otras intrusiones	✓	✓	✓	✓
Ausencia de disminución significativa de las condiciones ecológicas de las aguas superficiales. Anexo V 2.3.2 de la DMA.	Ausencia de afección significativa a las condiciones químicas y ecológicas del agua superficial por transferencia de contaminantes desde la MAS.	✓		✓	✓
Ausencia de afección significativa a las características químicas de las aguas superficiales. Anexo V 2.3.2 de la DMA.	Ausencia de afección significativa a las condiciones químicas y ecológicas del agua superficial por transferencia de contaminantes desde la MAS.	✓		✓	✓
Ausencia de daño significativo a ETDAS. (Anexo V 2.3.2 de la DMA)	Ausencia de daño significativo a ETDAS por transferencia de contaminantes de la MAS	✓		✓	✓

Ausencia de deterioro de la calidad de las aguas para el consumo humano (Artículo 4(2)(c) (iii)) y Anexo III 4 de la DAS)	Cumple las exigencias del articulo 7(3) de la DMA (ZPAP)	✓		✓	✓

4.4.1 Procedimiento práctico

La evaluación del estado químico de las masas de agua subterránea se lleva a cabo en dos fases:

- fase 1: Verificar si se ha excedido alguno de los valores umbral o normas de calidad. Si no se han producido excesos en ninguno de los puntos de control, el estado de la masa de agua subterránea será bueno.

Nota: El valor umbral que se utilizará en el paso 1 será el valor más estricto que se determine usando la metodología que se describe en el capítulo 4.3. Este enfoque es consecuente con el principio de precaución.

- fase 2: En caso de que se haya superado una o más veces una norma de calidad o valor umbral, debe llevarse a cabo una "investigación adecuada". Esto implicará ir avanzando en los tests de clasificación pertinentes para determinar si el exceso está impidiendo el cumplimiento del buen estado químico.

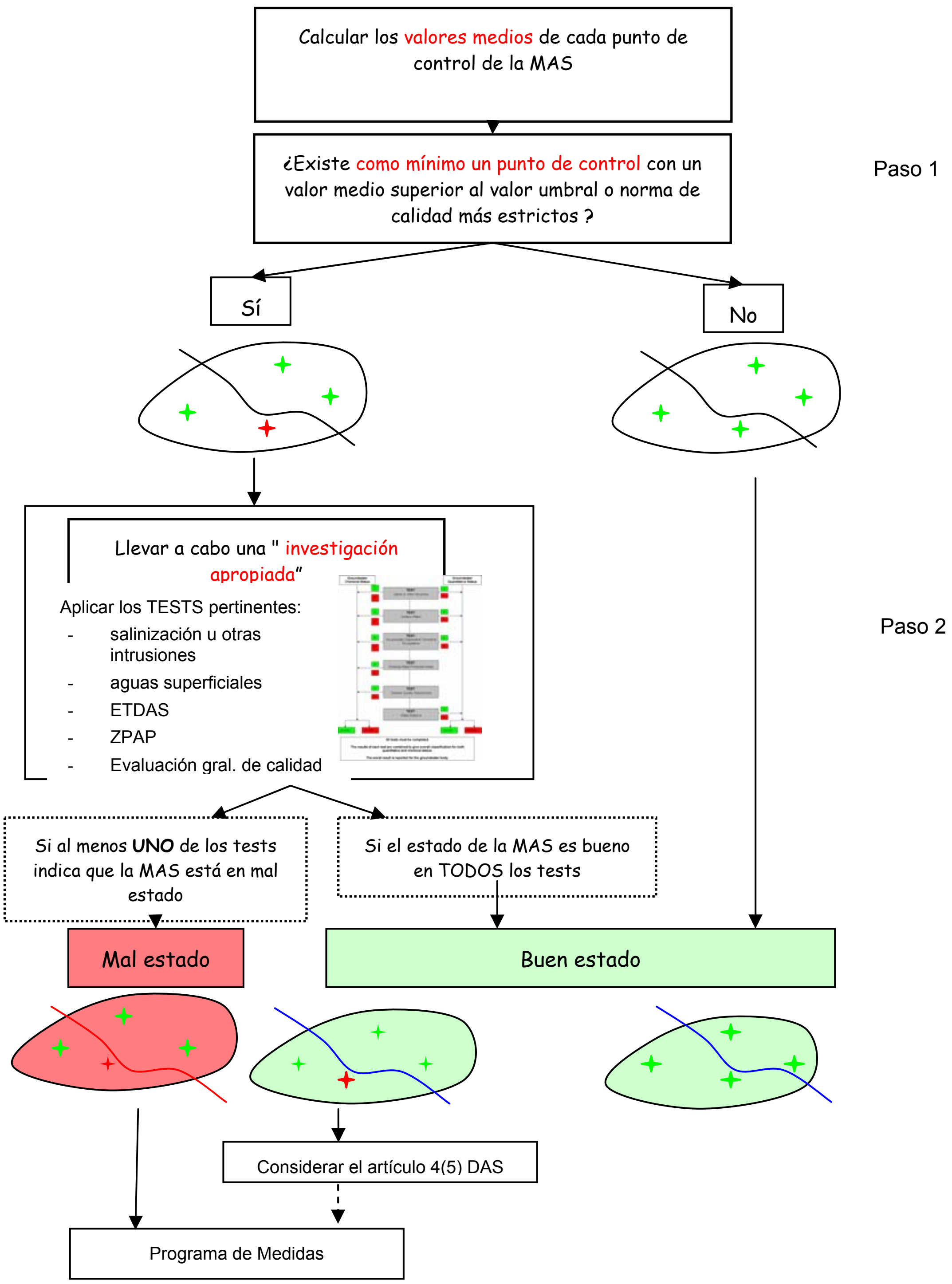


Figura 4. Procedimiento general para la evaluación del estado químico de una masa de agua subterránea (MAS).

4.4.2 Test: Evaluación general del estado químico de la totalidad de la masa de agua subterránea

Este test considera la evaluación de:

- un riesgo medioambiental significativo derivado de los contaminantes presentes en la totalidad de la masa de agua subterránea (artículo 4(2)(b) (i) y anexo III 3 de la DAS), y
- un deterioro significativo de la capacidad de soportar los usos humanos (artículo 4(2)(b) (iv) de la DAS).

Basándose en las exigencias legales, la evaluación general del estado químico de las aguas subterráneas se centra en la totalidad de la masa de agua subterránea y considera los elementos siguientes:

- **criterios** para la evaluación del estado químico de las aguas subterráneas para este test *(normas de calidad de las aguas subterráneas y valores umbral)*
- **agregación de los datos**
- **alcance del incumplimiento**
- **confianza** en la evaluación, considerando el valor de las concentraciones.

En el marco de la evaluación, los grupos de masas de agua subterránea merecerían una atención y tratamiento especial. Las MAS pueden agruparse con fines de control siempre que se garantice que pueden lograrse eficazmente el seguimiento y los objetivos medioambientales de cada una de ellas[23]. El documento guía sobre seguimiento de las aguas subterráneas distingue entre la agrupación de MAS que están en riesgo y las que no están en riesgo. Cuando las masas de agua subterránea se encuentran en riesgo, se recomienda disponer como mínimo de un punto de control por cada masa; en las masas que no están en riesgo no se necesita un punto de control por cada uno de sus componentes.

Cuando los resultados del control muestren que se han superados las normas de calidad o los valores umbral en uno o más puntos de control, debería confirmarse si las masas que los componen se encuentran en el mismo estado químico. Así pues, se recomienda dividir el grupo de masas de agua subterránea en las masas que lo componen y mejorar el modelo conceptual y la delimitación de las masas en caso de que uno de los puntos de control exceda las normas de calidad de las aguas subterráneas o los valores umbral. Cada masa de agua subterránea que compone el grupo debería tratarse como una masa de agua subterránea individual y los tests propuestos deberían aplicarse en consecuencia.

Procedimiento propuesto (véase la figura 5):

- Paso 1 (agregación): Verificar si la concentración media en algún punto de control excede una norma de calidad o valor umbral. En caso negativo, se recomienda que la masa de agua subterránea está en un buen estado químico con respecto al parámetro pertinente. No se precisa investigación ni evaluación posterior. En caso de exceso, debe seguirse el paso 2 del procedimiento.
- Paso 2 (grupos de masas de agua subterránea): En el caso de MAS agrupadas, el grupo debe dividirse y deben delimitarse adecuadamente los componentes individuales en los que se haya registrado un exceso, tomando como base un modelo conceptual mejorado y tratando las masas de agua en el test como masas de agua subterránea separadas.
- Paso 3 (superación de norma de calidad o valor umbral): Calcular el alcance espacial del incumplimiento referido a los valores medios, para cada sustancia y compararlo con un grado de incumplimiento aceptable para que el estado químico de una MAS sea bueno. Se propone aplicar una metodología sencilla, que considera la porción del área o volumen de la masa de agua subterránea representado por los puntos de control donde se han superado las normas de calidad o los valores umbral, en comparación con el área o volumen total de la MAS. Para que pudiera aceptarse, dicha porción no debería superar el 20 %[24] del total de la MAS.

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[23] Guidance Document No. 15: Groundwater Monitoring (2007)

[24] El criterio del 20% se sugiere como criterio por defecto; en función de la situación específica en la masa de agua subterránea y en la red de control, puede seleccionarse un porcentaje diferente o un enfoque alternativo para determinar el alcance del exceso utilizado. Debe incluirse en el PHC una explicación y descripción resumida de la metodología que se haya aplicado.

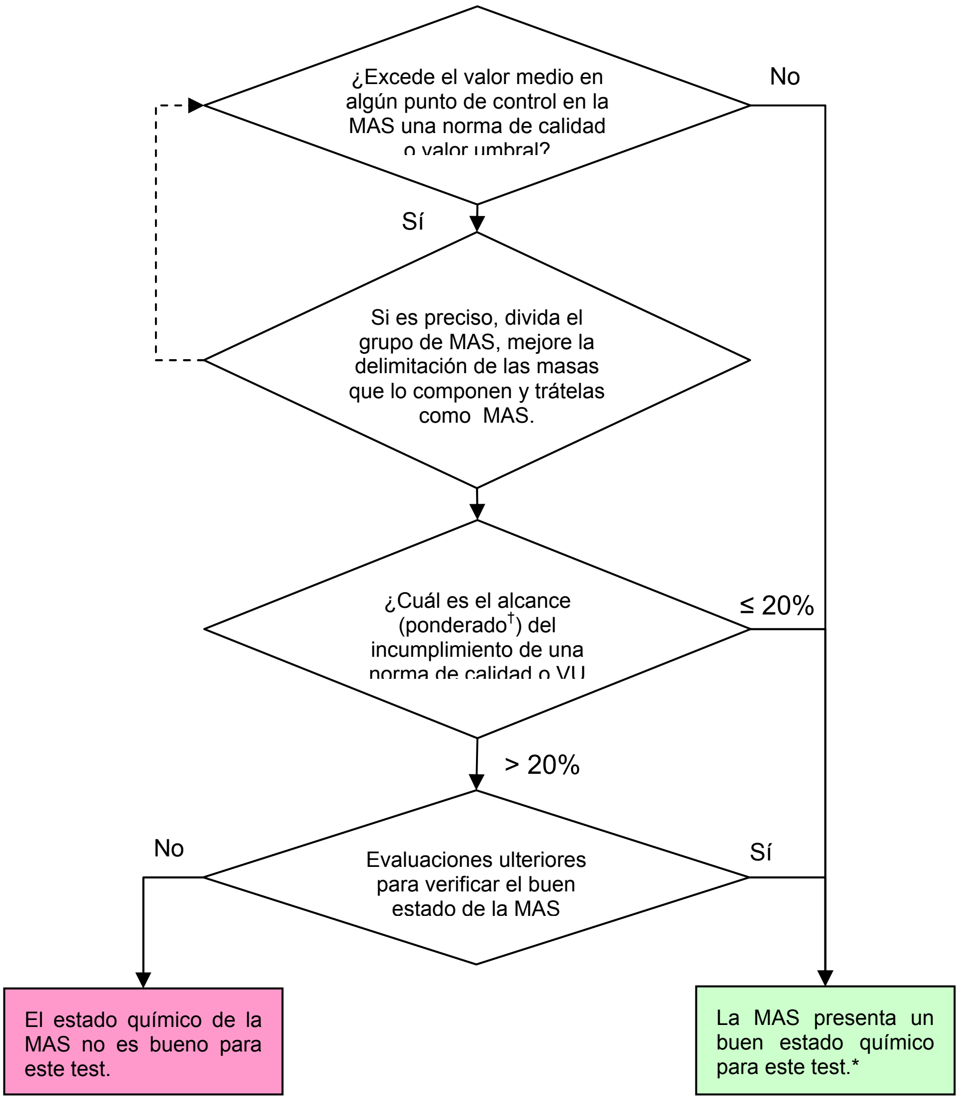
- Paso 4 (confianza): Si la porción afectada es superior al 20 % del total o si se cumplen otros criterios relevantes, una evaluación ulterior debería detectar si la masa de agua subterránea está o no en buen estado. La evaluación en cuestión podría apoyarse en un análisis de la fiabilidad, de modo que pudiera distinguir si el alcance del exceso identificado es aceptable. Una evaluación de fiabilidad de este tipo podría tener en cuenta la incertidumbre analítica, la incertidumbre producida por la red de control y la incertidumbre producida por la variación de las concentraciones, En caso de que los datos sean insuficientes, podría adoptarse un enfoque determinista, evaluando las presiones y los impactos con más detalle.

Algunos métodos estadísticos apuntan a aspectos del diseño de las redes de control -por ej. la distribución de los puntos de control- que hay que considerar de antemano. Algunos métodos de integración -por ej. kriging- ya toman en consideración una distribución heterogénea de los emplazamientos usando índices ponderados.

Si no se cumplen las precondiciones sobre diseño de la red en la totalidad de la masa de agua subterránea, puede ser de ayuda el procedimiento de agregación, la delimitación de las sub-masas de agua subterránea y/o la ponderación de los puntos de control individuales.

Cuando se trate de sub-masas de agua subterránea adecuadamente delimitadas, se propone que la evaluación se lleve a cabo para cada sub- masa de agua subterránea, procediendo a la agregación de cada uno de los resultados de cada sub-masa para dar un resultado relativo a la totalidad de la masa de agua subterránea.

Una aproximación de ponderación de este tipo puede servir para considerar la variabilidad en el seno de la masa de agua subterránea que se ha identificado a través del modelo conceptual –presiones, vulnerabilidad, impacto- así como en el diseño de la red de seguimiento. El método de ponderación debería adecuarse a los principios del método de clasificación.



† Un método de ponderación puede ayudar a tomar en consideración el modelo conceptual -por ej. presión, vulnerabilidad, situación del impacto- dentro de la masa de agua subterránea, así como el diseño de la red de seguimiento.

*…Actuar de conformidad con el artículo 4(5) de la DAS

Figura 5. Procedimiento propuesto para la evaluación general del estado químico de una masa de agua subterránea (MAS) considerada globalmente.

4.4.3 Test: Salinización u otras intrusiones

Este test considera la evaluación de la salinización u otras intrusiones de conformidad con el anexo V.2.3.2. de la DMA.

Los distintos tipos de intrusiones que se consideran en esta evaluación aparecen ilustrados en la figura 6 (Fuente: UKTAG). Entre ellos se encuentran:

- la intrusión marina detectada frecuentemente en los acuíferos costeros, particularmente en la cuenca Mediterránea, y
- la intrusión salina de origen natural, resultante de la influencia de aguas de formación o de una pérdida de capas salinas –caso de las evaporitas- en la masa de agua subterránea.

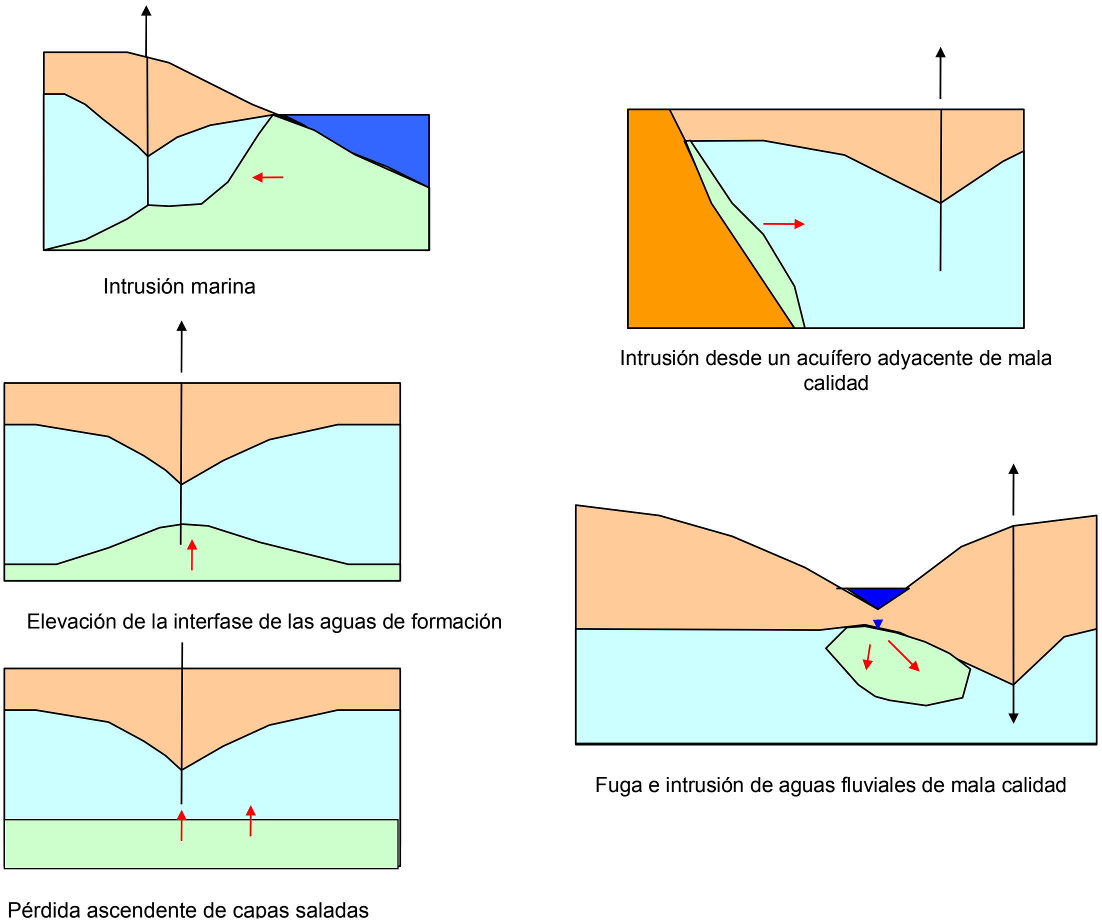


Figura 6. Diferentes tipos de intrusión

Basándose en los requisitos legales, la evaluación de la salinización u otras intrusiones considera los elementos siguientes:

- **criterios** para la evaluación del estado químico de las aguas subterráneas para este test *(normas de calidad del agua subterránea y valores umbral)*
- **agregación de datos**
- **alcance** del incumplimiento de las normas de calidad o valores umbral
- **localización** de los puntos donde se superan las normas de calidad o los valores umbral
- **confianza** en la evaluación.

Además, el test está vinculado con la evaluación del estado cuantitativo de la MAS, y con la evaluación de las tendencias significativas o sostenidas al aumento de la contaminación.

La evaluación del estado cuantitativo debe llevarse a cabo con carácter previo al test sobre el estado químico, que habrá identificado aquellos ámbitos en los que existe presión debida al bombeo y con ello un riesgo de salinización o de otras intrusiones.

No se alcanza un buen estado químico del agua subterránea si:

- el valor medio en un punto de control relevante supera un valor umbral **y**
- existe una tendencia significativa y sostenida al aumento en uno o más parámetros clave en uno o varios puntos de control relevantes, o
- hay un impacto significativo en un punto de captación como consecuencia de la intrusión.

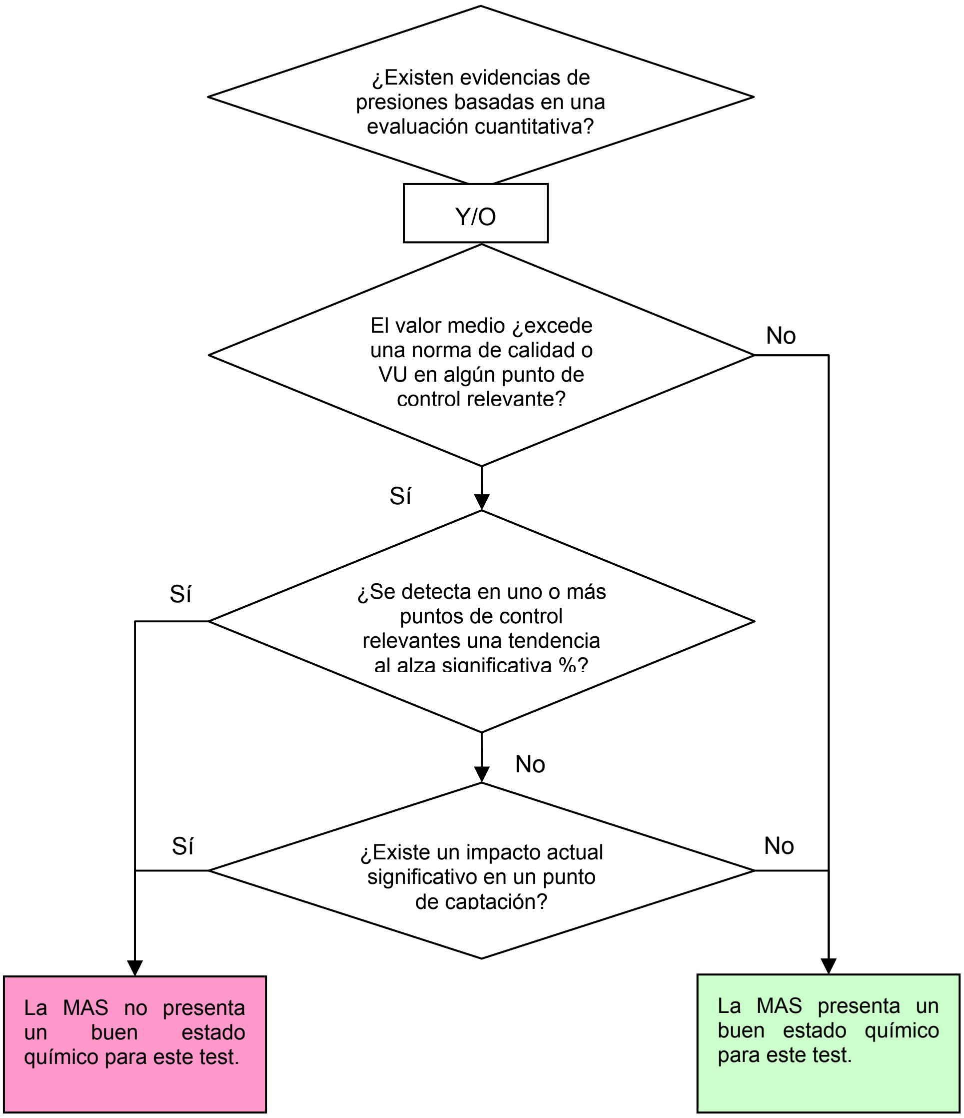
Los valores umbral pertinentes serán el nivel de referencia para parámetros clave, es decir, Cl^- y SO_4^{2-} o conductividad eléctrica.

Algunas masas de agua subterránea tienen elevados niveles naturales de salinidad, debido a la geoquímica del acuífero o las unidades estratigráficas adyacentes que actúan como fuente. Para este test, debido a la compleja fluctuación de la calidad del agua subterránea adyacente a la interfase entre agua dulce y salada, los valores umbral numéricos no serían determinantes por sí solos. Se propone un enfoque basado en "líneas de evidencia" para confirmar la existencia de una intrusión como la citada.

Con respecto a la intrusión de agua marina salada en una masa de agua subterránea y la situación especial del abastecimiento de agua potable en las islas, puede ser apropiado diferenciar entre la intrusión horizontal, que refleja un problema regional, y la intrusión vertical, que tiene una importancia más local y un alcance limitado. La base principal para esta diferenciación es la comprensión conceptual de la masa de agua subterránea.

Procedimiento propuesto (véase la figura 7):

- Paso 1 (evidencias):
  - identificar las zonas en las que se producen altas concentraciones salinas naturales (de procedencia marina o geológica)
  - identificar las zonas en las que existe presión provocada por el bombeo y riesgo de salinización o de otras intrusiones (*ver el capítulo 5.3.4*)
- Paso 2 (agregación y localización):
  - identificar puntos de control pertinentes donde los valores medios superan las normas de calidad relevantes y los valores umbral
  - considerar la localización de dichos puntos junto con las zonas donde se generan presiones provocadas por los bombeos y los riesgos de salinización o de otras intrusiones (identificados en el test de estado cuantitativo del agua subterránea, ver el cap. 5.3.4).
  - considerar el modelo conceptual de la masa de agua subterránea. La intrusión horizontal está produciendo sobre todo un problema regional, mientras que la intrusión vertical puede ser representativa de un problema puntual localizado.
- Paso 3 (tendencia): Calcular las tendencias en parámetros clave, como Cl^- y SO_4^{2-} o conductividad eléctrica, así como cualquier otra sustancia significativa que indique una expansión de las intrusiones (*véase la sección 6.3.4*).
- Paso 4 (impactos): Identificar cualquier impacto significativo en puntos de captación como consecuencia de la intrusión.



Considere el modelo conceptual -presiones, vulnerabilidad, situación de impacto- de la MAS en cada uno de los pasos que conforman la evaluación.

Figura 7. Procedimiento propuesto para evaluar la salinización y otras intrusiones

4.4.4 Test: Disminución significativa de la calidad química y ecológica de las masas asociadas de aguas superficiales, producida por la transferencia de contaminantes procedentes de la masa de agua subterránea

Este test considera la evaluación de:

- una disminución significativa de las condiciones ecológicas de las aguas superficiales, y
- una disminución significativa de la calidad química de las aguas superficiales.

Basándose en las exigencias legales, la evaluación considera los elementos siguientes:

- **Criterios** para la evaluación del estado químico del agua subterránea para este test *(normas de calidad de las aguas subterráneas y valores umbral) -*
- **Agregación de datos**
- **Situación** de los puntos donde se superan las normas de calidad o los valores umbral
- **Confianza** en la evaluación.

El estado se determina a través de una combinación de resultados de clasificación de las aguas superficiales y de una evaluación de las entradas de compuestos químicos (transferencia de contaminantes) procedentes de las masas de agua subterránea y que penetran en las masas de agua superficial. El test se diseñó para determinar en qué medida la transferencia de contaminantes procedentes de las aguas subterráneas hacia las aguas superficiales o cualquier otro impacto consecuente en la ecología de las aguas superficiales es suficiente para amenazar los objetivos de la DMA para las masas de aguas superficiales asociadas citadas.

El test debe llevarse a cabo en todas las masas de agua subterránea que estén vinculadas a masas de agua superficial en riesgo, considerando el modelo conceptual de cada masa de agua subterránea.

Procedimiento propuesto (véase la figura 8):

- Paso 1 (agua superficial en riesgo): ¿La masa de agua superficial no consigue alcanzar los objetivos medioambientales (está en un estado peor que bueno) y la masa de agua subterránea contribuye a ello?
- Paso 2 (Agregación de datos y localización):
  - Identificar toda superación de un valor umbral pertinente en la masa de agua subterránea en alguna de las concentraciones medias calculadas en cada punto de control pertinente.
  - Considerar si alguno de los casos en que se ha excedido un valor umbral pertinente se ha producido en una zona en la que puedan transferirse contaminantes a las aguas superficiales.

  Paso 3 (transferencia de contaminantes): Efectuar una estimación de la cantidad y concentración de contaminantes que está siendo o puede ser transferida al receptor agua superficial y los posibles impactos. La carga contaminante global en las aguas superficiales procedente de las aguas subterráneas puede calcularse a partir de los factores de dilución agua subterránea-agua superficial y de los índices de atenuación. Cuando la contribución de la carga contaminante que procede de las aguas subterráneas en las aguas superficiales es significativa -mayor del 50% de la carga-, la masa de agua subterránea está en mal estado.

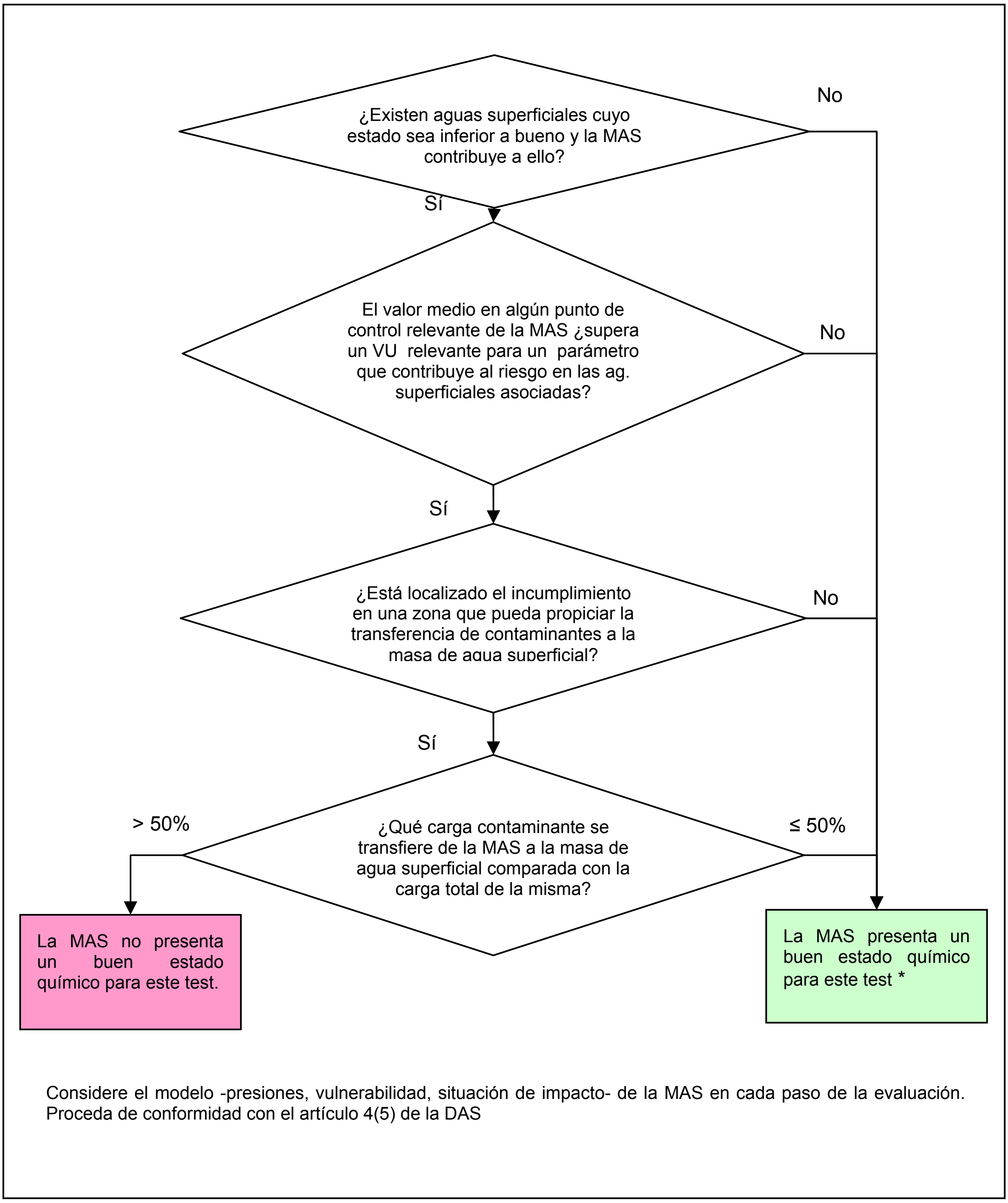


Figura 8. Procedimiento propuesto para verificar la disminución significativa de la calidad ecológica o química de las masas de agua superficial asociadas

4.4.5 Test: Daño significativo a los ecosistemas terrestres dependientes de las aguas subterráneas (ETDAS) producido por la transferencia de contaminantes procedentes de la masa de agua subterránea

Este test considera la evaluación de un daño significativo a los ETDAS (DMA, anexo V 2.3.2)

Basándose en los requisitos legales, la evaluación considera los elementos siguientes:

- **Criterios** para la evaluación del estado químico de las aguas subterráneas para este test *(normas de calidad y valores umbral del agua subterránea)*

- **agregación de datos**
- **situación** de los puntos en los que se hayan superado las normas de calidad o los valores umbral
- **confianza** en la evaluación.

El test debería determinar la posibilidad de que las concentraciones de contaminantes en una masa de agua subterránea conduzcan a un impacto sobre un ETDAS que sea suficiente para amenazar los objetivos de la DMA u otros objetivos relevantes para las zonas protegidas.

El test debería llevarse a cabo en todas las masas de agua subterránea que estén vinculadas a un ETDAS que haya sufrido -o esté en riesgo de sufrir- un daño significativo, considerando el modelo conceptual de cada masa de agua subterránea durante cada etapa de la evaluación.

Procedimiento propuesto (véase la figura 9):

- Paso 1 (ETDAS afectado): ¿Existe algún ETDAS afectado -o que esté en riesgo- que sea directamente dependiente de la masa de agua subterránea que está siendo evaluada?
- Paso 2 (Agregación de datos y localización):
  - identificar los casos en que se hayan superado los valores umbral pertinentes en el agua subterránea usando las concentraciones medias calculadas en cada punto de control pertinente.
  - determinar la ubicación de los puntos en los que se hayan superado los valores umbral relevantes para determinar si existe una zona en la que puedan transferirse contaminantes al ETDAS.
  - paso 3 (transferencia de contaminantes): efectuar una estimación de la cantidad y concentración de los contaminantes que se están transfiriendo -o pueden transferirse- al receptor (ETDAS) y los posibles impactos. La carga contaminante global procedente de las aguas subterráneas que desemboca en los ecosistemas terrestres dependientes puede estimarse a partir de una comprensión de los factores de dilución agua subterránea-ETDAS y de los índices de atenuación.

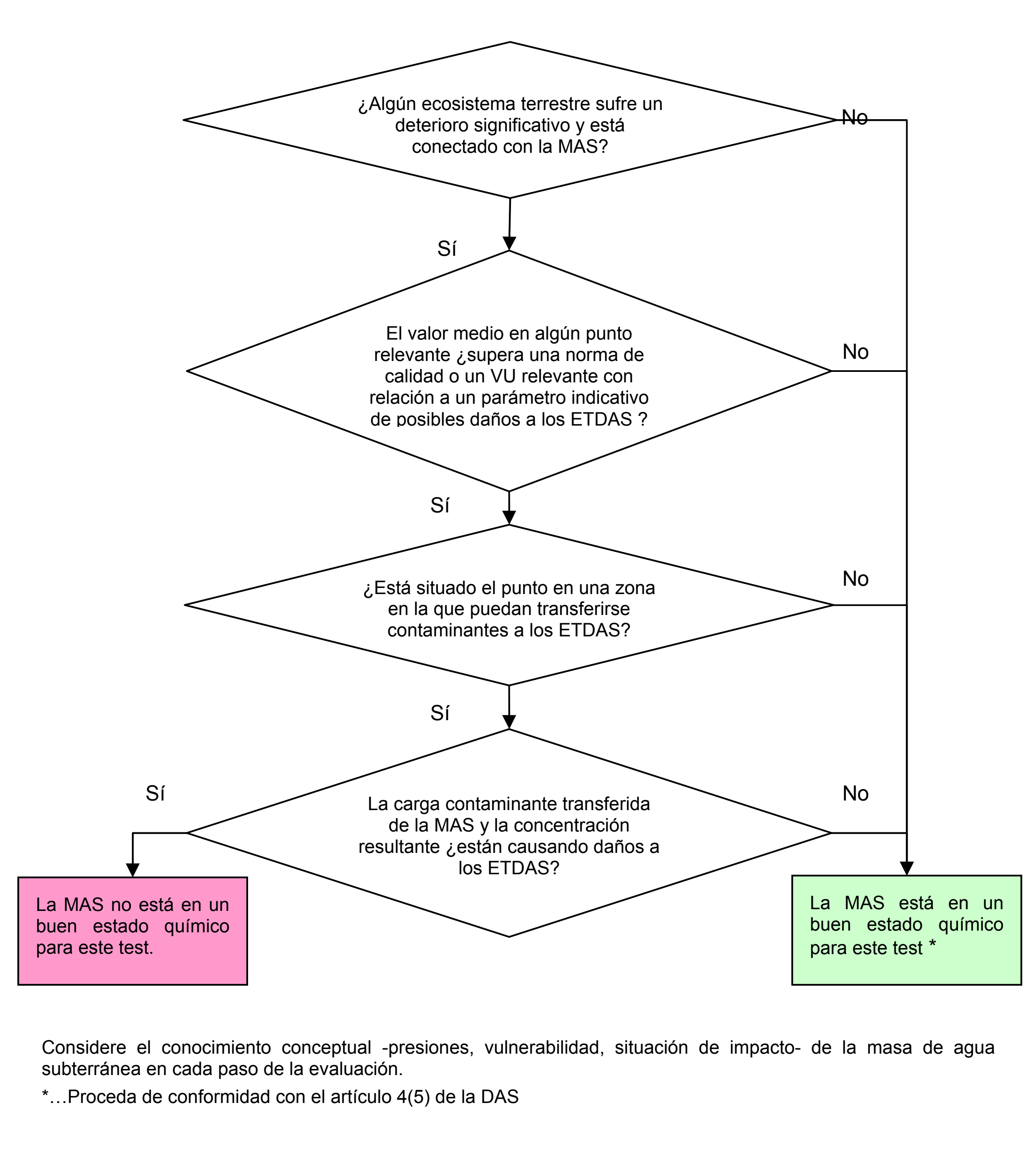


Figura 9. Procedimiento propuesto para la evaluación del daño significativo a los ecosistemas terrestres directamente dependientes de la masa de agua subterránea

4.4.6 Test: Cumplimiento de las disposiciones del artículo 7(3) de la DMA (zonas protegidas para la captación de agua potable).

Este test evalúa el deterioro de la calidad de las aguas para el consumo humano (Artículo 4(2)(c) (iii)) y Anexo III 4 de la DAS). Este capítulo debería leerse conjuntamente con las guías anteriormente publicadas, en particular la de seguimiento de las aguas subterráneas[25] y la relativa a las aguas subterráneas en zonas protegidas para la captación de agua potable[26]. De conformidad con ésta última, se consideran a las ZPAP como masas de agua subterránea y las medidas de protección se centran en perímetros de protección.

[25] Guidance Document No. 15 Groundwater Monitoring (2007)

[26] Guidance Document No. 16 Groundwater in Drinking Water Protected Areas (2007)

De conformidad con el artículo 7.3 de la DMA, los Estados miembros velarán por la necesaria protección de las masas de agua especificadas "*con objeto de evitar el deterioro de su calidad, contribuyendo así a reducir el nivel del tratamiento de purificación necesario para la producción de agua potable*" *[…]"*

Los elementos de la guía sobre las aguas subterráneas en zonas protegidas para la captación de agua potable[26] que ofrecen un mayor interés para la evaluación del estado de las aguas subterráneas son los siguientes:

- se recomienda que cuando una captación sea competencia de la directiva de aguas potables[27], el control del agua no depurada se lleve a cabo de conformidad con los principios de vigilancia y control operativo en lo relativo a la frecuencia de las mediciones. Los Estados miembros deben garantizar previamente que el control sea representativo y suficiente para detectar los cambios significativos y sostenidos en la calidad del agua subterránea producidos por actividad humana. La guía sobre el seguimiento de las aguas subterráneas contiene recomendaciones sobre la selección de los puntos de control y sobre su agrupación.
- la evaluación del riesgo de deterioro debería llevarse a cabo para todos los parámetros individuales que se controlan de conformidad con la directiva de agua potable. Esto incluye los parámetros químicos, radiológicos y microbiológicos.
- los puntos de cumplimiento deben situarse en el punto o cerca del punto donde se capta el agua potable y antes de que se lleve a cabo ningún tratamiento de depuración.
- los datos de referencia sobre la calidad actual de las aguas subterráneas son necesarios para aquellos contaminantes que pueden plantear un riesgo de deterioro, que pueden utilizarse como referencia para evaluar el riesgo de deterioro (tendencias futuras). Cuando existan suficientes datos disponibles de la supervisión de las aguas subterráneas para definir niveles básicos[28], se recomienda que los puntos de partida se basen en esos datos. De otro modo, la evaluación tendría que posponerse hasta que hubiera suficientes datos disponibles.
- para las captaciones futuras, los niveles básicos de las captaciones y los niveles de tratamiento deben determinarse en el momento en que se desarrolle y se empiece a aplicar la propuesta de captación de agua potable.
- el cierre de una captación de agua potable motivado por su deterioro se considera como un indicador de violación del artículo 7(3) si el deterioro se debe a efectos humanos.
- puede ser aceptable un cierto grado de mezcla para igualar la calidad del agua sin tratar dentro de un pozo, o incluso inevitable, por la naturaleza de la infraestructura utilizada para la captación. No obstante, la mezcla de agua procedente de distintos campos de pozos podría ocultar cambios significativos y sostenidos en la calidad del agua subterránea.
- la evaluación del estado de cumplimiento debería centrarse en si se han producido cambios significativos y sostenidos en la tendencia de la calidad del agua sin tratar en el punto de captación, tal como se determina en los programas de seguimiento. A falta de cambios como los expuestos, es razonable asumir que no se necesitan cambios en los niveles de tratamiento. Si las tendencias son significativas y sostenidas y ya se ha instaurado el tratamiento, en la mayoría de los casos cualquier deterioro tendrá implicaciones que se prolongarán en el tiempo en el nivel de tratamiento. En los casos en que no se hayan superado las normas para el agua potable y el tratamiento no esté aún instaurado, deben evaluarse el potencial de deterioro futuro y sus implicaciones en el tratamiento.
- sólo si existen evidencias de cambios significativos en la calidad del agua no tratada que puedan atribuirse a un impacto humano deberá evaluarse el impacto sobre el nivel de tratamiento donde tenga lugar la captación. De este modo puede minimizarse la recogida y evaluación de datos adicionales.
- para poder evaluar los cambios en el "nivel" del tratamiento de depuración, sería necesario un conocimiento del proceso de tratamiento, que incluiría los parámetros que tenía que tratar cuando se instaló, en qué grado debía tratarlos, y el uso de materiales consumibles como productos químicos.

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[27] Directiva comunitaria 98/83/CE

[28] "*Nivel básico' es el valor medio medido por lo menos durante los años de referencia 2007 y 2008 sobre la base de los programas de control aplicados De conformidad con el artículo 8 de la DMA o, en el caso de sustancias identificadas después de los citados años de referencia, durante el primer período para el que se disponga de un período representativo de datos de control* [artículo 2(6) DAS]

- Resulta difícil orientar sobre qué constituye una modificación en el nivel de tratamiento, pero se insta a los Estados miembros a que tomen en consideración los factores que se enumeran a continuación, con un enfoque de caso por caso:
  – si se necesita aumentar durante un cierto tiempo el nivel del tratamiento, ¿se trata de un aumento temporal o de un aumento a largo plazo?
  – ¿cuál es la tendencia general en la aplicación del tratamiento en ese emplazamiento?
  – ¿se necesitan equipos nuevos?
  – el objetivo de alguno de los cambios en el equipo o en los productos químicos ¿es aumentar el tratamiento, o simplemente hacerlo más eficaz? Un cambio en el proceso de tratamiento puede reflejar cambios tecnológicos y no un aumento del nivel de tratamiento como tal.
  – si tiene lugar la mezcla de fuentes diferentes, ¿qué fin persigue? ¿Se trata de un indicador de que existe un cambio significativo y sostenido de la calidad del agua sin tratar dentro de la ZPAP?
- Deben reseñarse las alteraciones, la clausura y el abandono de las fuentes existentes de abastecimiento de agua potable por causa de contaminación, de modo que los datos obtenidos puedan utilizarse para reforzar el sistema de control que aún con todo el empeño, puede que no siempre detecte los incidentes de contaminación. Esos datos pueden utilizarse también para evaluar en qué medida están siendo eficaces las distintas medidas de protección necesarias.
- Debe resaltarse que los cambios en la calidad de las aguas subterráneas pueden ser inducidos no sólo por la liberación directa de contaminantes, sino también por los efectos de la captación. Estos efectos también deben tenerse en cuenta.

En el ámbito de la evaluación del estado químico, los perímetros de protección no tienen una función específica. Los perímetros de protección que pueden ser delimitados por los Estados miembros de conformidad con el artículo 7(3) de la DMA se relacionan con medidas que garanticen la protección necesaria con el fin de evitar el deterioro de la calidad. Además, los perímetros de protección pueden ser útiles cuando se agrupen las captaciones con fines de seguimiento y evaluación. En los casos en que varias captaciones individuales de aguas subterráneas forman parte de un grupo de fuentes de abastecimiento dentro de un perímetro de protección y el sistema de seguimiento es consistente y representativo, es posible que sólo sea necesario someter a seguimiento y evaluación una selección representativa de las captaciones.

Procedimiento propuesto (véase la figura 10):

Además de la evaluación del cumplimiento de las exigencias de la directiva de aguas potables, que es un proceso bastante sencillo, tal como establece el artículo 7(2), el artículo 7(3) requiere un examen más cuidadoso y la elaboración de un procedimiento de test.

El procedimiento propuesto para la evaluación del estado químico de las aguas subterráneas en lo relativo al artículo 7(3) considera los requisitos legales y las recomendaciones formuladas en las guías pertinentes y puede resumirse del siguiente modo:

- el test hace referencia a los puntos de control pertinentes (ZPAP) que recomienda la guía sobre seguimiento [29]:
- paso 1 (cambio en el nivel de tratamiento): no debe existir ninguna prueba de que se haya producido un aumento del tratamiento inducido por cambios en la calidad del agua -cantidad de agua- lo que incluye la consideración del cambio de la mezcla y el cierre de la captación.
- paso 2 (deterioro de la calidad del agua): la evaluación del deterioro de la calidad del agua se centra en la calidad del agua sin tratar en el punto de captación.
  – identificar el nivel básico con respecto a contaminantes pertinentes -químicos, radiológicos y microbiológicos- que planteen un riesgo de deterioro
  – identificar cambios significativos -evaluación de la tendencia considerando los niveles básicos y los valores medios anuales- que se atribuyan a un impacto humano
  – evaluar el impacto que tienen los cambios significativos aludidos en el nivel de tratamiento

[29] Guidance Document No. 15 Groundwater Monitoring (2007)

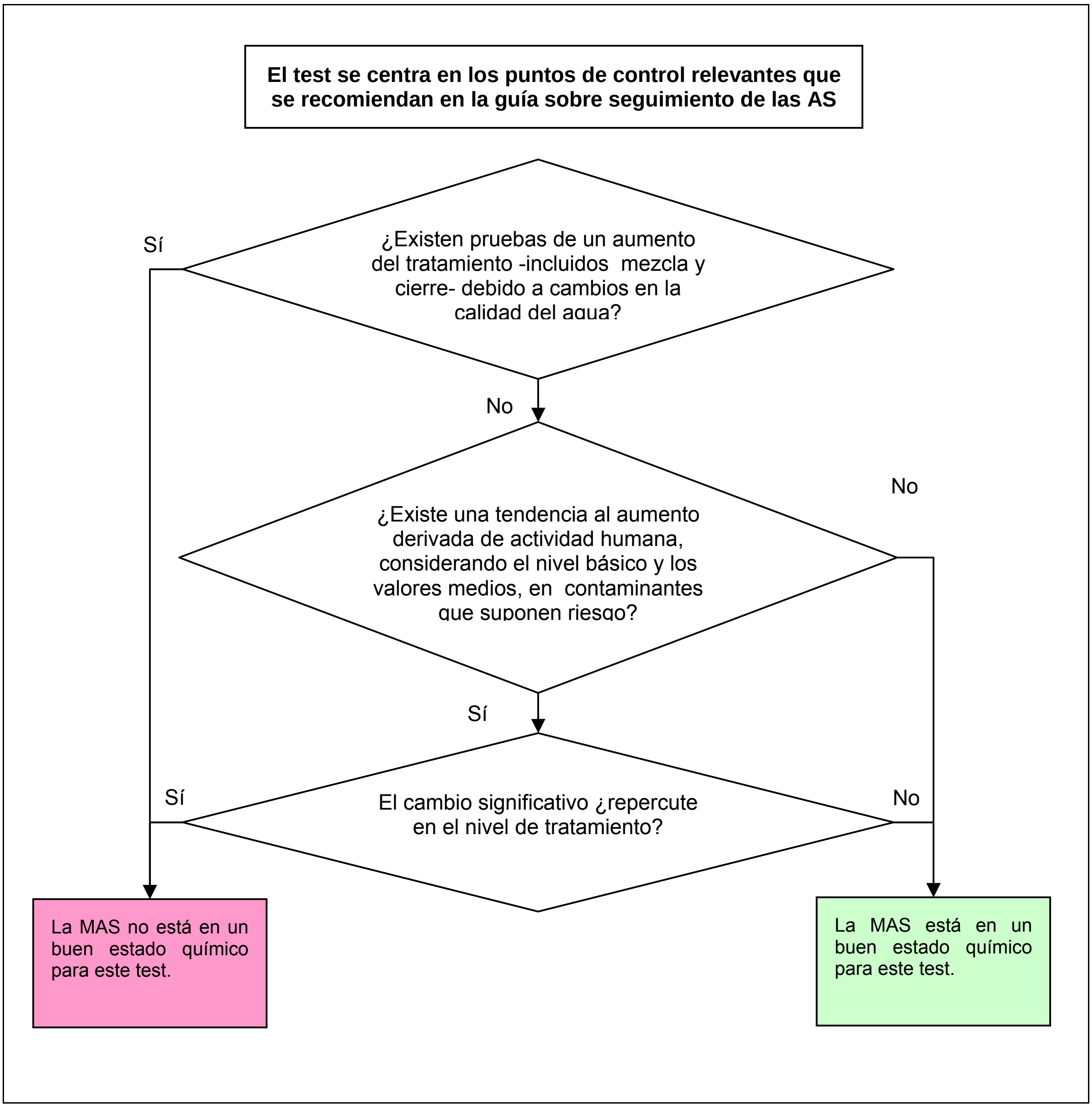

Figura 10. Procedimiento propuesto para el cumplimiento de los requisitos del artículo 7(3) de la DMA (ZPAP).

5 EVALUACIÓN DEL ESTADO CUANTITATIVO

5.1 Definición de buen estado cuantitativo

El buen estado cuantitativo se define en el anexo V 2.1.2 de la DMA. Tal como figura en este anexo, se logrará un buen estado cuantitativo de las aguas subterráneas cuando:

> “*El nivel del agua subterránea en la masa de agua subterránea es tal que la tasa media de extracción a largo plazo no excede del recurso disponible de agua subterránea.*
>
> *Del mismo modo, el nivel de las aguas subterráneas no es sometido a alteraciones antropogénicas como las que desembocarían en:*
>
> - incapacidad de lograr los objetivos medioambientales especificados en el artículo 4 para las aguas superficiales asociadas;
> - cualquier disminución significativa del estado de las aguas citadas; y
> - cualquier daño significativo a los ecosistemas terrestres que dependen directamente de la masa de agua subterránea[30].
>
> y alteraciones de la dirección del flujo que desembocan en posibles cambios temporales de nivel, o cambios continuos en una zona limitada espacialmente, pero cuando las inversiones citadas no causan la intrusión de agua salina ni de ningún otro tipo, y no indican una tendencia sostenida y claramente definida antropogénicamente en la dirección del flujo que pueda provocar las intrusiones citadas”.

5.2 Elementos de la evaluación del estado cuantitativo

Para que una masa de agua subterránea se encuentre en buen estado cuantitativo deberán cumplirse todos los criterios –objetivos- incluidos en la definición de buen estado (5.1). Estos objetivos son:

- la tasa media de captación a largo plazo no es superior al recurso hídrico disponible;
- no hay disminución significativa de las condiciones químicas y/o ecológicas de las aguas superficiales como resultado de una alteración antropogénica del nivel piezométrico o de un cambio de las condiciones del flujo, que conduciría a un incumplimiento de los objetivos pertinentes del artículo 4 de cualquiera de las masas de agua superficial asociadas;
- no se ha producido ningún daño significativo a los ecosistemas terrestres dependientes de las aguas subterráneas como resultado de una alteración antropogénica del nivel del agua;
- no existe intrusión salina ni otro tipo de intrusiones como resultado de cambios sostenidos de la dirección del flujo inducidos por la actividad humana.

Para verificar el cumplimiento de los objetivos expuestos puede adoptarse un sistema de clasificación del estado que desglose y compare uno por uno los distintos elementos de la definición de buen estado cuantitativo.

Todas las masas de agua subterránea -o grupos de masas- deberán ser sometidas a una evaluación del estado cuantitativo. No obstante, cuando existe un alto grado de confianza en que una masa de agua subterránea no está en riesgo de incumplir los objetivos de buen estado cualitativo, es razonable declarar que esa MAS se encuentra en buen estado, en consonancia con la adopción de un enfoque basado en el riesgo.

En el marco de la caracterización inicial y de la adicional, ya se habrá llevado a cabo una evaluación de presiones e impactos, para identificar las masas en riesgo de no alcanzar sus objetivos medioambientales. En este caso, las presiones se relacionarán con el estado cuantitativo. El proceso de caracterización implicará la reunión de la información especificada en el anexo II (2) tal como se precisa para apoyar la evaluación del estado, entre otros sobre la situación de las captaciones y la recarga artificial, los datos de captación/descarga, las características hidrogeológicas, las tasas de recarga, etc.

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[30] Un ecosistema terrestre dependiente de las aguas subterráneas (ETDAS) sufrirá un daño significativo si no logra alguno de sus objetivos de conservación. Por ejemplo, cuando existen impactos antropogénicos sobre las condiciones de las aguas subterráneas, por ej. el flujo, nivel o calidad, que desembocan en que un ETDAS no logra “condición favorable”. Los objetivos de conservación pueden relacionarse con el logro de los requisitos de conformidad con la legislación comunitaria, -Directiva 92/43/CEE o cualquier otra iniciativa pertinente de los Estados miembros-.

La DMA indica que el nivel piezométrico debe ser el principal parámetro para evaluar el buen estado cualitativo, No obstante, mientras que el control de los niveles de agua es esencial para determinar los impactos e identificar tendencias prolongadas, es insuficiente por sí solo y generalmente se necesitarán otros parámetros e información adicional. En el anexo 1 se incide más sobre el uso de los niveles piezométricos. En la guía sobre seguimiento de las aguas subterráneas[31] se apuntan otros parámetros pertinentes. Esta combinación de información, conocida como **enfoque del peso de la evidencia** ("*weight of evidence approach*") debe garantizar la fiabilidad de la evaluación del estado.

5.3 Procedimiento para la evaluación del estado cuantitativo de las aguas subterráneas

Para determinar el estado cuantitativo global de una masa de agua subterránea deben aplicarse una serie de tests que consideren los impactos de las alteraciones a largo plazo inducidas por el hombre del nivel de las aguas subterráneas o de su flujo. Cada test evaluará si una masa de agua subterránea cumple los objetivos medioambientales pertinentes. No todos los objetivos medioambientales se aplicarán a todas las masas de agua subterránea. Por ello, sólo serán necesarios los tests pertinentes para su aplicación en caso necesario.

Algunos de los elementos del estado cuantitativo se superponen con los de la evaluación del estado químico, en particular la evaluación relativa a la intrusión salina. En este caso, las evaluaciones del estado químico y cuantitativo para ese elemento pueden combinarse y llevarse a cabo un único test. En otras circunstancias será necesario compartir la información relativa a la evaluación del estado químico y del cuantitativo.

5.3.1 Test: Balance hídrico (escala de masa de agua subterránea)

Para que una masa de agua subterránea esté en buen estado con respecto a este test, la extracción anual media de la masa de agua subterránea a largo plazo[32] no debe exceder la recarga media a largo plazo, minorada por la cuantía de los caudales ecológicos a largo plazo. Este test considera los efectos acumulados por toda la masa y es un test referido a toda la masa.

Cuando existe información fiable sobre los niveles piezométricos en el conjunto de la masa de agua subterránea, dicha información pueden utilizarse para identificar la presencia de un descenso sostenido a largo plazo de los niveles provocado por la extracción de agua subterránea. La presencia de este descenso indicará que no se cumplen las condiciones de buen estado y que la masa está en mal estado. No obstante, es posible que los niveles piezométricos por sí solos no proporcionen una clasificación fiable y por ello una alternativa es la realización de una evaluación de balance hídrico.

Para el test de balance hídrico se debe evaluar la extracción media anual con respecto a un "recurso disponible de agua subterránea" en la masa de agua subterránea. El recurso disponible de agua subterránea significa la tasa media anual a largo plazo de la recarga global de la masa menos la tasa anual a largo plazo de flujo necesario para lograr la calidad ecológica para las aguas superficiales asociadas especificadas en el anexo 4, evitar cualquier disminución significativa del estado ecológico y evitar cualquier daño significativo a los ecosistemas terrestres dependientes de las aguas subterráneas.

El recurso de agua subterránea disponible es un valor aproximado, basado en la recarga y las necesidades de caudales para mantener las condiciones ecológicas de las masas de agua superficial y de los ecosistemas terrestres que dependen de la masa de agua subterránea. Conviene reseñar que, al tratarse de un test que se aplica a toda la masa de agua subterránea, tal vez no siempre sea posible definir claramente las necesidades locales de caudal de ríos y humedales. Además, el recurso de agua subterránea disponible para la masa de agua subterránea puede no estar enteramente disponible para su extracción debido a que las condiciones hidrogeológicas -por ej., transmisividad y almacenamiento- dificultan su explotación desde el punto de vista económico y práctico. También puede variar la distribución del "recurso de agua disponible" en la masa de agua subterránea, en relación con receptores sensibles, hecho que habrá que tener en cuenta para la evaluación del estado. En muchos casos el límite de mal estado no se encontrará simplemente allí donde la

[31] Documento guía nº 15 Seguimiento de las aguas subterráneas (2007)

[32] La consideración de las mediciones "a largo plazo" –captación, recarga, nivel del agua- pretende minimizar la influencia de los factores climáticos naturales a corto plazo y los impactos de la captación. Las mediciones a largo plazo permiten que los efectos a corto plazo puedan diferenciarse de las pautas y tendencias a largo plazo. Para los fines de la DMA, la duración necesaria de los registros dependerá de las condiciones hidrogeológicas y medioambientales asociadas a la masa de agua subterránea. Se recomienda que como mínimo sean no menos de 6 años (un ciclo de gestión de cuenca hidrográfica).

extracción supere el recurso disponible, sino que puede situarse muy por debajo. En algunas situaciones puede ser hasta de un 20% menor.

La recarga anual media debe calcularse para toda la masa de agua subterránea, incluyendo todas las entradas al acuífero -por ej. entradas laterales procedentes de estratos impermeables contiguos-. Las directrices elaboradas por la FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación) contienen información adicional sobre el cálculo de las recargas (Naciones Unidas, 1998).

La tasa de extracción media anual debería incluir todas las salidas de agua de la masa de agua subterránea, incluyendo todas las porciones confinadas del acuífero que estén conectadas. Puede considerarse que forma parte de las salidas la evaporación que se produce en masas de agua extensas, por ej. en graveras y en sistemas terrestres de drenaje. La decisión sobre descontar el agua captada que se ha devuelto localmente al acuífero o a un río -por ejemplo, retornos de riego o procedentes de la evacuación de agua de una cantera/mina- debe basarse en una evaluación de tipo hidrogeológico, teniendo en cuenta los impactos que afectan a la masa.

Deben determinarse tanto las necesidades de caudal ecológico de las aguas superficiales como las de los ecosistemas terrestres dependientes de las aguas subterráneas, así como el impacto de la captación del agua subterránea sobre flujos de baja cuantía. Dependiendo del grado en que las presiones derivadas de la captación afecten a la masa de agua subterránea podrán utilizarse unos métodos u otros. En algunos casos se pueden utilizar los conocimientos técnicos locales, herramientas simples, o modelos más sofisticados.

Cuando exista un flujo lateral o vertical entre masas de agua subterránea adyacentes y otros acuíferos, esa componente deberá tenerse en cuenta cuando se lleve a cabo el test de balance hídrico. En algunos casos los flujos pueden ser entradas –recarga- y en otros casos, salidas. También pueden agruparse las masas de agua subterránea para simplificar la evaluación del balance hídrico.

La figura 11 es un esquema de este test. Las estimaciones utilizadas para el cálculo de los distintos elementos deberían basarse en las mejores estimaciones disponibles. En algunos ambientes hidrogeológicos será difícil obtener cifras precisas -por ejemplo en acuíferos cársticos- y por ello habrá una cierta incertidumbre asociada a la evaluación. Es importante que la incertidumbre se refleje y se considere en la evaluación de la confianza asociada a los informes sobre el estado. En muchos casos, esta incertidumbre y confianza en la evaluación no podrán cuantificarse, porque pueden estar relacionadas con la incertidumbre en la comprensión del sistema físico, el modelo conceptual y otros aspectos considerados.

Cuando una masa de agua subterránea cubre zonas geográficamente extensas o comprende distintos acuíferos, puede ser apropiado subdividirla en partes más pequeñas que sean representativas para llevar a cabo este test. Cada parte debe ser adecuadamente delimitada para los objetivos de este test. Cuando las masas de agua subterránea se subdividen, el test debe aplicarse por separado a cada una de las partes. El estado global de la masa de agua subterránea para este test será entonces el menos favorable de los resultados de los distintos componentes individuales, siempre que los resultados en cuestión sean significativos.

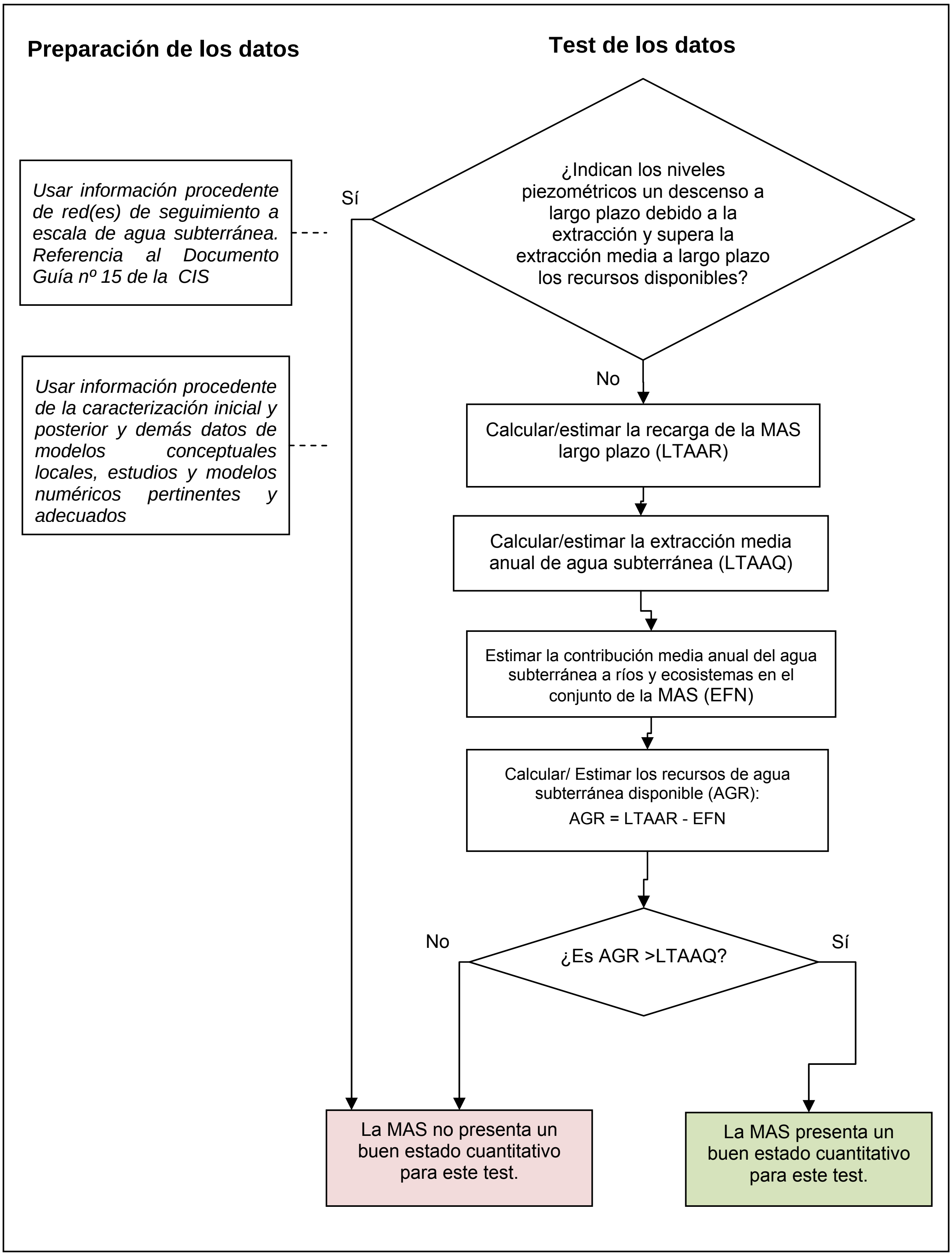


Figura 11. Esquema del procedimiento y necesidades de datos para el test de balance hídrico

LTAAQ – extracción media anual a largo plazo de agua subterránea

LTAAR – recarga media anual a largo plazo

EFN – caudales ecológicos a largo plazo

AGR – recursos de agua subterránea disponibles

5.3.2 Test: Flujo de agua superficial

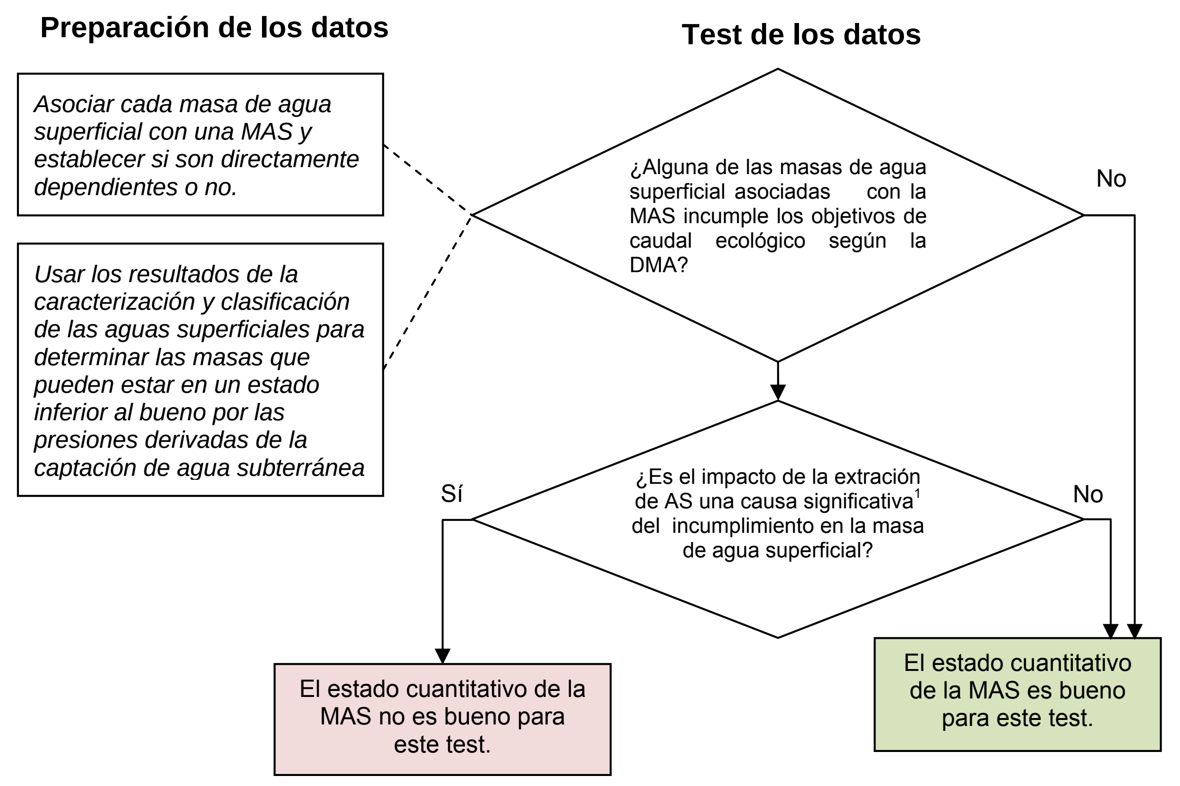
Para que una masa de agua subterránea se encuentre en buen estado para este test, no debe producirse ningún deterioro significativo de las características químicas o ecológicas de las aguas superficiales que afecten al logro de los objetivos reseñados en el artículo 4 de la DMA. Este test incluye tanto ríos como otras masas de agua superficial, como lagos, a las que se aplican los objetivos para las aguas superficiales de la DMA.

A diferencia del anterior, este test (véase la figura 12) toma en consideración si a escala local las presiones de la extracción de agua subterránea tienen un efecto significativo sobre las masas de agua superficial *consideradas de manera individual*, una vez que se han tenido en cuenta las distintas presiones sobre la(s) masa(s) de agua superficial. Dependiendo de la delimitación de las masas de agua, una MAS puede contener numerosas masas de agua superficial diferentes, cada una con sus propios objetivos.

Este test exige que se determinen las necesidades de flujo o de nivel de agua de las masas de agua superficial asociadas con MAS necesarias para contribuir a la consecución y el mantenimiento de un buen estado químico y ecológico. Los efectos de la extracción de agua subterránea pueden considerarse como una reducción del caudal en los ríos, y como una reducción del nivel en las restantes masas de agua superficial.

Si no se cumple este requisito de flujo/nivel como consecuencia de los efectos significativos derivados de la extracción de agua subterránea, la MAS se encontrará en mal estado, a no ser que la masa de agua superficial mantenga un estado ecológico bueno o alto. En todas las demás circunstancias, la MAS.

Frecuentemente no es posible medir con precisión la reducción de flujo/nivel que producen las presiones sobre las aguas subterráneas, puesto que, en muchas ocasiones, entre el momento en que se ejerce la presión de la extracción y la repercusión sobre la masa de agua superficial transcurre un tiempo, debido a la variabilidad y la respuesta de los sistemas hidrogeológicos. La imposibilidad de cumplir los requisitos necesarios de flujo/nivel en cualquier masa de agua superficial puede deberse también a la extracción de agua subterránea o de agua superficial. Por ello, será necesario estimar en qué medida el incumplimiento en las aguas superficiales es atribuible a las aguas subterráneas. Se ha sugerido un posible umbral para medir su importancia cuando más del 50% de la extracción permisible dentro de toda la zona de captación aguas arriba puede atribuirse a las aguas subterráneas. No obstante, el umbral que se utilice dependerá de cada Estado miembro y deberá tener en cuenta la incertidumbre en el proceso de evaluación y la importancia socio-económica de la extracción de agua subterránea con respecto a la de agua superficial.



[1]Test de importancia: Por ejemplo, si más del 50% -u otro umbral adecuado que tenga en cuenta la incertidumbre del procedimiento de evaluación y la importancia socioeconómica de la extracción de agua subterránea con respecto a la de agua superficial- del volumen admisible de abstracción de agua superficial puede atribuirse al agua subterránea, entonces se considerará importante.

Figura 12. Esquema del procedimiento propuesto para la evaluación del estado cuantitativo del elemento agua superficial

5.3.3 Test: Ecosistemas terrestres dependientes de las aguas subterráneas (ETDAS)

Para que una MAS se encuentre en buen estado no debe producirse ningún daño significativo para un ecosistema terrestre dependiente de dicha masa de agua subterránea. Los tests para evaluar el estado químico y el estado cuantitativo de ecosistemas terrestres dependientes de aguas subterráneas están estrechamente relacionados entre sí.

Para realizar este test es necesario determinar la situación medioambiental necesaria para apoyar y mantener las condiciones en un ecosistema terrestre dependiente de las aguas subterráneas, a saber, el flujo o el nivel necesario para el mantenimiento de comunidades vegetales dependientes.

Si no se cumplen las condiciones y se determina que el nivel de la masa de agua subterránea y el cambio del flujo debido a las captaciones son significativos, el estado de la masa de agua subterránea será deficiente. En todos los demás casos, la masa de agua subterránea estará en buen estado, pero potencialmente en riesgo. En la figura 13 se describe el procedimiento para este test.

En el marco de la caracterización inicial y de caracterizaciones adicionales deberá haberse realizado un ejercicio de investigación para determinar todos los ecosistemas terrestres dependientes de aguas subterráneas deteriorados, o en riesgo de estarlo, como resultado de las presiones que soporta el agua subterránea. Esta evaluación deberá haberse realizado sobre la base de criterios tales como las comunidades de indicadores ecológicos, la probable conexión con la masa de agua subterránea, la proximidad a presiones antropogénicas, acreditadas por conocimientos de ámbito local e informes sobre las condiciones del lugar. En la evaluación del estado solamente se considerarán los lugares respecto de los cuales se haya determinado que actualmente están “en riesgo”, partiendo del supuesto de que los ecosistemas terrestres dependientes de aguas subterráneas que “no están en riesgo” no provocarán el deterioro del estado de una masa de agua subterránea.

En muchos casos no será posible cuantificar con un alto grado de fiabilidad las aportaciones necesarias en este tipo de ecosistemas. Y ello se debe a que podría no existir información específica sobre el lugar en cuestión o información suficientemente detallada sobre todos los lugares. En tales circunstancias, la masa de agua subterránea estará en buen estado para este test, y se utilizarán los resultados del examen inicial de riesgos y de cualquier otro test disponible para decidir si los lugares en cuestión deben considerarse "en riesgo", en cuyo caso tendrán prioridad en investigaciones ulteriores.

5.3.4 Test: Intrusión salina u otras intrusiones

Para que una MAS esté en buen estado para este test no deberá existir intrusión salina prolongada ni intrusiones de otro tipo de agua de mala calidad que sea el resultado de un nivel sostenido o una presión hidrostática del agua inducidos antropogénicamente, de una reducción del flujo o de una alteración de la dirección del flujo como consecuencia de la captación. **Nota:** también podría producirse una intrusión salina prolongada incluso sin alteración de la dirección del flujo. Debido a las diferencias de densidad entre el agua salina y el agua dulce, una reducción de los niveles del agua o de la presión hidrostática provocará por sí sola la intrusión salina. Un descenso del gradiente hidráulico hacia la fuente de agua salina así como el correspondiente descenso en el flujo del agua subterránea favorecerán la intrusión salina antes de que el descenso de los niveles del agua sea suficiente para provocar un cambio en la dirección del flujo.

En este test, la intrusión se interpreta como una intrusión de agua de mala calidad en la masa de agua subterránea procedente de otra masa de agua (anexo V 2.3.2) más que el desplazamiento de un penacho de agua de mala calidad dentro de la masa. La intrusión podría provenir de una masa de agua situada más arriba, más abajo o adyacente a la masa cuyo estado se está evaluando.

Este test se combina con el test del estado químico para medir la intrusión salina, y se describe con mayor detalle en el capítulo 4.4.3 y la figura 7.

Cuando se realice la evaluación, se tendrán debidamente en cuenta los impactos históricos prolongados de la explotación, particularmente en acuíferos confinados y acuíferos con un bajo índice de recarga.[33] Los índices históricos de bombeo podrían haber provocado un descenso significativo de los niveles del agua subterránea o de los niveles piezométricos -p.ej. de centenares de metros- debido a una explotación excesiva, aun cuando desde entonces se haya reducido hasta niveles sostenibles, hasta alcanzar un equilibro actual con los índices de recarga. En tales casos, aun cuando el balance hídrico indique que no se sobrepasan los recursos disponibles, podría estar produciéndose una intrusión continuada y la calidad del agua subterránea podría seguir deteriorándose. Cuando se produzca una intrusión en la masa de agua, deberá aplicarse el test de intrusión salina.

Cuando la alteración de origen humano de los niveles piezométricos produzca cambios geoquímicos dentro de la propia masa de agua subterránea, y estos cambios ocasionen un deterioro de la calidad del agua dentro de la masa; y cuando estos cambios sean significativos y potencialmente puedan causar que se supere un valor umbral o una norma de calidad o cualquier otro objetivo pertinente de la DMA, deberán ser tomados en consideración en los tests del estado químico, (véase el capítulo 4.4.3). Un ejemplo de este proceso podría ser la oxidación del agua subterránea u otro cambio geoquímico en un acuífero anteriormente confinado a causa de una extracción excesiva que provoque la movilización o liberación de contaminantes. La gestión de la extracción de agua subterránea para el mantenimiento de las condiciones necesarias que minimicen el potencial incumplimiento del estado debido a los cambios geoquímicos inducidos por la actividad humana formará parte de un programa de medidas para dicha masa de agua subterránea. La definición de las medidas se sale del ámbito de este documento, pero cabría prever que dichas medidas incluyan el mantenimiento de acuíferos confinados en condiciones de confinamiento mediante el establecimiento de criterios sobre el nivel mínimo del agua, para evitar un futuro deterioro de su estado.

[33] En este contexto, el bajo índice de recarga se utiliza para hacer referencia a zonas semiáridas. La definición de lo que constituye una zona semiárida es cuando la relación entre la precipitación media anual y la evapotranspiración potencial es <0,5 (UNESCO, 1979).

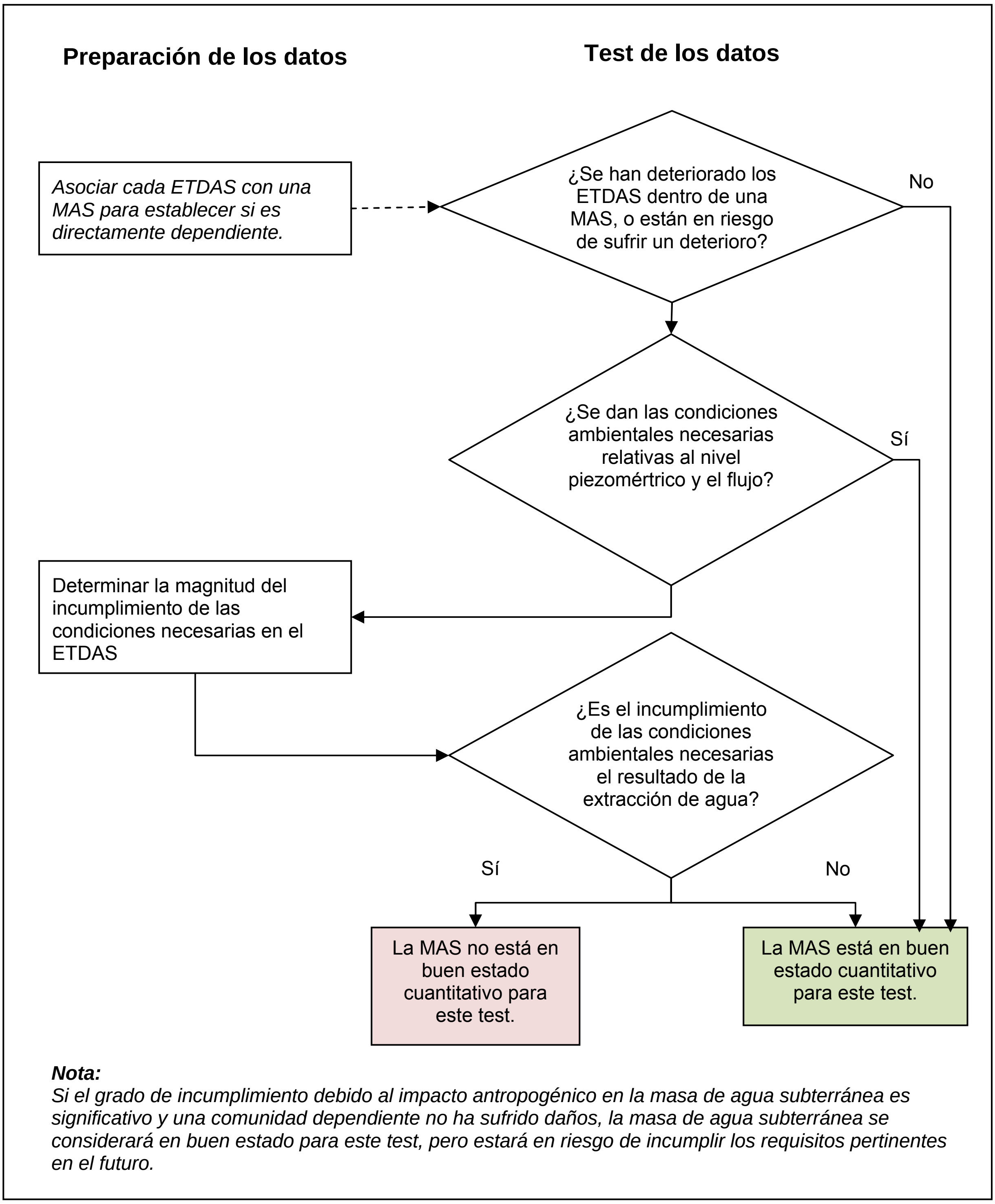


Figura 13. Esquema del procedimiento propuesto para el elemento ETDAS en la evaluación del estado cuantitativo

6 EVALUACIÓN DE TENDENCIAS Y DE LA INVERSIÓN DE LAS TENDENCIAS

6.1 Definición de tendencias significativas y sostenidas al aumento de la contaminación e inversión de las tendencias

La DMA y la DAS establecen que los Estados miembros deberán determinar si existen tendencias al aumento significativo y sostenido de las concentraciones de contaminantes, grupos de contaminantes o indicadores de contaminación encontrados en las masas o grupos de masas de agua subterránea respecto de las cuales se haya determinado que están en riesgo (anexo V 2.4.4 de la DMA y artículo 5 de la DAS). Los Estados miembros deberán asimismo invertir dichas tendencias: *"los Estados miembros habrán de aplicar las medidas necesarias para invertir toda tendencia significativa y sostenida al aumento de la concentración de cualquier contaminante debida a las repercusiones de la actividad humana con el fin de reducir progresivamente la contaminación de las aguas subterráneas."* (artículo 4.1.b)iii) de la DMA). Las medidas deben ir dirigidas a reducir progresivamente la contaminación y a impedir nuevos deterioros de las aguas subterráneas (artículo 5.2 de la DAS).

Una tendencia significativa y sostenida al aumento es *"cualquier aumento significativo desde el punto de vista estadístico y medioambiental de la concentración de un contaminante, grupo de contaminantes o indicador de contaminación en aguas subterráneas para el que se haya determinado la necesidad de una inversión de la tendencia, de conformidad con el artículo 5"* (artículo 2.3 de la DAS).

Una *tendencia significativa desde el punto de vista estadístico* es aquella que haya sido determinada utilizando una técnica reconocida de evaluación de tendencias.

Una tendencia *significativa desde el punto de vista medioambiental* es aquélla estadísticamente significativa y que, de no invertirse, derivaría en el incumplimiento de uno o más de los objetivos medioambientales estipulados en la DMA.

6.2 Elementos de la evaluación de tendencias y de la inversión de las tendencias

La evaluación de tendencias sólo deberá realizarse en las masas de agua subterránea que estén en riesgo de incumplir los objetivos estipulados en el artículo 4 de la DMA en relación con cada uno de los contaminantes que contribuyan a que la MAS haya sido caracterizada como tal (anexo IV de la DAS). Esto no sólo incluye a las masas de agua identificadas en 2004 en cuanto al cumplimiento de los objetivos del artículo 5 de la DMA, sino también a todas las masas de agua subterránea respecto de las cuales se haya determinado que están en riesgo como resultado de una actualización de la evaluación de riesgos y/o de nuevos resultados obtenidos mediante el control de vigilancia.

También podría ser necesario iniciar una evaluación de las tendencias en las masas de agua subterránea que no estén en riesgo actualmente a fin de distinguir las tendencias prolongadas como consecuencia de cambios de las condiciones naturales y de la actividad humana (anexo V 2.4.2 de la DMA).

Los Estados miembros definirán el punto de partida de las inversiones de tendencia de manera que se puedan invertir las tendencias en el tiempo para evitar un (futuro) incumplimiento de los objetivos medioambientales pertinentes (artículo 5.3 y anexo IV, B de la DAS). Este punto de partida se definirá como porcentaje de la norma de calidad de las aguas subterráneas o del valor umbral pertinente, y se notificará en el PHC.

Los Estados miembros identificarán en los planes hidrológicos de cuenca las MAS que presenten tendencias a un aumento significativo y sostenido y, cuando proceda, aquéllas donde se hayan invertido las tendencias. El PHC explicará asimismo de manera resumida la forma en que se hayan utilizado los resultados obtenidos en los distintos puntos de control para identificar dichas tendencias (artículo 5.4 de la DAS).

Los Estados miembros podrán también realizar evaluaciones de tendencia adicionales a fin de verificar que los penachos procedentes de sitios contaminados no representan una amenaza para el logro de los objetivos del artículo 4 de la DMA; en particular, que no se expandan ni deterioren el estado químico de la masa o grupos de masas de agua subterránea, y que no supongan un riesgo para la salud humana y el medio ambiente (artículo 5.5 de la DAS).

En el marco de la evaluación de tendencias significativas y sostenidas al aumento y de la evaluación de la inversión de las tendencias deberán tomarse en consideración los siguientes elementos (véase también la figura 14):

- cuál es el método estadístico correcto para evaluar las tendencias en cada punto de control (como el análisis de regresión);
- cómo tratar los valores obtenidos mediante el seguimiento que se sitúan por debajo del límite de cuantificación;
- cuál es la duración adecuada de las series temporales;
- cómo considerar los niveles básicos de sustancias que se producen de manera natural y antropogénica;
- cuál es el grado de fiabilidad aceptable de la evaluación de las tendencias:
- cómo establecer un punto de partida de la inversión de tendencias;
- cómo demostrar estadísticamente que se ha invertido la tendencia declarando el grado de fiabilidad de la identificación.

De conformidad con el mandato recibido por el grupo de redacción de este documento, los criterios sobre la evaluación de tendencias y la evaluación de la inversión de las tendencias deben considerar como fuente básica el Informe Técnico nº 1 de la CIS”[34]. Asimismo deben tenerse en cuenta el desarrollo de nuevas metodologías y las experiencias adquiridas en los Estados miembros.

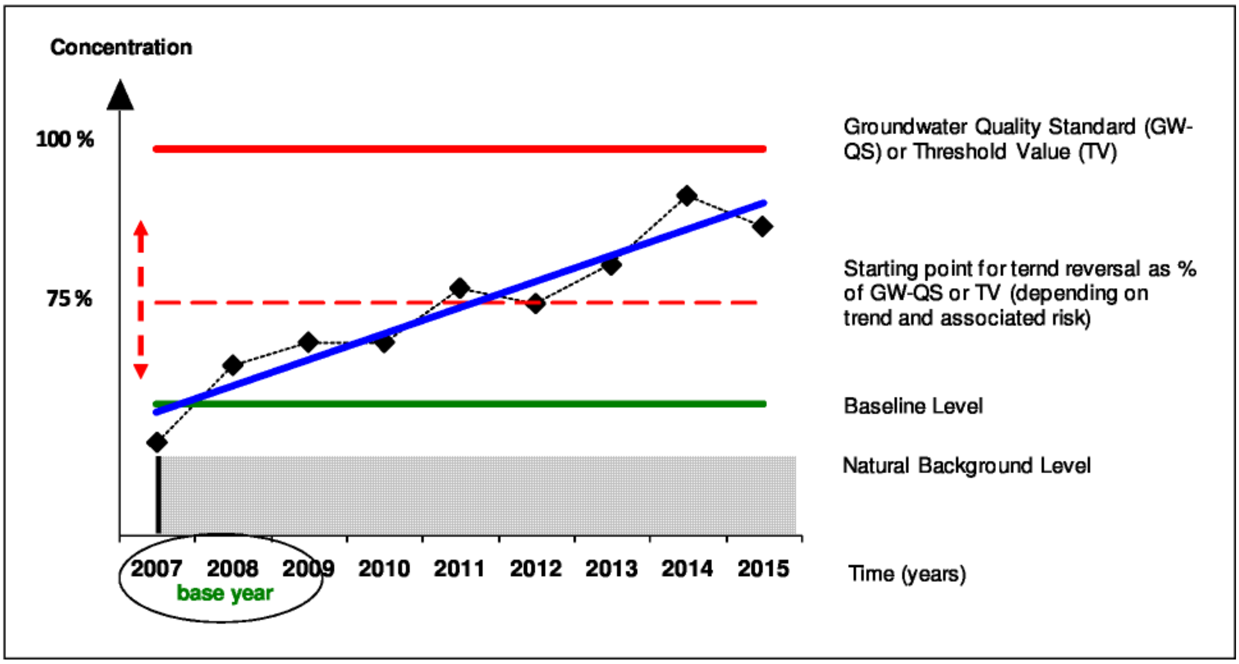


Figura 14. Elementos de la evaluación de tendencias y de inversión de las tendencias

6.2.1 Parámetros considerados

El anexo V 2.4.4 de la DMA y el artículo 5.1 de la DAS establecen que se determinará toda tendencia significativa y sostenida al aumento de las concentraciones de los contaminantes, grupos de contaminantes o indicadores de contaminación detectada en masas de agua subterránea o grupos de masas de agua subterránea en riesgo. A diferencia de la evaluación del estado químico, ninguna de las directivas establece de manera explícita qué parámetros deben someterse a esta evaluación.

El punto de partida de la inversión de las tendencias se establecerá en relación con las normas de calidad de las aguas subterráneas recogidas en el anexo I de la DAS y/o los valores umbral establecidos en el artículo 3 para parámetros que supongan un riesgo para la MAS. Se considera, por consiguiente, que debe realizarse una evaluación de las tendencias y de la inversión de éstas para los parámetros que representen un riesgo para la masa de agua subterránea.

La evaluación de tendencias podría realizarse también para cualquier otro parámetro –natural- que pueda ocurrir en cualquier punto de la masa de agua subterránea como consecuencia de la actividad humana, si los Estados miembros consideran que existe potencial para que en un futuro aparezcan tendencias significativas para el medio ambiente.

[34] Technical Report No. 1: Statistical aspects of the identification of groundwater pollution trends and aggregation of monitoring results – WG 2.8 Statistics (2001).

Esta información podrá utilizarse en la caracterización y evaluación de riesgos, y constituye una alerta temprana ante posibles problemas futuros para las masas de agua subterránea que actualmente estén en riesgo, así como para aquéllas que no lo estén.

La evaluación de tendencias para comprobar que no se expanden los penachos contaminantes es muy específica de cada caso y debe centrarse en los contaminantes o indicadores de contaminación correspondientes a los respectivos tests del estado de las aguas subterráneas.

6.2.2 Diseño de la red de seguimiento

De conformidad con el anexo IV A, 2.a) de la DAS, las características de la red de seguimiento –determinación de frecuencias de medida y selección de puntos de control- deberá ser suficiente para:

- garantizar que las tendencias al aumento puedan distinguirse de las variaciones naturales con un nivel adecuado de fiabilidad y precisión;
- determinar con tiempo suficiente las tendencias al aumento para que puedan adoptarse medidas;
- tener en cuenta las características temporales, físicas y químicas, de la masa de agua subterránea, incluidas las condiciones de flujo y los índices de recarga del agua subterránea, así como el tiempo que ésta tarda en atravesar el suelo o el subsuelo.

El anexo IV A, 2.b) de la DAS establece asimismo que *"se utilizarán métodos de control y análisis acordes con los principios internacionales de control de la calidad, entre ellos, si procede, las normas CEN o los métodos nacionales normalizados, para garantizar que se proporcionen datos de calidad científica equivalente que puedan compararse".*

6.2.3 Datos de la red de seguimiento

La evaluación de tendencias y de la inversión de las tendencias se basará en los datos obtenidos en los controles de vigilancia y operativo en los distintos puntos de control. Esta determinación de tendencias se llevará a cabo por primera vez en 2009, si es posible, y teniendo en cuenta los datos recopilados con anterioridad al ciclo en curso del PHC, a fin de permitir una evaluación fiable de las tendencias e informar sobre las mismas en el primer PHC (anexo IV A,2.a,ii y anexo IV A,3).

Cuando dispongan de datos de seguimiento adicionales que sean representativos, los Estados miembros tendrán libertad para incluirlos en la evaluación cuando puedan contribuir a mejorar la fiabilidad de la misma. No obstante, los datos deberán ser directamente comparables con los datos de seguimiento previstos en la DMA -p.ej. con respecto a los métodos de análisis, el muestreo y el control de calidad-.

6.2.4 Utilización de los niveles básicos

Para la determinación de tendencias en las concentraciones de sustancias que se produzcan naturalmente y como resultado de las actividades humanas se considerarán también los niveles básicos (anexo IV A,3 de la DAS).

"Nivel básico" es el valor medio medido por lo menos durante los años de referencia 2007 y 2008 sobre la base de los programas de control aplicados De conformidad con el artículo 8 de la Directiva 2000/60/CE o, en el caso de sustancias identificadas después de los citados años de referencia, durante el primer período para el que se disponga de un período representativo de datos de control" (artículo 2.6 de la DAS).

El nivel básico proporciona un punto de referencia respecto al cual puedan medirse futuros cambios -tendencias- en las concentraciones de contaminantes. Los Estados miembros podrán utilizar todos los demás datos representativos[35] de que puedan disponer que sean anteriores a la aplicación de los programas de seguimiento previstos en el artículo 8 de la DMA. **Atención**: el nivel básico no debe confundirse con el nivel de referencia (natural).

De conformidad con el anexo V 2.4.4 de la DMA, el año de base corresponde al año en que se midieron los niveles básicos. **Atención**: no debe confundirse el año de base de la evaluación de tendencias con el punto de partida de la inversión de tendencias.

6.2.5 Duración de las series temporales utilizadas

La duración de las series temporales que deben utilizarse en la evaluación de tendencias dependerá de cómo reacciona la masa de agua subterránea a los cambios en las prácticas que se desarrollan en la superficie del suelo -modelo conceptual-, de la capacidad del método de test de tendencias para

[35] Véase la guía pertinente sobre muestreo y seguimiento QA/QC en la que se encontrará una descripción completa de cómo garantizar que los datos se hayan generado utilizando métodos reproducibles y que son representativos de la MAS.

detectar las tendencias y de la calidad de los datos (véase tratamiento de valores menores que el límite de cuantificación (LC), capítulo 3.4). Los datos de calidad deficiente y los altos LC en el pasado, así como las series temporales demasiado largas, podrían tener una influencia significativa y duradera en los resultados de la evaluación de tendencias, aun cuando los datos recientes puedan ser de buena calidad.

Para evitar posibles sesgos en la evaluación global -p.ej. a escala de masa de agua subterránea o a escala regional- es preferible utilizar series temporales de datos de la red de seguimiento de una duración constante. La extensión mínima de las series temporales que deben utilizarse, en términos de número de mediciones normalizadas y del número mínimo de años considerados, dependerá de la frecuencia del seguimiento, del método estadístico, del punto de partida de la inversión de tendencias y de la potencia del método. La extensión máxima de las series temporales que deben utilizarse dependerá del modelo conceptual de la MAS, de la evolución temporal de las concentraciones y de la variabilidad de los datos. Una serie temporal demasiado larga podría dar resultados de tendencias sesgados por cambios que se hayan producido en los primeros años de la serie temporal. En consecuencia, podría ser de utilidad probar con una serie temporal larga para comprobar si se producen cambios significativos en la tendencia. Si es éste el caso, habrá que investigar utilizando solamente datos recientes, siempre que su duración sea suficiente para evaluar las tendencias. Sin embargo, se recomienda siempre cautela para garantizar que la duración de la serie temporal considerada sigue siendo coherente con el modelo conceptual de la MAS -p.ej. tasas de transferencia, tiempos de residencia, etc-. Como regla general, nunca deben descartarse datos a menos que se demuestre que son incorrectos como consecuencia de algún error cometido en el muestreo o en las determinaciones analíticas.

6.2.6 Metodología de evaluación de tendencias

La evaluación se basará en un método estadístico conocido y apropiado, como el análisis de regresión (anexo IV A,2.c)). Habida cuenta de que “significativo” se refiere a significación estadística -además de medioambiental-, el método elegido debe poder probar la significación estadística de la tendencia en cuestión.

Cuando se definan los puntos de partida de la inversión de las tendencias, el tiempo transcurrido desde el punto de partida hasta el momento en que se superan las normas de calidad de las aguas subterráneas o los valores umbral deberá ser suficiente para que la metodología de evaluación de tendencias utilizada pueda detectar una tendencia significativa, es decir, que el tiempo transcurrido sea suficiente para detectar una tendencia significativa desde el punto de vista medioambiental y para adoptar medidas para invertir dicha tendencia. La capacidad de un método para detectar un aumento determinado en las concentraciones de contaminantes con una probabilidad determinada se denomina “potencia” del método[36].

A fin de distinguir con un grado adecuado de fiabilidad y precisión entre variación natural y tendencias, la metodología para evaluar la tendencia también debe incluir, cuando proceda, un test de estacionalidad, es decir, cuando en las concentraciones se produzcan variaciones significativas dentro de un mismo año.

6.2.7 Confianza en la evaluación

El grado de fiabilidad asociado a cualquier tendencia identificada o inversión de tendencia deberá demostrarse y registrarse (anexo V 2.4.4 de la DMA y anexo IV B,3. de la DAS).

Para que una tendencia sea estadísticamente significativa se recomienda como norma que la fiabilidad de la evaluación sea de un 95%.

6.2.8 Punto de partida de la inversión de tendencias

La DAS establece en su artículo 5.3 que los Estados miembros definirán puntos de partida para la implantación de medidas destinadas a invertir las tendencias, y el anexo IV, parte B de la DAS especifica los criterios para el establecimiento de dichos puntos de partida. El punto de partida debe tener en cuenta el riesgo o los riesgos medioambientales asociados a la masa de agua subterránea, los objetivos medioambientales y las normas de calidad de las aguas subterráneas y/o los valores umbral que se hayan establecido para la masa de agua. El punto de partida será un porcentaje de dichas normas de calidad o valores umbral.

[36] Informe Técnico nº 1: Aspectos estadísticos de la identificación de las tendencias contaminantes de aguas subterráneas y agregación de los resultados del seguimiento – GT 2.8 Statistics (2001).

Como norma general, el punto de partida será el momento en el cual la concentración del contaminante alcance el 75% de los valores paramétricos de las normas de calidad las aguas subterráneas y de los valores umbral pertinentes, a menos que:

a) sea necesario un punto de partida anterior para permitir que las medidas de inversión impidan del modo más rentable, o al menos mitiguen en la medida de lo posible, cualquier cambio adverso significativo en la calidad del agua subterránea;

b) se justifique un punto de partida distinto si el límite de detección -o el límite de cuantificación- no permite establecer la presencia de una tendencia cifrada en el 75% de los valores paramétricos; o

c) la tasa de aumento y la reversibilidad de la tendencia sean tales que, de tomarse un punto de partida posterior para aplicar medidas de inversión de la tendencia, éste seguiría permitiendo que dichas medidas impidan del modo más rentable, o al menos mitiguen en la medida de lo posible, cualquier cambio adverso significativo desde el punto de vista medioambiental en la calidad del agua subterránea. Este punto de partida posterior no podrá suponer retraso alguno en el cumplimiento de los plazos para el logro de los objetivos medioambientales.

Un punto de partida diferente podría estar justificado también cuando las concentraciones de referencia naturales y los valores umbral estén muy cerca unas de otros o sean los mismos (caso 2 en el apartado 4.3.3).

El punto de partida para aplicar medidas encaminadas a invertir las tendencias depende principalmente de las características de la MAS -según definición en el modelo conceptual- y de su capacidad de responder a dichas medidas. El punto de partida elegido debe permitir a los Estados miembros invertir estas tendencias de la manera más rentable antes de que las concentraciones de contaminantes causen cambios adversos significativos en la calidad del agua subterránea. En MAS que reaccionen muy lentamente a los cambios podría ser necesario un punto de partida anterior; para las masas de agua subterránea que responden con rapidez podría justificarse un punto de partida posterior.

Una vez establecido un punto de partida para una tendencia, éste no se modificará durante el ciclo de seis años del plan hidrológico de cuenca (anexo V, B, 2 de la DAS).

6.2.9 Metodología de evaluación de la inversión de las tendencias

Tal como establece la DAS (anexo IV B, 3), deberá demostrarse la inversión de tendencias.

En el Informe Técnico nº 1[37] se describe una metodología de evaluación de la inversión de tendencias, que esté basada en un análisis de regresión, en el que se analiza cada serie temporal para determinar si se ha producido un cambio en la tendencia. Esto ocurre cuando una tendencia sostenida y significativa al aumento va seguida de una tendencia significativa al descenso.

6.2.10 Calendario de la evaluación de tendencias y de la inversión de las tendencias

La determinación de tendencias se llevará a cabo por primera vez en 2009, si es posible, y en lo sucesivo, una vez cada seis años como mínimo (anexo IV A, 2. ii) de la DAS), teniendo en cuenta los datos existentes obtenidos en el control de vigilancia y el control operativo, así como los datos de seguimiento recopilados antes del comienzo del programa de seguimiento. Esto permitirá informar sobre las tendencias en el primer PHC (anexo IV A, 2. a), ii) y anexo IV A, 3).

Habida cuenta de que el proyecto de PHC se someterá a la participación pública un año antes de su entrada en vigor, se recomienda que, si es posible, los Estados miembros evalúen las tendencias y la inversión de tendencias antes de presentar el proyecto de PHC.

6.3 Tests para evaluación de tendencias y de la inversión de las tendencias

Para cumplir los requisitos previstos en la DMA y la DAS, la evaluación de tendencias deberá:

- determinar si una masa de agua subterránea en riesgo está sometida a una tendencia significativa y sostenida al aumento que de conformidad con el artículo 5.1 y 5.2 deba invertirse; estas tendencias entran dentro de dos categorías generales (véase la tabla 3):
  - *“que presenten un riesgo para los usos legítimos, reales o potenciales, del medio acuático”*

[37] Informe Técnico nº 1: Aspectos estadísticos de la identificación de las tendencias contaminantes en aguas subterráneas y agregación de los resultados de seguimiento – GT 2.8 Statistics (2001)

– *"que representen un riesgo para la calidad de los ecosistemas acuáticos" o "para los ecosistemas terrestres"*

- en el marco de la evaluación del estado químico (evaluación de la intrusión salina y objetivos para zonas protegidas para la captación de agua potable) (véase la tabla);
- evaluar, cuando corresponda, el impacto de penachos de contaminación procedentes de fuentes contaminantes y lugares contaminados que puedan comprometer el cumplimiento de los objetivos especificados en la DMA y la DAS (artículo 5.5 de la DAS) (véase la tabla 4).

La evaluación de la inversión de las tendencias es necesaria si una MAS está sometida a una tendencia significativa y sostenida al aumento que, de conformidad con el artículo 5.1 y 5.2 deba invertirse.

Tabla 3. Evaluación de tendencias (artículo 5.1 y 5.2 de la DAS). Resumen de elementos y tests correspondientes

Evaluación de tendencias (artículo 5.1 y 5.2 de la DAS)	**Test**	**Evaluación de tendencias**	**Evaluación de la inversión de tendencias**	**Determ. a nivel de la MAS**	**Puntos de control pertinentes**
Determinar e invertir tendencias que supongan un riesgo significativo para los usos reales o potenciales del medio acuático	Ningún daño a los usos legítimos.	x	x	x	x
Determinar e invertir tendencias que supongan un riesgo significativo para la calidad de los ecosistemas acuáticos	Ningún daño a los ecosistemas acuáticos.	x	x	x	x
Determinar e invertir tendencias que supongan un riesgo significativo para los ecosistemas terrestres	Ningún daño a los ecosistemas terrestres.	x	x	x	x

Tabla 4. Evaluación adicional de tendencias. Resumen de elementos y tests correspondientes

Nueva evaluación de tendencias	**Test**	**Evaluación de tendencias**	**Evaluación de inversión de tendencia**	**Determ. a nivel de la MAS**	**Puntos de control pertinntes**
Evaluación de penachos (artículo 5.5 de la DAS)					
Se considerará una evaluación de tendencias para comprobar que los penachos resultantes de lugares contaminados no se expanden, no deterioran el estado químico de la masa o grupo de masas de agua subterránea y no suponen un riesgo para la salud humana ni para el medio ambiente (DAS, art. 5.5).	No hay expansión de penachos que supongan deterioro del estado químico ni riesgo para la salud humana ni el medio ambiente.	x			x
Evaluación del estado					
En la masa de agua subterránea no hay entradas ni conato de entrada de agua de mar ni de agua de una composición química sustancialmente diferente de otras masas de agua subterránea o aguas superficiales que pueda causar contaminación (DMA, anexo V 2.3.2).	No hay intrusión salina ni de otro tipo.	x			x
No hay deterioro de la calidad de las aguas para el consumo humano (DAS, artículo 4.2.c), iii) y anexo III 4)	Cumple los requisitos del artículo 7.3 de la DMA Zonas protegidas de captación de agua potable	x			x

6.3.1 Determinación de tendencias significativas desde el punto de vista medioambiental y escala de la evaluación (artículo 5.1 de la DAS)

La DAS establece en su artículo 5.1 que los Estados miembros determinarán si la *masa de agua subterránea* está afectada por una tendencia significativa y sostenida al aumento desde el punto de vista medioambiental inducida antropogénicamente.

Habida cuenta de que la evaluación de tendencias se basa en los datos procedentes del seguimiento individual o de los puntos de control operativo, será necesario un procedimiento para combinar los resultados de las distintas evaluaciones de tendencias y de inversión de tendencias en los puntos de control a fin de medir la tendencia a nivel de la masa de agua subterránea (artículo 5.4.a) de la DAS).

Para determinar si una tendencia es significativa desde el punto de vista medioambiental pueden aplicarse los mismos principios que para evaluar el estado químico. Esto significa que la evaluación de tendencias deberá aplicarse a la misma escala que se utilice para medir la magnitud de la tendencia, es decir, podría ser necesario realizar la evaluación de tendencias en los puntos de control individuales, en los grupos de puntos de control o agregando los resultados obtenidos en toda la MAS. Por ejemplo, cuando se examine la importancia medioambiental de un riesgo medioambiental extenso procedente de los contaminantes -p.ej. como consecuencia de fuentes de contaminación difusa-, deben agregarse los datos de la tendencia en la MAS porque todos los puntos de control podrían considerarse importantes. Cuando el riesgo afecte a un ecosistema específico -acuático o terrestre- que dependa del agua subterránea, lo importante podrían ser las tendencias en los puntos de control individuales o en los grupos de puntos de control por su relevancia en que la MAS no alcance los objetivos medioambientales.

6.3.2 Test: “Riesgo para los usos existentes, reales o potenciales del medio acuático” (DAS, artículo 5.1 y 5.2)

Este test permite determinar las tendencias de relevancia medioambiental causadas por la extensión del impacto o por el riesgo procedente de contaminantes -por ej. de fuentes de contaminación difusas que afecten a toda la MAS-. Para poder realizar la evaluación deberán agregarse los datos sobre las tendencias procedentes de toda la MAS y, en consecuencia, todos los puntos de control podrían considerarse importantes. Si la evaluación general de tendencias a escala de MAS detecta una tendencia sostenida al aumento, una evaluación específica en los puntos de control podría ayudar a centrar, de una manera más eficaz, las medidas encaminadas a invertir dichas tendencias.

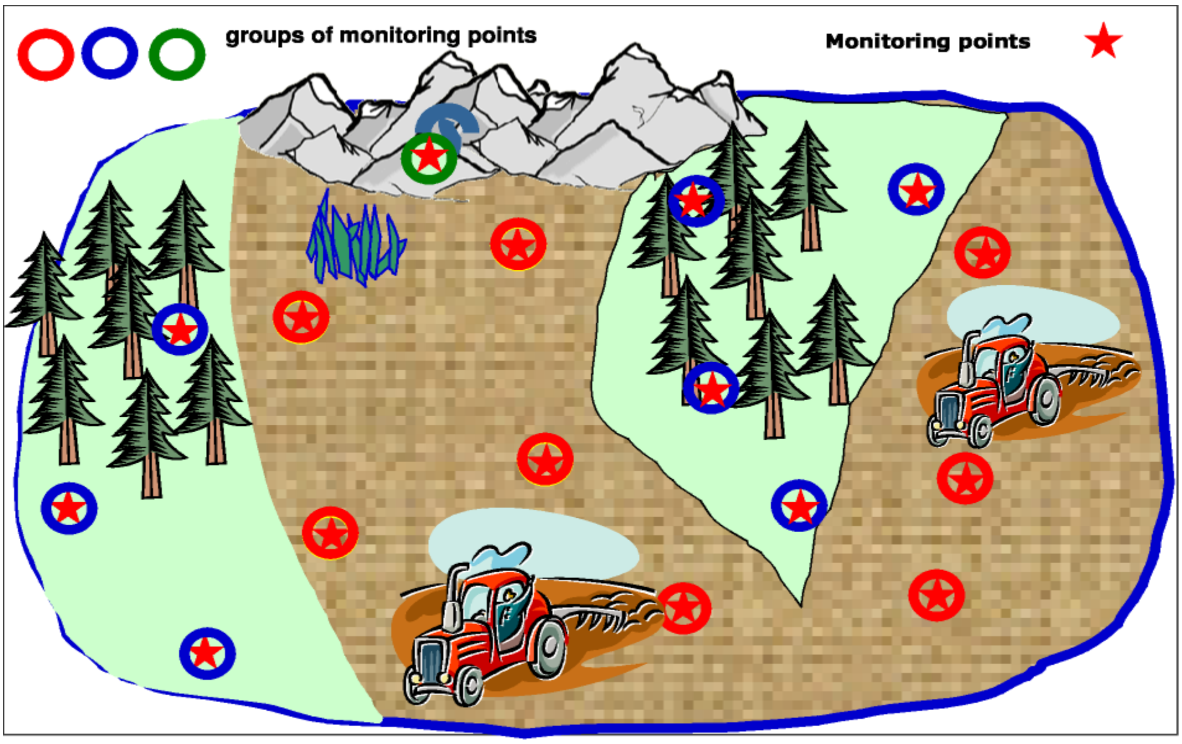


Figura 15. Selección de todos los puntos de control que se consideran pertinentes para el test de riesgo para usos legítimos. Agrupación opcional de puntos de control según modelo conceptual.

La evaluación de impactos de ámbito más local -por ej. fuentes de contaminación difusas regionales o fuentes de contaminación puntuales- exige que se agrupen los puntos de control en la masa de agua subterránea. Según el modelo conceptual -presiones pertinentes, vulnerabilidad del acuífero, etc.-, solamente deben utilizarse los "grupos" de puntos de control pertinentes.

6.3.3 Test: "Riesgo para ecosistemas acuáticos" y "Riesgo para ecosistemas terrestres" (DAS, artículo 5.1 y 5.2)

El test de riesgo para ecosistemas acuáticos y terrestres es comparable a la evaluación mencionada anteriormente, relativa a los impactos de ámbito más local. Es similar a la evaluación del estado que sólo utiliza los puntos de control pertinentes en la masa de agua subterránea -por ej. puntos de control en zonas donde los contaminantes podrían pasar a la masa de aguas superficiales o a un ecosistema terrestre dependiente-. En el caso de los ecosistemas acuáticos y terrestres, un único punto de control pertinente podría ser suficiente para indicar que en la masa de agua subterránea existe una tendencia significativa siempre que dicho punto de control pertinente indique una tendencia.

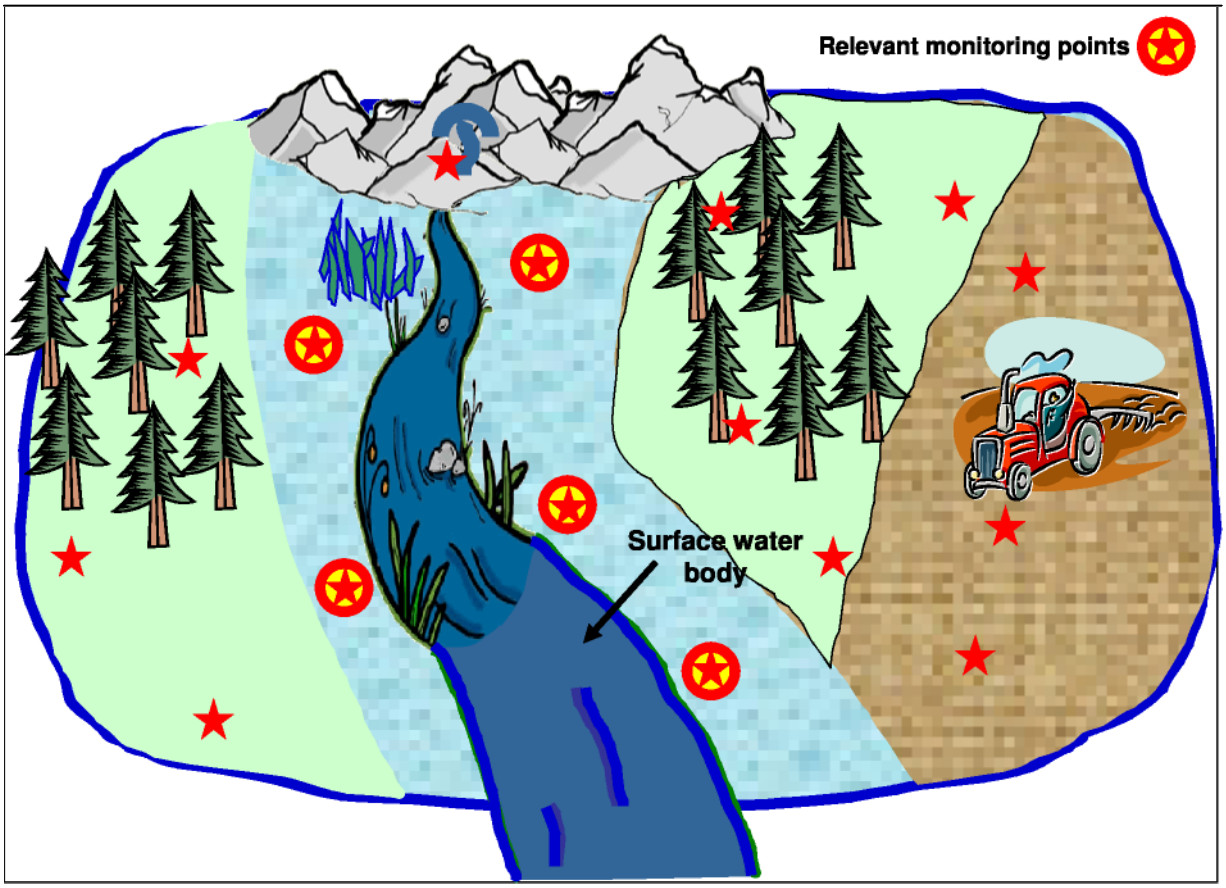


Figura 16. Selección de puntos de control considerados pertinentes para el test sobre riesgo para ecosistemas acuáticos y terrestres.

6.3.4 Evaluación de tendencias como apoyo de la evaluación del estado

La evaluación de tendencias forma parte integral del análisis del estado para detectar intrusiones salinas o de otro tipo (véase capítulo 4.4.3) y del test para determinar que el agua destinada al consumo humano no ha sufrido deterioro y cumple los requisitos especificados en el artículo 7.3 de la DMA (véase capítulo 4.4.6) (tabla 4). La evaluación de tendencias en estos casos se aplica en puntos de control que sean apropiados para los procedimientos pertinentes de evaluación del estado.

6.3.5 Evaluación de tendencias como apoyo de la caracterización de penachos de contaminación

Podría ser necesaria una evaluación de tendencias para garantizar que los penachos procedentes de lugares contaminados no se expanden (artículo 5.5 de la DAS) (tabla 4). El término "expandir" se utiliza aquí para indicar penachos en cuyo interior aumenta la masa general de contaminantes, es decir, el término indica que existe una fuente activa. La evaluación debe centrarse en los penachos pertinentes que puedan suponer un riesgo para la salud humana y el medio ambiente o deteriorar el estado químico de las masas de agua subterránea. Cuando proceda y sea necesario, se realizará una evaluación de las tendencias en los puntos de control que puedan verse afectados. Esta evaluación podría incluir puntos de control que no formen parte de la red de control de vigilancia y control operativo. La evaluación se centrará en los parámetros pertinentes dentro del penacho.

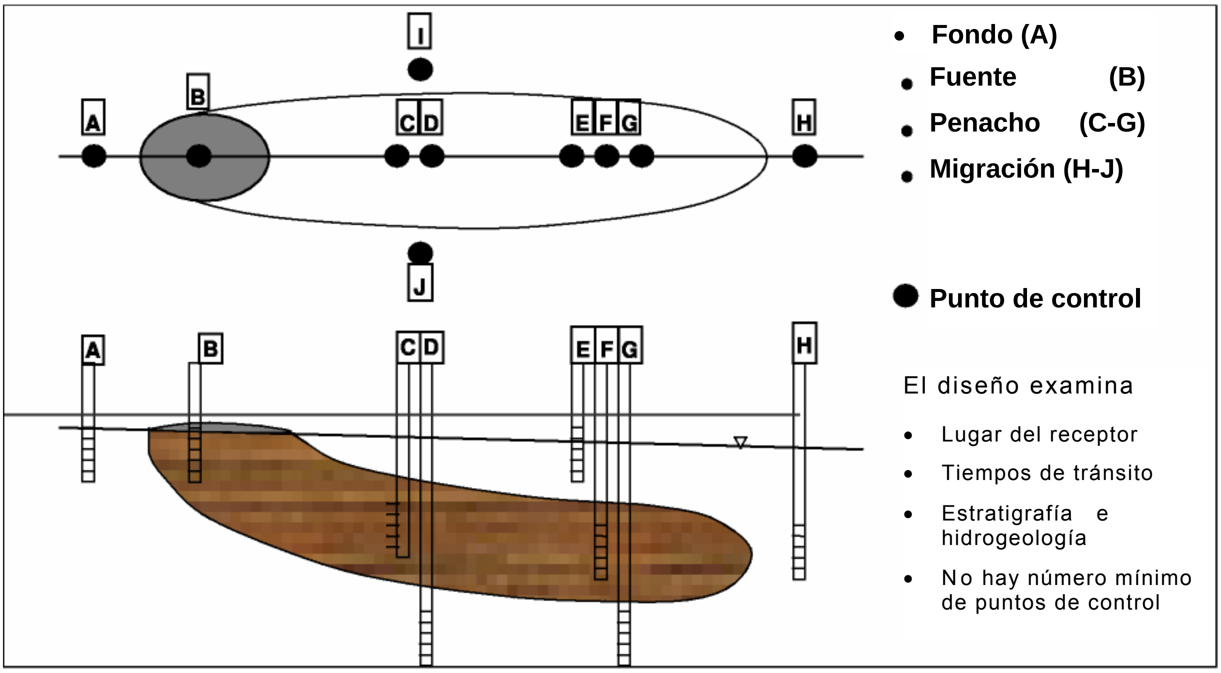


Figura 17. Red de seguimiento para comprobar que no se expanden los penachos

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8 ANEXO 1: PRINCIPIOS DE APLICACIÓN DE FACTORES DE DILUCIÓN Y ATENUACIÓN

Los valores umbral tienen como finalidad última proteger receptores, como los ecosistemas de aguas superficiales, los ecosistemas terrestres dependientes de aguas subterráneas y los usos para el consumo humano. La mayor protección se logrará definiendo los valores umbral al nivel de la norma de calidad medioambiental del receptor o una norma de uso pertinente, y será necesario su cumplimiento en cada punto comprendido entre la zona de recarga y la zona de descarga de los sistemas de aguas subterráneas. No obstante, podría no ser siempre necesario fijar estos valores de una manera tan estricta porque pueden ocurrir procesos de dilución y de atenuación entre la zona de recarga y el receptor. Tanto si el receptor es una corriente de aguas superficiales, un manantial o un pozo de bombeo, el agua receptora es siempre una mezcla de aguas con diferentes tiempos de permanencia y diferente contribución de contaminantes. Los valores umbral pueden fijarse de manera que reconozcan estas distintas contribuciones desde aguas someras y más profundas, eligiendo un valor que, a largo plazo, impida suficientemente que el agua del manantial sobrepase la norma de calidad ambiental (NCA) para aguas superficiales o los ecosistemas terrestres.

Al tiempo que se tienen en cuenta la dilución y la atenuación cuando se calculan los valores umbral, es importante considerar la posición de los puntos de control en el régimen de flujo y los tiempos de tránsito hacia el receptor, tanto en dirección horizontal como vertical. Respecto de esta última, es importante recordar que la edad de las aguas subterráneas suele aumentar con la profundidad, y las aguas subterráneas jóvenes y someras se mezclan con las aguas subterráneas más antiguas al incorporarse a la corriente fluvial o al alcanzar los pozos de extracción. Dadas las diferencias que existen entre las distintas tipologías de acuíferos en los Estados miembros, podemos distinguir diferentes tipos de seguimiento, entre los que se incluyen la utilización de pozos de bombeo, sondeos específicos de seguimiento, manantiales y sondeos de observación de niveles múltiples. Estos tipos de seguimiento podrían tener una posición diferente dentro del sistema de flujo de las aguas subterráneas así como distribuciones de tiempo de permanencia distintas. La aplicación de factores de dilución y atenuación es especialmente sensible para el seguimiento en profundidades someras y en tiempos de permanencia cortos desde la zona de recarga. A fin de alcanzar un nivel adecuado de protección, los factores de dilución y atenuación deben ser adaptados a la mezcla de aguas en el receptor que se produce de forma natural con tiempos de permanencia cortos y largos.

8.1 Dilución

La dilución incluye, por lo general (véase figura 18 A):

- la extensión de las zonas donde los contaminantes entran en el sistema con respecto a toda la cuenca hidrográfica;
- la distribución de tiempos de permanencia de las aguas subterráneas que alimentan la corriente fluvial, que viene determinada por el campo de flujo tridimensional;
- el volumen de aguas subterráneas que alimentan la corriente fluvial con respecto a otras fuentes de agua, entre las que se incluyen la escorrentía superficial y el abastecimiento de aguas superficiales procedente de aguas arriba que están fuera de la masa de agua subterránea.

En la figura 18 A, cerca del 10% de la zona de recarga es contaminada por una fuente difusa, por ejemplo pesticidas en tierras de cultivo. En las tierras de cultivo próximas al curso fluvial las líneas de flujo tienen recorridos cortos hasta la corriente fluvial y contribuyen a la contaminación del río. A la corriente fluvial se incorporan también aguas no contaminadas procedentes de otras zonas, entre las que se incluyen tierras agrícolas con líneas de flujo y tiempos de tránsito demasiado largos como para que contribuyan de manera significativa. Se puede calcular el factor de dilución general considerando la distribución de tiempos de permanencia de las tierras agrícolas y la distribución de los tiempos de permanencia de otras zonas no contaminadas. Se recomienda tomar en consideración las aportaciones a largo plazo de una duración media cuando deban definirse los factores de dilución, sin olvidar las consecuencias de la rotación de cultivos y los futuros cambios en el uso del suelo.

8.2 Atenuación

Procesos reactivos como sorbción y transformación pueden reducir aún más la amenaza de contaminación de los receptores, y podrían utilizarse en el cálculo de valores umbral. La figura 18 B ilustra el efecto de la atenuación, lo que significa que los contaminantes son transformados o ralentizados con respecto al propio transporte de las aguas subterráneas. En la metodología descrita pueden utilizarse factores de atenuación adicionales. Tal como establece la DAS (anexo II.2), estos factores incluyen la “tendencia de dispersión, la persistencia y el potencial de bioacumulación” de los contaminantes.

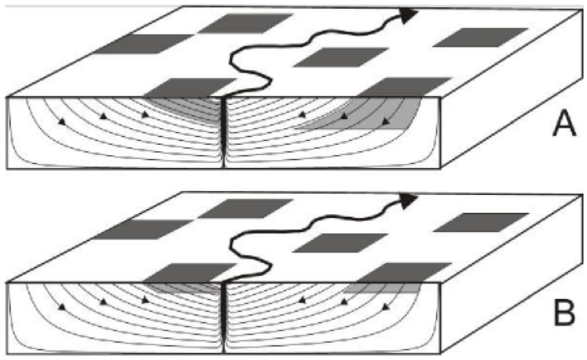


Figura 18: Ilustración de factores que determinan cómo la dilución y la atenuación pueden afectar el cálculo de valores umbral. A: sólo dilución, B: dilución y atenuación. El modelo conceptual se basará preferentemente en una comprensión tridimensional del sistema de aguas subterráneas y tomará en consideración la mezcla de aguas no contaminadas y contaminadas que descargan en el receptor.

Para el seguimiento a profundidades someras se pueden aplicar los factores de dilución y atenuación cerca de la zona de recarga, y deben ser adaptados a las profundidades del seguimiento a fin de que garanticen una protección suficiente. Para el ejemplo de la figura 18 A y un seguimiento en profundidades someras de las zonas de recarga, un factor de dilución de 0,1 parece proteger suficientemente la calidad de las aguas superficiales porque un 10% aproximadamente de la superficie del suelo que cubre la masa de agua subterránea contribuye a la contaminación de la corriente. El valor umbral pertinente se definió como: VU = NCA*FA/FD. Esto significa que el valor umbral de las aguas subterráneas = norma de calidad ambiental de las aguas superficiales (1/0,1) en esta situación específica. Si incluimos también la atenuación, y estimamos para el ejemplo ilustrativo un factor de atenuación de 3, el valor umbral podría elevarse a NCA*3/0,1 y aún ser suficiente para proteger este receptor de aguas superficiales.

Los factores de atenuación y dilución podrán aplicarse asimismo para establecer los criterios de uso, salvo que los puntos de control donde debe medirse el cumplimiento con respecto a los valores umbral estén situados en lugares con tiempos de tránsito largos desde el punto de captación. Aquí, los factores de atenuación y dilución pueden utilizarse para atajar los efectos de la mezcla natural del agua que tiene lugar cuando se bombea desde un acuífero, y las líneas de flujo someras y profundas contribuyen a la calidad del agua que se mide en el pozo de captación o en sus inmediaciones. El proceso de mezcla es conceptualmente muy similar a la mezcla que se produce en una corriente fluvial cuando un recorrido corto y otro largo convergen en la zona de transición de aguas subterráneas y aguas superficiales. La decisión sobre si es apropiado o no utilizar factores de dilución y atenuación para establecer criterios de uso deberán tomarla los propios Estados miembros.

9 ANEXO 2: UTILIZACIÓN DEL SEGUIMIENTO DEL NIVEL PIEZOMÉTRICO DE LAS AGUAS SUBTERRÁNEAS PARA EVALUAR SU ESTADO

La definición de estado cuantitativo que hace la DMA está enmarcada en términos de la relación que existe entre una serie de factores a nivel de las aguas subterráneas. Sólo la utilización del nivel piezométrico de las aguas subterráneas no garantiza una clasificación fiable. Los flujos de aguas subterráneas son igualmente importantes, aunque éstos no pueden medirse directamente, sino sólo estimarse sobre la base de mediciones hidrológicas y meteorológicas. Consideramos que los niveles de las aguas subterráneas por sí solos no deben determinar el estado cuantitativo. Este anexo presenta una sugerencia de cómo podrían, en la práctica, utilizarse dichos niveles. Sobre los parámetros adicionales necesarios para evaluar el estado cuantitativo se trata en la guía de seguimiento sobre la DMA (Unión Europea, 2007).

Elemento Balance hídrico: Si los niveles piezométricos descienden de una manera sostenida y prolongada, este descenso confirmará que, durante el período del registro, el volumen de extracción es mayor que el de recarga, lo que indica un estado deficiente en relación a este factor. No obstante, unos niveles sostenidos no indican necesariamente un buen estado, puesto que el agua necesaria para mantener constante este nivel podría provenir de aguas superficiales, lo que podría causar un daño ecológico.

Elemento Aguas superficiales: Cuando existe una conexión plena -al 100%- entre aguas superficiales y aguas subterráneas, los ríos tienden a estabilizar el nivel piezométrico de manera que las variaciones son mínimas. En tales circunstancias, el nivel piezométrico no es un indicador útil de la interacción entre aguas superficiales y aguas subterráneas. Si no existe ninguna conexión entre las aguas superficiales y las aguas subterráneas, el nivel en el acuífero puede estar por encima o por debajo del nivel del río y, una vez más, nada indica acerca de la repercusión de las aguas subterráneas en el río.

Elemento Ecosistemas dependientes de aguas subterráneas: El nivel piezométrico de las aguas subterráneas en ecosistemas terrestres o sus inmediaciones es fundamental para mejorar el modelo conceptual de cómo funcionan estos ecosistemas. Es un mecanismo esencial para confirmar la conexión con aguas subterráneas, mientras que el seguimiento del nivel no aporta ni una sola señal que apunte o confirme dicha conexión. Se trata, más bien, de una combinación de mediciones del nivel absoluto, del registro de las variaciones en el acuífero, los estratos de los humedales y la zona de aguas libres. Casi con toda probabilidad incluirá algún tipo de modelo que se haya elaborado para confirmar la fiabilidad del modelo conceptual. Este modelo incluirá las aguas superficiales, las aguas subterráneas o ambas.

Elemento Intrusión: La determinación de intrusión se basará en la calidad, más que en la medición de los niveles.

En acuíferos de baja permeabilidad y acuíferos kársticos, las estaciones de la red de seguimiento podrían no reflejar fielmente la superficie piezométrica y, en algunas zonas, el concepto de superficie piezométrica carecerá por completo de importancia. En tales circunstancias, podría ser mejor utilizar otros indicadores del estado cuantitativo -y cualitativo-, como el caudal de ríos y manantiales.

Proponemos que el mejor uso que puede darse a los datos sobre niveles piezométricos es para confirmar el funcionamiento de la masa de agua subterránea y, luego, utilizar los conocimientos de cómo funciona la masa de agua subterránea para determinar si su estado es bueno o no. Las variaciones del nivel a largo plazo serán las de mayor utilidad. Si los datos que se obtienen en un punto de control son inconsistentes, ello podría servir para delimitar una zona que necesitará mayores esfuerzos para comprender el funcionamiento del sistema de circulación de las aguas subterráneas.

10 ANEXO 3. CASOS PRÁCTICOS

10.1 Caso práctico 1: Aplicación de la DMA y la DAS en Alemania

Información específica
Título/nombre: Aplicación de la Directiva Marco del Agua y de la Directiva de Aguas Subterráneas en Alemania.
Tipo:
Enlace web:
Objetivo: Aplicación del planteamiento alemán para el establecimiento de valores umbral relativos a las aguas subterráneas.
Contribución a…
Aspectos básicos: valores umbral
Contribuciones específicas
Antecedentes La guía sobre el estado de las aguas subterráneas y la evaluación de tendencias propone una metodología para fijar valores para las masas de agua subterránea y evaluar su estado, así como para el cumplimiento, en la práctica, de los requisitos pertinentes previstos en la DMA y la DAS. Los debates en el transcurso de la elaboración del documento revelaron que las circunstancias y marcos nacionales en los Estados miembros aconsejan cierta flexibilidad en la implantación y aplicación de las disposiciones. El objetivo es obtener resultados comparables, al tiempo que se permite cierta flexibilidad en cuanto al modo de alcanzarlos. **Antecedentes científicos** Las aguas subterráneas son un elemento de capital importancia para el equilibrio medioambiental. Forman parte del ciclo hidrológico y desempeñan importantes funciones ecológicas. Los recursos hídricos subterráneos próximos a la superficie abastecen de agua a las plantas y constituyen biotopos húmedos de gran valor. Las aguas subterráneas descargan en manantiales y alimentan arroyos y ríos, por lo que la calidad y la cantidad de las aguas subterráneas influyen también en las aguas superficiales. Más del 70% del agua potable de Alemania procede de aguas subterráneas, lo que las convierte en el principal recurso de agua potable. Además, las aguas subterráneas son un hábitat por derecho propio y albergan una gran diversidad biológica. En consecuencia, para un desarrollo sostenible y para garantizar el abastecimiento de agua en el futuro es de suma importancia que se adopten medidas cautelares orientadas al uso que protejan todas las aguas subterráneas. **Las aguas subterráneas como bien protegido por derecho propio** Tomando como base la importancia particular que las aguas subterráneas tienen para el medio ambiente y para los humanos, el enfoque adoptado en Alemania consiste en considerar las aguas subterráneas en su conjunto como un bien que hay que proteger. La experiencia ha demostrado que para proteger las aguas subterráneas de una manera integral y preventiva no basta con proteger sencillamente sus usos. Las aguas subterráneas son un componente integral del ciclo hidrológico y del medio ambiente en su conjunto. Esta opinión está en consonancia con la legislación vigente y ha sido incorporada en distintas leyes y ordenanzas aprobadas a nivel federal y a nivel de los *Länder*. **Determinación de valores umbral para las aguas subterráneas** El artículo 3.2 de la DAS contempla la posibilidad de establecer valores umbral a nivel nacional, en las cuencas hidrográficas o en la parte de una cuenca hidrográfica internacional situada en territorio de un Estado miembro, o a escala de masa o grupo de masas de agua subterránea. En Alemania se establecerán los valores umbral a nivel nacional. Se garantiza así un procedimiento uniforme y comparable en todos los estados federales (*Länder*), que reduce la carga administrativa y permite economizar costes. Asimismo, los valores umbral constituyen la base de nuevas normas legales -p.ej. sobre gestión de residuos o conservación del suelo-.

Metodología alemana para obtener los valores umbral para aguas subterráneas

La metodología alemana para obtener los valores umbral para aguas subterráneas sigue el concepto de los denominados umbrales marginales, y tiene en cuenta los requisitos en materia de protección de la salud así como aquéllos para la protección de ecosistemas acuáticos y terrestres. Los valores umbral obtenidos son aplicables, en principio, a todas las masas de agua subterránea. Se elimina así la compleja y lenta tarea de obtener valores umbral individuales para cada masa de agua subterránea.

Dicha metodología se basa en los conocimientos científicos y considera las condiciones geológicas e hidrogeológicas del territorio alemán en su conjunto. El cálculo se basa, principalmente, en los aspectos toxicológicos para la salud humana y para el medio ambiente, y fundamentalmente utiliza normas ya establecidas en directivas de la UE y en valores adoptados por organismos de la UE. En el caso de la toxicología para la salud humana, se toman en consideración los valores límite de la Directiva de Aguas Potables, salvo en lo relativo a la distribución a la población. Cuando no existan, los valores se obtendrán sobre la base de esta Directiva, en cuyo caso los criterios decisivos incluyen especialmente el olor, el sabor y el color. Para la ecotoxicología se utilizan varias fuentes de datos comparables para calcular los valores umbral en el siguiente orden:

En primer lugar se toman siempre como punto de partida las normas de calidad vinculantes en materia de ecotoxicología medioambiental para las comunidades bióticas acuáticas de aguas superficiales que incluyen, en particular, las normas de calidad medioambiental para determinar el estado químico de las aguas superficiales, Directiva 76/464/CEE relativa a la contaminación causada por el vertido de determinadas sustancias peligrosas, y las normas sobre sustancias prioritarias. Éstas no se adoptan cuando los niveles de referencia o el contenido de materia en suspensión de las aguas superficiales son importantes para calcular la norma de calidad ambiental. A tenor de los conocimientos actuales, parece estar justificado recurrir a los resultados obtenidos en las evaluaciones de ecosistemas de aguas superficiales. Los organismos que viven en aguas subterráneas reaccionan con mayor sensibilidad porque no tienen ninguna posibilidad de escapar, y los contaminantes suelen disponer de más tiempo para influir en su entorno debido a la baja velocidad a la que circulan las aguas subterráneas.

Cuando la legislación vigente no establece normas de calidad ambiental, se utilizan valores PNEC (concentración prevista sin efecto). Estos valores se han calculado sobre la base de los conocimientos más recientes y de conformidad con los principios uniformes y transparentes más estrictos aplicables a toda la UE (Documentos guía); son sometidos a examen por parte de un gran número de expertos y son conformes a las disposiciones de la legislación europea en materia de sustancias químicas y reconocidos en el “informe de evaluación de riesgos".

Si tampoco existen valores establecidos a nivel europeo, se tomarán los valores de concentración máxima admisible (MPC) o de adición máxima admisible (MPA) de un informe de Países Bajos como base para establecer los valores umbral, utilizando para ello el mismo método de extrapolación estadística que el utilizado para calcular los valores PNEC.

Los valores umbral se establecen siempre de acuerdo con los valores más bajos obtenidos mediante el cálculo toxicológico para la salud humana y el medio ambiente. Habida cuenta de que este valor puede situarse por debajo de las concentraciones naturales en aguas subterráneas, por ejemplo en el caso de metales pesados, se evaluará el valor umbral sobre la base del nivel de referencia (VU = NR). En tales casos, el valor es aplicable únicamente a esa masa de agua subterránea específica. Asimismo debe introducirse un límite mínimo de 0,01 µg/L para las sustancias orgánicas no naturales para las que se obtienen valores muy bajos mediante el tipo de cálculo ecotoxicológico, a menos que no existan resultados concretos de pruebas que justifiquen un valor inferior. Habida cuenta de que en todos los casos se utiliza el valor más estricto como valor umbral, esta metodología protege todos los receptores contemplados en la DMA y la DAS.

Resultados obtenidos. Conclusiones y recomendaciones

Accesibilidad a los resultados

10.2 Caso práctico 2. Establecimiento de valores umbral en los Países Bajos

Información específica
Título/nombre: Establecimiento de valores umbral en los Países Bajos
Tipo:
Enlace web: http://www. kaderrichtlijnwater.nl
Objetivo: Establecimiento de los valores umbral y metodología en Países Bajos
Contribución a…
Aspectos básicos: valores umbral, niveles de referencia
Contribuciones específicas Descripción de la metodología general para calcular los valores umbral que se describen en este documento. Desde dicha perspectiva, en los Países Bajos se hace una distinción entre los enfoques a corto y a largo plazo.

2. ENFOQUE A LARGO PLAZO

2.1 Objetivo y condiciones de contorno: valores umbral como base de la calidad de las aguas subterráneas

Debido a su peculiar situación geohidrológica, en la que no existen límites hidrogeológicos, las masas de agua subterránea en los Países Bajos son relativamente extensas. No obstante, y a pesar de su larga tradición en gestión del agua, los Países Bajos aún no han decidido cómo resolver la protección de los receptores ni qué papel desempeñan los valores umbral en esta protección. Los principales aspectos de la función que desempeñan los valores umbral en la protección de los receptores son:

- el alcance de la interacción real de aguas subterráneas con un receptor específico: el impacto de la calidad de aguas subterráneas en los receptores es a menudo limitado respecto a otros impactos;
- la extensión de la zona asociada a receptores respecto de la extensión de la masa de agua subterránea;
- el grado de eficacia de medidas encaminadas a mejorar la protección de los receptores: cambiar el impacto de aguas subterráneas en los receptores es una tarea onerosa y podría requerir mucho tiempo debido a los largos tiempos de tránsito de las aguas subterráneas.

La extensión de los receptores suele ser pequeña si se compara con la de una masa de agua subterránea. Asimismo, las escalas temporales de las masas de agua subterránea desde el punto de infiltración hasta la llegada al receptor se sitúan en torno a decenios, siglos o incluso una duración mayor, y en el transcurso de este transporte tienen lugar los procesos de atenuación y dilución. En consecuencia, los valores umbral en los Países Bajos deben guardar relación con la calidad base de las aguas que prevalece en una masa de agua subterránea. Esta calidad base garantiza la protección de los receptores pertinentes, es decir, ecosistemas terrestres y acuáticos que dependen de aguas subterráneas y de las aguas subterráneas que se destinan al consumo humano. Los problemas potenciales con estas funciones locales deben resolverse, por consiguiente, con valores umbral para toda la masa de agua subterránea. Sin embargo, la protección específica de funciones o valores específicos de aguas subterráneas debería realizarse mediante medidas específicas adicionales.

Las medidas adicionales encaminadas a restablecer los ecosistemas terrestres y acuáticos o a proteger la calidad del agua potable serán específicas y de ámbito local. El enfoque se basa en que se indiquen los espacios protegidos de la red “Natura 2000” y se determinen por separado las zonas protegidas de aguas subterráneas como zonas distintas –especiales- con objetivos “locales” en materia de calidad de las aguas y donde, además de las medidas generales, se apliquen medidas locales adecuadas que permitan cumplir estos objetivos.

Este enfoque se base asimismo en los siguientes razonamientos pragmáticos:

- los esfuerzos y costes administrativos para calcular valores umbral para cada receptor pertinente serán considerables;
- el tiempo para calcular valores umbral de la manera ampliada que propone la guía es limitado. A final de 2007, los Países Bajos calcularon valores umbral como propone este documento con vistas a su implantación legal a finales de 2008.
- la guía no tiene en cuenta las diferencias existentes entre los receptores pertinentes identificados que existen en una masa de agua subterránea.

Los valores umbral indicarán, por consiguiente, la calidad base de las aguas subterráneas regionales, en lugar de la norma de calidad ambiental (NCA) del receptor local más crítico.

Como consecuencia de las razones expuestas más arriba, el enfoque utilizado en los Países Bajos será ligeramente diferente de los de las figuras 3 y 4 de la guía. El enfoque comienza con la selección de uno o más receptores pertinentes, y se calculan los valores criterio (VC) para cada uno de estos receptores. Tras comparar los VC con el nivel de referencia, el resultado de la primera parte de la figura 4 trata sobre el cálculo de un valor umbral (VU) pertinente para cada masa de agua subterránea. Este VU se introducirá en el segundo rectángulo de la figura 3 de la guía. En la segunda parte de esta figura se llevará a cabo la "investigación adecuada" para los receptores pertinentes seleccionados.

3. ENFOQUE A CORTO PLAZO

3.1 Selección de sustancias

El procedimiento para seleccionar y establecer los valores umbral es oneroso y lento, por lo que el enfoque a corto plazo se centra en las sustancias que sean motivo de preocupación, es decir:

- sustancias cuya caracterización apunta a que no se cumplirán los objetivos medioambientales;
- los conocimientos más recientes sobre los niveles de determinadas sustancias en relación con los riesgos para la salud humana y el medio ambiente.

La necesidad de calcular valores umbral para otras sustancias se establecerá después de una nueva caracterización de las masas de agua superficial y de agua subterránea prevista entre 2008 y 2012. Se dará prioridad a las sustancias mencionadas en el anexo II, parte B de la DAS.

3.2 Establecimiento de los valores umbral

En los Países Bajos se establecen las normas medioambientales de una manera integrada para garantizar la coherencia entre las normas sobre los diferentes aspectos medioambientales. En este sentido se ha decidido fijar valores umbral siguiendo la actual versión de la guía sobre el cálculo de los límites de riesgo ambiental en el marco del proyecto "Normas internacionales y nacionales sobre calidad ambiental para sustancias en los Países Bajos" (INS: van Vlaardingen y Verbruggen, 2006). Este Documento guía fue elaborado de conformidad con la DMA y adaptado en cumplimiento de los Documentos técnicos de orientación[38] allí donde la DMA no era aplicable. Se propondrá como valor umbral el más bajo de los dos límites de riesgo ambiental (ERL). La concentración máxima admisible (MPC) se utilizará como valor umbral para las sustancias de origen natural que se producen en el medio ambiente, como los metales y las sales.

Con el enfoque de fijar normas para las sustancias de origen natural, es habitual calcular la MPC sumando la adición máxima admisible (MPA) al nivel de referencia (NR). La MPA puede ser una interpretación más detallada de la pequeña adición mencionada en la presente guía. En el caso de los metales, la MPC se calcula como la suma del NR y la MPA. Esta MPA para metales es un valor constante basado en el riesgo. Para los fosfatos, la MPA dependerá de los objetivos ecológicos y se determinará, por tanto, en función del receptor más importante en la masa de agua subterránea. Hasta ahora no se ha hecho ninguna diferenciación para el NR, pero los NR para las masas de agua subterránea identificadas pueden ser muy diferentes de aquéllos de las masas de agua subterránea de las inmediaciones. Se calcularán NR para cada masa de agua subterránea individual, lo que puede derivar en valores umbral para sustancias de origen natural diferentes para cada masa de agua subterránea.

Paso 1: cálculo de los límites de riesgo ambiental (ERL): calcular los $ERL_{eco,\ natural}$ de la adición máxima admisible (MPA) y el nivel de referencia (NR) para obtener las concentraciones máximas admisibles (MPC):

Sustancias de origen natural

- Cloro: $ERL_{eco,\ natural}$ = MPC-Cl
- Metales: $ERL_{eco,\ natural}$ = MPC-metales = MPA-metales + $BI_{masa\ de\ agua\ subterránea}$, suponiendo un valor constante de MPA para las distintas masas de agua subterránea
- Fosfatos: $ERL_{eco,\ natural}$ = MPC-P = $MPA\text{-}P_{masa\ de\ agua\ subterránea}$ + $BI_{masa\ de\ agua\ subterránea}$, suponiendo una función de la MPA y el NR de la masa de agua subterránea;

[38] Manual sobre el marco metodológico para el cálculo de normas de calidad medioambiental para sustancias prioritarias de conformidad con el artículo 16 de la Directiva Marco del Agua (2000/60/CE).

Agua potable

- ERL$_{\text{salud humana}}$ = norma de calidad del agua potable
- Si ERL$_{\text{salud humana}}$ < NR$_{\text{masa de agua subterránea}}$, ERL$_{\text{salud humana}}$ = NR$_{\text{masa de agua subterránea}}$

Paso 2: cálculo de los ERL más bajos (salud humana o eco, sustancias de origen natural)

- seleccionando los receptores pertinentes
- tomando el ERL más bajo de los receptores pertinentes seleccionados (eco o agua potable)

Paso 3: cálculo del valor umbral:

- comparando el valor ERL con el nivel de referencia
- si ERL < NR el valor umbral será = NR
- si ERL > NR el valor umbral será = CV

3.3. Nivel de referencia

En los Países Bajos está en funcionamiento desde 1979 una red de medición de la calidad de las aguas subterráneas. La distribución de los pozos de observación por todo el país es bastante homogénea y tiene en cuenta los usos predominantes del suelo y la combinación de tipos de suelo para discernir la calidad de las aguas subterráneas y las tendencias a escala regional. Cada pozo de observación está equipado con tres filtros a profundidades de 10, 15 y 25 m respectivamente. Para calcular el nivel de referencia se han seleccionado filtros de longitudes comprendidas entre 1 y 5 m y situados en una columna de agua de 10 m en la zona saturada a una profundidad de 1 m como mínimo del suelo. La parte superior del filtro se sitúa a menos a 2 m por debajo del nivel piezométrico. Para la ubicación de los sondeos se han evitado los puntos de contaminación conocidos, aunque a estos niveles ya no existen aguas subterráneas en estado natural en los Países Bajos. Para obtener los niveles de referencia, para cada sondeo de observación y filtro se examinan las series temporales de las observaciones. En la masa de agua subterránea Central Graben (Hondonada Central) no hay ningún sondeo de observación de la red de medición. El nivel de referencia de esta masa de agua subterránea se establece con los datos de los pozos de captación de agua subterránea. Se supone que la mediana de cada serie temporal es la que mejor representa la distribución. A partir de los valores de la mediana se calcula un percentil 50 y un percentil 90, y para establecer el nivel de referencia se utilizan dos planteamientos:

- uso del percentil 50 sin ningún procedimiento de selección previa;
- uso del percentil 90 con selección previa basada en el impacto antropogénico.

Cuando las concentraciones son bajas -metales pesados, pesticidas-, el tratamiento de los valores por debajo del “Límite de Detección” (LD) que sugiere la guía puede tener una fuerte repercusión en los niveles de referencia y dar niveles de referencia artificiales. En consecuencia, es necesario considerar la posibilidad de apartarse del tratamiento de los valores LD propuesto en la guía y sustituir todos los valores LD que se produzcan en una serie temporal por los LD más bajos, excluyendo los LD menores de cero o por debajo de valores negativos.

En el primer enfoque no se realiza una selección previa de las muestras. Para evitar contabilizar dos veces el impacto antropogénico se toma el nivel de referencia en el percentil 50. La ventaja de este procedimiento es que no se elimina ninguna muestra del conjunto de datos.

En el segundo enfoque, las muestras se seleccionan en función de las concentraciones de sulfatos, cloruros y nitratos para suprimir las muestras afectadas antropogénicamente. Para tener en cuenta la diferencia de las condiciones geohidrológicas y geohidroquímicas se hace una distinción entre el modo en que la presión antropogénica en el ecosistema afecta al agua salobre y al agua dulce en una masa de agua subterránea. Se aplican aquí diferentes algoritmos para establecer qué observaciones de aguas subterráneas salobres y de aguas subterráneas dulces se descartarán y cuáles no, tomando en consideración las condiciones geohidrológicas y geohidroquímicas. Tras la eliminación de las muestras afectadas antropogénicamente, se toma el nivel de referencia de la parte inferior del intervalo de fiabilidad del percentil 90.

Por último, el nivel de referencia se determina en el valor más alto de ambos enfoques.

Resultados obtenidos. Conclusiones y recomendaciones

Accesibilidad a los resultados

10.3 Caso práctico 3. Cálculo de niveles de referencia y valores umbral en una masa de agua subterránea en Rumania

Información específica

Título/nombre: Establecimiento de valores umbral para una masa de agua subterránea contaminada por vertidos para alcanzar los objetivos medioambientales de DMA y DAS.

Tipo: Proyecto holandés-rumano en el marco del Programa holandés de preadhesión

– Servicio ambiental. El proyecto ha sido financiado por EVD (Agencia internacional de negocios y cooperación) y tiene dos asociados del Gobierno de Países Bajos: el Ministerio de la Vivienda, Planificación y Medio Ambiente y SenterNovem/Bodem+. Las organizaciones de la parte rumana son el Ministerio de Medio Ambiente y Desarrollo Sostenible y la Administración Nacional “Apele Române”. El Ministerio, “Apele Române” y la Dirección General de Aguas Banat son beneficiarios.

El proyecto lo lleva a cabo un consorcio de consultores (Grontmij Nederland bv, Witteveen+Bos, Ecorys y BDO Conti Audit) en estrecha cooperación con las partes mencionadas.

Enlace web:

Objetivo: Rumania recibió, en el marco de este proyecto asistencia técnica por parte de Países Bajos en la implantación de tres directivas europeas: la DMA, la nueva DAS y la Directiva sobre Vertidos. El proyecto tiene como principal objetivo formular medidas para restaurar aguas subterráneas contaminadas por vertidos en una zona piloto de la región de Banat (suroeste del país), donde se encuentran dos grandes vertederos, Parta y Jimbolia.

Un programa de seguimiento especial estudió la influencia de estos vertederos en las aguas subterráneas y se elaboró un modelo de transporte. Para evaluar exactamente los resultados y formular el programa de medidas más idóneo, se calcularon, en primer lugar, niveles de referencia (NR) y valores umbral (VU) para la masa de agua subterránea situada debajo de ambos vertederos, a saber ROBA03 y Timisoara. Para calcular los NR y VU se formularon y aplicaron directrices por primera vez, de cara a su uso ulterior por parte de otras Direcciones Generales del Agua del país.

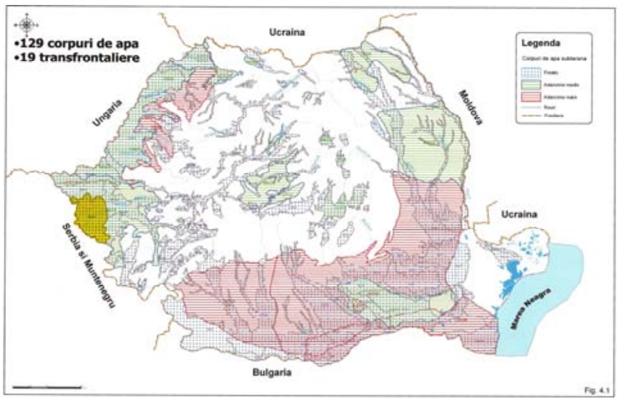
Contribución a…

Aspectos básicos: cálculo de los niveles de referencia y valores umbral.

Contribuciones específicas: Formular directrices y una metodología para calcular los NR y VU para Rumania, incluidas hojas de cálculo Excel para los diferentes pasos de los cálculos.

Caracterización

Un informe sobre el artículo 5 de la DMA caracterizaba la masa de agua subterránea ROBA03 Timisoara (con una extensión de 2.577 km² en territorio rumano) en situación de riesgo porque las concentraciones de nitratos y amoniaco sobrepasan los niveles establecidos para el agua potable



Rumania y sus masas de agua subterránea delineadas (en amarillo, la masa piloto)

Cuenca hidrográfica del río Banat y la masa de agua subterránea piloto (ROBA03)

ROBA03 está alojada en un acuífero poroso poco profundo formado por arena y grava con capas intermedias de arcilla y limo. El acuífero se explota hasta 15 m en llanuras de inundación y bancales, y hasta 30–35 m en los interfluvios. La conductividad hidráulica varía entre 10 y 50 m/día. En lugares reducidos existe una espesa capa superior de arcilla, especialmente cerca del vertedero de Jimbolia, pero las condiciones generales del flujo son las características de los acuíferos someros.

La masa de agua subterránea ROBA03 se recarga principalmente con las precipitaciones (recarga neta 15–30 mm/año) y con el agua de ríos de praderas durante las crecidas y las inundaciones. Cuando descienden los niveles, los ríos drenan la capa freática salvo en las inmediaciones del río Bega. El río Bega recarga permanentemente el acuífero porque su curso está muy encauzado en sus márgenes.

Resultados obtenidos. Conclusiones y recomendaciones

Tomando como base el Documento guía GTC "Estado químico y valores umbral de las aguas subterráneas, versión 2.0 (25.10.07)" y las recomendaciones del proyecto BRIDGE, para calcular los NR y VU para la masa de agua subterránea ROBA03 se introdujeron en una base de datos Excel todos los informes químicos desde 1976 hasta 2006 -207 pozos de observación, 3.300 muestras, 45.000 análisis- organizados en una hoja por año y una fila por muestra.

Para el cálculo de los NR y VU se dispuso de los siguientes indicadores:

- 1975 - 2008: pH, EC, Cl-, SO42-, NO3-, NO2-, Alcalinidad, Ca2+, Mg2+, Fe y NH4-.
- 1986 - 2008: también Na+, K+, Mn2+
- 1993 - 2008: también Zn2+
- 1996 - 2008: también PO4
- 2006 - 2008: también se analizaron Cu, Ni y Pb por primera vez en 2006.

Se filtró la base de datos calculando errores en el equilibrio entre iones en todas las muestras (sin excluir ningún dato) y los parámetros estadísticos, y utilizando también la correlación entre la suma de aniones y la conductividad medida. Se eliminaron todas las muestras identificadas como no fiables. A continuación se excluyeron los pozos con influencias antropogénicas en dos fases (Cl < 200 mg/l; NO3 < 10 mg/l). Se establecieron los valores umbral comparando los niveles de referencia del agua potable con las normas de calidad de las aguas superficiales.

Los resultados finales del cálculo de los NR y VU han sido los siguientes (aunque sólo para algunas de las sustancias utilizadas en los análisis y sustancias responsables del riesgo de no cumplir el requisito de buen estado, es decir nitratos y amonio):

Cuadro 10: Resultado de los VU para la masa de agua subterránea GWB03, 2008

		NR Percentil 90 Pozos con: NO3 < 10 mg/L, Cl < 200 mg/L	Normativa rumana sobre agua potable	Normativa rumana sobre aguas superficiales	**VU**
Número de pozos		*92*			
Cl	mg/L	103			
SO4	mg/L	197			
NH4	mg/L	2,11	0,50	1,0	**2,11**
K	mg/L	11,9			
NO3	mg/L	7,7			
NO2	mg/L	0,21			
EC	µS/cm	1409			
Ni	µg/L	0,005			
Fe	mg/L	3,43			
Mn	mg/L	0,60			
Zn	mg/L	0,067			

1) *Directrices de la UE sobre compuestos químicos en el agua potable (Sulivan et al., 2005)*

Principales conclusiones basadas en la metodología utilizada:

- La mayoría de los datos sobre la masa de agua subterránea GWB03 piloto no estaban disponibles en formato digital, por lo que hubo que realizar un gran esfuerzo para digitalizarlos. Es importante tener esto en cuenta porque es una tarea que requiere una gran capacidad y mucho tiempo. No obstante, es una tarea necesaria no sólo para esta finalidad, sino también de cara a futuras actividades relacionadas con la Directiva Marco del Agua y la Directiva de Aguas Subterráneas;
- La metodología utilizada incluye la elaboración y el tratamiento de datos utilizando MSExcel, por lo que se deberán tener conocimientos suficientes sobre esta aplicación;
- La metodología descrita en el Documento guía de la UE exige ciertos conocimientos básicos en materia de hidrogeoquímica. Sin estos conocimientos, el cálculo de los NR y VU, aunque será posible, será más laboriosa (y el estudio de los problemas pertinentes)

Recomendaciones

- Probablemente se obtendrán los mejores resultados siguiendo un enfoque paso a paso.

Perspectivas. Siguientes pasos y accesibilidad a los resultados

Todos los Directores Generales del Agua de Rumania están siguiendo los pasos prácticos utilizados para calcular los NR y VU, sobre la base de esta primera aplicación de las directrices de la UE, realizada por la Dirección General del Agua Banat y con la ayuda de expertos neerlandeses. El enfoque desarrollado en el marco de este proyecto y los resultados obtenidos serán publicados en la página web del Ministerio de Medio Ambiente y Desarrollo Sostenible: http://www.mmediu.ro. Los documentos elaborados para Rumania están basados en documentos guía de la UE, aunque han sido convertidos en instrumentos y medidas de apoyo más prácticos.

Se puede obtener información adicional sobre la implantación de los valores umbral y la estrategia rumana previa solicitud a la Sra. R. Balaet, ruxandra.balaet@mmediu.ro del Ministerio de Medio Ambiente y Desarrollo Sostenible. Asimismo, los interesados en obtener información sobre el proyecto podrán solicitarla a su director Sr. FJL Vliegenthart (frank.vliegenthart@grontmij.nl) o al Sr. P. Schipper (peter.schipper@grontmij.nl) de Grontmij Nederland B.V.

10.4 Caso práctico 4. Concentraciones naturales elevadas de sulfatos en acuíferos kársticos

Información específica

Título/nombre: Algunas consideraciones sobre la influencia de las aguas subterráneas y superficiales con sulfatos procedentes de yesos sobre los niveles de referencia. El informe, redactado por Ingenieurbüro en diciembre de 2006, está publicado en alemán, con un sumario en inglés. El título es: "Einige Bemerkungen zur bedingten Hintergrundbelastung von Grund- und Oberfläschenwässern mit Sulfaten in Gipskartsgebieten"

Tipo: Evaluación de la fiabilidad del parámetro sulfato en un medio kárstico. Las zonas de yesos están localizadas en Alemania.

Enlace web: www.eurogypsum.org. Asociación Europea de Fabricantes de Yeso y Productos de Yeso

Objetivo: Explicación de elevados contenidos de ión sulfato en acuíferos kársticos.

Contribución a…

Directiva Marco del Agua: niveles de referencia, valores umbral

Contribuciones específicas: Concentraciones elevadas de sulfatos en acuíferos kársticos

Descripción.

Características de las aguas subterráneas con elevados contenidos de sulfatos de origen geológico.

El contacto del agua con depósitos de yeso produce elevados contenidos de sulfatos. Valores superiores a 500 mg/L indican un contacto directo del agua con el sustrato de yesos en el terreno. Debido a que el contenido de sulfatos se debe al sulfato cálcico (yeso), pueden detectarse también valores elevados de dureza del agua.

La conductividad es un indicador adicional de utilidad para distinguir acuíferos en contacto con yesos. En este caso la influencia de otros parámetros en la conductividad deberá tomarse en cuenta, en particular los cloruros. No obstante, la conductividad es un buen indicador cuando los cloruros y otros parámetros no son relevantes. En zonas con depósitos de yesos, los autores distinguen entre cavidades con agua en el karst procedente de la infiltración de agua de lluvia y otras aguas en contacto con el sustrato de yeso.

Los valores característicos de conductividad, sulfato y dureza encontrados en una zona kárstica con yesos de 0,6 km2 en Baja Sajonia son:

	Conduct. (μS/cm)	Sulfato (mg/L)	Dureza total (mg/L)
Cavidad con manantial	1.728	1.324	67
Arroyo con manantial. Dic 2000	1.625	1.180	63
Surgencia próxima a los yesos	1.910	1.472	78

No obstante, en la misma zona hay aguas que no están en contacto con el sustrato con yesos, hecho corroborado por los siguientes valores medidos de sulfato y conductividad:

	Conductividad (μS/cm)	Sulfato (mg/L)	Dureza total (mg/L)
Flujo de drenaje en un valle con pastos	180	23	5
Arroyo con manantial fuera del contacto con los yesos	177	18	4

Ejemplos en acuíferos kársticos prácticamente saturados (Völker, 1999):

	Conductividad (µS/cm)	Sulfato (mg/L)	Dureza total (mg/L)
Manantial “Kniequelle”	2.580	1.200	85
Manantial “Neuer Garten”	2.310	1.140	84
Manant. kárstico “Uftrunger See”	2.480	1.215	89
Cavidad con agua subterránea “Heimkehle”	2.028	1.490	89

Influencia sobre las aguas superficiales

Las aportaciones de agua al arroyo procedentes del drenaje del karst afectan a los acuíferos vecinos a lo largo de amplias zonas. El agua tiene una alta calidad medioambiental y ecológica. El contenido en sulfato no ha sido medido hasta la realización de este estudio.

El arroyo drena una zona del Bundsandstein y muestra valores bajos de ión sulfato -19-62 mg/L durante el periodo 26/04/2002 A 20/03/2004- en un tramo de varios kilómetros en un valle.

A partir del punto donde el arroyo entra en contacto con la zona de karst con yesos la situación cambia de manera significativa, con los aportes de sulfatos, cuyas concentraciones pasan de 91 mg/L a 472 mg/L en el punto de control 44.

La influencia de esta zona de karst se acentúa especialmente durante el estiaje, en que el caudal de los manantiales se reduce considerablemente.

El sulfato disuelto es transportado a lo largo de varios kilómetros hacia una zona sin yesos y puede ser detectado claramente a 10 km de distancia de la zona de yesos.

Las concentraciones de sulfatos se deben exclusivamente a causas geológicas y no a contaminación. No existe influencia de actividad humana. Las variaciones en las concentraciones de sulfato se explican por la dilución producida por infiltración de aportaciones estacionales.

Influencia en acuíferos con circulación muy reducida

Los acuíferos en contacto con yesos y otras formaciones –en este caso con porosidad intergranular- muestran un estado de saturación completa de sulfato. No obstante, cuando se acumula el agua subterránea a consecuencia de la infiltración de agua de lluvia, puede detectarse una cierta dilución. Una fluctuación mayor no es relevante pues el yeso se disuelve rápidamente. Como prueba de este hecho se adjunta la siguiente tabla en la que figura la evolución de la dilución del yeso en el arroyo:

Tiempo (seg.)	Conductividad (µS/cm)
0:00	240
0:10	360
0:20	530
0:30	624
0:40	920
0:50	1.300
0:60	1.630
0:120	1.920

Resultados obtenidos. Conclusiones y recomendaciones. Las aguas subterráneas no contaminadas contienen habitualmente menos de 50 mg/L de sulfatos. Esta concentración se supera frecuentemente en zonas kársticas con yesos, donde los niveles normales están comprendidos entre 500 mg/L y 1.400 mg/L. Estas concentraciones son el resultado de la disolución de los yesos. En estas zonas el agua subterránea es poco ácida y no se produce daño ecológico. El pH es ligeramente alcalino (pH= 7.2)y el sulfato natural no produce un efecto tóxico en el medio ambiente. La disolución del sulfato en los yesos es un proceso inevitable.

Por ello, **recomendamos** que, si se demuestra que es sulfato es exclusivamente de origen natural, sin influencia de actividad humana, no se establezca un valor umbral. Si no es ese el caso, el establecimiento del valor umbral es obligatorio, siempre que exista un riesgo de no alcanzar el buen estado. En ese caso, la investigación relativa a cationes como el Cu^{++} debería ayudar a la comprensión del proceso. La presencia de cloruros que indiquen intrusión salina y el nivel del pH para detectar oxidación de sulfuros en piritas deben ser asimismo objeto de estudios adicionales. Se recomienda asimismo que en países con depósitos de yesos o formaciones yesíferas sólo se deberían establecer valores umbral en puntos concretos y cuando haya constancia de influencia antropogénica.

Accesibilidad de los resultados. Este estudio está disponible en versión electrónica en la Secretaría de Eurogypsum: info@eurogypsum.org

Los siguientes documentos están disponibles bajo pedido en dicha dirección:

1. Karst investigation by Hydrochemical Method (North Lithuanian Karst region) Julios Taminskas, Kazimieras Dilys, Institute of Geography;

2. The gochemical behaviour and environmental effect of gypsum and gypsum board waste disposal J.M. Schmitt & P. Viennot C.I.G., Ecôle des Mines de Paris. Eurogypsum Congress 1998.

3. Basic processes and mechanisms governing the evolution of karst. Wolfgang Dreybrodt and Franci Gabrovsek, 1999

10.5 Caso práctico 5: Evaluación del estado cuantitativo de las aguas subterráneas en los Países Bajos

Información específica
Título/nombre: Evaluación del estado cuantitativo de dos masas de agua subterránea en los Países Bajos. Proyectos de restauración natural en Groot Salland (NL)
Tipo:
Enlace web: Boetelerveld: http://www. landschapoverijssel. nl/terreinen/boetelerveld. htm
Olde Maten y Veerslootlanden: http://provincie.overijssel. nl/beleid/natuur_en_platteland/landinrichting/item_89390/strategisch/projectinformatie
Objetivo: Aplicación de la evaluación del estado cuantitativo
Contribución a…
Aspectos básicos: evaluación del estado cuantitativo
Contribuciones específicas: Examen de 4 tests propuestos para evaluar el estado cuantitativo.

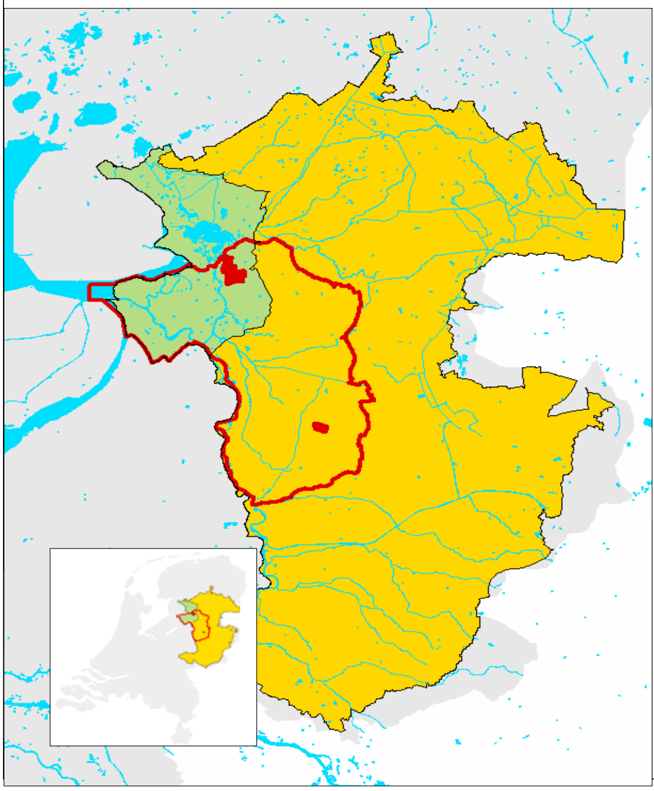
Caracterización

La cuenca hidrográfica "Waterschap Groot Salland" (82.000 ha) está situada en la parte holandesa del Rin Esta zona alberga dos grandes ecosistemas terrestres dependientes de aguas subterráneas reconocidos como lugares de Natura 2000 – Boetelerveld (173 ha) y "Olde Maten y Veerslootlanden (993 ha). Ambas zonas son los restos de zonas naturales mucho más extensas. La masa de agua subterránea situada bajo Boetelerveld (GWB B en la figura 1) es arenosa y está formada por capas de arena del Pleistoceno de unos 100 m de espesor. Las capas impermeables de arcilla y bolos dificultan el drenaje de las precipitaciones y el ecosistema natural era un humedal cubierto de brezales.

La masa de agua subterránea bajo Olde Maten y Veerslootlanden (GWB A en la figura 1) está formada por extensas capas de arcilla y turba del Holoceno. También aquí el drenaje es escaso; el ecosistema natural eran pantanos.

A partir de la década de 1950 una red de zanjas y canales de drenaje convirtió esta pobre zona rural en tierras de cultivo intensivo. Para la gestión del Agua se ajusta el nivel en las zanjas y se consigue optimizar los niveles del agua subterránea para la agricultura. Como resultado de este tipo de cultivo, los ecosistemas terrestres dependientes de las aguas subterráneas han desaparecido en su mayor parte. Queda un pequeño número de lugares fuertemente influenciados por el bajo nivel de las aguas subterráneas así como por las aguas del Rin, ricas en nutrientes, que en la temporada seca entran en la red de zanjas.

La política en Países Bajos de gestión del agua y la naturaleza aspira a poder conservar y restaurar las zonas con tipos de hábitat naturales típicos del país que aún existen. En este contexto se han tomado varias medidas para elevar el nivel de las aguas subterráneas en estas zonas y mejorar su calidad.



Leyenda

Capa freática limítrofe Groot Saland
Ecosistema terrestre dependiente de aguas subterráneas
Masas de agua subterránea Rin-Oeste
Masa de agua subterránea A (arcilla / turba sobre arena)
Masa de agua subterránea B (arena)

Resultados obtenidos. Conclusiones y recomendaciones

En este caso se evalúa el estado cuantitativo de las dos masas de agua subterránea que se describen más arriba. La evaluación comprende 4 pruebas: balance hídrico, intrusión salina, ecosistemas acuáticos y ecosistemas terrestres.

Test del balance hídrico:

Debido a un excedente de precipitaciones netas, de la prueba del balance hídrico se infiere que no hay afección al buen estado de las masas de agua subterránea [capítulo 5.3.1 de la Guía].

Intrusión salina:

En este ámbito, el riesgo de elevación del interfaz de agua salada, principalmente en la captación de aguas subterráneas muy profundas, está controlado por un sistema permanente de “alerta temprana”. En consecuencia, se previenen las intrusiones salinas, y la prueba sobre este problema no afecta el buen estado de las aguas [capítulo 5.3.4 de la Guía].

Aguas superficiales (ecosistemas acuáticos):

Los cursos de agua en la cuenca de Groot Salland son casi todos artificiales y tienen por objeto drenar y prevenir inundaciones; adoptaron su forma actual en las décadas de 1960 y 1970 principalmente. Todas estas masas de aguas superficiales han sido designadas, por consiguiente, como “muy modificadas”. Los objetivos ecológicos para estas aguas -niveles máximos y buen estado- vienen determinados en parte por la calidad de las aguas del Rin que entran durante la temporada seca. El logro del buen estado no depende en gran medida de la cantidad de aguas subterráneas que se filtran en estas aguas superficiales, por lo que la prueba sobre la cantidad de agua subterránea que entra en las aguas superficiales no afecta al buen estado de la masa de agua subterránea [capítulo 5.3.2 de la Guía].

Ecosistemas terrestres dependientes de aguas subterráneas:

Las primeras medidas para elevar la capa freática del acuífero Boetelerveld se tomaron ya en la década de 1970. Las zanjas se llenaron, lo que mejoró la conservación de las precipitaciones en la zona. En 2000 se construyó un canal con un nivel de agua elevado alrededor de la zona para drenar mejor las precipitaciones y elevar el nivel de las aguas subterráneas. Una medición de las captaciones de agua potable en otras partes de la masa de agua subterránea llevó a la conclusión de que los efectos de estas captaciones son de escasa importancia para la capa freática en los dos espacios de Natura 2000. También se han adoptado medidas para elevar el nivel de las aguas subterráneas en Olde Maten y Veerslootlanden. Desde 2000, año de la entrada en vigor de la DMA, las condiciones hidrológicas en ambas zonas no han sufrido ningún deterioro. Estas condiciones son suficientemente favorables para conservar las dos zonas en su estado actual. Se considera, por tanto, que el estado de ambas masas de agua subterránea es bueno [capítulo 5.3.3 de la Guía].

Si, por el contrario, desde 2000 se hubieran deteriorado las condiciones hidrológicas, el principio de “uno fuera, todos fuera” propiciaría una valoración global del estado de ambas masas de agua subterránea en 2009 como deficiente, a pesar de que los ecosistemas terrestres dependientes de aguas subterráneas son pequeños respecto de la masa global de estas aguas (véase figura 1).

Perspectivas. Siguientes pasos. Accesibilidad a los resultados

Como ha quedado dicho, la gestión del agua y la naturaleza en los Países Bajos aspira a restaurar y ampliar aún en los espacios de Natura 2000 los tipos de hábitat deseados. Para ello es necesario seguir mejorando las condiciones hidrológicas respecto de la situación en 2000. El objetivo es restablecer las condiciones hidrológicas necesarias a más tardar en 2015. Las medidas incluyen la mejora de la calidad de las aguas superficiales entrantes, elevar los niveles de estas aguas, cavar zanjas alrededor de la zona, además de otras medidas en los espacios de Natura 2000. No obstante, hasta qué punto son factibles estas mejoras es aún objeto de investigación y debate. Aún no ha concluido el proceso de evaluación de costes y beneficios, y la falta de aceptación social (especialmente en lo relativo a la pérdida de producción agrícola) podría impedir la entrada en vigor de determinadas medidas. Por otra parte, algunas medidas podrían no ser tan eficaces como se prevé. Por último, algunas alteraciones de las condiciones hidrológicas desde la década de 1950 son irreversibles, por ejemplo, la construcción en la parte occidental de Flevopolders ha incrementado considerablemente el flujo subterráneo hacia el oeste, a costa del agua de infiltración local. Se prevé que en el transcurso de 2009 se aprueben los objetivos y las medidas necesarias. Los objetivos fijados en el plan hidrológico de cuenca de 2009 corresponderán a la situación en 2000. El intento de alcanzar los objetivos para 2015, así como las medidas correspondientes, se mencionan en dicho plan hidrológico para 2009, al objeto de exponer claramente las aspiraciones de las actuales políticas.

10.6 Caso práctico 6. Propuesta del Grupo de Trabajo CIS 2.8 sobre la evaluación de tendencias y la inversión de tendencias

Información específica
Título/nombre: Propuesta del GT CIS 2.8 sobre metodología para evaluar las tendencias y la inversión de tendencias a escala de la masa de agua subterránea
Tipo: Conclusiones del GT CIS 2.8 "Aspectos estadísticos de la determinación de tendencias contaminantes de aguas subterráneas y agregación de los resultados del seguimiento"
Enlace web: www.DMAgw.net
Objetivo: El objetivo del GT CIS 2.8 era, entre otros, establecer un método adecuado y pragmático para evaluar las tendencias y la inversión de tendencias en toda la masa de agua, incluida la determinación de requisitos mínimos de evaluación. Los métodos debían ser adecuados para su aplicación en toda la UE sobre la base de las disposiciones de la DMA y teniendo en cuenta las fuentes de contaminación difusas y puntuales.
Contribución a…
Aspectos básicos: evaluación de tendencias y de la inversión de las tendencias
Contribuciones específicas Procedimientos para evaluar tendencias y la inversión de tendencias a nivel de la masa de agua subterránea. Tratamiento de valores por debajo del LC. Requisitos mínimos desde una perspectiva
Caracterización El GT CIS 2.8 creó en 2000 y 2001 un consorcio de 16 países de la UE -11 participantes, 5 observadores- y desarrolló una metodología para agregar datos y evaluar tendencias e inversión de tendencias. Las condiciones del método eran: un método único, estadísticamente correcto y pragmático, para todas las masas de agua subterránea, aplicable a parámetros de todo tipo. Los participantes aportaron los conjuntos de datos en 21 masas de agua y 69 parámetros así como un inventario de los métodos aplicados. El resultado del proyecto incluye un método para evaluar la red de seguimiento, las metodologías para la agregación de datos, una evaluación de tendencias y otra de inversión de las tendencias, el tratamiento de valores menores que LC, los requisitos estadísticos mínimos, documentación exhaustiva y una herramienta de *software* para prueba y verificación. Todo ello está disponible en la página web del proyecto.
Resultados obtenidos. Conclusiones y recomendaciones El procedimiento completo de evaluación de tendencias y de la inversión de tendencias comprende los siguientes pasos: 1. Tratamiento de valores menores que el LC. Regularización temporal de los datos de calidad de las aguas subterráneas en los puntos de control. 3. Agregación de los datos para la masa de agua subterránea. 4. Test de tendencias y de inversión de tendencias. **Evaluación de tendencias** *Test de tendencias propuesto:* Se propone el test de regresión lineal generalizada ANOVA basado en el suavizador LOESS para medir tendencias monotónicas estadísticamente significativas a escala de masa de agua subterránea. Respecto a la extensibilidad y potencia, los métodos lineales -basados en un modelo lineal- superan los métodos no paramétricos basados en la prueba Mann-Kendall y, en consecuencia, se optó por los métodos lineales. La metodología propuesta considera los siguientes requisitos específicos: aplicabilidad a todo tipo de parámetros, extensibilidad a factores potenciales de ajuste y potencia suficiente para detectar tendencias. La robustez se consideró menos importante que la capacidad y la extensibilidad -la validación de datos es responsabilidad de los Estados miembros-. *Potencia del test:* Uno de los hallazgos durante la fase de evaluación de datos fue que una tendencia significativa al aumento debe detectarse con una potencia del 90% para la mayoría de las sustancias si el aumento en la concentración de contaminantes es al menos del 30% o incluso mayor, dependiendo del tipo de contaminante. Con el punto de partida por defecto para la inversión de tendencias del 75% de la norma de calidad o valor umbral, un aumento del 33% de la concentración de contaminantes significaría que no se alcanza el buen estado de la masa.

Se señaló la importancia de los datos procedentes del control operativo para evaluar las tendencias porque, de lo contrario, los datos serían insuficientes para detectar a tiempo la tendencia.

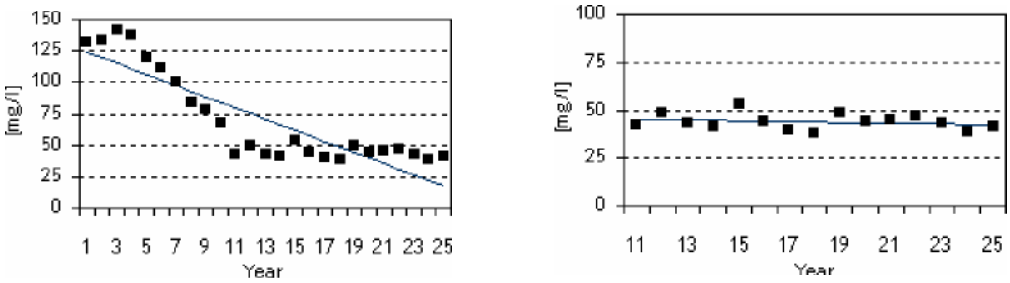
Duración mínima de la serie temporal: Para establecer la duración mínima de la serie temporal para detectar las tendencias se tuvieron en cuenta el calendario de aplicación de la DMA así como su requisito mínimo relativo a la frecuencia de seguimiento (anual). Como el seguimiento comenzó en 2007, y en 2015 está prevista una revisión y actualización de los PHC, cabe suponer que en 2015 se dispondrá de los datos recogidos entre 2007 y 2014. Esto equivale a una serie temporal de 8 años con 8 valores como mínimo.

Puesto que la evaluación de tendencias estadística con menos de 8 mediciones anuales podría ser cuestionable, se recomienda realizar análisis de tendencias con un mínimo de 8 mediciones. En el caso de mediciones semestrales, el número total de muestras no será inferior a 10, y a 15 cuando sean trimestrales. En cada caso, el periodo entre las mediciones debe ser como mínimo de 5 años, porque los cambios a corto plazo pueden distorsionar la detección de tendencias prolongadas.

Duración máxima de las series temporales: Si se evalúan series temporales largas, existe el riesgo de obtener resultados de tendencias claramente afectadas por cambios en los primeros años de las series temporales, por lo que se propone restringir estas series a los últimos 15 años.

Una alternativa sería aplicar un método flexible para comprobar si se ha producido algún cambio significativo de tendencia (lineal) -p.ej. mediante un método de inversión de tendencias de dos secciones-. Si se ha producido un cambio significativo, la sección reciente podría someterse a una evaluación de tendencias. **Observación**: Deben considerarse el modelo conceptual y el tiempo de residencia del agua subterránea.

Figura 19: Influencia de la duración de la serie temporal en la detección de una tendencia



Estacionalidad: A fin de evitar sesgos por los efectos estacionales, las muestras se tomarán en una época determinada del año. En particular, para las mediciones anuales, se procurará que las mediciones se tomen siempre en el mismo trimestre o en una época determinada del año. Los efectos de la estacionalidad pueden deberse también a frecuencias de seguimiento distintas entre los diferentes lugares. La estacionalidad causa una alta variación aleatoria que reduce la capacidad del análisis de tendencias. El método propuesto permite también medir la estacionalidad.

Falta de datos: En las series temporales pueden faltar observaciones, pero se evitará que falten dos o más valores consecutivos, porque ello causaría un sesgo debido a la extrapolación.

Evaluación de la inversión de tendencias

Test de inversión de tendencias propuesto: Para medir la inversión de tendencias se propone el modelo de dos secciones, fácil de interpretar, flexible y muy sensible para detectar cualquier inversión. Se trata de un método lineal basado en un modelo de regresión lineal ampliado, en el que encaja una tendencia lineal con un cambio en el intervalo.

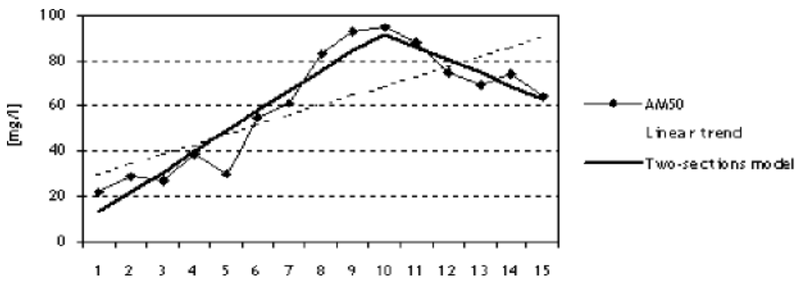


Figura 20: Modelo de dos secciones para medir la inversión de tendencias

Duración mínima de las series temporales: Para la segunda revisión y actualización de los PHC en 2021 -con datos de 2007-2020-, se recomienda realizar al menos 14 mediciones, con regularidad anual, a fin de garantizar un cierto nivel de capacidad de detección de una inversión de tendencias. Si los datos son semestrales o trimestrales, se examinarán 10 años como mínimo. Las mediciones semestrales comprenderán, al menos, 18 valores, y cuando sean trimestrales, serán necesarios 30 valores como mínimo.

Duración máxima de la serie temporal: 30 años.

Preparación de datos

Tratamiento de valores menores que el límite de cuantificación (LC): El tratamiento de datos deberá ser consistente, ya que los LC pueden cambiar en el tiempo. Para el tratamiento de medidas inferiores al LC se aplicará el "enfoque minimax" (minimizar el riesgo máximo). Para evitar sesgos -tendencias inducidas-, el análisis de tendencias se realizará con un LC_{max} constante. Se eliminarán todas las mediciones –mayores o menores que el LC- en las que el LC sobrepase el LC_{max} , y los LC que no sobrepasen el LC_{max} serán sustituidos por el LC_{max} . En el sitio web puede encontrarse una definición y ejemplos de LC_{max}.

Sustitución de valores menores que el LC: Se recomienda calcular las tendencias sobre la base de AM50 -50 significa que los valores <LC son sustituidos por un LC del 50%- siempre que AM0/AM100 ~ 0.6. En tales circunstancias, el sesgo máximo no sobrepasa del 25%. Si se dispone de una norma de calidad o un valor umbral, el LC no deberá superar el 60% de la norma de calidad o el valor umbral. En general, si AM0/AM100 < 0.6, toda evaluación de tendencias deberá basarse a nivel del lugar de muestreo siempre que existan suficientes datos disponibles.

Regularización: Para cada punto de control y cada período de agregación, la media aritmética de los datos de concentraciones se calcula examinando los valores menores que el LC. Los períodos de agregación (regularización) posibles son trimestrales, semestrales o anuales y, para evitar sesgos, dichos períodos deberán ser los mismos en cada punto de control de la masa de agua subterránea que se someta a una evaluación de tendencias.

Agregación espacial: Se propone que el método de evaluación de tendencias esté basado en la media aritmética a escala de masa de agua subterránea, es decir, la media aritmética de las medias aritméticas de todos los puntos de control.

Accesibilidad a los resultados. El proyecto finalizó en diciembre de 2001. Los informes, datos y la aplicación informática están disponibles en la página web del proyecto: www.DMAgw.net El informe definitivo se ha publicado como:*"Technical Report No. 1: Statistical aspects of the identification of groundwater pollution trends and aggregation of monitoring results. WG 2.8 Statistics (2001)"* [Informe Técnico nº 1: Aspectos estadísticos de la determinación de tendencias contaminantes en aguas subterráneas y agregación de los resultados de seguimiento – GT 2.9 Statistics (2001)]

10.7 Caso práctico 7. Tendencias en relación con presiones y vulnerabilidad

Información específica

Título/nombre: Tendencias en relación con presiones, seguimiento y propiedades de los sistemas de aguas subterráneas

Tipo: Resultados del proyecto de FP6 Aquaterra, TREND2 "Tendencias"

Enlace web: http://www.attempto-projects.de/aquaterra/21.0.html

Objetivo:

Probar que es preferible adaptar la detección a las presiones que soporta el sistema de aguas subterráneas al seguimiento y sus propiedades hidrológicas y químicas. Ilustra asimismo cómo determinando la edad de las aguas mejora la detección de tendencias.

Contribución a…

Directiva Marco del Agua: tendencias, seguimiento, tiempos de tránsito, establecimiento de la

Contribuciones específicas: usos del suelo, presiones, tiempos de respuesta, determ. de la edad

Caracterización

Aquaterra investigó con el proyecto TREND2 métodos operativos para evaluar, cuantificar y extrapolar tendencias en aguas subterráneas. Se probaron técnicas de análisis de tendencias en una gran variedad de casos europeos, como depósitos de llanura en los Países Bajos y Alemania, acuíferos de yeso en Bélgica y un acuífero fracturado con una gruesa capa no saturada en Francia.

Se definió tendencia como "*el cambio en la calidad de aguas subterráneas en un período de tiempo específico y una región determinada, relacionado con el uso del suelo o la gestión de la calidad del agua".* El análisis de tendencias para la DAS tiene por objeto distinguir estos cambios antropogénicos de las variaciones naturales con un nivel adecuado de fiabilidad y precisión (DAS, anexo IV, 2. a), i)). Es evidente que las variaciones temporales debidas a factores climatológicos y meteorológicos pueden complicar la detección de tendencias, al igual que el factor de la variabilidad espacial, especialmente cuando, como se exige, se agregan las tendencias a escala de la masa de agua subterránea. Las variaciones espaciales pertinentes incluyen: 1. los recorridos y tiempos de tránsito, 2. las presiones y entradas contaminantes, y 3. la reactividad química de las masas de agua subterránea. Estas variaciones se traducen en un comportamiento de tendencias muy variable, más allá de la propia masa de agua subterránea, porque podría haber pozos en el recorrido conectados a una zona con entradas significativas de contaminantes, pero también otros conectados a entradas de contaminantes de menor entidad.

Las técnicas de análisis de tendencias intentan reducir la variabilidad no relacionada con los propios cambios antropogénicos, por lo que la detección de tendencias es más eficaz cuando se reduce la mencionada variabilidad espacial y temporal, teniendo en cuenta las características físicas y químicas de la masa de agua subterránea, incluidas las condiciones de flujo, los índices de recarga y el tiempo de tránsito en la zona no saturada (DAS, anexo IV, 2 a), iii)). Para el análisis de tendencias existen varias técnicas estadísticas, de simulación y combinaciones de ambas. En el marco del proyecto TREND2 se ensayaron algunas técnicas prometedoras, incluidos algunos planteamientos para determinar la edad y la función de las transferencias (Visser et al. 2008).

Resultados obtenidos. Conclusiones y recomendaciones

El enfoque comparativo TREND2 reveló que no existe un único enfoque aplicable a todas las condiciones hidrogeológicas y todos los lugares de seguimiento. No obstante, la reducción de la variabilidad incluyendo información sobre presiones, hidrología e hidroquímica contribuyó a mejorar la detección de tendencias pertinentes en cada lugar hidrogeológico estudiado. Algunas conclusiones específicas son:

- se recomienda la agrupación de pozos para mejorar la eficacia de la detección;
- es preferible agruparlos en función de las presiones -a menudo relacionadas con el uso del suelo-, vulnerabilidad -distribución de tiempos de tránsito, profundidad de la zona no saturada- y características químicas -tipo de rocas, contenido de materia orgánica- (Figura 1);

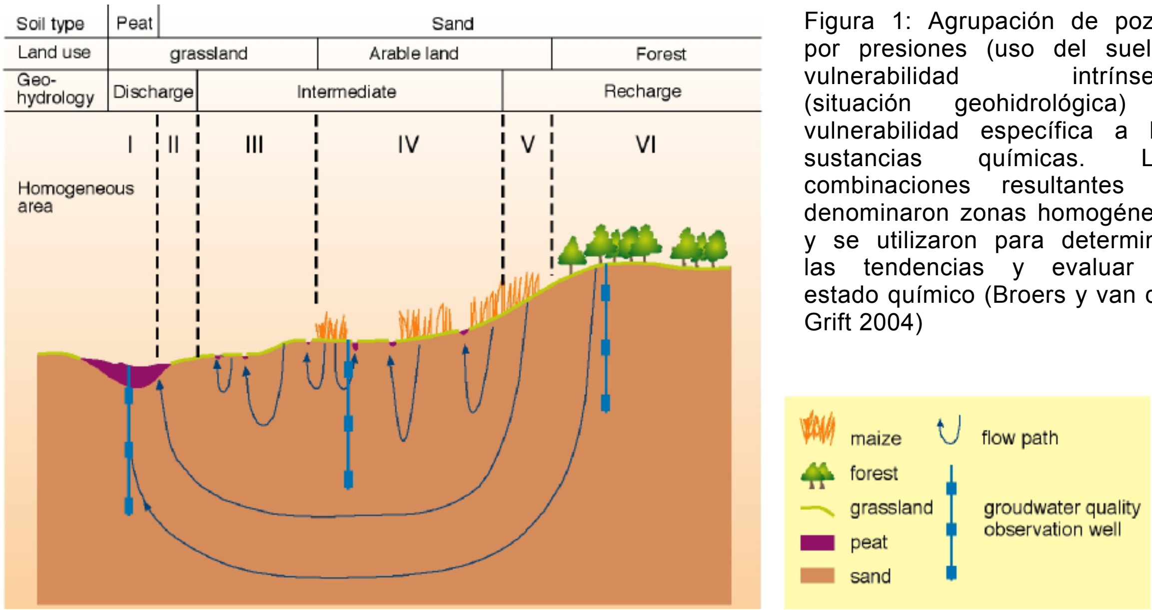


Figura 1: Agrupación de pozos por presiones (uso del suelo), vulnerabilidad intrínseca (situación geohidrológica) y vulnerabilidad específica a las sustancias químicas. Las combinaciones resultantes se denominaron zonas homogéneas y se utilizaron para determinar las tendencias y evaluar el estado químico (Broers y van der Grift 2004)

- la agrupación de pozos para el análisis de tendencias debe considerar también la profundidad porque las aguas subterráneas envejecen en la profundidad, y los cambios pueden ser completamente diferentes a gran profundidad y a poca profundidad (figura 2);

- es fundamental distinguir entre pozos de captación y manantiales, por un lado, y sondeos de observación sin bombeo, por otro.

– Los pozos de bombeo y los manantiales contienen normalmente una mezcla de aguas de diferentes capas, y la calidad del agua resultante es la consecuencia de la mezcla de aguas con tiempos de tránsito muy diferentes. Un factor que complica las mediciones es el hecho de que los aportes a la mezcla de aguas jóvenes y aguas más antiguas pueden cambiar con el tiempo.

– La calidad del agua que suele medirse en sondeos de observación corresponde normalmente a una edad específica del agua, y una vez determinada la edad del agua se puede relacionar la serie temporal a un período de infiltración específico.

– Si se producen diferentes tipos de seguimiento en una masa de agua subterránea, el mejor modo de detectar tendencias es agrupando estos tipos por separado.

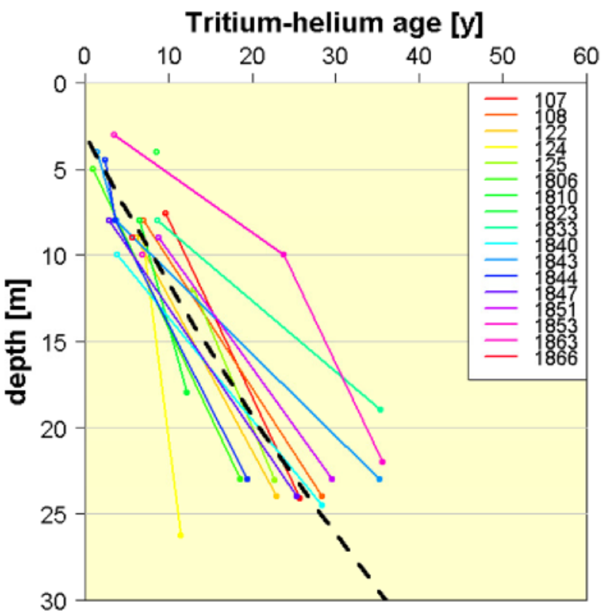


Figura 2: Aumento de la edad del agua subterránea con la profundidad, determinado por una ecuación analítica (línea de trazos) y determinación de la edad por tritio-helio en 14 pozos de observación de niveles múltiples (color distinto para cada pozo)

- El espesor de la zona no saturada es una de las variables de control en la elección de técnicas de análisis de tendencias. Las zonas no saturadas de gran espesor provocan largos tiempos de respuesta que dificultan la rápida detección de tendencias por cambios antropogénicos.

- Las técnicas para determinar la edad resultaron ser muy adecuadas en zonas con depósitos no consolidados y capas freáticas poco profundas (figura 3), pero se descubrió que su uso era limitado en acuíferos con porosidad dual y zonas no saturadas muy espesas.

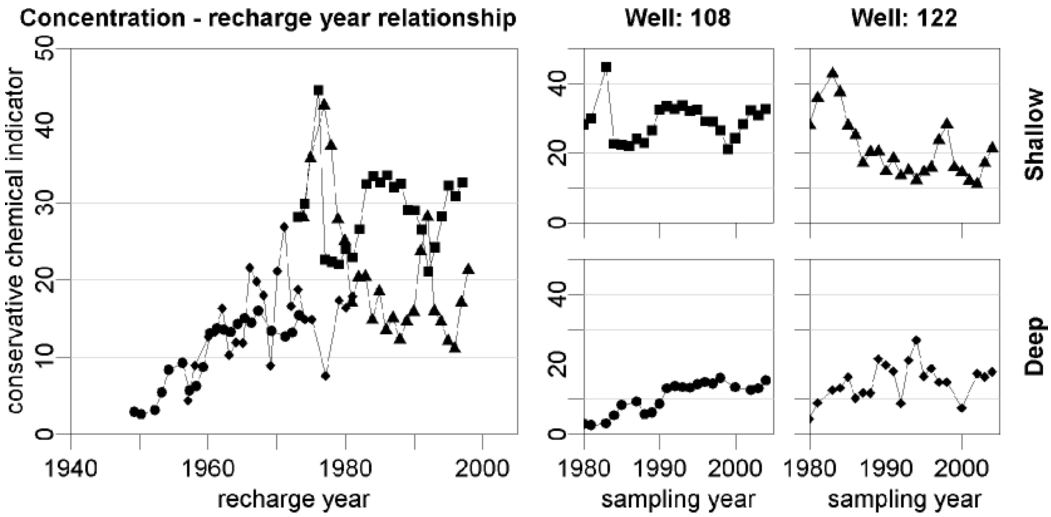


Figura 3: Conversión de la serie temporal medida en sondeos de observación individuales de capas múltiples a poca profundidad (10 m por debajo del nivel de las aguas superficiales) y a mayor profundidad (25 m por debajo del nivel de las aguas superficiales) en un gráfico de serie temporal agregada utilizando el año de recarga como eje X tras haber determinado su edad utilizando tritio-helio (Visser et al. 2007). La serie temporal agregada muestra una tendencia sostenida al aumento con mayores concentraciones a medida que crece el tiempo de recarga.

Accesibilidad a los resultados Los datos e informes de la investigación están disponibles en el la página web: http://www.attempto-projects.de/aquaterra/21.0.html

Referencias:

Batlle Aguilar, J., Orban, P., Dassargues, A. and Brouyère, S., 2007. Identification of groundwater quality trends in a chalk aquifer threatened by intensive agriculture in Belgium. Hydrogeology Journal, 15(8): 1615.

Broers, H.P. (2002). Strategies for regional groundwater quality monitoring. Netherlands Geographical Studies no. 306, Ph.D. Thesis University of Utrecht, Países Bajos.

Broers, H.P. and van der Grift, B., 2004. Regional monitoring of temporal changes in groundwater quality. Journal of Hydrology, 296(1-4): 192-220.

Loftis, J.C., 1996. Trends in groundwater quality. Hydrological Processes, 10: 335-355.

Pinault, J.L. and Dubus, I.G., 2008. Stationary and non-stationary autoregressive processes with external inputs for predicting trends in water quality. Journal of Contaminant Hydrology, In Press, Accepted Manuscript.

Visser, A., Broers, H.P., Van der Grift, B. and Bierkens, M.F.P., 2007b. Demonstrating Trend Reversal of Groundwater Quality in Relation to Time of Recharge determined by 3H/3He. Environmental Pollution, 148 (3): 797-807.

Visser, A., Broers, H.P., , I.G. Dubus, J.L. Pinault, M. Korcz, Batlle Aguilar, J., Orban, P., and Brouyère, S and M.F.P. Bierkens (2008) Discussion of methods for the detection and extrapolation of trends in groundwater quality. Aquaterra deliverable T2.12, submitted to Journal of Hydrology.

10.8 Caso Práctico 8. Agregación de tendencias en masas de agua subterránea

Información específica

Título/nombre: Agregación de tendencias en la masa de agua subterránea

Tipo: resultados del proyecto de Aquaterra TREND2 “Tendencias en aguas subterráneas”

Enlace web: http://www.attempto-projects.de/aquaterra/21.0.html

Objetivo:

Procedimiento de agregación de las tendencias en estaciones de seguimiento individuales en la masa de agua subterránea, incluida una evaluación del nivel de fiabilidad y el número de estaciones necesarias. Identificación de la inversión de tendencias a escala de la masa de agua subterránea.

Contribución a…

Directiva Marco del Agua: tendencias, inversión de las tendencias, agregación, nivel de fiabilidad

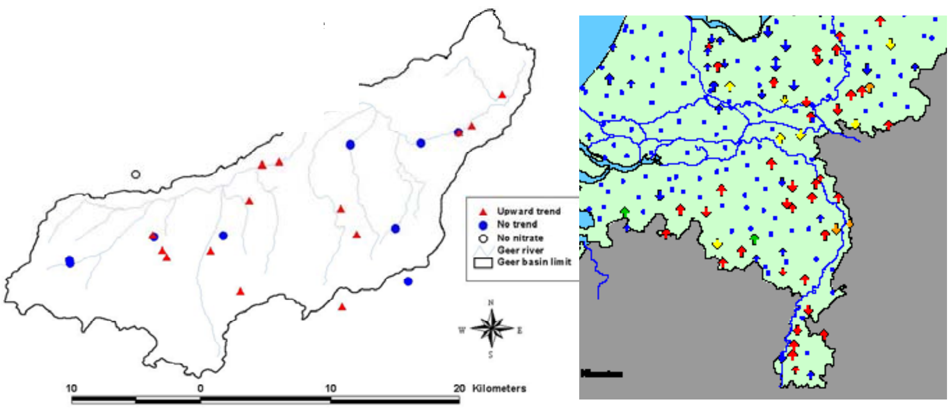
Contribuciones específicas: procedimiento de agregación, tiempos de respuestas a los impactos, determinación de la edad

Caracterización

El proyecto de Aquaterra TREND 2 consistió en el desarrollo de métodos operativos para evaluar, cuantificar y extrapolar las tendencias en sistemas de aguas subterráneas. Las técnicas de análisis fueron ensayadas en una amplia gama de casos europeos, que incluía depósitos de llanura no consolidados en los Países Bajos y Alemania, acuíferos yesíferos en Bélgica y un acuífero fracturado con una potente zona no saturada en Francia.

Se definió tendencia como “*el cambio en la calidad de aguas subterráneas en un período de tiempo específico y una región determinada, relacionado con el uso del suelo y la gestión del agua”.* El análisis de tendencias para la DAS tiene por objeto distinguir entre los cambios antropogénicos y las variaciones naturales con un nivel adecuado de fiabilidad y precisión (DAS, anexo IV, artículo 2.a),i)). Es evidente que las variaciones temporales causadas por factores climatológicos y meteorológicos pueden complicar la detección de tendencias, al igual que el factor de la variabilidad espacial, especialmente cuando, como se exige, se agregan las tendencias a escala de la masa de agua subterránea. Las variaciones espaciales pertinentes incluyen: 1. los recorridos y los tiempos de tránsito, 2. las presiones y entradas contaminantes, y 3. la reactividad química de las masas de agua subterránea. Estas variaciones derivan en un comportamiento muy variable de las tendencias a escala de la masa de agua subterránea, porque podría haber pozos en el recorrido conectados a una zona con fuertes entradas de contaminantes.

Figura 1: Variabilidad espacial de las tendencias en la cuenca del Geer, Bélgica (izquierda) y el sureste de los Países Bajos (derecha)



A pesar de que la agrupación de sondeos en función de las presiones y profundidades de seguimiento ya contribuye a determinar las tendencias (véase estudio de caso 1), a menudo se observa una gran variabilidad espacial en las direcciones que siguen las tendencias y las pendientes de la tendencia en la totalidad de una masa de agua subterránea (figura 1). La aplicación de la DAS requiere "un procedimiento en el que las evaluaciones de las tendencias individuales en las estaciones de control contribuyan a determinar una tendencia significativa y sostenida en la masa de agua subterránea. A continuación se ilustran dos modos posibles de agregar las tendencias individuales a escala de la masa de agua utilizando datos de la red de seguimiento neerlandesa en Brabante Norte. La red de seguimiento comprende sondeos normalizados con rejillas fijas a profundidades específicas. Los sondeos consisten en piezómetros agrupados de 2" de diámetro y rejillas de 2 metros de longitud a una profundidad de entre 8 y 25 metros (Broers, 2002). El subsuelo de Brabante Norte está formado por depósitos de arena y grava fluviales no consolidados procedentes del río Mosa, cubiertos de una capa de entre 2 y 5 m de espesor de depósitos fluvio-periglaciares y eólicos del Pleistoceno medio-superior de arena fina y arcilla. La provincia Brabante Norte es una zona relativamente llana con altitudes que oscilan entre 0 m sobre el nivel medio del mar (MSL) en el norte y oeste y 30 m en el sureste. Las capas freáticas son por lo general poco profundas; se sitúan entre 1 y 5 metros por debajo del suelo.

Perspectivas. Siguientes pasos. Accesibilidad a los resultados

Como primer paso en la agregación de tendencias se recomienda agrupar los sondeos de seguimiento en función de las presiones, la vulnerabilidad y las propiedades hidrológicas, tales como la distribución probable de los tiempos de tránsito en la masa de agua subterránea (véase el otro caso práctico). Existen dos modos de agregar entre los que elegir:

1. estadístico, por ejemplo, definiendo la pendiente media de la tendencia y el correspondiente intervalo de fiabilidad; y
2. determinístico, por ejemplo, utilizando la determinación de la edad para agregar series temporales en el eje X normalizado que indique el tiempo de recarga.

Ambos enfoques se ilustran a continuación utilizando los resultados del proyecto Aquaterra.

Ejemplo 1: Agregación utilizando las pendientes medias de las tendencias

En primer lugar se determinan todas las pendientes de las tendencias de los puntos de control individuales a través de una regresión lineal o una línea sólida Kendall-Theil (Helsel y Hirsch 1992). A continuación se determinan las tendencias agregadas tomando la mediana de todas las pendientes de las tendencias y se examina si la mediana de todas estas pendientes es significativamente diferente de cero (Broers y van der Grift 2004). Se establece una tendencia agregada significativa al aumento para el grupo de pozos cuando el nivel de fiabilidad del 95% de la mediana se sitúa completamente por encima de la línea de pendiente cero (figura 2). Se determinará una tendencia a la baja cuando el intervalo completo de fiabilidad se sitúa por debajo de la línea de pendiente cero. Aquí, los intervalos de fiabilidad en torno a la pendiente media se determinaron de manera no paramétrica, de acuerdo con Helsel y Hirsch (1992, p.70), utilizando un cuadro de la distribución binomial. Conviene observar que las tendencias podrían haber cambiado de dirección a diferentes profundidades del acuífero, debido a las diferentes edades de las aguas subterráneas y a las correspondientes entradas de contaminantes durante el período de infiltración.

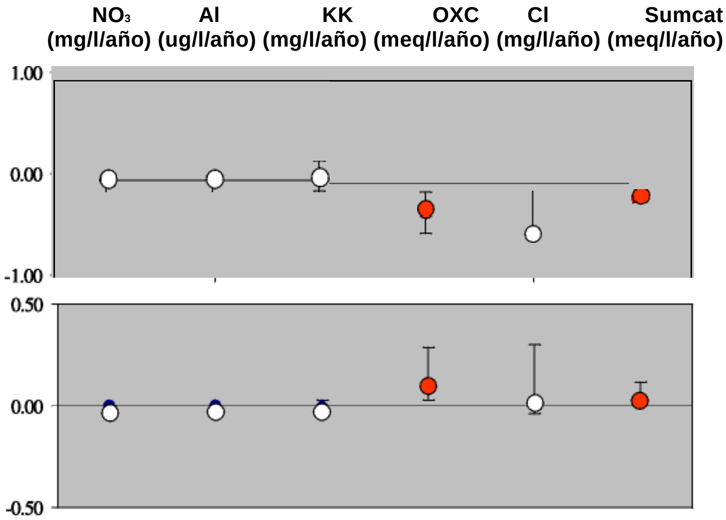


Figura 2: Pendientes de las tendencias medias agregadas de zonas de recarga agrícolas en la provincia de Brabante Norte para 6 indicadores químicos de rejillas a poca profundidad (gráfico superior) y rejillas a mayor profundidad (gráfico inferior). Fuente: Visser et al. 2005.

OXC = capacidad de oxidación. Sumcat = suma de cationes. Se detectaron tendencias significativas al aumento (símbolos rellenos) de OXC a niveles someros, y de Sumcat a mayor profundidad, y tendencias a la baja de Sumcat a niveles someros y de OXC a mayor profundidad.

Una de las conclusiones de agregar tendencias por un procedimiento estadístico es que suele ser necesario un gran número de pozos de observación -entre 20 y 40- para demostrar estadísticamente las tendencias debido a la gran variabilidad temporal y espacial observada, que es inherente a los datos sobre la calidad de las aguas subterráneas.

Ejemplo 2: Agregación basada en el tiempo de recarga utilizando la determinación de la edad

Una nueva técnica de agregación prometedora es utilizar la edad para determinar el período de recarga de las aguas subterráneas y relacionar los datos de concentración medidos con el tiempo de recarga obtenido. Esta técnica ha demostrado funcionar bien en sistemas de seguimiento basados en pozos de observación de niveles múltiples en zonas con acuíferos porosos. En el ejemplo se utilizaron las edades averiguadas con tritio-helio para determinar el tiempo de tránsito hasta las rejillas de control. En lugar del momento del muestreo, se utilizaron estos tiempos de tránsito para relacionar la serie temporal de las concentraciones medidas con el tiempo de recarga. A continuación, se agregaron los resultados de las 28 series temporales en el tipo de zona “uso del suelo: agricultura intensiva en zonas de recarga” en un gráfico y se analizaron utilizando el cálculo LOWESS de regresión lineal suavizada (Cleveland 1979) y ordinaria (figura 3). El método permitió determinar con éxito la inversión de tendencias de las concentraciones de nitratos en este tipo de zonas. La tendencia observada se puede comparar perfectamente con la historia de las entradas de contaminantes agrícolas, deducidas de una serie de datos históricos sobre producción y utilización de fertilizantes y estiércol con varios tipos de cultivos. La inversión de tendencias más fácil de demostrar fue la correspondiente a sustancias conservativas en solución y a indicadores tales como la “capacidad de oxidación” (Visser et al. 2007). Las tendencias al descenso en aguas subterráneas más recientes también pudieron demostrarse en lo relativo a solutos tales como los nitratos, que se transforman en nitrógeno cuando encuentran la desnitrificación por materia orgánica reactiva o sulfuros a cierta profundidad del subsuelo.

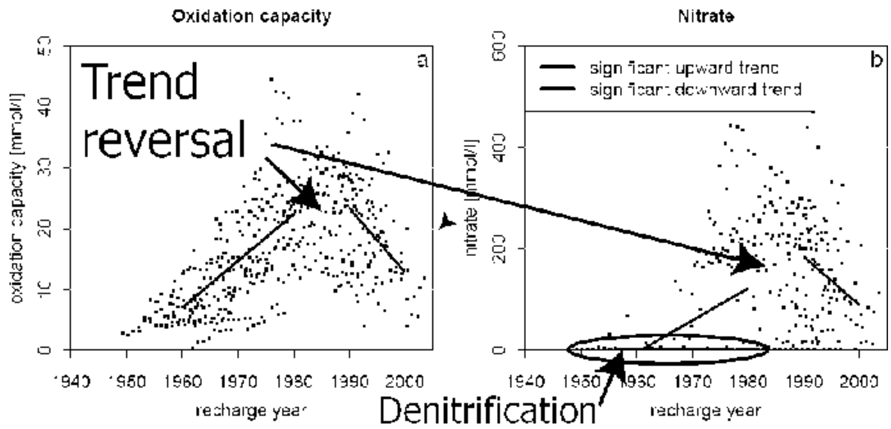


Figura 3:

Agregación utilizando la edad para determinar el año de recarga correspondiente a las concentraciones medidas. La inversión de tendencias quedó significativamente demostrada (P<0.005) en la capacidad de oxidación y nitratos.

Accesibilidad a los resultados

Los datos e informes de investigación están disponibles en la página web: http://www.attempto-projects.de/aquaterra/21.0.html

Referencias:

Batlle Aguilar, J., Orban, P., Dassargues, A. and Brouyère, S., 2007. Identification of groundwater quality trends in a chalk acuífero threatened by intensive agriculture in Belgium. Hydrogeology Journal, 15(8): 1615.

Broers, H.P. (2002). Strategies for regional groundwater quality monitoring. Netherlands Geographical Studies no. 306, Ph.D. Thesis University of Utrecht, los Países Bajos.

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 19

GUIDANCE ON SURFACE WATER CHEMICAL MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE

EUROPEAN COMMISSION

environment

Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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FOREWORD

The Water Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive. In particular, one of the objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, a range of guidance documents have been developed and endorsed by the Water Directors during the period 2002-2008 (18 documents in total). They provide Member States with guidance on e.g. the identification of water bodies (CIS Guidance No. 2), the analysis of pressures and impacts (CIS Guidance No. 3), monitoring (CIS Guidance No. 7) etc. in the broad context of the development of integrated river basin management plans as required by the WFD.

As a follow-up, and in the context of the development of the new Priority Substances Directive (2008/105/EC) developed under Article 16 of the Water Framework Directive, Member States have expressed the need to clarify chemical monitoring issues concerning priority substances and other chemical substances covered by the WFD. This has resulted in the decision to develop a new guidance document which would complement the existing series (in particular the Monitoring CIS Guidance No. 7 and the Groundwater Monitoring CIS Guidance No. 15). For this purpose, an informal drafting group has been established under the umbrella of the CIS Chemical Monitoring Activity (CMA). This drafting group has been coordinated by Germany and the EC Joint Research Centtre, and involved a range of experts from other Member States and from stakeholder organisations

The present Guidance Document is the outcome of this drafting group. It contains the synthesis of the output of discussions that have taken place since December 2006. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the procedure of Guidance development through meetings, workshops, conferences and electronic media, without binding them in any way to this content. It also contains inputs from the AMPS (Analysis and Monitoring of Priority Substances) Report, as well as from the EAQC-WISE (European Analytical Quality Control in support of WISE) funded under the 6th Framework Programme.

"*We, the water directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this Guidance during our informal meeting under the French Presidency in Paris (24-25 November 2008). We would like to thank the participants of the Chemical Monitoring Activity and, in particular, the leaders of the inputs drafting group for preparing this high quality document. We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive and its daughter Priority Substances Directive.*

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

We also commit ourselves to assess and decide upon the necessity for reviewing this document in the light of scientific and technical progress and experiences gained in implementing the Water Framework Directive and Priority Substances Directive".

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1. PURPOSE OF THIS GUIDANCE DOCUMENT

A strategy for dealing with pollution of water from chemicals is set out in Article 16 of the Water Framework Directive 2000/60/EC (WFD). As a first step of this strategy, a list of priority substances was adopted (Decision 2455/2001/EC) identifying 33 substances of priority concern at Community level. The proposal of a Directive of the European Parliament and of the Council on environmental quality standards in the field of water policy (developed under Article 16 of Directive 2000/60/EC) has the objective to ensure a high level of protection against risks to or via the aquatic environment arising from these 33 priority substances by setting European environmental quality standards. In addition, the WFD requires Member States to identify specific pollutants in the River Basins and to include them in the monitoring programmes. Monitoring of both WFD priority substances and other pollutants for the purpose of determination of the chemical and ecological status shall be performed according to Article 8 and Annex V of the WFD.

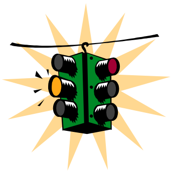
Member States have expressed the need for more guidance on implementation details of the monitoring for chemical substances. In-line with previous documents under the WFD Common Implementation Strategy (WFD CIS) this guidance document has, therefore, been developed as mandated through the Chemical Monitoring Activity (Mandate of Chemical Monitoring Activity 2005-2006). While not being legally-binding, it presents the common view of EU Member States on how to monitor chemical substances in the aquatic environment. This document should present best practices, complement existing CIS guidance and give links to relevant guidance and international standards or procedures already in practice. Guidance on groundwater monitoring is given in a separate document elaborated by CIS Working Group C[1].

This guidance includes the monitoring of the WFD priority substances, other specific pollutants and all other chemical parameters relevant in the assessment of the ecological or chemical status of a water body or in the assessment of programmes of measures. The guidance focuses on monitoring including sampling and laboratory analyses, it covers also in-situ field monitoring of physico-chemical quality elements, but not the monitoring of hydromorphological elements.

This document represents the current state of technical development in a field that is undergoing continuous changes through ongoing scientific research. This denotes that the guidance is open to continuous improvements according to the boundary conditions set in the WFD with possible updates along the 6 years river basin management cycle of the Directive. Since there is an overlap between WFD and the Marine Strategy Framework Directive (Directive 2008/56/EC) as regards chemical pollutants in territorial waters a link between monitoring activities for both Directives has to be established. However, this guidance refers to monitoring of inland, transitional and coastal water bodies under the WFD, and includes some areas of territorial waters also covered by the MSFD. It does not cover some specific aspects of marine monitoring.
Member States will have the opportunity to adjust their monitoring programmes starting in 2007 according to technical progress and the outcome of discussions on the proposal of a

[1] CIS Guidance document No. 15 'Groundwater Monitoring', European Commission, 2006

Directive on environmental quality standards in the field of water policy, amending Directive 2000/60/EC.



Look out!
Issues of compliance, statistical treatment and reporting of monitoring data are not within the mandate of this guidance document

2. BACKGROUND

The Water Framework Directive, including its amendments and existing guidance, provides the background for this guidance document. Links with these documents are indicated and sections of these documents of specific importance are provided for easier reading.

In the Water Framework Directive provisions regarding monitoring of chemical substances in surface waters are laid down in Article 8 and the Annex V.

Look in:
Water Framework Directive 2000/60/EC Article 8 and Annex V

1. Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district.

The Directive sets the Environmental Quality Standards and the basic provisions for compliance checking.

Look in:
European Parliament legislative resolution of 17 June 2008 on the Council common position with a view to the adoption of a directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and 2000/60/EC (11486/3/2007 – C6-0055/2008 – 2006/0129(COD))

General guidance on monitoring water quality elements can be found in the guidance document No. 7 MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE produced by Working Group 2.7 - Monitoring. The document deals with both chemical and biological parameters, but specific requirements on guidance for chemical monitoring under the WFD like, e.g., sampling, analytical methods and quality assurance have not been covered completely.

Look in:
Guidance document No. 7 - MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE

The monitoring requirements depend to a large extent on the pressures and impacts that have been identified for the specific water body. Monitoring requirements can, therefore, change with ongoing assessments and changes in anthropogenic pressures and impacts.

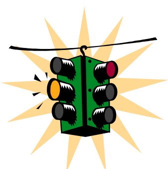
Look in:
Guidance document No. 3 - ANALYSIS OF PRESSURES AND IMPACTS

The Final Draft of the "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status" specifies minimum performance criteria for analytical methods used by laboratories mandated by competent authorities of the Member States for chemical monitoring of water status as well as rules for demonstrating the quality of analytical results.

Look in:
Final Draft of the "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status"

The content of this document has been based on the activities of the Expert Group on Analysis and Monitoring of Priority Substances (AMPS), the Chemical Monitoring Activity (CMA) and discussions throughout the ongoing WFD implementation process.

Look in:
EU REPORT CONTRIBUTIONS OF THE EXPERT GROUP ON ANALYSIS AND MONITORING OF PRIORITY SUBSTANCES AMPS to the Water Framework Directive Expert Advisory Forum on Priority Substances and Pollution Control (EUR 21587 EN)



Look out!
The guidance for chemical monitoring will have to be adapted to regional and local circumstances keeping in mind that the development in water status should be monitored by Member States on a systematic and comparable basis throughout the Community.

3. TERMS AND DEFINITIONS

Selected terms and definitions of specific importance for the chemical monitoring according to WFD are listed here. In addition, some terms of utmost importance are given here using the exact wording from WFD, daughter directives and the CIS guidance documents to assist clarity. All other terms, which have already been agreed upon and defined elsewhere in WFD and associated documents, are not listed here, but are used without amendment.

Look in:
Water Framework Directive 2000/60/EC Article 2

1. Surface water means inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters.

3. Inland water means all standing or flowing water on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of territorial waters is measured.

7. Coastal water means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.

24. Good surface water chemical status means the chemical status required to meet the environmental objectives for surface waters established in Article 4(1)(a), that is the chemical status achieved by a body of surface water in which concentrations of pollutants do not exceed the environmental quality standards established in Annex IX and under Article 16(7), and under other relevant Community legislation setting environmental quality standards at Community level.

Look in:
Guidance document No. 7 - MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE

"Significant quantities"
2.7.3 Selection of quality elements
...Those priority list substances discharged into the river basin or sub-basins must be monitored. Other pollutants also need to be monitored if they are discharged in significant quantities in the river basin or sub-basin. No definition of 'significance' is given but quantities that could compromise the achievement of one of the Directive's objectives are clearly significant, and as examples, one might assume that a discharge that impacted a Protected Area, or caused exceedance of any national standard set under Annex V 1.2.6 of the Directive or caused a biological or ecotoxicological effect in a water body would be expected to be significant.

Specific Terms and Definitions for the Guidance of Chemical Monitoring

Whole water:
"Whole water" is synonym for the original water sample and shall mean the water sample when solid matter and the liquid phase have not been separated.

Liquid (dissolved) fraction:
"Liquid (dissolved) fraction" shall mean an operationally defined fraction of whole water from which suspended particulate matter has been removed by an appropriate methodology.

Suspended particulate matter:
"Suspended particulate matter (SPM)" shall mean the particulate matter fraction of the whole water sample after separation with an appropriate methodology.

Total concentration of the analyte:
"Total concentration of the analyte" shall mean the total concentration of the analyte in the whole water sample, reflecting both dissolved and particle bound concentrations of the analyte.

Dissolved concentration of the analyte:
"Dissolved concentration of the analyte" shall mean the concentration of the analyte in the liquid (dissolved) fraction of a whole water sample.

Particle bound concentration of the analyte:
"Particle bound concentration of the analyte" shall mean the concentration of the analyte bound to SPM.

Discharged:
A substance is considered being discharged into a river basin when it is being introduced via point or diffuse sources or accidental releases.

4. MONITORING DESIGN RELATED TO SURVEILLANCE, OPERATIONAL AND INVESTIGATIVE MONITORING

4.1. General – Monitoring Design

The surface water monitoring network shall be established in accordance with the requirements of Article 8 of the Water Framework Directive (WFD). The monitoring network shall be designed so as to provide a coherent and comprehensive overview of ecological and chemical status within each river basin.

On the basis of the characterisation and impact assessment carried out in accordance with Article 5 and Annex II of the WFD, Member States shall establish for each river basin management plan period three types of monitoring programmes:

- surveillance monitoring programme,
- operational monitoring programme and,
- if necessary, an investigative monitoring programme.

Designing Surveillance/Operational Monitoring Programmes

All available information about chemical pressures and impacts should be used for setting up the monitoring strategy. Such information would include substance properties, pressure and impact assessments and additional information on sources, e.g., emission data, data on where and for what a substance is used, and existing monitoring data collected in the past.

In many cases, it will be relevant to use a stepwise screening approach to identify non-problem areas, problem areas, major sources etc. This approach may for instance start with providing an overview of expected hot spots and sources to receive a first impression of the scale of the problem. Thereafter, a more focused monitoring can be performed directed to relevant problem areas and sites. For many substances, screening of the levels in water as well as in biota with limited mobility and in sediment will be the best way to get the optimum information within a given amount of resources. When the problem areas are identified, analysis of a limited number of water samples can be performed.

The monitoring programmes will need to take account of variability in time and space (including depth) within a water body. Sufficient samples should be taken and analysed to adequately characterise such variability and to generate meaningful results with proper confidence.

The use of numerical models with a sufficient level of confidence and precision for designing the monitoring programmes can also be helpful.

The documentation of progressive reduction in concentrations of priority substances and other pollutants, and the principle of no deterioration are key elements of WFD and require appropriate trend monitoring. Member states should consider this when designing their monitoring programmes. Data obtained in surveillance and operational monitoring may be used for this purpose.

4.2. Sampling Strategy

Important principles of sampling strategy have been described in the CIS guidance document No.7 (e.g., 2.4., 2.7.2, 5.2.5). Depending on the objective of the monitoring, the physico-chemical properties of the substance to be monitored and the properties of the water body under study water, sediment and/or biota samples have to be taken.

The set-up of the monitoring strategy includes decisions on the sampling locations, sampling frequencies and methods. This selection is a compromise between a sufficient coverage of samples in time and space to generate meaningful results with proper confidence and limiting the monitoring costs.

As the establishment of environmental quality standards (EQS) has been limited for the majority of priority substances to water only, the principle matrix for assessing compliance[2] with respect to EQS is whole water, or for metals, the liquid fraction obtained by filtration of the whole water sample. EQSs referring to concentrations in biota have been established only for mercury, hexachlorobenzene, and hexachlorobutadiene at Community level. In order to allow Member States flexibility depending on their monitoring strategy, they may either monitor and apply the EQSs for biota, or introduce stricter EQS for water in order to provide the same level of protection as the EQS for biota. Furthermore, Member States may opt to establish and apply EQSs for sediment and/or biota for other substances listed in the proposed Directive. These EQSs shall offer at least the same level of protection as the EQS for water.

For other pollutants, the matrix for analysis should be in line with the matrix for which national EQS have been derived.

Water/SPM

WFD chemical status is generally assessed from analyses of water samples for substances with stated chemical water quality criteria. However, supporting parameters for the assessments of the ecological and chemical status may have to be analysed in water or other matrices.

The type of water sample to be taken at each site is part of the strategy for the monitoring programme. For most water bodies spot samples are likely to be appropriate. In specific situations, where pollutant concentrations are heavily influenced by flow conditions and temporal variation and if pollution load assessments are to be performed, other more representative types of samples may be beneficial. Flow-proportional or time-proportional samples may be better in such cases. In stratified water bodies such as lakes, some estuaries and coastal areas, waters samples may be taken in different depths to give a better representation of the water column compared to a single sampling depth. For example, multiparameter probes (e.g., CTD-probes) can be employed to detect stratifications.

[2] For the purpose of this guidance document the term compliance means that

a) reported annual average concentrations or reported concentrations of priority substances/other pollutants do not exceed the EQS laid down in Directive on Environmental environmental quality standards in the Field of water policy and amending Directive 2000/60/EC.

b) environmental objectives specified in the WFD such as no deterioration of the status of a water body, good chemical status of a water body, or trend reversal have been achieved.

In general, reliable data on emission sources reduce monitoring costs because they give a good basis for choosing proper sampling locations, and optimising the number of sampling sites and the appropriate sampling frequencies.

Look in:
Water Framework Directive 2000/60/EC Article 16(7)

The Commission shall submit proposals for quality standards applicable to the concentrations of the priority substances in surface water, sediments ***or*** *biota.*

Whole water data may be generated by analysis of the whole water sample, or by separate determinations on liquid and SPM fractions. If it can be justified – for example by considerations of expected contaminant partitioning – it may be argued that there is not a need to analyse a particular fraction. If a sampling strategy is selected involving only liquid or SPM fractions, then, Member States shall justify the choice with measurements, calculations, etc.

However, demonstrating compliance with EQS in water may be problematic in some cases. Examples include:

- available analytical methods are not sufficiently sensitive or accurate for quantification of substances at the required concentration level (see 6.1),
- water bodies with high and fluctuating SPM content and varying properties (sampling representative water sample is problematic).

Sediment and Biota[3]
To check compliance with biota EQS values, the most appropriate indicator species among fish, molluscs, crustaceans and other biota should be monitored (this will be dealt with in a separate guidance document, see footnote 3).

In addition to chemical and ecological status assessement, the prevention of further deterioration of the status of aquatic ecosystems is another important objective of the WFD. Monitoring of contaminants in sediment and biota may be used to assess the long-term impacts of anthropogenic activity and thus, to assess the achievement of the above mentioned objective. It includes the determination of the extent and rate of changes in levels of environmental contamination.

Hydrophobic and lipophilic substances that tend to accumulate in sediment and biota may be monitored in these matrices for resource effective trend monitoring in order to:

- assess compliance with the no deterioration objective (concentrations of substances are below detection limits, declining or stable and there is no obvious risk of increase) of the WFD,
- assess long-term changes in natural conditions and those resulting from widespread anthropogenic activity,

[3] Further guidance on monitoring of WFD relevant substances in biota and sediment is under development within the Chemical Monitoring Activity of the European Commission

- monitor the progressive reduction in the concentrations of priority substances (PS) and the phasing out of priority hazardous substances (PHS).

Furthermore, the use of sediment and biota in monitoring hazardous substances is important in other issues of WFD implementations, viz.:

- identify fate and behaviour of pollutants,
- describe the general contaminant status and supply reference values for regional and local monitoring programmes,
- accumulating matrices give an integrated and less varible measure of the contaminant burden over a longer time period, and consequently, an improved statistical power for time series analysis

The selection of the monitoring matrix has implications on the monitoring frequencies on both scientific and cost grounds.

If sediment or biota are used for temporal trend monitoring it is recommended, if practicable, that the quantitative objectives of the monitoring are determined before any monitoring programme is started. For instance, the quantified objective could be to detect an annual change of 5 % within a time period of 10 years with a power of 90 % at a significance level of 5 % with a one-sided test.

Sediment samples should be collected at an appropriate frequency that will have to be defined on a local basis, where appropriate, taking into account the sedimentation rate of the studied water body and hydrological conditions (e.g., flood events). Typical sampling frequency will vary from once every 1 to 3 years for large rivers or estuaries that are characterised by high sedimentation rates, to once every 6 years for lakes or coastal areas with very low sedimentation rates.

The locations for sediment trend monitoring should be representative of a water body or a cluster of water bodies. Where possible, sampling should be performed in non-erosion areas, which are representative of sediment formation. For dynamic systems it might be useful to collect suspended matter for monitoring purposes.

In case of using biota in trend monitoring it is common practice to collect samples at least once per year during the non-spawning season.

Representativeness is a key point, i.e. how well a sample reflects a given area or how much area the sample represents given a certain level of statistical significance. For example, it is essential to collect specimens for analysis well away from the mixing zones when the sampling point is downstream of a significant discharge.

To improve the power of the monitoring programme samples should be collected from areas characterised by relatively low natural variability.

4.3. Use of Models as a Tool in WFD Monitoring

Numerical models are important tools for planning monitoring strategies and designing monitoring programmes. They can help to understand the spatial and temporal variations in pollutant concentrations. For instance, measurements in sediments and biota combined with models can be used to estimate dissolved water concentrations for some contaminants, particularly hydrophobic organic compounds. Thus, appropriately validated and tested models can provide, within the impact and pressure assessments, additional evidence that EQS will not be violated in a specific water body under the most adverse conditions.

Given the current levels of uncertainty, concentrations of contaminants estimated by modelling cannot be used for the purpose of compliance checking for water bodies that are at risk of failing WFD provisions. The approach can, however, be used in surveillance monitoring for estimation of concentrations in water bodies that are shown to be not at risk when the uncertainty of the model is considered.

According to partitioning theory, relationship curves and/or mechanistic models can be used to estimate a corresponding, or equilibrium water concentration from measured levels of hydrophobic contaminants in biota/sediments. This way, areas can be cost-efficiently scanned using sediments and biota to compare contaminant levels in different areas and to identify possible sources of contaminants to the area.

Relationship curve models are based on correlations between chemical measurement data and some descriptor, whereas mechanistic models are based on processes giving rise to the observed data. Some examples are the relationship curve models such as OMEGA (EU Rebecca project) or BCFWIN (MEYLAN et al. 1999)[4] and mechanistic models, such as Bioaccumulation Fish Model (MACKAY 2001)[5] and SEDFLEX[6]. One example of relationship curve models is the use of bioaccumulation factors (BAF) in relation to the partitioning coefficient between octanol and water (K_{OW}). BAFs have been used for the past 25 years to describe the net increase of organic contaminant concentrations from water to biota, as BAF = $CHEMICAL_{Animal}/CHEMICAL_{Water}$. Because BAF is related linearly to K_{OW}[7], this relationship curve can be used to calculate the water concentration of a chemical when the level in biota and its partitioning coefficient are known. In the absence of environmental measurements of a chemical in biota and water to calculate BAFs, this relationship is also a useful tool for exposure and risk assessments of new chemicals. This issue is being explored by several programmes, such as: Registration, Evaluation and Authorisation of CHemicals (REACH)[8] in the EU (European Commission 2004), the Canadian Environmental Protection Act (CEPA)'s Domestic Substances List (DSL) (ENVIRONMENT CANADA 2003)[9], and the US EPA high production chemicals assessments (WALKER et al. 2004)[10].

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4 Meylan, W. M.; Howard, P. H.; Boethling, R. S.; Aronson, D.; Printup, H.; Gouchie, S. (1999) Improved method for estimating bioconcentration/bioaccumulation factor from octanol/water partition coefficient. Environ. Toxicol. Chem. 18, 664-672.

5 Mackay, D. (2001) Multimedia Environmental Models; The Fugacity Approach. Lewis Publishers, CRC Press, Boca Raton, Florida.

6 Saloranta, T. M., Andersen, T., Næs, K. (2006) Flows of dioxins and furans in coastal food webs: inverse modeling, sensitivity analysis, and application of linear system theory. Environmental Toxicology and Chemistry 25, No. 1, pp. 253–264.

7 This only holds provided the contaminant is not metabolised by the animal quickly, and if the concentration in the animal is expressed on lipid weight basis

8 European Commission. Why do we need REACH? REACH in brief; European Commission, Environment Directorate General: Brussels, 2004; 18 pp.

9 Environment Canada. Existing Substances Evaluation Bulletin; Ottawa ON, 2003, 9 pp. http://www.ec.gc.ca/Substances/ese/ eng/what_new.cfm.

10 Walker, J. D.; Knaebel, D.; Mayo, K.; Tunkel, J.; Gray, D. A. (2004) Use of QSARs to promote more cost-effective use of chemical monitoring resources. 1. Screening industrial chemicals and pesticides, direct food additives, indirect food additives and pharmaceuticals for biodegradation, bioconcentration and aquatic toxicity potential. Water Qual. Res. J. Can. 39, 35-39.

The mechanistic model SEDFLEX is composed of a dispersion part simulating the sources, transport and sinks of contaminants in a fjord, estuary or lake system, and a food web part that calculates uptake and accumulation in biota as well as quantification of different food sources, mainly from sediment or from water[6]. When emission data are added to the dispersion part, SEDFLEX can predict how changes in the environment would be reflected in water, biota or sediment concentrations, respectively, and what the response time would be.

The predictive power of models is only valid within the framework and limits defined by its assumptions. Models with a sufficient level of confidence can be helpful for designing the monitoring programmes. However, it is important to define the desired level of confidence and consider uncertainties associated with chemical measurements in biota/sediments as well as with other parameters used in the model. As a result, estimated water concentrations may vary considerably. By the use of model sensitivity analyses, combined with knowledge on uncertainty of measurement, the confidence of the modelled concentrations can be assessed. The level of confidence will be site and chemical specific. It is crucial that the model performance is carefully documented. Existing knowledge gaps must be quantified and taken into account as uncertainty factors when applying models.

In using sediments and biota as a first level screening for certain chemicals in the monitoring programme, water measurements may be downscaled. The initial screening will help to identify areas of concern and where to direct effort, such as a follow up with water samples and direct measurements. This process provides good grounds for using models, where appropriate.

4.4. Monitoring Frequency

Look in:
Water Framework Directive 2000/60/EC Annex V 1.3.4

For the surveillance monitoring period, the frequencies for monitoring parameters indicative of physico-chemical quality elements given below should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgement.

For operational monitoring, the frequency of monitoring required for any parameter shall be determined by Member States so as to provide sufficient data for a reliable assessment of the status of the relevant quality element. As a guideline, monitoring should take place at intervals not exceeding those shown in the table below unless greater intervals would be justified on the basis of technical knowledge and expert judgement.

Guidance document No. 7 - MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE, 2.1

The monitoring frequencies given in WFD, Annex V 1.3.4 of once-a-month for priority substances and once-per-three-months for other pollutants will result in a certain confidence and precision. More frequent sampling may be necessary e.g., to detect long-term changes, to estimate pollution loads and to achieve acceptable levels of confidence and precision in assessing the status of water bodies. In general, it is advisable to take samples in equidistant time intervals over a year, e.g., every four weeks resulting in 13 samples to compensate for missing data due to unusual weather conditions (drought, floods, etc.) or laboratory problems. In case of pesticides and other seasonally variable substances, which show peak concentrations within short time periods, enhanced sampling frequency compared to that specified in the WFD may be necessary in these periods. For example, the best sampling time for detecting concentration peaks of pesticides due to inappropriate application is after heavy rainfall within or just after the application period. Moreover, failure to comply with good agricultural practice, e.g., inappropriate cleaning of equipment during or at the end of the season before winter can also cause pesticide peak concentrations. Other reasons for enhanced sampling frequency include seasonal pressure from tourism, seasonal industrial activities, which are common practice for example in pesticide production etc. The results of those measurements should be compared with the MAC-EQS. For the calculation of the annual average concentrations results have to be weighted according to the associated time interval (time weighted average). For example, 12 equidistant values per year with two additional values in November could be accounted for with reduced weights for the three November values. In other words, the three November values would be averaged and a "November mean" be used in the calculation of the annual average value. Using this approach, any individual values should still trigger an immediate investigation if high levels are detected.

Collecting composite samples (24h to one week) might be another option to detect peak concentrations of seasonally variable compounds.

To estimate the pollutant load, which is transferred across Member State boundaries and into the marine environment, an enhanced sampling frequency may be advisable. In case of spot sampling for substances, which show a wide range of concentrations, biweekly sampling, i.e. 26 samples a year may be justified. Flow-proportional or time-proportional sampling may be beneficial in such cases.

Reduced monitoring frequencies, and under certain circumstances, even no monitoring may be justified when monitoring reveals/has revealed that concentrations of substances are far below the EQS, declining or stable and there is no obvious risk of increase.

The monitoring frequencies quoted in the Directive may not be practical for transitional and coastal waters, Nordic lakes, which can be iced for several months, and for Mediterranean rivers which may contain no water for several months each year.

4.5. Surveillance Monitoring

4.5.1. Objectives

According to WFD Annex V1.3.1 the objectives of surveillance monitoring of surface waters are to provide information for:

- supplementing and validating the impact assessment procedure detailed in Annex II;
- the efficient and effective design of future monitoring programmes;
- the assessment of long-term changes in natural conditions; and
- the assessment of long-term changes resulting from widespread anthropogenic activity.

It should be stressed that surveillance monitoring is not intended for:

- mapping and analysing water quality problems;
- testing the effectiveness of the programme of measures;
- obtaining a detailed or complete overview of the quality of all types of water.

Such information is to be gathered within operational monitoring, investigative monitoring, and existing non-WFD related monitoring activities.

It is recommended to use monitoring data, which have to be reported according to other European Directives and international river and sea conventions for the purpose of surveillance monitoring (e.g., 76/464/EWG, Nitrates Directive 91/676/EEC, OSPAR JAMP), where appropriate.

4.5.2. Selection of Monitoring Points

The criteria for selecting the surveillance monitoring points are given in WFD Annex V 1.3.1. Water bodies probably at risk, probably not at risk and not at risk of failing the environmental objectives should be covered adequately.

	**Look in:** Water Framework Directive 2000/60/EC Annex V 1.3.1 Guidance document No. 7 - MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE, 2.7.2

Sampling points should include major rivers as well as points at the downstream end of relevant sub-catchments.

Sampling points for general physico-chemical parameters supporting the biological quality elements need to be representative of the sampling site of the biological elements (although it is recognised that physical characteristics may necessitate some flexibility in this regard). For priority substances and other pollutants, other sampling points may be selected.

Where possible, it is recommended to establish surveillance monitoring sites with fixed monitoring stations and automatic samplers allowing the collection of mixed samples. If not available, spot samples should be collected. Where possible, water level and flow should be recorded as well as pH, conductivity, and temperature, e.g., by using suitable probes.

In case of transboundary waters, consultations about the proposed water body and surveillance monitoring sites should be held between the Member States involved.

Monitoring sites to be used for pollution load estimation (country boundaries and transition from inland waters to marine environment), should, where possible, include representative water quantity as well as quality monitoring.

Representative approaches related to diffuse and widespread sources are often relevant in surveillance monitoring. In such cases sufficient monitoring points must be sampled within a selection of water bodies in order to assess the magnitude and impact of the pressures. Results can be scaled up by using measurements of biota or sediment samples from a larger number of bodies.

4.5.3. Selection of Monitoring Parameters

Chemical monitoring comprises three categories of parameters:

- substances that have to be assessed in respect of compliance with European environmental quality standards (EQS), e.g., priority substances
- other polluting substances, e.g., river-basin-specific substances, for which no European EQS are available and which have, hence, to be assessed in respect of compliance with national or river-basin-specific EQS
- primary physico-chemical parameters, e.g., nutrients, oxygen, temperature, salinity, conductivity, pH, which support interpretation of biological data and those required for reliable interpretation of the results of chemical measurements (e.g., DOC, Ca, SPM content).

For the purpose of surveillance monitoring, priority substances discharged into river basins or sub-basins must be analysed. Other pollutants defined as any substance liable to cause pollution in particular those listed in Annex VIII also need to be monitored if they are discharged in significant quantities in the river basin or sub-basin. In addition, relevant physico-chemical parameters should be measured.

4.6. Operational Monitoring

4.6.1. Objectives

Operational monitoring shall be undertaken (Annex V.1.3.2) in order to:

- establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and
- assess any changes in the status of such bodies resulting from the programmes of measures.

Contrary to surveillance monitoring, operational monitoring is characterised by spatial and temporal flexible monitoring networks, problem-oriented parameter selection and sampling.

The operational monitoring programme may be modified during the planning period (6 years) if the monitoring results indicate there is a reason to do so. The monitoring frequency can be reduced, for example, when an effect is no longer deemed to be significant or the pressure in question has been eliminated. This applies when good, or better, chemical and ecological status has been achieved. As soon as the good status has actually been achieved and there is no risk of failing the environmental objectives, the operational monitoring can be stopped and surveillance monitoring will suffice. If operational monitoring aims at the assessment of changes in the status of water bodies resulting from programme of measures, it might be justifiable to reduce monitoring frequencies or suspend monitoring for a certain time period as long as no change in the status can be expected.

4.6.2. Selection of Monitoring Points

The criteria for selecting operational monitoring sites are given in WFD Annex V 1.3.2.

	**Look in:** Water Framework Directive 2000/60/EC Annex V 1.3.2 Guidance document No. 7 - MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE, 2.8.2

If there are significant chemical pressures from point sources, sufficient locations must be selected to assess the magnitude and impact of these point sources according to Annex V of the WFD.

If there are significant chemical pressures from diffuse sources the water body selected for operational monitoring must be representative of the occurrence of the diffuse pressures, and of the relative risk of failure to achieve good surface water status. However, it should be taken into account that water bodies can only be grouped where the type and magnitude of pressure are similar.

Aggregation of water bodies is possible if the water bodies can be compared in respect of geography, hydrology, geomorphology, trophic level and extent of human pressures. In such cases, Member States shall provide evidence that the water body where monitoring is carried out is indeed representative of the group of water bodies.

Provided that there is a good documentation that local sources are absent, a few water samples from a number of representative bodies should be sufficient to identify non-problem areas affected only by diffuse input via long-range transport of pollutants.

4.6.3. Selection of Monitoring Parameters

In order to assess the magnitude of the chemical pressure to which bodies of surface water are subjected, Member States shall monitor for any priority substances and other pollutants discharged in significant amounts to the water body concerned. In addition, physico-chemical parameters relevant for reliable interpretation of the results of chemical measurements (e.g., DOC, Ca, SPM content) should be measured.

4.7. Investigative Monitoring

4.7.1. Objectives

Investigative monitoring may be required in specified cases (Annex V.1.3.3). These are given as:

- where the reason for any exceedance (of environmental objectives) is unknown,
- where surveillance monitoring indicates that the objectives set under Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established,
- in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives,
- to ascertain the magnitude and impacts of accidental pollution.

Investigative monitoring may also include alarm or early warning monitoring, for example, for the protection of water bodies used for drinking water abstraction that may be subject to accidental pollution.

Investigative monitoring may also be triggered when a water body has been identified as being at risk of failing the objectives due to chemical pressures on the basis of the assessment of biological elements.

4.7.2. Selection of Monitoring Points/Matrix/Parameters

The starting point of investigative monitoring will often be that surveillance or operational monitoring have revealed that the EQS values are exceeded, but the causes of the failures are unknown or poorly understood. It is, however, very difficult to give general guidance on how to proceed in investigative monitoring since a case by case approach is the only way forward to take account of local conditions, the type of pressures, and the specific aim of the investigation. This will in general require expert knowledge and judgment. The necessary monitoring points, the matrix and parameters to be monitored as well as the frequency of sampling and the duration of the monitoring have to be adjusted to the specific case or problem under investigation. Investigative monitoring is characterised by spatial and temporal flexible sampling and can be stopped as soon as the cause of non-compliance has been identified. When a programme of measures is in operation and its effect can be expected to be measurable, a suitable operational monitoring has to be established. In the case of accidental pollution, investigative monitoring can be ceased as soon as the magnitude of the impact of the accidental pollution has been ascertained.

Before starting investigative monitoring, thorough pressure analysis may be required. In particular, it is important to clarify whether point or diffuse sources have to be taken into account as potential cause for non-compliance.

In order to identify the causes of exceedance of EQS in a water body or several water bodies, Member States shall monitor the priority substance(s) or other pollutant(s) of which the water concentration exceeds EQS.

5. TECHNIQUES FOR SAMPLING

5.1. General Remarks on Sampling

The quality of assessments based on the results from the chemical analyses is dependent on the quality of the sampling and on understanding the inherent variability in the media from which samples are taken. The variability of contaminant concentrations in aquatic systems is often difficult to quantify and can often be higher than uncertainties associated with the analyses themselves. Nevertheless, the overall uncertainty needs to be considered in the data evaluation and needs to be addressed in the design of a representative monitoring programme. The design of a monitoring programme includes the selection of sampling points and matrix as well as sampling frequencies as described in Chapter 4. For example in the case of water sampling, the exact position of sampling points including sampling depths depends on local conditions, e.g., parameters such as vertical and lateral mixing, water homogeneity and possibilities to use appropriate sampling equipment (see e.g., ISO 5667-6).

It is vital that all the personnel involved in sampling are sufficiently educated and trained in the procedures applied and fully aware of the risks and consequences of taking inappropriate samples. They should understand the objectives of the monitoring programme, the further treatment of the samples taken and have a certain understanding of the hydro-geochemical processes in the water body. The sampling should include a routine sampling report sufficiently detailed to document the sampling performed and include observations relevant for the assessment of the monitoring results.

QA/QC procedures are necessary to ensure the quality of the sampling activities of a monitoring programme, including care to preserve sample integrity (see ISO 5667-14 and other guidelines). Quality assurance of sampling including selection of sample, pre-treatment, sub-sampling, preservation, storage and transport is essential for the quality of final results of the chemical analyses. Quality control of the sampling should include measures that enable estimation of sampling precision. Other measures could be participation in sampling inter-comparison trials.

5.1.1. Existing Guidance Documents

Guidance on sampling techniques may be found in the ISO Standard on Water Quality – Sampling 5667 (www.iso.org), the guidelines of the OSPAR Convention (www.ospar.org) for the Joint Assessment and Monitoring Programme (JAMP) or the HELCOM COMBINE manual (http://www.helcom.fi/groups/monas/CombineManual/en_GB/main/).

5.2. Water Sampling

	**Look in:** ISO Standard Series 5667, Part 1, 3, 4, 6 and 9 OSPAR JAMP Guidelines: Chlorophyll a in Water, Nutrients and Oxygen Manual for Marine Monitoring in the COMBINE Programme of HELCOM

Water sampling procedures usually include in situ field measurements of physical and chemical parameters, e.g., water flow, temperature, conductivity (salinity), dissolved oxygen, pH, transparency, and fluorescence either in the surface water or in a vertical profile. When the results of these in situ measurements influence the sampling (e.g., the selection of sampling depths) precise guidelines on how to make decisions must be included in the sampling instructions. In stratified water bodies, the densities of phytoplankton and related chemical parameters can change dramatically across a vertical discontinuity. This must be reflected in the sampling strategy (see 4.2) and instructions.

The sampling equipment is selected according to the type of water body and to the sample requirements (e.g., size and integrity) for performing the analyses of the monitoring programme. It must be without risks of contaminating the sample, both from the construction materials of the sampler (adsorption and/or release of compounds) and from the previous use for sampling in other water bodies (memory effects).

Sample containers, transport and storage should not lead to any contamination or changes in the relevant chemical properties of the sample. Some precautions, depending on the nature of the contaminants to be analysed, must be taken to avoid contamination of the sample. Plastic materials except polytetrafluoroethylene (PTFE) must not be used for the samples to be analysed for hydrophobic organic contaminants (e.g., PCBs, PAHs). Samples taken for the analysis of organic contaminants must be stored in glass, PTFE or stainless steel containers. Samples collected for analysis of metals can be stored in closed plastic or glass containers. For mercury, samples must be stored in acid-washed borosilicate glass or quartz containers, as mercury can move through the walls of plastic containers. For organotins, samples are preferably stored in glass containers, but containers of other materials such as polycarbonate or aluminium are also suitable. The type of containers should always be selected after consulting the laboratory performing the chemical analyses, or the containers should be supplied by the laboratory. Depending on the parameter to be determined, specific conditioning and/or cleaning of sample containers prior to use may be required.

Sample preservation is needed in many cases to avoid loss or transformation of substances due to redox processes, degradation of organic matter, and precipitation of metals as hydroxides or evaporation of gaseous or volatile constituents.

If samples are analysed within 24 h and stored in the dark at 1-5 °C, sample composition, and hence, results of chemical analyses will not change significantly. Examples of exceptions are nutrients in low concentrations. Storage of samples at temperatures below -20 °C may allow the sample to be stored for longer time periods. However, freezing is not appropriate for volatile components. It is also necessary to remove suspended matter, algae and other micro-organisms by filtering the sample before freezing to avoid changes in dissolved concentrations of substances caused by ,e.g., disruption of cells. Moreover, the risk of precipitation of, e.g., calcium carbonate at low temperatures and other processes such as co-precipitation and colloid coagulation during freezing should be considered.

The laboratory performing the chemical analyses should agree on the procedures for preservation and storage of samples.

The sampling report should include key parameters such as date, time, location and grid reference, depth, preservation method and a unique identifier, together with any field observation made for inclusion in the reporting of the monitoring results.

5.3. Sampling of Suspended Particulate Matter (SPM)

Analysis of strongly hydrophobic organic substances in SPM can be a suitable surrogate for whole water analysis. The separation of SPM from the water can be accomplished by appropriate filtration (limited to the collection of small amounts of SPM), centrifuging either in the field or in the laboratory or by sedimentation. Commonly, filtration through 0.45 µm glass-fibre depth filters is used. The qualities and quantities of SPM collected by centrifugation, filtration or by using sediment traps differ from each other. None of these techniques allows the collection of the total amount of suspended particles. Therefore, when using SPM for analysis the sampling technique has to be indicated.

Look in:
ISO Standard Series 5667 Part 17

OSPAR JAMP Guidelines for the Estimation of Riverine PAH Inputs into the North Sea and the North-East Atlantic

These guidance documents focus mainly on river sampling but the principles can be adapted for other categories of water body. The following factors are essential in deciding on the sampling regime:

- Horizontal and vertical variations in suspended solids.
- Variations in time and space in suspended solids considering especially seasonal variations, base-flow and storm flow conditions, tidal influence and influence from primary production on suspended solids.
- The volume of sample required to minimize the error producing effects caused by inhomogeneities in the water body and to meet analytical requirements.

The sampling report should also include a descriptive comments field to allow the sampler to record the procedure undertaken on site, the appearance of the water etc.

Regarding sampling containers and sample storage for SPM, see description in chapter 5.4.

5.4. Sediment Sampling[3]

	**Look in:** ISO Standard Series 5667, Part 12, 15 and 19 OSPAR JAMP Guidelines for Monitoring Contaminants in Sediments

As a general principle, the sampling procedure should not alter the properties of the sediment (e.g., by contamination or disturbing the sample). A wide range of sampling devices is available, especially for collecting marine sediments. The choice of equipment should be made depending on the local conditions at the site of sampling, e.g., water depth and type of sediment. Box or other corers, which are capable of sampling the surface sediment without disturbing the sediment structure, are recommended. In case grab samplers are used, all precautions should be taken to limit disturbing the sediment. Retrospective temporal trend studies necessarily involve the collection of samples using a box corer or large-diameter gravity corer, or an equivalent device. Alternatively, for shallow or tidal waters, hand coring may be appropriate.

As suggested above, it is good practice to complete a sampling report, which may include a general description of collected samples including colour, homogeneity (presence or absence of stratification), presence or absence of animals (indication of bioturbation), surface structures, odour and any visible contamination (e.g., oil sheen).

The sub-sampling of sediments should preferably be performed immediately after sampling. Some precautions, depending on the nature of analysed contaminants, must be taken to avoid contamination of the sample. Samples taken for the analysis of organic contaminants must be stored in glass, polytetrafluoroethylene (PTFE) or stainless steel containers. Sediments collected for analysis of metals can be stored in closed plastic or glass containers. For mercury, samples must be stored in acid-washed borosilicate glass or quartz containers, as mercury can move through the walls of plastic containers. For organotins, storage of samples is preferably done in amber glass bottles, but containers of other materials such as polycarbonate or aluminium are also suitable. If the monitoring programme requires analysis of the fine sediment fraction, the sample should be split using appropriate sieving techniques.

Samples which are analysed within 48 h after sampling should be stored at 1-5 °C in the dark (short-term storage). For long-term storage, samples should be stored frozen, at – 20 °C or below, or dried. Freeze-drying samples at low temperature (e.g., < 10 °C) is the preferred alternative to freezing, if it can be ensured that analytes do not evaporate to a substantial degree.

5.5. Biota Sampling[3]

	**Look in:** OSPAR JAMP Guidelines for Monitoring Contaminants in Biota Manual for Marine Monitoring in the COMBINE Programme of HELCOM

Fish, mussels and seabird eggs are commonly used for monitoring of contaminants in the aquatic environment.

The natural variability within biota samples should be reduced by an appropriate sampling design, keeping in mind that age, size, sex and sexual maturity status are criteria to keep homogeneous in a given class of the sampled biota. Biota sampling should only take place when fish and bivalves are in a stable physiological state, and outside the normal period of spawning.

Fish should be collected from areas characterised by relatively low natural variability. Shellfish should preferably be collected from sub-tidal regions, or as near to the same depth and exposure (i.e. in terms of light and wave action) as possible in order to reduce variability in contaminant uptake.

Fish can be sampled from either research vessels or commercial vessels. In both cases, several precautions must be taken to reduce contamination. Clean containers should be available on deck to hold the samples temporarily before they are taken to the ship's laboratory. Personnel should wear clean gloves, free of the contaminants to be analysed, when collecting mussels by hand and when fish are taken from the net. Where appropriate, biota samples should be rinsed with water to remove any material adhering to the surface. When collecting mussels by ship, a commercial mussel dredge can be used.

Freezing of samples will degrade soft tissues. Therefore, sub-samples of particular tissue for analysis should be drawn immediately after catching the fish and immediately deep-frozen. Mussels should be depurated and cleaned prior to preservation and analysis. Dissection must be done under clean conditions on a clean bench by trained personnel, wearing clean gloves and using clean stainless steel knives. The use of blades made of ceramics or titanium is recommended to reduce the risk of Cr and Ni contamination. The soft tissue samples should be analysed immediately or stored at temperatures below – 20 °C.

Biological samples to be used for analysis of organic contaminants should be stored frozen e.g., wrapped in pre-cleaned alumina foil in suitable containers of glass, stainless steel or alumina. Plastic material, except PTFE, must not be used.

For metal analysis, biota samples should be wrapped separately in suitable material (e.g., polyethylene or PTFE) and frozen. Sub-samples (e.g., liver) should be stored in suitable acid-cleaned containers, preferably of glass, and frozen or freeze-dried immediately.

6. TECHNIQUES FOR ANALYSIS

Article 8, Paragraph 3 of the WFD requires that "technical specifications and standardised methods for analysis and monitoring of water status shall be laid down in accordance with the procedure laid down in Article 21". Moreover, Annex V.1.3.6 of the WFD states that the standards for monitoring of quality elements for physico-chemical parameters shall be "*any relevant CEN/ISO standards or such other national or international standards which will ensure the provision of data of an equivalent scientific quality and comparability*".

The strengths of such methods are that they are well established and have often been subjected to collaborative trials to give an illustration of their interlaboratory comparability and applicability. They may not represent the current state of the art in all cases, and usually, represent a compromise in performance that is tailored to a number of different users' goals and operational needs.

In general, performance-based methods shall be used in surveillance and operational monitoring. They shall be described clearly, properly validated[11] and where possible leave laboratories the flexibility to select from several options. Irrespective of what method is applied in chemical monitoring certain minimum performance criteria have to be met, which are laid down in the Final Draft "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status", and discussed in the framework of the EAQC-WISE project[12].

According to this draft commission Directive the laboratories may select any analytical method of their choice for the purpose of monitoring under Article 8 and Annex V of the Directive 2000/60/EC provided they meet the minimum performance criteria set out in this document or by the national competent authorities.

Laboratories can consult chapter 6.5 and Annex II to identify suitable methods for monitoring of priority substances and other pollutants. Available certified reference materials relevant to WFD monitoring[13] are listed in Annex III. The Annex III was elaborated within the EU-project EAQC-WISE[12] .

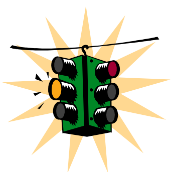
[11] see e.g., the protocols for method validation developed within the NORMAN network, funded under the 6th RTD Framework Programme, European Commission, http://www.norman-network.com.
[12] EAQC-WISE project, funded under the 6th RTD Framework Programme, European Commission, http://www.eaqc-wise.net/
[13] Bercaru, B. Gawlik, F. Ulberth, C. Vandecasteele (2003) Reference materials for the monitoring of the aquatic environment - a review with special emphasis on organic priority pollutants. Journal of Environmental Monitoring 5, 697-705.

6.1. Method Performance Criteria

Look in:
Final Draft "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status"

Minimum performance criteria have been defined for the limit of quantification (LOQ) and the measurement uncertainty U (expanded uncertainty of measurement). They are, where possible, linked to the EQS. In the following chapters 6.1.1/6.1.2 guidance will be given on how to determine/estimate these parameters in a pragmatic way.

If no suitable analytical method is available that meets these minimum performance criteria for a particular priority substance, e.g., tributyltin compounds or short-chain chloroalkanes, Member States shall ensure that monitoring is carried out using best available techniques not entailing excessive costs. The use of more resource intensive methodologies, if these can provide the needed performance, at reduced frequencies, is encouraged in these cases.



Look out!
The mandate M/424 for standardisation adressed to CEN for the development or improvement of standards in support of the Water Framework Directive including methods for the analysis of tributyltin compounds, polybrominated diphenyl ethers, polynuclear aromatic compounds, C_{10}-C_{13} chloroalkanes, and organochlorine pesticides in water has been adopted.

6.1.1. Uncertainty of Measurement[14,15,16,]

According to ISO guide 99[17], measurement uncertainty has been defined as *'a non-negative parameter characterising the dispersion of the quantity values being attributed to a measurand, based on the information used'*.

Measurement uncertainty (U_m) is typically expressed as a laboratory result ± the measurement uncertainty.

U_m should normally be expressed as the combined expanded uncertainty using a coverage factor k = 2 where k is a numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty. This provides a confidence level of approximately 95 %.

[14] Nordtest Report TR537. Handbook for calculation of measurement uncertainty in environmental laboratories, 2nd Edition, 2004.
[15] EURACHEM/CITAC Guide: "Quantifying Uncertainty in Analytical Measurement", 2nd Edition, 2000
[16] ISO/IEC "GUM" (with BIPM, IFCC, IUPAC, IUPAP, OIML): "Guide to the expression of uncertainty in measurement", 1993.
[17] ISO guide 99 International vocabulary of metrology - Basic and general concepts and associated terms (VIM), ISO/IEC 2007

The ability to provide a measurement uncertainty is a requirement of ISO 17025, and hence, is necessary for laboratories providing analytical results for the WFD. The knowledge of the measurement uncertainty is also important to confirm that the limit of quantification is equal to or less than that required.

It should be noted that whichever method is used to obtain a value for the measurement uncertainty, the value obtained will always only represent an estimate of the true spread of possible results. The method selected for estimating the measurement uncertainty should be chosen so as to include as many principal sources of contributing errors as possible.

Detailed guidance on the statistical and practical approaches available for estimating the measurement uncertainty can be obtained from the references below.

In general, two possible approaches to estimating measurement uncertainty can be used, either separately or as complementary techniques.

Bottom-up Approach

Firstly, a detailed analysis of the contributing errors from each of the methodological elements can be undertaken. This requires a stepwise analysis of each of the principal causes of measurement uncertainty in the analytical process followed by an estimation of their individual contribution of possible error. Examples of the potential principal causes of error are measurements of mass and volume, instrumental variability and the imperfect correction of systematic errors. Potential sources of data to inform this estimation of measurement uncertainty are within laboratory calibration records for subsidiary equipment such as glassware and balances, instrument repeatability data, data on calibration standard purity etc. This general overall approach of summing individual errors can lead to an underestimation of the measurement uncertainty due to the risk of overlooking an important contributing element. However, knowledge of the magnitude of the contributing errors from each step or process in the analytical method can be helpful to identify the significant errors and target any improvement activities at the most significant sources of error contributing to the overall measurement uncertainty.

Top-down Approach

The second approach of estimating measurement uncertainty is to use data from the analysis of certified reference materials, routine control samples, or interlaboratory trials. Care should be taken to ensure that the control samples include all the analytical steps for the test method. As part of this consideration, any significant bias component to the overall error that is not included within the control samples should also be accommodated into the calculation. Any bias indicated from interlaboratory trials should also be included into the overall estimate of measurement uncertainty.

The measurement uncertainty will vary across the concentration range of the analytical method. Where the range of application of the analytical method is large and there are a number of key threshold values for the analytical results within that range, it may be necessary to estimate the measurement uncertainty at different concentration values. This can be undertaken by dividing the method analytical range into a series of representative sections and estimating the measurement uncertainty for each of them. Alternatively, the measurement uncertainty for any given concentration can be calculated by obtaining values for it at a number of different concentrations, and then, using this data to graphically plot change with concentration and subsequently deriving an equation for change in uncertainty against concentration.

6.1.2. Limit of Detection/Limit of Quantification[18]

6.1.2.1 Limit of Detection

As the concentration of a substance being measured approaches the lower capabilities of the analytical system, it becomes increasingly difficult to distinguish the sample response from background noise. The analyst's confidence that the measurand is actually present diminishes and the consequent risk of reporting a false positive value or failing to detect the presence of a measurand increases.

Therefore, by convention analytical results below this lower confidence limit are referred to as less than the limit of detection. There has historically been a range of definitions for limit of detection. However, the limit of detection is now commonly defined as the concentration of a substance for which there is an adequately high probability of detection when making a single analytical measurement.

It is important to recognise that the value obtained by either calculation will only ever be an estimate of the 'true' limit of detection. If only a few replicates are used in the following calculations, the uncertainty in the value obtained for the limit of detection can be very high. Undertaking more measurements increases the confidence in the limit of detection value obtained, but typically 10 or 11 degrees of freedom are taken as satisfactory. For example, if a limit of detection is calculated with 11 degrees of freedom, an observed limit of detection of 1 could correspond to a 'true' value of any value between 0.7 and 2.0.

Therefore, caution should be used when comparing values for limit of detection from different laboratories or methodologies as an apparently 'better' limit of detection may not be significantly different from an alternative.

Calculation of the Limit of Detection

The limit of detection may be calculated as follows:

$$LOD = 3 * sbl$$

where sbl is the standard deviation of the blank in the signal domain.

A number of separate analyses are undertaken of a real sample containing concentrations of the measurand at or near the blank level and the total standard deviation of the blank corrected results calculated. In order to obtain a reasonable estimate of the LOD, it is preferable to base the calculation on 10 or more measurements of the signal response for the blanks.

[18] WRC report NS30 (1989) A Manual on Analytical Quality Control for the Water Industry. ISBN 0902156853

Chromatographic Analyses
Measurement of blank concentrations in some analytical techniques can be difficult as the instrumental software or hardware may impose peak detection threshold values or peak smoothing algorithms etc., which suppress small signals. This occurs most often for chromatographic methods. When this situation is encountered, it is normal to artificially increase the signal using one of the following methods:

- Use a real sample containing a very low, but measurable concentration of the analyte.
- Fortify a sample that contains no analyte to a very low, but measurable concentration.
- Dilute a sample extract containing a higher concentration of the analyte to achieve the required very low but measurable concentration.

It should be noted that when uncorrected blank signals are used to calculate the limit of detection, increasing the absolute concentration of the blank as above will inevitably produce a higher value for the estimate of the limit of detection.

6.1.2.2 Limit of Quantification
Within the normal range of application of an analytical method, as the concentration of a substance undergoing measurement decreases, there is a tendency for the uncertainty in the results obtained to increase. In principle, it is possible to quote any analytical result and an associated uncertainty of measurement. However, at the lower reaches of an analytical system's capability the uncertainty of measurement increases to a degree such as to make interpretation of the subsequent data difficult. Therefore, a limit of quantification is used to express the concentration at which the accuracy is satisfactory for quantitative measurement.

Definition of Limit of Quantification The Limit of Quantification means a stated multiple of the limit of detection at a concentration of the determinand that can reasonably be determined with an acceptable level of accuracy and precision. The limit of quantification can be calculated using an appropriate standard or sample, and may be obtained from the lowest calibration point on the calibration curve, excluding the blank;
LOQ should be determined experimentally following the procedure given in 6.1.2.1.

6.2. Water Analysis

According to the European Parliament legislative resolution of 17 June 2008 on the Council common position with a view to the adoption of a directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and 2000/60/EC (11486/3/2007 – C6-0055/2008 – 2006/0129(COD)), EQS are expressed as total concentrations in the whole water sample except for cadmium, lead, mercury and nickel. The EQS for metals refers to the dissolved concentration measured in the liquid (dissolved) fraction of a water sample obtained by filtration through a 0.45 µm filter.

This implies reporting monitoring results except for metals as whole water concentrations. Whole water data may be generated by analysis of the whole water sample, or by separate analyses of the liquid and SPM fractions.

Unfortunately, most available analytical methods have not been validated for water samples containing substantial amounts of SPM. This can result in incomplete extraction of hydrophobic organic contaminants adsorbed to SPM, and thus, to an underestimation of the whole water concentration. Specific information whether methods can be applied to the analysis of SPM containing samples can be found in the substance guidance sheets (Annex II).

The SPM content of the water sample is not critical for the analyses of polar and highly water soluble compounds such as some pesticides (e.g., alachlor, atrazine, simazine, diuron, isoproturon) and volatile compounds (benzene, dichloromethane, 1,2-dichloromethane, trichloroethane, tetrachloroethene, trichloroethene, tetrachloromethane, trichlorbenzene, naphthalene). Those compounds can be analysed in the whole water or in the filtered sample.

In case of hydrophobic compounds, which strongly adsorb to particles, including e.g., pentabromodiphenylether or 5 and 6 ring polycyclic aromatic hydrocarbons special care is required to ensure complete extraction of the particle bound fraction. Separate analysis of SPM and of the liquid could be a good option. If it can be justified, for example by considerations of expected contaminant partitioning, analysis of the SPM fraction as surrogate for whole water may be appropriate. Nevertheless, in water bodies with extremely low SPM content (e.g., < 3 mg/L) the dissolved fraction of those contaminants has to be determined.

Dependent on the SPM content of the sample and its organic carbon content, medium polar compounds can adsorb in varying amounts to SPM. In such cases, both fractions (dissolved and adsorbed concentrations) have to be considered.

For the determination of dissolved metal concentrations water samples have to be passed through a membrane filter of 0.45 µm pore size. In principle and if possible, this filtration should be done in the field to prevent changes during transportation and subsequent storage due to adsorption processes etc. It is essential to ensure that filters are clean and to pre-clean them, if necessary. In addition, filters should be pre-washed with small sample volumes before collecting the filtrate for metal analysis. If possible (in the light of health and safety instructions), the filtrate shall be acidified with nitric acid to ensure that the pH is less than 2. For more information consult the respective substance guidance sheets and the methods referred to therein.

Bioavailable metal concentrations depend on various parameters including pH, Ca and Mg concentrations, as well as dissolved organic carbon concentration. Hence, measuring these parameters in parallel with the metals can assist in the interpretation of results, where appropriate. In case of cadmium, the measurement of hardness is mandatory because EQS values have been derived for five classes of hardness.

6.3. Sediment/SPM Analysis[3]

With the exception of PBDE, there are no standardised methods specifically developed for the analysis of sediments/SPM available for priority substances likely to be found in sediment. However, existing standard methods for soil analysis summarized in Annex I may probably be applied to sediments with or without slight modification.

Comprehensive guidance on the analysis of marine sediments including sample pre-treatment, storage, and normalisation is given in OSPAR JAMP Guidelines for Monitoring Contaminants in Sediments.

	**Look in:** OSPAR JAMP Guidelines for Monitoring Contaminants in Sediments

In general, < 2 mm fraction of the sediment should be analysed for organic contaminants while the less than 63 µm fraction should be analysed for metals. If the specific purpose of the monitoring requires analysis of the fine sediment fraction, the sample should be split using appropriate sieving techniques[19].

The degree of accumulation of a contaminant depends on the sediment and SPM characteristics (grain size, composition and surface properties). It is essential to compare analytical results from sediments and SPM with similar properties or to compare normalised results to assess the degree of contamination. Therefore, particle size analyses, measurements of organic carbon content or measurement of other common normalisation parameters, such as Li and Al are advised. Detailed guidance for sediments on the use of normalizing parameters is given in Annex 5 of the JAMP Guideline for Monitoring Contaminants in Sediments.

For sediments, measurements of the two operationally defined parameters Acid Volatile Sulfides (AVS) and Simultaneously Extractable Metals (SEM) can provide information on the bioavailability of metals, although guidance on the interpretation of AVS is still in preparation in the EU EQS Technical Guidance – Metals section.

6.4. Biota Analysis[3]

At present, formally approved standard methods for the analysis of priority pollutants and other contaminants in biota are scarce and only available for metals, PAH, PCB and some other organic contaminants.

Comprehensive guidance on the analysis of marine biota (seabird eggs, fish, shellfish) including selection of species and suitable tissue, sampling, sample pre-treatment and storage is given in OSPAR JAMP Guidelines for Monitoring Contaminants in Biota.

	**Look in:** OSPAR JAMP Guidelines for Monitoring Contaminants in Biota Manual for Marine Monitoring in the COMBINE Programme of HELCOM

Most organic contaminants accumulate in the lipid tissue of the species studied. Therefore, concentrations should be provided on lipid weight basis as well as weight basis or the lipid

[19] Smedes, F., Davies, I.M., Wells, D., Allan, A., Besada, V.: Quality assurance of sampling and sample handling (QUASH). Interlaboratory study on sieving and normalisation of geographically different sediments; QUASH Round 5 – August 2000. QUASH report, QUASH Project Office, FRS Marine Laboratory, PO Box 101, Victoria Road, Aberdeen, AB11 9DB, GB

content of the sample should be provided together with the analytical results. It is important to state whether total lipids or extractable lipids have been determined and the method for lipid determination should be specified. Whether or not a normalisation should be performed has to be adjusted to the objective of the monitoring.

6.5. Substance Guidance Sheets

According to the Final Draft "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status", laboratories may select any analytical method of its choice for the purpose of monitoring under Article 8 and Annex V of the Directive 2000/60/EC, except for operationally defined parameters, provided they meet the minimum method performance criteria.

To assist Member States in selecting appropriate methods, substance guidance sheets are provided as an Annex II to this guidance document, summarising basic information on physico-chemical properties of each substance and preliminary environmental quality standards expressed as annual average, AA-EQS, or expressed as maximum allowable concentration, MAC-EQS, respectively, for inland and other surface waters. Available EN or ISO standard methods for the analysis in water, and where appropriate, in sediment or biota, are specified including information on sampling, storage and pre-treatment, performance characteristics and a short description of the principle. Where required other analytical methods are mentioned and respective references given. For laboratories wishing to undertake their own method surveys important links to websites providing information on standardised analytical methods are given in Table 1.

Table 1: List of html- links regarding Standard Methods

http://www.cenorm.be/catweb/cwen.htm	On-line Catalogue of European Standards
http://www.iso.org/iso/en/CatalogueListPage.CatalogueList	ISO standards
http://standards.mackido.com/	This is a comprehensive catalogue of international standards, their nomenclature, and their reference details. ISO Standards EN Standards British Standards IEC Standards
http://standardmethods.org/	Since 1905, Standard Methods for the Examination of Water and Wastewater has represented "the best current practice of American water analysts." This comprehensive reference covers all aspects of water and wastewater analysis techniques. Standard Methods is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).
http://www.nemi.gov	List of all methods in the National Environmental Methods Index (NEMI)
http://www.epa.gov/epahome/standards.html	EPA methods and guidelines

6.6. Group Parameters and Definition of Indicator Substances

Some substances of interest are described in generic terms only. These generic substances may be composed of a finite number of isomeric forms where the potential number of different individual isomers can range from 2 (e.g., Endosulfan) to more than 200 (e.g., polybrominated diphenylethers) of which only a few are of environmental relevance. Moreover, it is often difficult or impossible to analyse all those isomers. Hence, analysis of indicator substances representative for the entire group is common practice. Indicator substances, which have to be analysed have been specified in the Position of the European Parliament adopted on 17 June 2008 on the Council common position with a view to the adoption of a directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and 2000/60/EC (11486/3/2007 – C6-0055/2008 (Table 2).

Table 2: Components of Group Parameters and Indicator Substances

Priority Substance	Recommended Components	Comments
Chlorpyrifos	Chlorpyrifos–ethyl	
Endosulfan	α-Endosulfan and ß-Endosulfan	Total concentration to be reported.
Pentabromodiphenyl Ether	BDE congener numbers 28, 47, 99, 100, 153, 154	These congeners constitute approximately 85 % of technical Penta – BDE formulations; Total concentration to be reported.
Hexachlorocyclohexane	α, β, γ, and δ-isomer*	Total concentration to be reported.
C10-13 Chloroalkanes	All C_{10} to C_{13} chlorinated paraffins (49 % to 70 % Chlorine)	Total of all isomers to be reported. Measurement will usually be done against a technical mixture.
Nonylphenol	All *4*-nonylphenol isomers present**	Total concentration of all para isomers to be reported.
Octylphenol	para-tert-Octylphenol***	
PAH	Benzo[b]fluoranthene/ Benzo[k]fluoranthene	Total concentration to be reported. Benzo[j]fluoranthene interferes with the determination of either Benzo [b]fluoranthene or Benzo[k]fluoranthene
Trichlorobenzenes (all isomers)	*1,2,3-*, *1,2,4-* and *1,3,5-*trichlorobenzene	Total concentration to be reported.
DDT total	*p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *p,p*'-DDD	Total concentration and concentration of *p,p'*-DDT to be reported.

* The CAS number 608-73-1 refers to technical HCH, hence, all relevant isomers have to analysed for

** Technical nonylphenol consists mainly (~ 90 %) of para-substituted nonylphenols and comprises theoretically 211 isomers; only 4-nonylphenols are of toxicological relevance

*** Octylphenol (CAS No 140-66-9) is a single isomeric compound: 4-(1,1',3,3'-tetramethylbutyl)-phenol (4-tert-octylphenol)

Although it is possible to calculate the value of a group parameter from its individual components, the interpretation of this value as regards EQS compliance may pose several practical difficulties with respect to the generation and interpretation of data. Principal amongst these difficulties is the uncertainty associated with a group parameter. If the group parameter comprises two substances that are present at equal concentrations, and the standard uncertainty of each substance is 10 %, the standard uncertainty of the sum of their concentrations will be 14 %. If, on the other hand, one concentration greatly predominates over the other, the standard uncertainty of the sum remains near to 10 %. If, for a similar example, there are 6 components of the group, the standard uncertainty could vary between 25 % and 10 % depending on whether the concentrations are similar, or if one is much larger than all the others. This dependency of the uncertainty on the number of components comprising a group and on their concentrations requires consideration when deriving requirements on measurement uncertainty for group parameters and their components.

6.7. Results below the Limit of Quantification

For the calculation of annual average concentrations, values below the limit of quantification shall be set to half of the value of the limit of quantification concerned. If the resulting annual average concentration is below the limits of quantification, the value shall be referred to as 'less than limit of quantification'.

This rule does not apply to total sums of a given group of substances. In those cases, results below the limit of quantification of the individual substances/isomers shall be set to zero.

	**Look in:** Final Draft “Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status”

7. COMPLEMENTARY METHODS[20,21]

7.1. Introduction

While checking compliance with the WFD provisions is currently based on chemical analysis of spot samples taken in a defined frequency, it is desirable to introduce other techniques for improving the quality of the assessment and to benefit from resource saving developments, as they become available. Currently advanced methods for environmental assessment (referred to as 'complementary methods in this chapter') are under development and evaluation.

[20] This chapter was elaborated in close cooperation with the EU-project SWIFT (www.swift-wfd.com).
[21] Allan, I. J., Vrana, B., Greenwood, R., Mills, G. A., Roig, B., Gonzalez, C. (2006) A “toolbox” for biological and chemical monitoring requirements for the European Union’s Water Framework Directive. Talanta 69, 302-322.

Examples of techniques are:

- In-situ probes for measuring physico-chemical characteristics (e.g., Dissolved Organic Carbon (DOC), pH, temperature, dissolved oxygen)

- Biological assessment techniques (e.g., biomarker analyses, bioassays/biosensors and biological early warning systems, immunosensors, etc.)

- Sampling and chemical analytical methods (e.g., sensors, passive sampling devices, test kits (see e.g., ISO 17381:2003 Water quality - Selection and application of ready-to-use test kit methods in water analysis), GC-MS or LC-MS screening methodologies)

Two types of complementary methods – (1) equipment for measuring physico-chemical characteristics and (2) chemical analytical methods – usually yield direct measures of the quality elements as defined in the WFD.

The third type – biological assessment techniques – are designed to respond to a wide range of (chemical) stressors, and are therefore, not exclusively linked to individual quality elements such as the different priority substances. Although very useful for many monitoring purposes, they cannot be used to check compliance of individual quality elements against an EQS.

These analytical and biological methods, as well as in-situ sampling techniques, are summarised in the table below. This table aims to provide simple guidance in the use of these tools, with a particular focus on typical indicators monitored, the type and relevance of the information obtained and a selection of performance criteria for these tools. Performance criteria tend to depend on the technique or method selected, and more importantly, on the type of information required. For example, performance criteria for the laboratory-based analysis of extracts from passive sampling devices are mostly similar to those for more conventional spot sampling[22]. Additional performance criteria for passive sampling are the result of (i) the requirement for accurate uptake rates to be used in the calculation of time-weighted average contaminant concentrations in water, and (ii) the in-situ field deployment that needs to follow relatively strict protocols[23] to ensure that data obtained are fit-for-purpose. A few examples of these techniques, some of them either well-known (e.g., the measurement of metallothionein in aquatic organisms upon exposure to trace metals) or tested during the SWIFT-WFD project[24] (e.g., the Multi-species Freshwater Biomonitor that allow real-time monitoring of changes in water quality based on physiological and behavioural monitoring of aquatic organisms) are given. These methods may be able to provide additional weight-of-evidence, mostly in cases where additional information on chemical quality or links between chemical and biological data is required. This is particularly important for situations that do not involve only comparisons with EQS (e.g., investigative monitoring). Scenarios for the efficient use of these tools and techniques are also given and support the possible uses described in section 7.2.

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[22] STAMPS project, funded under the 5th RTD Framework Programme, European Commission, www.port.ac.uk/research/stamps/

[23] BSI PAS 61:2006 Publicly available specification – Determination of priority pollutants in surface water using passive sampling

[24] SWIFT-WFD project, funded under the 6th RTD Framework Programme, European Commission, www.swift-wfd.com

7.2. Applications of Complementary Methods in WFD Monitoring

Use of Complementary Methods in the Design of Monitoring Programmes
Complementary methods can be used in the design of monitoring programmes for:

- Identification of problem as well as non-problem areas, e.g., by using screening methods (test kits) or passive sampling devices
- Selection of monitoring points, e.g., in the grouping of water bodies for operational monitoring complementary methods may be used to demonstrate the representativeness of sampling points.
- Selection of quality elements, e.g., the selection of other pollutants that are part of the ecological status. Information derived from bioassays and toxic identification and evaluation (TIE) may be used to select compounds based on ecological relevance.
- Justification of a reduction in sampling frequency, e.g., the use of sensors as screening tools. Sampling for chemical analysis with a validated method is triggered by a response of a sensor above a certain threshold. In that case, validation of the sensor can be limited to a performance criterion for false negative responses.

Use of Complementary Methods in Surveillance and Operational Monitoring
Complementary methods can be used in surveillance and operational monitoring provided that they meet the requirements laid down in the Final Draft "Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status".

Complementary methods may be used in surveillance monitoring to detect long-term changes. Biological assessment techniques can be used as a sum parameter to screen for the presence of substances in ecologically relevant concentrations. Passive samplers could be used alongside spot sampling in order to corroborate or contradict spot sampling data. This would be important weight-of-evidence for water bodies where contaminant concentrations are expected to show large temporal variation or when the contaminant source fluctuates.

Passive samplers (e.g., Semi-Permeable Membrane Devices (SPMD), Polar Organic Chemical Integrative Samplers (POCIS), Diffusion Gradient Thin Films (DGTs), Chemcatcher) are exposed in the aquatic environment for several days or up to weeks to yield time-integrated average concentration of organic contaminants or heavy metals. Passive sampling is less influenced by short-term fluctuations in concentrations than spot sampling. Since one of the primary objectives of the WFD is the assessment of the average concentrations of pollutants in water bodies, the determination of time-integrated concentrations using passive samplers seems to be a promising approach. Some of the passive samplers have been validated and provide high sampling rates (litre/day) for various contaminants (e.g., organic compounds of medium hydrophobicity, heavy metals), and thus, allow quantification of extremely low pollution levels in water[23]. This is a first step towards an internationally recognized standard.

Passive sampling can also be combined with ecotoxicology, where the extracts from the passive monitors are passed through multiple toxicological tests in a laboratory. This will enable assessment of the effects of a mixture of contaminants from an environmental monitoring point over a period of time. This integration of exposure and effects monitoring will facilitate more cost effective monitoring programmes as well as forming the basis of a risk based pollution control strategy.

Difficulties encountered include bio-fouling, back-calculating to water concentration and calibration. Thus, further research and validation is required before using this technology for compliance checking.

Passive samplers sample the freely-dissolved bioavailable water concentrations. Results may, therefore, deviate from the total water concentrations measured in spot samples. It may be possible, if average values for the levels of DOC, SPM and TOC content of the SPM are known, to use partitioning theory and $LogK_{oc}$-$logK_{ow}$ relationships to estimate the total concentrations with uncertainties for all assumptions made accounted for.

Use of Complementary Methods in Investigative Monitoring

The main goals of investigative monitoring are to identify the reason for any failure to achieve environmental objectives, in circumstances where the reason is unknown and to ascertain the magnitude and impact of accidental pollution.

For both purposes, test kits including, e.g., immunoassays specific to certain priority substances or other pollutants allow fast screening of large number of samples and can be cost-effective tools to identify pollution sources as well as to characterise the extent of accidental pollution.

Passive sampling devices might be of use in identifying sources of pollution, in particular, if extremely low levels have to be detected or when the source of pollution is not constant.

In case of MAC-EQS exceedance, investigative monitoring should be used to ascertain this non-compliance in more detail. Both, spot sampling and time-integrated measurements may not detect acutely toxic spikes of seasonally-variable compounds like pesticides; the use of *in situ* bioassays may be beneficial. These biological early warning systems also have the potential to help identify compounds that may need to be included in future risk assessments.

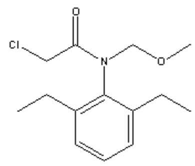
Table 3: A list of complementary methods relevant to WFD chemical monitoring including method performance criteria

Technique	Analytical Methods			*In-situ* Sampling Techniques		Biological Methods		
	Lab	**On-site**	***In-situ***	**Biomonitoring**	**Passive sampling**	**Direct toxicity assessment**	**Biological Early warning system**	**Biomarkers**
Examples	Immunoassay (e.g., atrazine), test kits, hand-held sensors (e.g., Palmsens)			MusselWatch programmes	Semi-permeable membrane device (SPMD), Chemcatcher	Daphtoxkit®	Mosselmonitor®, multi-species freshwater biomonitor	Measurement of metallothionein synthesis
Measurement	Analyte (operationally-defined) concentration or ranges of concentrations, general physico-chemical characteristics			Indicator of exposure to bioavailable analytes	Time-weighted average & operationally-defined analyte concentrations (truly dissolved and labile fractions for organic and metal contaminants, respectively)	(Non)-specific (e.g., genotoxicity) acute/chronic toxicity in water/sediment	Real-time monitoring of acute toxicity in an organism	Chemical and biological indicators of non-specific or specific exposure or effects of contaminants in water and sediments
Type of information obtained	Qualitative, semi-quantitative, quantitative			Semi-quantitative, qualitative	Qualitative, semi-quantitative or quantitative	Qualitative	Qualitative	Qualitative
Performance criteria	- LOD - LOQ - Calibration, quantification range				- LOD, LOQ (field) - Bias - Sensitivity		- Levels of false positives and negatives	
Implementation	- Rapid and/or on-site determination of concentrations, or screening of levels - Mapping of an area - Selection of samples for more accurate laboratory-based analysis			- Linking ecological and chemical information - Linking concentration with exposure and effects	- Assess long-term changes and trends in pollutant concentrations - Extrapolate total and total filtered concentrations - Screening for contaminant presence/absence - Metal speciation	- Detect adverse biological effects to indicate where operational or investigative monitoring required	- Early warning of changes in water quality at crucial sites - Detect and assess significant pollutant for updating risk assessments	- Early detection of biological imbalance - Linking ecological and chemical information - Linking concentration with exposure and effects
Applicable to:	Operational & investigative monitoring			Operational & investigative monitoring	Surveillance, operational & investigative monitoring	Operational & investigative monitoring	Operational & investigative monitoring	Operational & investigative monitoring

ANNEX I: List of ISO Standards for soil analysis

ISO 11465:1993	Soil quality - Determination of dry matter and water content on a mass basis - Gravimetric method
ISO 11466:1995	Soil quality - Extraction of trace elements soluble in aqua regia
ISO 11277:1998	Soil quality - Determination of particle size distribution in mineral soil material - Method by sieving and sedimentation
ISO 10694:1995	Soil quality - Determination of organic and total carbon after dry combustion (elementary analysis)
ISO 14869-1:2001	Soil quality - Dissolution for the determination of total element content - Part 1: Dissolution with hydrofluoric and perchloric acids
ISO 11047:1998	Soil quality - Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc - Flame and electrothermal atomic absorption spectrometric methods
ISO 14507:2003	Soil quality - Pretreatment of samples for determination of organic contaminants
ISO 14154:2005	Soil quality - Determination of some selected chlorophenols - Gas-chromatographic method with electron-capture detection
ISO 15009:2002	Soil quality - Gas chromatographic determination of the content of volatile aromatic hydrocarbons, naphthalene and volatile halogenated hydrocarbons - Purge-and-trap method with thermal desorption
ISO 16772:2004	Soil quality - Determination of mercury in aqua regia soil extracts with cold-vapour atomic spectrometry or cold-vapour atomic fluorescence spectrometry
ISO 22155:2005	Soil quality - Gas chromatographic quantitative determination of volatile aromatic and halogenated hydrocarbons and selected ethers - Static headspace method
ISO 11264:2005	Soil quality - Determination of herbicides - Method using HPLC with UV-detection
ISO 10382:2002	Soil quality - Determination of organochlorine pesticides and polychlorinated biphenyls - Gas-chromatographic method with electron capture detection
ISO 13877:1998	Soil quality - Determination of polynuclear aromatic hydrocarbons - Method using high-performance liquid chromatography
ISO 18287:2006	Soil quality - Determination of polycyclic aromatic hydrocarbons (PAH) - Gas chromatographic method with mass spectrometric detection (GC-MS)
ISO/DIS 22036	Soil quality - Determination of trace elements in extracts of soil by inductively coupled plasma atomic emission spectrometry (ICP/AES)
ISO 22892:2006	Soil quality - Guidelines for the identification of target compounds by gas chromatography and mass spectrometry
ISO/DIS 23161	Soil quality - Determination of selected organotin compounds - Gas-chromatographic method

ANNEX II: Substance Guidance Sheets

Compound	
Alachlor	

CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
15972-60-8	~ 2.97	~ 240

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.3	0.3	0.7	0.7

Available Standard Method
EN ISO 10695:2000
Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods [*Note: Alachlor is not explicitly mentioned in this standard but the method may also be applied to the analysis of alachlor provided the method has been properly validated for this compound*].

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling *ISO 5667-2:1991*

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.
After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ): 0.04 µg/L

Method Validation: no data available

Other Analytical Methods

SPE-GC-MS
Separation by gas chromatography, identification and quantification of the analyte by gas chromatography coupled to mass spectrometric detection (GC-MS) using electron impact (EI) mode.
GC-MS fragment ions: m/z 160, 188, 161 and 146 [1-3]
SPE extraction of 500 mL water; LOQ ~ 12 ng/L [1]
SPE extraction of 1 L water; LOQ ~ 3 ng/L [2]
SPE extraction of 200 mL water; LOQ ~ 30 ng/L [3]

GC-NPD
EPA method 507 [4]

LC-ESI-MS/MS
C18 SPE of 50 mL water; MRM 270 > 161.5; LOQ ~ 0.1 µg/L [5]

On-line SPE-LC-MS-MS
On-line SPE of 10 mL samples; MRM 270 > 238; LOQ ~ 47 ng/L [6]

References

[1] J. Quintana, I. Martí, F. Ventura, Monitoring of Pesticides in Drinking and Related Waters in NE Spain with a Multiresidue SPE-GC–MS Method Including an Estimation of the Uncertainty of the Analytical Results. *Journal of Chromatography A* 938, 2001, 3-13.

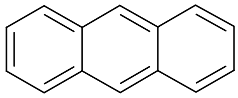
[2] T. D. Bucheli, F. C. Grüebler, S. R. Müller, R. P. Schwarzenbach, Simultaneous Determination of Neutral and Acidic Pesticides in Natural Waters at the Low Nanogram per Liter Level. *Analytical Chemistry* 69, 1997, 1569-1576.

[3] D. de Almeida Azevedo, S. Lacorte, T. Vinhas, P. Viana, D. Barceló, Monitoring of Priority Pesticides and Other Organic Pollutants in River Water From Portugal by Gas Chromatography–Mass Spectrometry and Liquid Chromatography–Atmospheric Pressure Chemical Ionization Mass Spectrometry. *Journal of Chromatography A* 879, 2000, 13-26.

[4] D. Barceló, Environmental Protection Agency and Other Methods for the Determination of Priority Pesticides and Their Transformation Products in Water. *Journal of Chromatography A*, 643, 1993, 117-143.

[5] R. A. Yokley, L. C. Mayer, S.-B. Huang, J. D. Vargo, Analytical Method for the Determination of Metolachlor, Acetochlor, Alachlor, Dimethenamid, and Their Corresponding Ethanesulfonic and Oxanillic Acid Degradates in Water Using SPE and LC/ESI-MS/MS. *Analytical Chemistry* 74, 2002, 3754-3759.

[6] M. Kuster, M. J. Lopez de Alda, C. Barata, D. Raldua, D. Barceló, Analysis of 17 polar to semi-polar pesticides in the Ebro river delta during the main growing season of rice by automated on-line solid-phase extraction-liquid chromatography-tandem mass spectrometry. *Talanta* 75, 2008, 390-401.

Compound *Anthracene*					
					
CAS Number 120-12-7	**Log K_{OW}** 4.55	**Water Solubility [mg/L]** 0.0434			

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.1	0.1	0.4	0.4

Available Standard Method
EN ISO 17993:2003
Determination of 15 polycyclic aromatic hydrocarbons (PAH) in water by HPLC with fluorescence detection after liquid-liquid extraction

Matrix Drinking, ground, waste and surface water

Sampling

Pretreatment

Storage

Method Description

EN ISO 17993:2003 specifies a method using high performance liquid chromatography (HPLC) with fluorescence detection for the determination of 15 selected polycyclic aromatic hydrocarbons (PAH).

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1996 in Germany

Matrix	l	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Drinking water	33	0	26.84	4.474	16.7

Other Analytical Methods

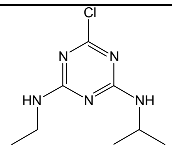
USA EPA 8270c, 1996 [1]
Semivolatile organic compounds by GC/MS
This method claims detection limits of 10 µg/L which is obviously too high. Other analytical methods based on this standard using modern GC/MS equipment however may attain the required low LOQs.

Comments

References
[1] http://www.accustandard.com/asi/pdfs/epa_methods/8270c.pdf

Compound

Atrazine



CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
1912-24-9	~ 2.5	~ 33

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.6	0.6	2.0	2.0

Available Standard Method
EN ISO 10695:2000
Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling *ISO 5667-1 and 5667-2*

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.
After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ):
Liquid/liquid extraction method: 0.5 µg/L
Liquid/solid extraction method: 0.015 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1993 for liquid/solid extraction

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Drinking water	13	0	0.133	0.0104	35.6

Other Analytical Methods

Gas Chromatography - Mass Spectrometry
GC-MS determination of the ions 200 and 215; LOQ ~ 1 ng/L (after SPE) [1-3] (EPA method 525)

GC-NPD
EPA method 507 [4]

GC-ECD
EPA method 505; microextraction with hexane and GC-ECD analysis [4]]

Liquid Chromatography - Mass Spectrometry
Identification and quantification of atrazine (and other pesticides) by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using positive electrospray ionization (ESI)
LC-MS fragment ions: m/z 216 and 174 [5]
LC-MS-MS transitions: 216 > 174 and 132 [6]
LOQ ~ 1 ng/L (depending on the SPE enrichment factor)

Comments

References

[1] Z. Cai, V. M. S. Ramanujam, D. E. Giblin, M. L. Gross, and R. F. Spalding, Determination of Atrazine in Water at Low- and Sub-Parts-Per-Trillion Levels by Using Solid-Phase Extraction and Gas Chromatography/High-Resolution Mass Spectrometry. *Analytical Chemistry* 65, 1993, 21-26.

[2] T. D. Bucheli, F. C. Grüebler, S. R. Müller, R. P. Schwarzenbach, Simultaneous Determination of Neutral and Acidic Pesticides in Natural Waters at the Low Nanogram per Liter Leve., *Analytical Chemistry* 69, 1997, 1569-1576.

[3] C. Planas, A. Puig, J. Rivera, J. Caixach, Analysis of pesticides and metabolites in Spanish surface waters by isotope dilution gas chromatography/mass spectrometry with previous automated solid-phase extraction; Estimation of the uncertainty of the analytical results. Journal of. Chromatography A 1131, 2006, 242–2522006, 242–252

[4] D. Barceló, Environmental Protection Agency and Other Methods for the Determination of Priority Pesticides and Their Transformation Products in Water. *Journal of Chromatography A* 643, 1993, 117-143.

[5] A. Di Corcia, C. Crescenzi, E. Guerriero, R. Saperi, Ultratrace Determination of Atrazine and Its Six Major Degradation Products in Water by Solid-Phase Extraction and Liquid Chromatography-Electrospray/Mass Spectrometry. *Environmental Science & Technology* 31, 1997, 1658-1663.

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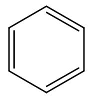
Compound

Benzene



CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
71-43-2	2.13	1750

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
10	8	50	50

Available Standard Method

ISO 11423-1:1997

Determination of benzene and some derivatives – Head-space gas chromatographic method

Matrix Water

Sampling

Pretreatment

Storage

Method Description

A defined volume of unfiltered water sample is heated in a gas-tight septum-covered vial. After establishment of equilibrium between the gaseous and the liquid phases, an aliquot of the gaseous phase is transferred to a gas chromatograph.

Limit of Quantification (LOQ): ~ 2 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1991 (Head Space GC – ISO 11423-1)

Matrix	*l*	*n_{AP} in %*	*$\bar{\bar{x}}$ in µg/L*	*s_R in µg/L*	*CV_R in %*
Surface water	8	14.3	5.6	0.88	15.7
Interlaboratory study 1991 (GC-FID – ISO 11423-2)					
Surface water	9	6.5	4.55	1.34	29.4

Other Analytical Methods

Determination of benzene and some derivatives - Method using extraction and gas chromatography (ISO 11423-2) The unfiltered water sample is extracted with a non-polar solvent (e.g. pentane) and the extract is analysed by GC-MS.
LOQ ~ 5 µg/L

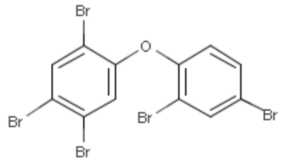
ISO 15680:2003
Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption. (Selected ion: 78)
LOQ ~ 2 ng/L for benzene

Comments

References

Compound

Pentabromodiphenylether



CAS Number	Log K_{OW}	Water Solubility [µg/L]
32534-81-9	6.57	13.3

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.0005	0.0002	*not applicable*	*not applicable*

Available Standard Method

No standardised method for the determination of PBDE in water available

ISO 22032:2006
Determination of selected polybrominated diphenylethers (PBDE) in sediment and sewage sludge - Method using extraction and gas chromatography/mass spectrometry

Matrix Sediment

Sampling *ISO 5667-13*

Pretreatment homogenizing, freezing and freeze-drying, grind and sieve it

Storage at 4 °C in the darkness in wide necked bottles

Method Description

ISO 22032:2006 specifies a method for the determination of selected PBDEs representative for penta-, octa-, and decaBDE technical formulations in sediment using gas chromatography/mass spectrometry in the electron impact or electron capture ionisation mode. Extraction of PBDEs from the dried sample by an organic solvent is followed by clean-up of the extract by e.g. multi-layer silica gel column chromatography. For quantification an internal standard calibration is applied.

Limit of Quantification (LOQ): When applying GC-EI-MS, the method is applicable to samples containing 0.05 µg/kg to 25 µg/kg of tetra- to decabromo congeners. Approximately ten times lower concentrations can be quantified when using GC-ENCI-MS.

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory Study 2004/2005

Matrix	*Substance*	*l*	n_{AP} in %	$\bar{\bar{x}}$ in µg/kg	s_R in µg/kg	CV_R in %
Sediment	BDE 47	16	0	362	50.5	14.0
	BDE 100	16	0	93.3	28.96	31.0
	BDE 99	16	0	518	99.6	19.2
	BDE 154	16	0	39.2	9.11	23.2
	BDE 153	16	0	47.7	9.28	19.5

Other Analytical Methods

Numerous studies of PBDEs in environmental samples are based on the determination by gas chromatography/mass spectrometry in the electron impact or negative ion chemical ionisation mode [1].

U.S. EPA Method 527 employs solid-phase extraction with analysis by gas chromatography/ mass spectrometry as described in PEPICH et al. 2005 [2], but MDL is fairly high (0.39 µg/l).

EPA Method 1614, 2007 [3] applies HRGC/HRMS for the analysis of PBDE in water, soil, sediment and tissue. MDL for BDE 99 is 0.00004 µg/l.

Comments

There are a few reports on extremely low levels of PBDEs in surface water samples [4,5]. The authors enriched 100 and 2500 L of water, respectively, on XAD resin. SPME has been proposed to extract selected BDE congeners from water samples by POLO et al. 2004 [6].

Environmental studies conducted primarily in Europe, Japan and North America indicate that these chemicals are ubiquitous in sediment and biota [7].

References

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[3] http://www.accustandard.com/asi/pdfs/epa_methods/1614.pdf.

[4] F. Luckey, B. Fowler, S. Litten, Establishing Baseline Levels of Polybrominated Diphenyl Ethers in Lake Ontario Surface Waters. The Second International Workshop on Brominated Flame Retardants, Stockholm University, Sweden, May 14-16, 2001, 337-339.

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Compound	
Cadmium and its compounds	

CAS Number	**Log K_D [L/kg]**	**Water Solubility [mg/L]**
7440-43-9	***suspended matter/water:*** 4.7 (Cd) [1] ***sediment/water****:* 3.6 (Cd) [1]	depending on compound

Water hardness [mg $CaCO_3$/L]	**AA-EQS [µg/L]** *(depending on water hardness classes)*		**MAC-EQS [µg/L]** *(depending on water hardness classes)*	
	Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
Class 1: < 40	≤ 0.08	0.2	≤ 0.45	≤ 0.45
Class 2: 40 to < 50	0.08		0.45	0.45
Class 3: 50 to < 100	0.09		0.6	0.6
Class 4: 100 to < 200	0.15		0.9	0.9
Class 5: ≥ 200	0.25		1.5	1.5

Available Standard Method

EN ISO 17294-2:2004

Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements

Matrix Drinking waters, ground waters, surface waters and waste waters

Sampling *ISO 5667-1, 5667-2 and 5667-3*

Pretreatment For dissolved elements, filter aqueous sample through a 0.45-µm pore membrane filter. Adjust the pH of the filtrate to < 2 with HNO_3.

Storage

Method Description

EN ISO 17294-2:2004 specifies a method for the determination of the cadmium in water (for example drinking water, surface water, groundwater, wastewater and eluates). Taking into account the specific and additionally occurring interferences, these elements can also be determined in digests of water, sludges and sediments.

The detection limits of most elements are affected by blank contamination and depend predominantly on the laboratory air-handling facilities available.

The lower limit of application is higher in cases where the determination is likely to suffer from interferences or in case of memory effects.

Limit of Quantification (LOQ):

Drinking water and relatively unpolluted water: 0.1 µg/L - 1.0 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1997 in Germany

Matrix	l	n_{AP} ***in %***	$\bar{\bar{x}}$ ***in µg/L***	s_R ***in µg/L***	CV_R ***in %***
Surface water	37	5.2	5.75	0.491	8.5

Other Analytical Methods

EN ISO 5961:1995 specifies two methods for the determination of cadmium using atomic absorption spectrometry (AAS) in an air-acetylene flame (aspiration of the acidified sample into the flame and measurement of the cadmium concentration at a wavelength of 228.8 nm) and by electrothermal atomization AAS (injection of the acidified sample into an electrically heated graphite tube of an electrothermal atomization atomic absorption spectrometer and measurement of the absorbance at a wavelength of 228.8 nm).

EN ISO 15586:2003 determination using atomic absorption spectrometry with electrothermal atomization in a graphite furnace. The detection limit of the method for each element depends on the sample matrix as well as of the instrument, the type of atomizer and the use of chemical modifiers. For water samples with a simple matrix (i.e. low concentration of dissolved solids and particles), the method detection limits will be close to instrument detection limits. The minimum acceptable LOQ for a 20 µL sample volume are specified.

EN ISO 11885:1997 specifies a method by inductively coupled plasma atomic emission spectroscopy.

EPA 200.8 (1994): Determination of trace elements in waters by inductively coupled plasma - mass spectrometry (LOQ: 0.5 µg/L); http://www.accustandard.com/asi/pdfs/epa_methods/200_8.pdf

Standard Methods Online (http://standardmethods.org/) 3125: Metals in Water by ICP/MS (LOQ: 0.003 µg/L)

Comments

References

Compound *C_{10-13}-Chloroalkanes*			$C_xH_{(2x-y+2)}Cl_y$ where x = 10-13 AND y = 1-13
CAS Number 85535-84-8	**Log K_{OW}** 4.39-8.69 (depending on chlorine content)		**Water Solubility [mg/L]** 0.15-0.47 (59% chlorine content)
AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters 0.4	**Other Surface Waters** 0.4	**Inland Surface Waters** 1.4	**Other Surface Waters** 1.4

Available Standard Method

ISO CD 12010
Error! Reference source not found.

Matrix

Sampling

Pretreatment

Storage

Method Description

Determination of the sum of SCCP in technical mixtures with chlorine contents 49 % to 67 % independent of the chlorine content and independent of the C-number distribution pattern of the congeners. No recognition of the chlorine content is necessary.
Extraction of the whole water sample by liquid-liquid-extraction by an organic solvent, alternatively by solid phase extraction. After concentration and clean up, capillary gas chromatography of the approximately 6300 congeners at a relatively short column within a short retention range. Detection of selected mass fragments by mass spectrometry in the selected ion monitoring mode using negative ion chemical ionisation (NCI). The selection of the mass fragments is specific for the variety of technical mixtures as well as for the chlorine content and C-number distribution patterns in environmental samples.
Alternative selections of mass fragment combinations for quantification are given in this standard too. The chromatogram is to be integrated over the full retention range of the SCCP. The quantification of the sum of SCCP is performed after calibrating by a multiple linear regression model with solutions of different technical mixtures and internal standardisation.
The method works with at minimum three different defined standard mixtures, which resemble the C-number distribution and the chlorine content of different technical mixtures. This reflects the fact that the variety in respect of chlorine content and C-number distribution of technical SCCP-mixtures as well as of SCCP in environmental samples cannot be described by a single defined standard. The selection of the mass fragments for quantification and the special calibration allow a quantification of the sum of SCCP independently of chlorine content and C-number distribution within an expanded measurement uncertainty of 35% to 45%.

Method Validation

no data available

Other Analytical Methods

GC-ECNI-HRMS in the SIM mode at an ion source temperature of 120°C [1]. The molecular compositions of commercial SCCPs and of SCCP-containing extracts were determined by monitoring the two most intensive ions in the [M-Cl]- cluster, one for quantification and the other for confirmation for the following formula groups:

C10 (Cl5 to Cl10), C11 (Cl5 to Cl10), C12 (Cl6 to Cl10), and C13 (Cl7 to Cl9), and assuming that integrated signals are proportional to molar concentrations weighted by the number of chlorine atoms in the formula group. Quantification was achieved by selecting the biggest peak corresponding to [M-Cl]- ion in the most abundant formula group present in the sample and correcting for variations in the formula group abundances between standard and sample. The analytical detection limit was 60 pg of injected SCCP at a signal-to-noise ratio of 4:1, while LOQ was 23 ng/g.

Short-column (62 cm) GC-ECNI- LRMS at an ion source temperature of 100°C using methane as reagent gas [2]. Detection limits in the full- scan mode ranged from 10 to100 pg depending on carbon chain length of the n-alkane and on the degree of chlorination. The method was applied to the analysis of SCCP in fish samples.

Metastable atom bombardment ionisation (MAB) and high resolution mass spectrometry [3]. The detection limits were estimated to be between 10 and 100 pg/L. The MAB method has been applied to the analysis of high-volume water samples.

GC-MS/MS electron ionisation (EI) for fast determination of the sum of short medium chain chlorinated paraffins [4]. Collision-induced reactions of m/z 91 → 53 (LOQ = 0.15 ng/µL), 102 →65 (LOQ = 0.2 ng/µL), and 102 → 67 (LOQ = 0.1 ng/µL) were used to quantify the total short- and medium-chain PCA content of pooled fish liver samples.

Quantification procedure using GC-ECNI-MS, which is independent of the chlorine content of the reference standard used for calibration [5]. The authors calculated the total response factors for seven standard CP mixtures of various chlorine contents (51-70%) from the relative total CP areas and found a linear correlation between the total response factors of CP mixtures and their chlorine contents (R2= 0.9494). Using this correlation, total response factors according to the chlorine content of the SCCPs present in the sample can be calculated and used for quantification.

SPE and carbon skeleton analysis after simultaneous catalytic dechlorination and hydrogenation by gas chromatography with mass spectrometric detection seems to be promising option for routine analsis of of SCCPs in water even though the method has not yet been fully validated [6,7]

Comments

Although some work has been conducted on development of selective and sensitive methods for SCCP analysis in recent years, for the time being, no fully validated procedure is available that could be recommended for routine monitoring of SCCPs in environmental samples.

SCCP concentrations in environmental samples analysed by GC-ECNI-MS can vary widely (by a factor of ten) depending on chlorine content of the standard used for quantification [8].

References

[1] G. T. Tomy, G. A. Stern, D. C. G. Muir, A. T. Fisk, C. D. Cymbalisty, J. B. Westmore, Quantifying C10-C13 polychloroalkanes in environmental samples by high-resolution gas chromatography/electron capture negative ion high-resolution mass spectrometry. *Analytical Chemistry* 69, 1997, 2762-2771.

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[5] M. Reth, Z. Zencak, M. Oehme, New quantification procedure for the analysis of chlorinated paraffins using electron capture negative ionization mass spectrometry. *Journal of Chromatography A* 1081, 2005, 225–231.

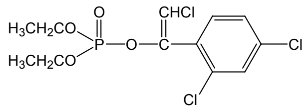
[6] F. Pellizzato, M. Ricci, A. Held, H. Emons. Analysis of short-chain chlorinated paraffins: a discussion paper. *International Journal of Environmental Analytical Chemistry* 9, 2007, 924-930.

[7] F. Pellizzato, M. Ricci, A. Held, H. Emons. Determination of short-chain chlorinated paraffins by carbon skeleton gas chromatography. *Organohalogen Componds* 70, 2008, 776-778.

[8] M. Coelhan, M. Saraci, H. Parlar, A comparative study of polychlorinated alkanes as standards for the determination of C10-C13 polychlorinated paraffins in fish samples. *Chemosphere* 40, 2000, 685-689.

Compound

Chlorfenvinphos



CAS Number	Log K_{OW}	Water Solubility [mg/L]
470-90-6	~ 3.81	~ 145 [1]

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	Other Surface Waters	Inland Surface Waters	Other Surface Waters
0.1	0.1	0.3	0.3

Available Standard Method

EN ISO 10695:2000

Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods

Note: Chlorfenvinphos is not explicitly mentioned in this standard but the method may also be applied to the analysis of chlorfenvinphos provided the method has been properly validated for this compound.

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.

After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

no data available

Other Analytical Methods

Solid-phase microextraction (SPME)

SPME in 4 mL glass vials with a 60 µm PDMS-DVB coated fibre at 60ºC [2].

Gas Chromatography - Mass Spectrometry

GC-MS determination of the ions 267, 323, 295 [2, 4]

LOQ ~ 25 ng/L [2]

LOQ ~ 1 ng/L (after SPE of 500 mL water) [4]

GC tandem MS-MS

Parent ion m/z 267; product ions m/z 159 and 203 [2]

LOQ ~ 25 ng/L [2]

Solid-phase extraction (SPE) – HPLC/UV

LOQ ~ 25 ng/L [5]

GC - Flame Photometric Detection (FPD)

EPA method 1657; LOQ ~ 2 ng/L (solvent extraction) [1, 6]

Comments

Existence of E and Z double bond isomers; the Z-isomer has a water solubility of 121 mg/L and the E-isomer of 7.3 mg/L (at 20ºC); the mixture 145 mg/L at 23ºC; log K_{OW} ~ 3.85 (Z-isomer) and 4.22 (E-isomer).

References

[1] US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile Information Sheet, URL: http://www.atsdr.cdc.gov/toxprofiles/tp83.html.

[2] C. Gonçalves, M. F. Alpendurada, Solid-phase micro-extraction–gas chromatography–(tandem) mass spectrometry as a tool for pesticide residue analysis in water samples at high sensitivity and selectivity with confirmation capabilities. *Journal of Chromatography A* 1026, 2004, 239-250.

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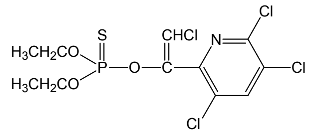
[4] C. Planas, A. Puig, J. Rivera, J. Caixach, Analysis of pesticides and metabolites in Spanish surface waters by isotope dilution gas chromatography/mass spectrometry with previous automated solid-phase extraction; Estimation of the uncertainty of the analytical results. *Journal of Chromatography A* 1131, 2006, 242–252.

[5]] C. Schlett, Multi-residue analysis of pesticides by HPLC after solid-phase extraction. *Fresenius' Journal of Analytical Chemistry.* 339, 1991, 344-347.

[[6] F.J. Lopez, J. Beltran, M. Forcada, F. Hernandez, Comparison of simplified methods for pesticide residue analysis; Use of large-volume injection in capillary gas chromatography. *Journal of Chromatography A* 823, 1998, 25-33.

Compound

Chlorpyrifos



CAS Number	Log K_{OW}	Water Solubility [mg/L]
2921-88-2	~ 4.96	~ 0.762

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.03	0.03	0.1	0.1

Available Standard Method

EN ISO 10695:2000

Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods

Note: Chlorpyriphos is not explicitly mentioned in this standard but the method may also be applied to the analysis of chlorpyriphos provided the method has been properly validated for this compound.

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.
After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

no data available

Other Analytical Methods

Solid-phase microextraction (SPME)
SPME in 4 mL glass vials with a 60 µm PDMS-DVB coated fibre at 60ºC [2]

Solid-phase extraction (SPE)
SPE with C18 cartridges; elution with ethylacetate [3]

Gas Chromatography - Mass Spectrometry
GC-MS determination of the ions 199, 197, 314, 316 [1-5]
LOQ ~ 1-2 ng/L [2, 5]

GC tandem MS-MS
Parent ion m/z 314; product ions m/z 286 and 258 [2]
LOQ ~ 1 ng/L [2]

GC-NPD:
LOQ ~ 20 ng/L [3]

GC - Flame Photometric Detection (FPD) [7]

Comments

Chlorpyrifos is a non-polar insecticide. If released to water, chlorpyrifos partitions significantly from the water column to sediments.

References

[1] M. Kirchner, E. Matisová, S. Hrouzková, J. de Zeeuw, Possibilities and limitations of quadrupole mass spectrometric detector in fast gas chromatography. *Journal of Chromatography A* 1090, 2005, 126-132.

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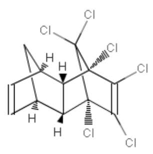
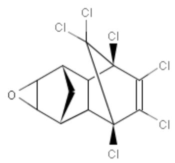
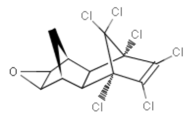
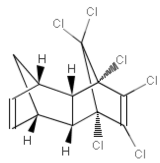
[7] F. J. Lopez, J. Beltran, M. Forcada, F. Hernandez, Comparison of simplified methods for pesticide residue analysis; Use of large-volume injection in capillary gas chromatography. *Journal of Chromatogaphy. A* 823, 1998, 25-33.

Compound			
 *Aldrin*	 *Dieldrin*	 *Endrin*	 *Isodrin*

	CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
Aldrin	309-00-2	~ 6.50	~ 0.011
Dieldrin	60-57-1	~ 6.2	~ 0.110
Endrin	72-20-8	~ 5.6	~ 0.20
Isodrin	465-73-6	~ 6.75	~ 0.014

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
Σ = 0.01	Σ = 0.005	*not applicable*	*not applicable*

Available Standard Method
EN ISO 6468:1996
Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

Liquid-liquid extraction of organochlorine insecticides, chlorobenzenes and PCBs by an extraction solvent. After concentration and clean-up the sample extracts are analysed by gas chromatography, using an electron-capture detector (GC-ECD).

The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): ~ 0.001 – 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study (Extraction of surface water with Hexane)

Substance	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in ng/L***	***s_R in µg/L***	***CV_R in %***
Dieldrin	14	0	33.3	17.2	51.7
Endrin	14	9.8	50.0	11.1	22.3

Other Analytical Methods

Solid-phase extraction gas chromatography - mass spectrometry
SPE with Oasis HLB cartridges; elution with dichloromethane.
GC-MS determination of the ions 66 for aldrin, 79 for dieldrin, 281 for endrin, and 193 for isodrine [1,2].

LOQ ~ 20 ng/L for aldrin,
10 ng/L for dieldrin,
15 ng/L for endrin, and
12 ng/L for isodrin (SPE extraction of 200 mL water) [1]

SPME GC-MS
SPME in 4 mL glass vials with a 60 µm PDMS-DVB coated fibre at 60ºC;
LOQ ~ 12 ng/L for aldrin, 9 ng/L for dieldrin, 60 ng/L for endrin, and 10 ng/L for isodrin [2]

SPE-GC- triple quadrupole-MS-MS
C18-SPE, 100 mL, SRM 263 > 193 (dieldrin), 261 > 191 (aldrin), 193 > 157 (isodrin); LOQ ~ 25 ng/L [3]

SPE-GC-NCI-MS
C18-SPE, 100 mL, LOQ ~ 25 ng/L [3]

Comments

References

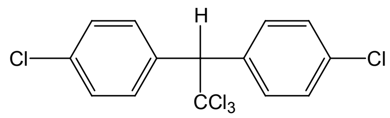
[1] S. Lacorte, I. Guiffard, D. Fraisse, D. Barceló, Broad Spectrum Analysis of 109 Priority Compounds Listed in the 76/464/CEE Council Directive Using Solid-Phase Extraction and GC/EI/MS. *Analytical Chemistry* 72, 2000, 1430-1440.

[2] C. Gonçalves, M.F. Alpendurada, Solid-phase micro-extraction–gas chromatography–(tandem) mass spectrometry as a tool for pesticide residue analysis in water samples at high sensitivity and selectivity with confirmation capabilities. *Journal of Chromatography A* 1026, 2004, 239-250.

[3] E. Pitarch, C. Medina, T. Portolés, F.J. López, F. Hernández, Determination of priority organic micro-pollutants in water by gas chromatography coupled to triple quadrupole mass spectrometry. *Analytica Chimica Acta* 583, 2007, 246–258.

Compound

DDT total
para-para-DDT



CAS Number		**Log K_{OW}**	**Water Solubility [mg/L]**
DDT total	*not applicable*	*p,p'*-DDT ~ 6.91	*p,p'*-DDT ~ 0.025
para-para-*D*DT	50-29-3	*o,p'*-DDT ~ 6.79	*o,p'*-DDT ~ 0.085
		p,p'-DDE ~ 6.51	*p,p'*-DDE ~ 0.12
		p,p'-DDD ~ 6.02	*p,p*'-DDD ~ 0.090

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
DDT total 0.025 para-para-DDT 0.01	DDT total 0.025 para-para-DDT 0.01	*not applicable*	*not applicable*

Available Standard Method
EN ISO 6468:1996
Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

Liquid-liquid extraction of organochlorine insecticides, chlorobenzenes and PCBs by an extraction solvent. After concentration and clean-up the sample extracts are analysed by gas chromatography, using an electron-capture detector (GC-ECD).

The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): ~ 0.001 – 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study (Extraction of p,p′-DDT with Hexane)

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in ng/L*	s_R *in µg/L*	CV_R *in %*
Drinking water	11	10.3	35.7	22.9	64.1

Other Analytical Methods

Solid-phase extraction - gas chromatography - mass spectrometry
SPE with Oasis HLB cartridges; elution with dichloromethane.
GC-MS determination of the ions 235 for DDT and DDD, and 246 for DDE.
The second qualitative ions are 165 for DDT and DDD, and 176 for DDE.

LOQ ~ 4 ng/L for *p,p'*-DDT,
11 ng/L for *o,p'*-DDT,
4 ng/L for *p,p'*-DDE, and
12 ng/L for *p,p*'-DDD (SPE extraction of 200 mL water) [1,2]

SPME - GC-MS
SPME in 4 mL glass vials with a 60 µm PDMS-DVB coated fibre at 60ºC; LOQ ~ 12 ng/L for DDT, 2 ng/L for

DDD and 1 ng/L for DDE [3]

GC-ECD
Bettinetti et al. detected 0.05 and 0.16 ng/L of dissolved pp'DDT and pp'DDE in the liquid water fraction of Lake Maggiore, Italy [4].

EPA methods 508 (GC-ECD) and 625 (GC-MS): Liquid-liquid extraction of 1 L water with dichloromethane.

Comments
Technical grade DDT consists of 65-80 % of *p,p'*-DDT, 15-21 % of *o,p'*-DDT, up to 4 % of *p,p*'-DDD. *p,p'*-DDE is a metabolite of DDT.
DDT is very persistent in the environment with a reported half-life between 2-25 years; it has a low solubility in water.

References

[1] S. Lacorte, I. Guiffard, D. Fraisse, D. Barceló, Broad Spectrum Analysis of 109 Priority Compounds Listed in the 76/464/CEE Council Directive Using Solid-Phase Extraction and GC/EI/MS. *Analytical Chemistry*, 2000, 1430-1440.

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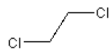
[4] R. Bettinetti, V. Croce, S. Galassi, P. Volta, Pp'DDT and pp'DDE accumulation in a food chain of Lake Maggiore (Northern Italy): testing steady-state condition, *Enviromental. Science and Pollution Research International* 13, 2006, 59-66.

Compound

1,2-Dichloroethane



CAS Number	Log K_{OW}	Water Solubility [g/L]
107-06-2	1.45	8.5-9.0

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
10	10	*not applicable*	*not applicable*

Available Standard Method

EN ISO 15680: 2003

Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption

Matrix drinking water, ground water, surface water, seawater and (diluted) waste water

Sampling *ISO 5667-1, 5667-2 and ISO 5667-3*

Pretreatment

Storage hermetically sealed at 4 °C, avoid direct sunlight, analysis within 5 days

Method Description

EN ISO 15680:2003 specifies a general method for the determination of volatile organic compounds (VOCs) in water by purge-and-trap isolation and gas chromatography (GC).

Detection is preferably carried out by mass spectrometry in the electron impact mode (EI), but other detectors may be applied as well.

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

no data available

Other Analytical Methods

EN ISO 10301:1997 specifies two methods for the determination of highly volatile halogenated hydrocarbons in water using gas chromatography with e.g. electron capture detector after: a) the extraction by an organic solvent or using, b) a head-space method (LOQ: 100 µg/L).

The EPA Method 1624 is designed to determine the volatile organic pollutants in water amenable to purge and trap gaschromatography-mass spectrometry.

Huybrechts et al. 2003 give a review of gas chromatography-based methods for analysis of volatile organic compounds in estuarine waters with special emphasis on monitoring [1].

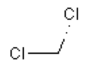
Purge and trap GC-MS
SIM-GC-MS detection of the ions 62, 98, 64; LOQ ~ 2 ng/L [2]
(Modification of EPA method 524.2:VOCs in Water Using GC-MS, http://www.accustandard.com/asi/pdfs/epa_methods/524_2.pdf,)

Comments

References

[1] T. Huybrechts, J. Dewulf, H. Van Langenhove, State-of-the-art of gas chromatography-based methods or analysis of anthropogenic volatile organic compounds in estuarine waters, illustrated with the river Scheldt as an example. *Journal of Chromatography A* 1000, 2003, 283-297.

[2] E. Martínez, S. Lacorte, I. Llobet, P. Viana, D. Barceló, Multicomponent analysis of volatile organic compounds in water by automated purge and trap coupled to gas chromatography–mass spectrometry. *Journal of Chromatography A* 959, 2002, 181-190.

Compound *Dichloromethane*	

CAS Number	**Log K_{OW}**	**Water Solubility [g/L]**
75-09-2	~ 1.3	~ 20

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
20	20	*not applicable*	*not applicable*

Available Standard Method
EN ISO 15680:2003
Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption

Matrix drinking water, ground water, surface water, seawater and (diluted) waste water

Sampling *ISO 5667-1, 5667-2 and ISO 5667-3*

Pretreatment

Storage at 4 °C air tight and no direct sunlight, analysis within 5 days

Method Description

EN ISO 15680:2003 specifies a general method for the determination of volatile organic compounds (VOCs) in water by purge-and-trap isolation and gas chromatography (GC).

Detection is preferably carried out by mass spectrometry in the electron impact mode (EI), but other detectors may be applied as well.

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient
n.a. = not available

Interlaboratory study

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Drinking water (0.2 µg/L)	11	n.a.	n.a.	n.a.	55
Surface water (0.2 µg/L)	10	n.a.	n.a.	n.a.	68

Other Analytical Methods

EN ISO 10301:1997 specifies two methods for the determination of highly volatile halogenated hydrocarbons in water using gas chromatography with e.g. electron capture detector after: a) the extraction by an organic solvent or using, b) a head-space method (LOQ: 100 µg/L).

The EPA Method 1624 is designed to determine the volatile organic pollutants in water amenable to purge and trap gaschromatography-mass spectrometry.

Huybrechts et al. 2003 give a review of gas chromatography-based methods for analysis of volatile organic compounds in estuarine waters with special emphasis on monitoring [1].

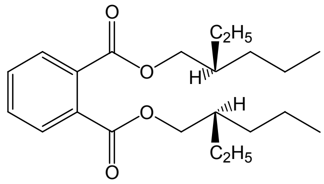
Purge and trap GC-MS
SIM-GC-MS detection of the ions 84, 86, 49; LOQ ~ 62 ng/L [2]
(Modification of EPA method 524.2 “VOCs in Water Using GCMS”)

Comments

References

[1] T. Huybrechts, J. Dewulf, H. Van Langenhove, State-of-the-art of gas chromatography-based methods or analysis of anthropogenic volatile organic compounds in estuarine waters, illustrated with the river Scheldt as an example. *Journal of Chromatography A* 1000, 2003, 283-297.

[2] E. Martínez, S. Lacorte, I. Llobet, P. Viana, D. Barceló, Multicomponent analysis of volatile organic compounds in water by automated purge and trap coupled to gas chromatography–mass spectrometry. *Journal Chromatography A* 959, 2002, 181-190.

Compound	
Di(2-ethylhexyl)phthalate (DEHP)	

CAS Number	**Log K_{OW}**	**Water Solubility [µg/L]**
117-81-7	7.5	3

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
1.3	1.3	*not applicable*	*not applicable*

Available Standard Method
EN ISO 18856: 2005
Determination of selected phthalates using gas chromatography/mass spectrometry

Matrix ground water, surface water, wastewater and drinking water

Sampling *ISO 5667-1, 5667-2 and 5667-3*

Pretreatment

Storage at 4 °C in the darkness, analysis within 4 days

Method Description

EN ISO 18856:2005 specifies a method for the determination of phthalates in water after solid phase extraction and gas chromatography/mass spectrometry.

Limit of Quantification (LOQ):
0.02 µg/L - 0.150 µg/L depending on the blank

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 2003

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in ng/L*	s_R *in ng/L*	CV_R *in %*
Surface water	7	0	373	257	69

Other Analytical Methods

SPME-GC-MS
GC-MS determination of the ion 149; LOQ ~ 15 to 30 ng/L [1,2]

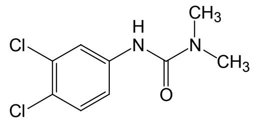
Comments
The analysis is difficult due to the omnipresence of phthalates. Specific care shall be taken to minimise blanks. The use of plastic material shall be avoided unconditionally.

References

[1] A. Peñalver, E. Pocurull, F. Borrull, R.M. Marcé, Comparison of different fibers for the solid-phase microextraction of phthalate esters from water. *Journal of Chromatography A* 922, 2001, 377-384.
[2] J. B. Baugros, B. Giroud, G. Dessalces, M. F. Grenier-Loustalot, C. Cren-Olivé. Multiresidue analytical methods for the ultra-trace quantification of 33 priority substances present in the list of REACH in real water samples. *Analytica Chimica Acta* 607, 2008, 191-203

Compound

Diuron



CAS Number	Log K_{OW}	Water Solubility [mg/L]
330-54-1	~ 2.7	~ 42

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.2	0.2	1.8	1.8

Available Standard Method

EN ISO 11369:1997

Determination of selected plant treatment agents in water by high performance liquid chromatography with UV detection after solid-liquid extraction.

Matrix Drinking and ground water

Sampling

Pretreatment

Storage

Method Description

The plant treatment substances in the water sample are extracted by solid-liquid extraction (SPE) on reversed-phase (RP)-C18 material, eluted with a solvent, and then separated, identified and quantified by high performance liquid chromatography (HPLC) using UV detection.

Limit of Quantification (LOQ): 0.1 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory trial

Matrix	*l*	*n_{AP} in %*	*$\bar{\bar{x}}$ in µg/L*	*s_R in µg/L*	*CV_R in %*
Drinking water	33	0	0.1026	0.0299	29.1
Ground water	32	5.1	0.2815	0.0570	20.2

Other Analytical Methods

Liquid Chromatography - Mass Spectrometry
Identification and quantification of diuron (and other pesticides) by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using positive electrospray ionization (ESI)
LC-MS fragment ions: m/z 233 [1,2]
LC-MS-MS transitions: 233 > 72 and 46 [3,4,5]

LOQ ~ 1 ng/L (depending on the SPE enrichment factor)

Liquid Chromatography – Diode Array Detector
Sea water analysis: Off-line SPE – LC-DAD; LOQ ~ 0.01 µg/L [6]

Gas Chromatography - Mass Spectrometry (after derivatisation)
Phenylurea herbicides require a derivatisation step to prevent the degradation of these thermolabile compounds in the GC injector; LOQ ~ 1 ng/L [7]
SPE-derivatisation-GC-MS; LOQ ~ 50 ng/L [8]

Comments

The EN ISO 11369 HPLC-UV method is only applicable for drinking and ground water, not to the analysis of contaminated surface water. GC-MS determination of phenylurea herbicides is difficult due to the necessary derivatisation step. LC-MS-MS seems to be the method of choice.

References

[1] C. Crescenzi, A. Di Corcia, R. Samperi, N. L. Dietz, E. Guerriero, Development of a Multiresidue Method for Analyzing Pesticide Traces in Water Based on Solid-Phase Extraction and Electrospray Liquid Chromatography Mass Spectrometry. *Environmental Science & Technology* 31, 1997, 479-488.

[2] R. Loos, G. Hanke, S. J. Eisenreich: Multi-Component Analysis of Polar Water Pollutants Using Sequential Solid-Phase Extraction Followed by LC-ESI-MS. *Journal of Environmental Monitoring* 5, 2003, 384-394.

[3] M. H. Lamoree, C. P. Swart, A. van der Horst, B. van Hattum, Determination of Diuron and the Antifouling Paint Biocide Irgarol 1051 in Dutch Marinas and Coastal Waters. *Journal of Chromatography A* 970, 2002, 183-190.

[4] R. J. C. A. Steen, A. C. Hogenboom, P. E. G. Leonards, R. A. L. Peerboom, W. P. Cofino, U. A. Th. Brinkman, Ultra-Trace-Level Determination of Polar Pesticides and Their Transformation Products in Surface and Estuarine Water Samples Using Column Liquid Chromatography–Electrospray Tandem Mass Spectrometry. *Journal of Chromatography A* 857, 1999, 157-166.

[5] M. Kuster, M. J. Lopez de Alda, C. Barata, D. Raldua, D. Barceló, Analysis of 17 polar to semi-polar pesticides in the Ebro river delta during the main growing season of rice by automated on-line solid-phase extraction-liquid chromatography-tandem mass spectrometry. *Talanta* 75, 2008, 390-401.

[6] G. Gatidou, A. Kotrikla, N. S. Thomaidis, T. D. Lekkas, Determination of the Antifouling Booster Biocides Irgarol 1051 and Diuron and their Metabolites in Seawater by High Performance Liquid Chromatography–Diode Array Detector. *Analytica Chimica Acta* 528, 2005, 89-99.

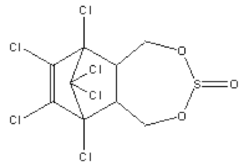
[7] A. C. Gerecke, C. Tixier, T. Bartels, R. P. Schwarzenbach, S. R. Müller, Determination of Phenylurea Herbicides in Natural Waters at Concentrations Below 1 ng l^{-1} Using Solid-Phase Extraction, Derivatisation, and Solid-Phase Microextraction–Gas Chromatography–Mass Spectrometry. *Journal of Chromatography A* 930, 2001, 9-19.

[8] P. Frank, M. Karg, Determination of phenylurea pesticides in water by derivatisation with heptafluorbutyric anhydride and gas chromatography – mass spectrometry. *Journal of Chromatography A* 634, 1993, 87-100.

Compound

Endosulfan

(alfa and beta isomer)



CAS Number	Log K_{OW}	Water Solubility [mg/L]
115-29-7	3.83	0.325

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	Other Surface Waters	Inland Surface Waters	Other Surface Waters
0.005	0.0005	0.01	0.004

Available Standard Method

EN ISO 6468:1996

Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes - Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, waste and surface water

Sampling

Pretreatment

Storage

Method Description

*EN ISO 6468:1996 d*escribes a method for determination of certain organochlorine insecticides, polychlorinated biphenyls (PCBs) and chlorobenzenes (except the mono- and dichlorobenzenes) in drinking water, ground water, surface waters and waste waters. The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): 0.001 up to 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\overline{\overline{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study (Extraction of β-Endosulfan with Hexane)

Matrix	*l*	n_{AP} *in %*	$\overline{\overline{x}}$ *in ng/L*	s_R *in µg/L*	CV_R *in %*
Surface water	14	6.6	21.2	14.4	67.9

Other Analytical Methods

SPE extraction of 500 ml water with 200 mg SDB, elution with ethyl acetate; GC-MS determination
LOQ for α-endosulfan ~ 11 ng/L [1]

SPE-GC-NCI-MS
C18-SPE, 100 mL, LOQ for α- or β-endosulfan ~ 25 ng/L [2]

The LOQ of these alternative SPE-GC-MS methods may be low enough if good equipment and well trained personnel are available. The uncertainty however is rather high (depends on required U whether this method will be feasible).

Comments

Technical endosulfan is a mixture of two stereoisomers, α- and β-endosulfan (in a ratio of 7:3). In the environment in particular in soil the metabolite endosulfan-sulfate is also present.

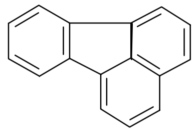
By the SPE extraction of higher water volumes lower LOQs could be achieved.
New research results show that sufficient LOQs in the low ng/L or even pg/L range can be achieved with negative chemical ionization (NCI) GC-MS, using SPE of 1 or 10 L water [3].

References

[1] J. Quintana, I. Martí, F. Ventura, Monitoring of Pesticides in Drinking and Related Waters in NE Spain with a Multiresidue SPE-GC–MS Method Including an Estimation of the Uncertainty of the Analytical Results. *Journal of Chromatography A* 938, 2001, 3-13.

[2] E. Pitarch, C. Medina, T. Portolés, F.J. López, F. Hernández, Determination of priority organic micro-pollutants in water by gas chromatography coupled to triple quadrupole mass spectrometry. *Analytica Chimica Acta* 583, 2007, 246–258.

[3] M. Oehme, N. Theobald, A.-C. Baaß, J. Hüttig, M. Reth, S. Weigelt-Krenz, Z. Zencak, M. Haarich, Identification of organic compounds in the North and Baltic Sea, Federal Environment Agency, Research Report 20025224, 2008, ISSN 1862-4804, http://www.umweltdaten.de/publikationen/fpdf-l/3509.pdf

Compound	
Fluoranthene	

CAS Number	Log K_{OW}	Water Solubility [mg/L]
206-44-0	5.16	0.265

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.1	0.1	1	1

Available Standard Method

EN ISO 17993:2003

Determination of 15 polycyclic aromatic hydrocarbons (PAH) in water by HPLC with fluorescence detection after liquid-liquid extraction

Matrix Drinking, ground, waste and surface water

Sampling

Pretreatment

Storage

Method Description

EN ISO 17993:2003 specifies a method using high performance liquid chromatography (HPLC) with fluorescence detection for the determination of 15 selected polycyclic aromatic hydrocarbons (PAH).

Limit of Quantification (LOQ):

Drinking and ground water: > 0.005 µg/L

Surface water: > 0.01 µg/L

Method Validation

l Number of laboratories

n_{AP} percental rate of outliers

$\bar{\bar{x}}$ Total mean after elimination of outliers

s_R standard deviation between the laboratories

CV_R reproducibility variation coefficient

Interlaboratory study 1996 in Germany

Matrix	l	n_{AP} in %	$\bar{\bar{x}}$ in µg/L	s_R in µg/L	CV_R in %
Spiked drinking water	30	10	46.48	4.225	9.1

Other Analytical Methods

USA EPA 8270c, 1996 [1]: Semivolatile organic compounds by GC/MS. This method claims detection limits of 10 µg/L which is obviously too high. Other analytical methods based on this standard using modern GC/MS equipment however may attain the required low LOQs.

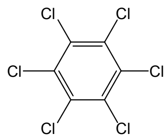
Comments

References

[1] http://www.accustandard.com/asi/pdfs/epa_methods/8270c.pdf

Compound

Hexachlorobenzene



CAS Number	Log K_{OW}	Water Solubility [mg/L]
118-74-1	5.73	0.006

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.01	0.01	0.05	0.05

Available Standard Method

EN ISO 6468:1996

Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

Liquid-liquid extraction of organochlorine insecticides, chlorobenzenes and PCBs by an extraction solvent. After concentration and clean-up the sample extracts are analysed by gas chromatography, using an electron-capture detector (GC-ECD).

The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): ~ 0.001 – 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study (Extraction with Hexane)

Matrix	l	n_{AP} in %	$\bar{\bar{x}}$ in ng/L	s_R in µg/L	CV_R in %
Surface water	15	0	48.8	16.6	34.1

Other Analytical Methods

Gas chromatography - mass spectrometry
GC-MS determination of the ion 284.

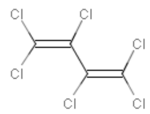
GC-ECD
EPA methods 505 (GC-ECD) and 625 (GC-MS): Liquid-liquid extraction of 1 L water with dichloromethane. LOQ ~ 3 ng/L

Comments

An overview of HCB levels in the aquatic environment is given by Barber et al. (2005) [1]

References

[1] J. L. Barber, A. J. Sweetman, D. van Wijk, K. C. Jones, Hexachlorobenzene in the global environment: Emissions, levels, distribution, trends and processes. *Science of The Total Environment* 349, 2005, 1-44.

Compound *Hexachlorobutadiene*	

CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
87-68-3	4.9	2.55 at 20 °C

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.1	0.1	0.6	0.6

Available Standard Method
EN ISO 10301:1997
Determination of highly volatile halogenated hydrocarbons - Gas-chromatographic methods

Matrix
Sampling *ISO 5667-1, 5667-2 and ISO 5667-3*

Pretreatment

Storage

Method Description

EN ISO 10301:1997 specifies two methods for the determination of highly volatile halogenated hydrocarbons in water using gas chromatography with e.g. electron capture detector after: a) the extraction by an organic solvent or using, b) a head-space method. The static headspace method may not offer sufficient sensitivity dependent on the instrumentation available.

Limit of Quantification (LOQ): 100 µg/L

Method Validation

no data available

Other Analytical Methods

EPA method 8260B [1]. Volatile Organic Compounds by GC/MS. This method is suitable for a variety of matrices.

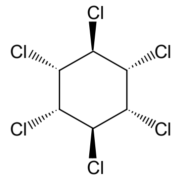
Comments

References

[1] http://www.accustandard.com/asi/pdfs/epa_methods/8260b.pdf

Compound

Hexachlorocyclohexane
(HCH)
α-, β-, γ- and δ- isomers



(γ-HCH; lindane)

CAS Number	Log K_{OW}	Water Solubility [mg/L]
608-73-1	α-HCH ~ 3.8 β-HCH ~ 3.78 γ-HCH ~ 3.72 δ-HCH ~ 4.14	α-HCH ~ 10 β-HCH ~ 5 γ-HCH ~ 7.3 δ-HCH ~ 10

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	Other Surface Waters	Inland Surface Waters	Other Surface Waters
0.02	0.002	0.04	0.02

Available Standard Method
EN ISO 6468:1996
Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

Liquid-liquid extraction of organochlorine insecticides, chlorobenzenes and PCBs by an extraction solvent. After concentration and clean-up the sample extracts are analysed by gas chromatography, using an electron-capture detector (GC-ECD).

The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): ~ 0.001 – 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study (Extraction of γ-HCH with Hexane)

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in ng/L*	s_R *in µg/L*	CV_R *in %*
Surface water	15	14.3	38.6	14.3	38.4

Other Analytical Methods

Solid-phase extraction gas chromatography - mass spectrometry
GC-MS determination of the ions 181, 217, and 219 for the HCHs [1-4]

LOQ ~ 10 ng/L for α-HCH,
5 ng/L for β-HCH,
5 ng/L for γ-HCH and
10 ng/L for δ- HCH (SPE extraction of 200 mL water) [1,2]

LOQ for γ-HCH (lindane) ~ 9 ng/L (SPE extraction of 500 mL water) [3].
LOQ for γ-HCH (lindane) ~ 2 ng/L (SPE extraction of 500 mL water) [4].

SPE-GC- triple quadrupole-MS-MS
C18-SPE, 100 mL, SRM 219 > 183; LOQ ~ 25 ng/L (for lindane) [5]

SPE-GC-NCI-MS
C18-SPE, 100 mL, LOQ ~ 25 ng/L (for lindane) [5]

EPA methods 508, 608 (GC-ECD). EPA 625 (GC-MS) may also be used but losses of HCH can occur due to the alkaline extraction procedure.

Comments
HCH exists in eight isomer forms. Technical-grade HCH was used as an insecticide and typically contained 10-15% γ-HCH (lindane) as well as the alpha (α), beta (β), and delta (δ) forms of HCH.

References

[1] S. Lacorte, I. Guiffard, D. Fraisse, D. Barceló, Broad Spectrum Analysis of 109 Priority Compounds Listed in the 76/464/CEE Council Directive Using Solid-Phase Extraction and GC/EI/MS. *Analytical Chemistry* 72, 2000, 1430-1440.

[2] D. de Almeida Azevedo, S. Lacorte, T. Vinhas, P. Viana, D. Barceló, Monitoring of Priority Pesticides and Other Organic Pollutants in River Water From Portugal by Gas Chromatography–Mass Spectrometry and Liquid Chromatography–Atmospheric Pressure Chemical Ionization Mass Spectrometry. *Journal of Chromatography A* 879, 2000, 13-26.

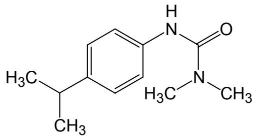
[3] J. Quintana, I. Martí, F. Ventura, Monitoring of Pesticides in Drinking and Related Waters in NE Spain with a Multiresidue SPE-GC–MS Method Including an Estimation of the Uncertainty of the Analytical Results. *Journal of Chromatography A* 938, 2001, 3-13.

[4] C. Planas, A. Puig, J. Rivera, J. Caixach, Analysis of pesticides and metabolites in Spanish surface waters by isotope dilution gas chromatography/mass spectrometry with previous automated solid-phase extraction; Estimation of the uncertainty of the analytical results. *Journal of Chromatography A*, 1131 2006, 242–252.

[5] E. Pitarch, C. Medina, T. Portolés, F.J. López, F. Hernández, Determination of priority organic micro-pollutants in water by gas chromatography coupled to triple quadrupole mass spectrometry. *Analytica Chimica Acta* 583, 2007, 246–258

Compound

Isoproturon



CAS Number	Log K_{OW}	Water Solubility [mg/L]
34123-59-6	~ 2.5	~ 70

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	Other Surface Waters	Inland Surface Waters	Other Surface Waters
0.3	0.3	1.0	1.0

Available Standard Method

EN ISO 11369:1997

Water quality - Determination of selected plant treatment agents in water by high performance liquid chromatography with UV detection after solid-liquid extraction.

Matrix Drinking and ground water

Sampling

Pretreatment

Storage

Method Description

The herbicides in the water sample are extracted by solid-liquid extraction (SPE) on reversed-phase (RP)-C18 material, eluted with a solvent, and then separated, identified and quantified by high performance liquid chromatography (HPLC) using UV detection.

Limit of Quantification (LOQ): 0.1 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Drinking water	32	0	0.1727	0.0394	22.8
Ground water	32	6	0.1110	0.0249	22.5

Other Analytical Methods

Liquid Chromatography - Mass Spectrometry
Identification and quantification of isoproturon (and other pesticides) by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using positive electrospray ionization (ESI).
LC-MS fragment ions: m/z 207 [1,2]
LC-MS-MS transitions: 207 > 72 [3,4]

LOQ ~ 1 ng/L (depending on the SPE enrichment factor)

Gas Chromatography - Mass Spectrometry (after derivatisation)
Phenylurea herbicides require a derivatisation step to prevent the degradation of these thermolabile compounds in the GC injector; LOQ ~ 1 ng/L [5].

SPE-derivatisation-GC-MS: LOQ ~ 40 ng/L [6]

Comments
The EN ISO 11369 HPLC-UV method is only applicable for drinking and ground water, not to the analysis of contaminated surface water. GC-MS determination of phenylurea herbicides is difficult due to the necessary derivatisation step. LC-MS-MS seems to be the method of choice.

References

[1] C. Crescenzi, A. Di Corcia, R. Samperi, N. L. Dietz, E. Guerriero, Development of a Multiresidue Method for Analyzing Pesticide Traces in Water Based on Solid-Phase Extraction and Electrospray Liquid Chromatography Mass Spectrometry. *Environmental Science & Technology* 31, 1997, 479-488.

[2] R. Loos, G. Hanke, S. J. Eisenreich: Multi-Component Analysis of Polar Water Pollutants Using Sequential Solid-Phase Extraction Followed by LC-ESI-MS. *Journal of Environmental Monitoring* 5, 2003, 384-394.

[3] R. Bossi, K. V. Vejrup, B. B. Mogensen, W. A. H. Asman, Analysis of Polar Pesticides in Rainwater in Denmark by Liquid Chromatography–Tandem Mass Spectrometry. *Journal of Chromatography A* 957, 2002, 27-36.

[4] M. Kuster, M. J. Lopez de Alda, C. Barata, D. Raldua, D. Barceló, Analysis of 17 polar to semi-polar pesticides in the Ebro river delta during the main growing season of rice by automated on-line solid-phase extraction-liquid chromatography-tandem mass spectrometry. *Talanta* 75, 2008, 390-401.

[5] A. C. Gerecke, C. Tixier, T. Bartels, R. P. Schwarzenbach, S. R. Müller, Determination of Phenylurea Herbicides in Natural Waters at Concentrations Below 1 ng l^{-1} Using Solid-Phase Extraction, Derivatisation, and Solid-Phase Microextraction–Gas Chromatography–Mass Spectrometry. *Journal of Chromatography A* 930, 2001, 9-19.

[6] P. Frank, M. Karg, Determination of phenylurea pesticides in water by derivatisation with heptafluorbutyric anhydride and gas chromatography – mass spectrometry. *Journal of Chromatography A* 634, 1993, 87-100.

Compound	
Lead and its compounds	

CAS Number	**Log K_D [L/kg]**	**Water Solubility [mg/L]**
7439-92-1	***suspended matter/water:*** 5.6 (Pb) [1] ***sediment/water***: 5.1 (Pb) [1]	depending on compound

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
7.2	7.2	*not applicable*	*not applicable*

Available Standard Method
EN ISO 17294-2:2004
Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements

Matrix Drinking waters, ground waters, surface waters and waste waters

Sampling *ISO 5667-1, 5667-2 and 5667-3*

Pretreatment For dissolved elements, filter aqueous sample through a 0.45-µm pore membrane filter. Adjust the pH of the filtrate to < 2 with HNO_3.

Storage

Method Description

EN ISO 17294-2:2004 specifies a method for the determination of the lead in water (for example drinking water, surface water, groundwater, wastewater and eluates). Taking into account the specific and additionally occurring interferences, these elements can also be determined in digests of water, sludges and sediments. The working range depends on the matrix and the interferences encountered.

Limit of Quantification (LOQ):
Drinking water and relatively unpolluted water:
0.1 up to 1 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1997 in Germany

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Surface water	39	2.5	13.6	1.13	8.3

Other Analytical Methods

EN ISO 15586:2003 determination using atomic absorption spectrometry with electrothermal atomization in a graphite furnace. The detection limit of the method for each element depends on the sample matrix as well as of the instrument, the type of atomizer and the use of chemical modifiers. For water samples with a simple matrix (i.e. low concentration of dissolved solids and particles), the method detection limits will be close to instrument detection limits. The minimum acceptable detection limit values for a 20 µL sample volume are specified.

EN ISO 11885:1997 specifies a method by inductively coupled plasma atomic emission spectroscopy.

DIN 38406-6:1998-07 determination using atomic absorption spectrometry

DIN 38406-16 (1990-03) specifies a voltammetric determination.

EPA 200.8 (1994) determination of trace elements in waters by inductively coupled plasma - mass spectrometry (LOQ: 0.6 µg/L)

Standard Methods Online (http://standardmethods.org/) 3125: Metals in Water by ICP/MS (LOQ: 0.005 µg/L)

Comments
References

Compound

Mercury and its compounds

CAS Number	Log K_D [L/kg]	Water Solubility [mg/L]
7439-97-6	***suspended matter/water:*** 5.3 (Hg) [1] ***sediment/water****:* 4.9 (Hg) [1]	Depending on compound

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.05	0.05	0.07	0.07

Available Standard Method
EN ISO 17852:2008
Determination of mercury by atomic fluorescence spectrometry
Matrix Drinking waters, ground waters and surface waters

Sampling *ISO 5667-1, 5667-2 and 5667-3*

Pretreatment stabilise with Potassium dichromate and acidification to pH< 2 with high purity Nitric Acid

Storage

Method Description
EN ISO 17852:2008 specifies a method for the determination of mercury in water using atomic fluorescence spectrometry.

Limit of Quantification (LOQ): appr. 0.001 µg/L (largely depends on the operational parameters)

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1999 in Great Britain

Matrix	l	n_{AP} ***in %***	$\bar{\bar{x}}$ ***in µg/L***	s_R ***in µg/L***	CV_R ***in %***
Surface water	18	9.4	44.2	11.57	25.8

Other Analytical Methods

EN 12338:1998 specifies the determination after enrichment by amalgamation

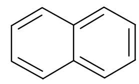
ISO 16590:2000 specifies methods involving enrichment by amalgamation

Comments

References

Compound

Naphthalene



CAS Number	Log K_{OW}	Water Solubility [mg/L]
91-20-3	3.3	31

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
2.4	1.2	*not applicable*	*not applicable*

Available Standard Method

EN ISO 17993:2003
Determination of 15 polycyclic aromatic hydrocarbons (PAH) in water by HPLC with fluorescence detection after liquid-liquid extraction

EN ISO 15680: 2003
Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption

Matrix Drinking, ground, waste and surface water

Sampling

Pretreatment

Storage

Method Description

EN ISO 17993:2003 specifies a method using high performance liquid chromatography (HPLC) with fluorescence detection for the determination of 15 selected polycyclic aromatic hydrocarbons (PAH).

EN ISO 15680:2003 specifies a general method for the determination of volatile organic compounds (VOCs) in water by purge-and-trap isolation and gas chromatography (GC). Annexes A, B and C provide examples of analytes that can be determined. Detection is carried out by mass spectrometry in the electron impact mode (EI).

Limit of Quantification (LOQ):
HPLC - Drinking and ground water: > 0.005 µg/L
HPLC - Surface water: > 0.01 µg/L
Purge-and-Trap/Thermal Desorption GC-MS:
> 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient
n.a. = not available

Interlaboratory study (ISO 17993)

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Spiked drinking water	33	3	52.85	15.5	29.3

Interlaboratory study (ISO 15680)

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Surface water (0.2 µg/L)	17	n.a.	n.a.	n.a.	32

Other Analytical Methods

USA EPA 8270c,1996, [1] claims detection limit of 10 µg/L, which is obviously too high. Other analytical methods based on this standard using modern GC/MS equipment however may attain the required low LOQs.

Comments

References

[1] http://www.accustandard.com/asi/pdfs/epa_methods/8270c.pdf

Compound *Nickel and its compounds*			
CAS Number 7440-02-0	**Log K_D [L/kg]** ***suspended matter/water:*** 4.6 (Ni) [1] ***sediment/water***: 4.0 (Ni) [1]	**Water Solubility [mg/L]** depending on compound	

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
20	20	*not applicable*	*not applicable*

Available Standard Method
EN ISO 17294-2:2004
Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements

Matrix Drinking waters, ground waters, surface waters and waste waters

Sampling *ISO 5667-1, 5667-2 and 5667-3*

For dissolved elements, filter aqueous sample through a 0.45 µm pore membrane filter. Adjust the pH of the filtrate to < 2 with HNO_3.

Storage

Method Description

EN ISO 17294-2:2004 specifies a method for the determination of the nickel in water (for example drinking water, surface water, groundwater, wastewater and eluates). Taking into account the specific and additionally occurring interferences, these elements can also be determined in digests of water, sludges and sediments. The working range depends on the matrix and the interferences encountered.

Limit of Quantification (LOQ):
Drinking water and relatively unpolluted water: 0.1 - 1.0 µg/l

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1997 in Germany

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Surface water	35	11	5.44	0.786	14.5

Other Analytical Methods

EN ISO 15586:2003 determination using atomic absorption spectrometry with electrothermal atomization in a graphite furnace. The detection limit of the method for each element depends on the sample matrix as well as of the instrument, the type of atomizer and the use of chemical modifiers. For water samples with a simple matrix (i.e. low concentration of dissolved solids and particles), the method detection limits will be close to instrument detection limits. The minimum acceptable detection limit values for a 20 µL sample volume are specified.

EN ISO 11885:1997 specifies a method by inductively coupled plasma atomic emission spectroscopy.

EPA 200.8 1994 [1]: Determination of trace elements in waters by inductively coupled plasma - mass spectrometry (LOQ: 0.5 µg/L)

Standard Methods Online (http://standardmethods.org/) 3125: Metals in Water by ICP/MS (LOQ: 0.02 µg/L)

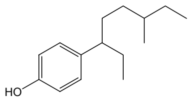
Comments

References

[1] http://www.accustandard.com/asi/pdfs/epa_methods/200_8.pdf

Compound

Nonylphenol
(4-nonylphenol)

(selected Isomer) 

CAS Number	Log K_{OW}	Water Solubility [mg/L]
84852-15-3	~ 4.48	~ 6

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.3	0.3	2.0	2.0

Available Standard Method

EN ISO 18857-1:2006
Determination of selected alkylphenols - Part 1: Method for non-filtered samples using liquid extraction and gas chromatography with mass selective detection

Matrix Drinking, ground and surface water

Sampling

Pretreatment

Storage

Method Description

Method for the determination of 4-nonylphenols (mixture of isomers) in non-filtered samples of drinking water, ground water and surface water.

Extraction of nonylphenol from the acidified water sample with toluene. Cleaning of the extract, if necessary with silica. Gas chromatographic separation and identification of the alkylphenol by mass spectrometry without derivatisation (mass fragments m/z 135 and 107). Quantification with an internal standard (^{13}C p-n-NP; m/z 113).

Limit of Quantification (LOQ): 0.02 to 0.2 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 2002

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Surface water	11	26.7	0.0828	0.016	18.8

Other Analytical Methods

Solid-phase extraction
Extraction of alkylphenols from water with solid-phase extraction (SPE) using C18 or polymeric adsorbents. Elution with methanol, acetone, ethylacetate, or dichloromethane [2-6].

Liquid Chromatography - Mass Spectrometry
Identification and quantification of the analytes by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using negative electrospray ionization (ESI).
LC-MS fragment ion: m/z 219 [2]
LC-MS-MS transitions: 219 > 133 and 219 > 147 [3,4]; LOQ ~ 5 ng/L
Internal standard: 4n-NP; transition 219 > 106

GC-MS after derivatisation
Several derivatisation techniques for alkylphenols prior to GC-MS determination have been reported.
E.g., the phenol group can be converted to a pentafluorobenzoylate ester (LOQ ~ 0.05 ng/L) [5], or silylated using bis(trimethylsilyl)trifluoroacetamide (BSTFA) (LOQ ~ 1 ng/L) [6], or methyl-N-(trimethylsilyl)trifluoroacetamide (MSTFA) [7].

Comments

Technical nonylphenol consists of 211 differently branched nonyl chains isomers; it consists mainly (~ 90 %) of 4-nonylphenol. Only recently, it was recognized that for a correct risk assessment, isomer-specific toxicological studies and analysis are important because the estrogenic effect of the individual nonylphenol isomers is heavily dependent on the structure of the alkyl side chain. It is estimated that in biological and environmental relevant matrices approximately 50 – 80 isomers are present [8,9]. Chromatographic separation of all isomers is not possible (at the time being); it might become feasible in the future with two-dimensional GC [8]. Therefore (for now), the sum of the different nonylphenol isomers should be analysed.
When using liquid chromatography (LC), the nonylphenols have to get chromatographically separated from the ethoxy carboxylate metabolites (NPECs) because they produce the same MS ions.
Nonylphenols are relatively polar compounds, and therefore GC-MS without derivatisation can give rise to poor chromatographic peaks. Thus, nonylphenols are often derivatized prior to GC-MS.

References

[1] European Commission, European Chemicals Bureau, European Union Risk Assessment Report, 4-Nonylphenol (Branched) and Nonylphenol. EUR 20387 EN, 2002, URL: http://ecb.jrc.it/existing-chemicals/.

[2] M. Petrović, D. Barceló, Determination of Anionic and Nonionic Surfactants, Their Degradation Products, and Endocrine-Disrupting Compounds in Sewage Sludge by Liquid Chromatography/Mass Spectrometry. *Analytical Chemistry* 72, 2000, 4560-4567.

[3] J. E. Loyo-Rosales, I. Schmitz-Afonso, C.P. Rice, A. Torrents, Analysis of Octyl- and Nonylphenol and Their Ethoxylates in Water and Sediments by Liquid Chromatography/Tandem Mass Spectrometry. *Analytical Chemistry* 75, 2003, 4811-4817.

[4] A. Jahnke, J. Gandrass, W, Ruck, Simultaneous Determination of Alkylphenol Ethoxylates and their Biotransformation Products by Liquid Chromatography/Electrospray Ionisation Tandem Mass Spectrometry. *Journal of Chromatography A* 1035, 2004, 115-122.

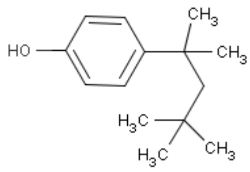
[5] H. M. Kuch, K. Ballschmiter, Determination of Endocrine-Disrupting Phenolic Compounds and Estrogens in Surface and Drinking Water by HRGC-(NCI)-MS in the Picogram per Liter Range. *Environmental Science & Technology* 35, 2001, 3201-3206.

[6] R. Liu, J. L. Zhou, A. Wilding, Simultaneous determination of endocrine disrupting phenolic compounds and steroids in water by solid-phase extraction – gas chromatography–mass spectrometry. *Journal of Chromatography A* 1022, 2004, 179-189.

[7] R. Haller, N. Hansen, Nonylphenols, Experimental Work Including Ruggedness Test, 2006, Eurofins, URL: http://www.ecn.nl/docs/society/horizontal/Report_ruggedness_NP.pdf

[8] K. Guenther, E. Kleist, B. Thiele, Estrogen-active nonylphenols from an isomer-specific viewpoint: a systematic numbering system and future trends. *Anal. Bioanal. Chem*. 384, 2006, 542-546.

[9] K. Guenther, V. Heinke, B. Thiele, E. Kleist, H. Prast, T. Raecker, Response to Comments on "Endocrine Disrupting Nonylphenols Are Ubiquitous in Food". *Environmental Science & Technoogy*. 37, 2003, 2624.

Compound *Octylphenol* *(4-tert-octylphenol)*		
CAS Number 140-66-9	**Log K_{OW}** 5.28	**Water Solubility [mg/L]** 5

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters 0.1	**Other Surface Waters** 0.01	**Inland Surface Waters** *not applicable*	**Other Surface Waters** *not applicable*

Available Standard Method
EN ISO 18857-1:2006
Determination of selected alkylphenols - Part 1: Method for non-filtered samples using liquid extraction and gas chromatography with mass selective detection

Matrix Drinking, ground and surface water

Sampling

Pretreatment

Storage

Method Description

Method for the determination of octylphenol in non-filtered samples of drinking water, ground water and surface water.

Extraction of octylphenol from the acidified water sample with toluene. Cleaning of the extract, if necessary with silica. Gas chromatographic separation and identification of the alkylphenol by mass spectrometry without derivatisation (mass fragments m/z 135 and 107). Quantification with an internal standard (^{13}C p-n-NP; m/z 113).

Limit of Quantification (LOQ): 0.005 – 0.2 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 2002

Matrix	*l*	*n_{AP} in %*	*$\bar{\bar{x}}$ in µg/L*	*s_R in µg/L*	*CV_R in %*
Surface water	13	13.3	0.0668	0.01789	26.8

Other Analytical Methods

Solid-phase extraction
Extraction of alkylphenols from water with solid-phase extraction (SPE) using C18 or polymeric adsorbents. Elution with methanol, acetone, ethylacetate, or dichloromethane [2-6].

Liquid Chromatography - Mass Spectrometry
Identification and quantification of the analytes by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using negative electrospray ionization (ESI).
LC-MS fragment ion: m/z 205 [2]
LC-MS-MS transitions: 205 > 133 [3-4]
Internal standard: 4n-NP; transition 219 > 106

GC-MS after derivatisation
Several derivatisation techniques for alkylphenols prior to GC-MS determination have been reported. E.g., the phenol group can be converted to a pentafluorobenzoylate ester (LOQ ~ 0.05 ng/L) [5], or silylated (LOQ ~ 2.6 ng/L) [6].

Comments

The term *octylphenol* represents a large number of isomeric compounds of the general formula $C_8H_{17}C_6H_4(OH)$. The octyl group may be branched in a variety of ways or be a straight chain. Of these potential isomers, 4-*tert*-octylphenol (CAS No. 140-66-9) is the most commercially (and toxicologically) important [7]. It has the MS-MS transistion 205 >133.

Another analytical standard is available: 4-octylphenol (CAS No. 1806-26-4). This standard contains linear octylphenol; it shows the characteristic MS-MS transistion 205 > 106.

References

[1] M. Ahel, W. Giger, Aqueous solubility of alkylphenols and alkylphenol polyethoxylates. *Chemosphere* 26, 1993, 1461-1470.

[2] M. Petrović, D. Barceló, Determination of Anionic and Nonionic Surfactants, Their Degradation Products, and Endocrine-Disrupting Compounds in Sewage Sludge by Liquid Chromatography/Mass Spectrometry. *Anaytical Chemistry* 72, 2000, 4560-4567.

[3] J. E. Loyo-Rosales, I. Schmitz-Afonso, C.P. Rice, A. Torrents, Analysis of Octyl- and Nonylphenol and Their Ethoxylates in Water and Sediments by Liquid Chromatography/-Tandem Mass Spectrometry. *Anaytical Chemistry* 75, 2003, 4811-4817.

[4] A. Jahnke, J. Gandrass, W, Ruck, Simultaneous Determination of Alkylphenol Ethoxylates and their Biotransformation Products by Liquid Chromatography/Electrospray Ionisation Tandem Mass Spectrometry. *Journal of Chromatography A* 1035, 2004, 115-122.

[5] H. M. Kuch, K. Ballschmiter, Determination of Endocrine-Disrupting Phenolic Compounds and Estrogens in Surface and Drinking Water by HRGC-(NCI)-MS in the Picogram per Liter Range. *Environmental Science & Technoogy* 35, 2001, 3201-3206.

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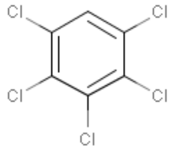
[7] OSPAR Commission, 2006 update, OSPAR background document on octylphenol, URL: http://www.ospar.org/documents/dbase/publications/p00273_BD%20on%20octylphenol%20_2006%20version.pdf

Compound	
Pentachlorobenzene	

CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
60-93-5	5.17	0.831

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.007	0.0007	*not applicable*	*not applicable*

Available Standard Method

EN ISO 6468:1996

Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

Liquid-liquid extraction of organochlorine insecticides, chlorobenzenes and PCBs by an extraction solvent. After concentration and clean-up the sample extracts are analysed by gas chromatography, using an electron-capture detector (GC-ECD).

The method is applicable to samples containing up to 50 mg/L of suspended solids.

Limit of Quantification (LOQ): ~ 0.001 – 0.01 µg/L

Method Validation

no data available

Other Analytical Methods

Gas chromatography - mass spectrometry

GC-MS determination of the ions 250, 215, 180

GC-ECD

EPA methods 505 (GC-ECD) [1] and 625 (GC-MS) [2]: Liquid-liquid extraction of 1 L water with dichloromethane.

LOQ ~ 3 ng/L

GC- triple-quad MS-MS [3]

SPE extraction of 100 mL water (elution with ethyl acetate / DCM) followed by GC- triple-quad MS-MS. Precursor ions 248 and 250, product 142; LOQ = 25 ng/L.

With NCI and the extraction of bigger water volumes, a lower LOQ might be achieved.

Comments

If released to water, pentachlorobenzene will adsorb strongly to sediments and will bioconcentrate in fish. It will be subject to evaporation with a half-life of 6.5 hours estimated for evaporation from a river 1 m deep, flowing at 1 m/sec and a wind velocity of 3 m/sec. The volatilization half-life from a model pond, which considers the effects of adsorption, can be estimated to be about 60 days. It will not be expected to significantly biodegrade or hydrolyze.

References

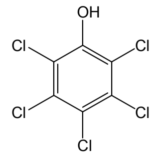
[1] http://www.accustandard.com/asi/pdfs/epa_methods/505.pdf

[2] http://www.accustandard.com/asi/pdfs/epa_methods/625.pdf

[3] E. Pitarch, C. Medina, T. Portolés, F.J. López, F. Hernández, Determination of priority organic micro-pollutants in water by gas chromatography coupled to triple quadrupole mass spectrometry. *Analytica Chimica Acta* 583, 2007, 246-258.

Compound

Pentachlorophenol



CAS Number	Log K_{OW}	Water Solubility [mg/L]
87-86-5	~ 5.0	~ 14

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	Other Surface Waters	Inland Surface Waters	Other Surface Waters
0.4	0.4	1	1

Available Standard Method

EN 12673:1998

Gas chromatographic determination of some selected chlorophenols in water

Matrix Drinking, ground, rain, waste, sea and surface water

Sampling

Pretreatment

Storage

Method Description

This European Standard describes the gas chromatographic determination of 19 chlorophenols in water.

The methods consists of acetylaction of the chlorophenols with acetic anhydride followed by liquid/liquid extraction with hexane and determination by gas chromatography (GC) and electrone capture detection (ECD) or mass selective detection (MSD).

Limit of Quantification (LOQ): 0.1 µg/L (Extraction volume:50 mL)

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study November 1996

Matrix	l	n_{AP} *in %*	$\bar{\bar{x}}$ *in µg/L*	s_R *in µg/L*	CV_R *in %*
Drinking water	12	22.2	0.11	0.028	24
Surface water	13	7.1	0.20	0.042	21

Other Analytical Methods

Gas Chromatography - Mass Spectrometry

Characteristic ions for MS detection (of acetate): 266, 264, 268, 270 (DIN EN 12673).

Silyl derivatisation GC-MS

Derivatisation with Bis(trimethylsilyl)trifluoroacetamide (BSTFA); MS quantification ions 323, 321, 93.
Dynamic concentration range: 1-1500 µg/L (without enrichment)

Solid-phase extraction

SPE with styrene-divinylbenzene (SDB) cartridges at pH 2.6; elution with 4 mL methanol; recovery ~ 90 % [2].

SPME-GC-MS

SPME from 2 mL sample volume; scan MS acquisition; claiming a LOQ of ~ 5 ng/L [3]

Derivatisation SPME-GC-MS

Derivatisation with acetic anhydride in 22 mL headspace vials followed by SPME and GC-MS determination (scan mode); LOQ ~ 3 ng/L [4].

SPE-LC-MS

LC-MS of Pentachlorophenol is difficult due to bad ionisation of the hydroxy group. However, off- and on-line SPE-LC-MS methods have been reported.

On-line SPE extraction of 100 mL river water (pH 3) using LiChrolut EN precolumns; elution with the water-acetonitrile-methanol gradient; LC-APCI-MS analysis; LOQ in SIM mode ~ 0.1 ng/L [5]

On-line SPE extraction of 10 mL river (pH 2.5) water using polymeric adsorbents; LC-APCI-MS analysis; LOQ in SIM mode ~ 5 ng/L [6]

Off-line SPE with PS-DVB membrane extraction disk of 500 mL tap water, elution with acetonitrile; LC-APCI-MS with post-column addition of diethylamine; SIM ions 263, 265, 267; LOQ ~ 20 ng/L [7].

Comments

The SPME-GC-MS and SPE-on-line-LC-MS methods have lower LOQ but are not standardized.
Other derivatisation reagents such as pentafluorobenzoyl chloride can be used prior to GC analysis.

References

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[2] I. Rodríguez, M. C. Mejuto, M. H. Bollaín, R. Cela, Evaluation of two solid-phase extraction procedures for the preconcentration of chlorophenols in drinking water, *Journal of Chromatography A* 786, 1997, 285-292.

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[7] O. Jauregui, E. Moyano, M.T. Galceran, Liquid Chromatography-Atmospheric Pressure Ionization Mass Spectrometry for the Determination of Chloro- and Nitrophenolic Compounds in Tap Water and Sea Water, *Journal of Chromatography A* 787, 1997, 79-89.

Compound	
Benzo[a]pyrene	$C_{20}H_{12}$
Benzo[b]fluoroanthene	$C_{20}H_{12}$
Benzo[g,h,i]perylene	$C_{22}H_{12}$
Benzo[k]fluoroanthene	$C_{20}H_{12}$
Indeno[1,2,3-cd]pyrene	$C_{22}H_{12}$

	CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
Benzo[a]pyrene	50-32-8	6.13	0.00162
Benzo[b]fluoroanthene	205-99-2	5.78	0.0015
Benzo[k]fluoroanthene	207-08-9	6.11	0.0008
Benzo[g,h,i]perylene	191-24-2	6.63	0.00026
Indeno[1,2,3-cd]pyrene	193-39-5	6.70	0.00019

	AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
	Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
Benzo[a]pyrene	0.05	0.05	0.1	0.1
Benzo[b]fluoroanthene *Benzo[k]fluoroanthene*	Σ = 0.03	Σ = 0.03	*not applicable*	*not applicable*
Benzo[g,h,i]perylene *Indeno[1,2,3-cd]pyrene*	Σ = 0.002	Σ = 0.002	*not applicable*	*not applicable*

Available Standard Method
EN ISO 17993: 2003
Determination of 15 polycyclic aromatic hydrocarbons (PAH) in water by HPLC with fluorescence detection after liquid-liquid extraction

Matrix Drinking, ground, waste and surface water

Sampling

Pretreatment

Storage

Method Description

EN ISO 17993:2003 specifies a method using high performance liquid chromatography (HPLC) with fluorescence detection for the determination of 15 selected polycyclic aromatic.

Limit of Quantification (LOQ):
Drinking and ground water: > 0.005 µg/L
Surface water: > 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\overline{\overline{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

National interlaboratory study for spiked drinking water 1996 (German)

Substance	***l***	***n_{AP} in %***	***$\overline{\overline{x}}$ in pg/L***	***s_R in pg/L***	***CV_R in %***
Benzo[a]pyrene	33	3.1	20.43	4.17	20.4
Benzo[b]fluoroanthene	33	3.1	27.41	4.719	17.2
Benzo[k]fluoroanthene	32	3.2	10.87	2.382	21.9

Benzo[g,h,i]perylene	32	6.2	25.21	5.941	23.6
Indeno[1,2,3-cd]pyrene	29	12	26.31	4.417	17.9

Other Analytical Methods

EPA 8270c [1] claims detection limit of 10 µg/L which is obviously too high. Other analytical methods based on this standard using modern GC/MS equipment however may attain the required low LOQs.

Comments

The methods do not attain low enough LOQs and uncertainties for compliance checking with the AA-EQS for the sum of *Benzo[b]fluoroanthene and Benzo[k]fluoroanthene as well as the sum of Benzo[g,h,i]perylene and Indeno[1,2,3-cd]pyrene.* In addition, not enough validation data are available regarding the analysis of surface water samples in particular samples containing substantial amounts of SPM.

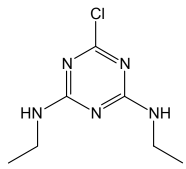
A new ISO standard for the determination of PAH in water using gas chromatography with mass spectrometry detection in under development (ISO/CD 28540)

References

[1] http://www.accustandard.com/asi/pdfs/epa_methods/8270c.pdf

Compound

Simazine



CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
1912-24-9	~ 2.2	~ 6.2

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
1	1	4	4

Available Standard Method

EN ISO 10695:2000

Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.
After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ):

Liquid/liquid extraction method: 0.5 µg/L
Liquid/solid extraction method: 0.012 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1993 for liquid/solid extraction

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Drinking water	12	16.4	0.058	0.0044	27.3

Other Analytical Methods

Gas Chromatography - Mass Spectrometry
GC-MS determination of the ions 201and 186; LOQ ~ 1 ng/L (after SPE) [1, 2]
(EPA method 525)

GC-NPD
EPA method 507 [3]

GC-ECD
EPA method 505; microextraction with hexane and GC-ECD analysis [32]

Liquid Chromatography - Mass Spectrometry
Identification and quantification of simazine (and other pesticides) by liquid chromatography coupled to (tandem) mass spectrometric detection (LC-MS-MS) using positive electrospray ionization (ESI).
LC-MS fragment ions: m/z 202 and 124 [4]
LC-MS-MS transition: 202 > 132 [5, 6]
LOQ ~ 1 ng/L (depending on the SPE enrichment factor)

Comments

References

[1] T. D. Bucheli, F. C. Grüebler, S. R. Müller, R. P. Schwarzenbach, Simultaneous Determination of Neutral and Acidic Pesticides in Natural Waters at the Low Nanogram per Liter Level. *Anaytical Chemistry* 69, 1997, 1569-1576.

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[32] D. Barceló, Environmental Protection Agency and Other Methods for the Determination of Priority Pesticides and Their Transformation Products in Water. *Journal of Chromatography A*, 643, 1993, 117-143.

[4] C. Crescenzi, A. Di Corcia, R. Samperi, N. L. Dietz, E. Guerriero, Development of a Multiresidue Method for Analyzing Pesticide Traces in Water Based on Solid-Phase Extraction and Electrospray Liquid Chromatography Mass Spectrometry. *Environmental Science & Technoogy* 31, 1997, 479-488.

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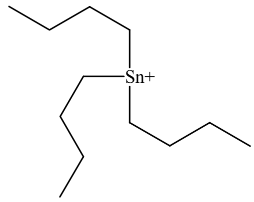
Compound

Tributyltin compounds



CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
688-73-3	3.1 - 4.1	~ 2 mg/L

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.0002	0.0002	0.0015	0.0015

Available Standard Method

EN ISO 17353:2005

Determination of selected organotin compounds - Gas chromatographic method

Matrix Drinking, surface and waste waters containing not more than 2g/L of suspended material.

Sampling

Pretreatment

Storage

Method Description

Method for the identification and quantification of organotin compounds and/or cations in water.
Compounds:
Monobutyltin cation (MBT) $BuSn^{3+}$
Dibutyltin cation (DBT) Bu_2Sn^{2+}
Tributyltin cation (TBT) Bu_3Sn^{+}
Tetrabutyltin (TTBT) Bu_4Sn

Organotin compounds in water are ethylated with sodium tetraethyl-borate ($NaBEt_4$) and extracted with hexane. The extract can be cleaned with silica. After concentration, the tetra-substituted OTC are separated by capillary gas chromatography and detected with a suitable system (MS, FPD, AED). The concentration is determined by calibration over the total procedure using an internal standard mixture.

Limit of Quantification (LOQ): 0.010 – 1 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1998 in Germany

Matrix	*l*	*n_{AP} in %*	*$\bar{\bar{x}}$ in ng/L*	*s_R in µg/L*	*CV_R in %*
Spiked surface water	11	8.3	388.2	92.16	23.7

Other Analytical Methods

LLE-EI-GC-MS
100 mL seawater, pH 5.4, derivatisation with $NaBEt_4$, hexane extraction; LOQ ~ 0.8 ng/L [1].

GC-NCI-MS
LOQ 0.1 ng/L [2].

Liquid phase microextraction (LPME) – GC-MS-MS
4mL water sample; 4-fluorophenyl derivatisation; LOQ 0.36 ng/L [3].

LLE-GC-FDP

1 L sea water, pH 5.5, ethylation in aqueous phase with $NaBEt_4$, iso-octane/n-pentane extraction; LOQ 0.01 ng/L [4].

LLE-LC-MS

At pH 4 using hexane-ethylacetate (70:30); ion-trap LC–APCI-MS; m/z 323 and 307; LOD 35 µg/L for TBT [5].

GC-ICP-MS

Extraction of 1 L sample at clean room conditions. Derivatisation followed by GC-ICP/MS, LOQ ~0.01 ng/L [6,7]

Comments

Only tributyltin cation is required for WFD monitoring. In the environment different anions (OH-, Cl-, Br-, acetate) are associated with TBT. Analytical methods are assumed to derivatise all forms.

EQS values for TBT refer to the tributyl-cation, hence result shall be expressed in the same way.

Care has to be taken when comparing result with data from scientific literature because some authors express results as µg Sn /L.

References

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[2] K. Mizuishi, M. Takeuchi, T. Hobo. Trace analysis of tributyltin and triphenyltin compounds in sea water by gas chromatography–negative ion chemical ionization mass spectrometry. *Journal of Chromatography A* 800, 1998, 267-273.

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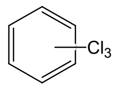
[6] M. Monperrus., E. Tessier., D. Amouroux, O.F.X. Donard. Simultaneous speciation of mercury and butyltin compounds in natural waters and snows by propylation and species specific isotope dilution mass spectrometry analysis. *Anal Bioanal Chem*, 381, 2005, 854-862.

[7] M. Monperrus, O. Zuloaga, E. Krupp, D. Amouroux, R. Wahlen, B. Fairman, O.F.X. Donard. Rapid, accurate and precise determination of tributyltin in sediments and biological samples by species specific isotope dilution-microwave extraction-gas chromatography-ICP mass spectrometry. *J. Anal. Atomic Spetrosc.* 18(3), 2003, 247-253.

Compound *Trichlorobenzenes* *(all isomers)*		
CAS Number 12002-48-1	**Log K_{OW}** 4.02 – 4.49	**Water Solubility [mg/L]** 6-19

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters 0.4	**Other Surface Waters** 0.4	**Inland Surface Waters** *not applicable*	**Other Surface Waters** *not applicable*

Available Standard Method
EN ISO 15680
Water quality - Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption

Matrix drinking water, ground water, surface water, seawater and (diluted) waste water

Sampling *ISO 5667-1, 5667-2 and ISO 5667-3*

Pretreatment

Storage at 4 °C air tight and no direct sunlight, analysis within 5 days

Method Description

EN ISO 15680:2003 specifies a general method for the determination of volatile organic compounds (VOCs) in water by purge-and-trap isolation and gas chromatography (GC).

Detection is preferably carried out by mass spectrometry in the electron impact mode (EI), but other detectors may be applied as well

Selected ions: 180, 182, 145

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient
n.a. = not available

Interlaboratory study

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in ng/L*	s_R *in ng/L*	CV_R *in %*
Drinking water (0.2 µg/L)	5	n.a.	n.a.	n.a.	27
Surface water (0.2 µg/L)	4	n.a.	n.a.	n.a.	35

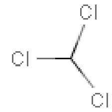
Other Analytical Methods

ISO 6468:1996: Water quality - Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes - Gas chromatographic method after liquid-liquid extraction. LOQ ~ 0.01µg/l.

Comments In water, trichlorobenzenes are likely to be adsorbed onto sediments and to bioconcentrate in aquatic organisms. Evaporation from water may be a significant removal process.
References

Compound

Trichloromethane



CAS Number	Log K_{OW}	Water Solubility [mg/L]
67-66-3	1.97	8.7

AA-EQS [µg/L]		MAC-EQS [µg/L]	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
2.5	2.5	*not applicable*	*not applicable*

Available Standard Method

EN ISO 15680: 2003

Gas-chromatographic determination of a number of monocyclic aromatic hydrocarbons, naphthalene and several chlorinated compounds using purge-and-trap and thermal desorption

Matrix drinking water, ground water, surface water, seawater and (diluted) waste water

Sampling *ISO 5667-1, 5667-2 and ISO 5667-3*

Pretreatment

Storage at 4 °C air tight and no direct sunlight, analysis within 5 days

Method Description

EN ISO 15680:2003 specifies a general method for the determination of volatile organic compounds (VOCs) in water by purge-and-trap isolation and gas chromatography (GC).

Detection is preferably carried out by mass spectrometry in the electron impact mode (EI), but other detectors may be applied as well.

Limit of Quantification (LOQ): 0.01 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient
n.a. = not available

Interlaboratory study

Matrix	*l*	n_{AP} *in %*	$\bar{\bar{x}}$ *in ng/L*	s_R *in ng/L*	CV_R *in %*
Drinking water (0.2 µg/L)	15	n.a.	n.a.	n.a.	29
Surface water (0.2 µg/L)	13	n.a.	n.a.	n.a.	30

Other Analytical Methods

EN ISO 10301:1997 specifies two methods for the determination of highly volatile halogenated hydrocarbons in water using gas chromatography with e.g. electron capture detector after: a) the extraction by an organic solvent or using, b) a head-space method (LOQ: 100 µg/L).

The EPA Method 1624 is designed to determine the volatile organic pollutants in water amenable to purge and trap gas chromatography-mass spectrometry.

Huybrechts et al. 2003 give a review of gas chromatography-based methods for analysis of volatile organic compounds in estuarine waters with special emphasis on monitoring. [1]

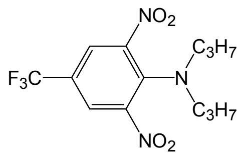
Comments

References

[1] T. Huybrechts, J. Dewulf, H. Van Langenhove, State-of-the-art of gas chromatography-based methods for analysis of anthropogenic volatile organic compounds in estuarine waters, illustrated with the river Scheldt as an example. *Journal of Chromatography A* 1000, 2003, 283-297.

Compound

Trifluralin



CAS Number	**Log K_{OW}**	**Water Solubility [mg/L]**
1582-09-8	~ 5.3	~ 0.3

AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
0.03	0.03	*not applicable*	*not applicable*

Available Standard Method

EN ISO 10695:2000
Determination of selected organic nitrogen and phosphorus compounds - Gas chromatography methods

Matrix Drinking waters, ground waters, surface waters and waste waters containing up to 50 mg/L of suspended solids

Sampling

Pretreatment

Storage

Method Description

Liquid/liquid extraction with dichloromethane or liquid/solid extraction (SPE) on reversed-phase (RP)-C18 material or other adsorbent. Elution of the cartridges with e.g. methanol or acetone.
After concentration, the sample extracts are analysed by gas chromatography, using a nitrogen-phosphorus or mass spectrometric detector.

Limit of Quantification (LOQ): ~ 0.05 µg/L

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study 1993 for liquid/solid extraction

Matrix	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in µg/L***	***s_R in µg/L***	***CV_R in %***
Raw water	14	8.6	0.296	0.0264	46.3

Other Analytical Methods

Gas Chromatography - Mass Spectrometry
GC-MS determination of the ions 306, 264, 336 [1-5]
LOQ ~ 13 ng/L (SPE extraction of 500 mL water) [1]
LOQ ~ 5 ng/L (SPE extraction of 200 mL water) [4]
LOQ ~ 1 ng/L (SPE extraction of 500 mL water) [5]

EPA method 508.1 (GC-ECD) [6]
SPE-GC- triple quadrupole-MS-MS
C18-SPE, 100 mL, 306 > 264; LOQ ~ 25 ng/L [7]

SPE-GC-NCI-MS
C18-SPE, 100 mL, LOQ ~ 25 ng/L [7]

Comments

If released to water, trifluralin is expected to biodegrade under both aerobic and anaerobic conditions and to undergo direct photolytic degradation. It is expected to bioconcentrate in fish and aquatic organisms and adsorb strongly to sediment and suspended organic matter. It may also volatilize from water to the atmosphere. If released to the atmosphere, trifluralin is expected to undergo a rapid gas-phase photolysis.

References

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[2] M. Kochman, A. Gordin, P. Goldshlag, S. J. Lehotay, A. Amirav, Fast, High-Sensitivity, Multipesticide Analysis of Complex Mixtures With Supersonic Gas Chromatography–Mass Spectrometry. *Journal of Chromatography A* 974, 2002, 185-212.

[3] S. Lacorte, I. Guiffard, D. Fraisse, D. Barceló, Broad Spectrum Analysis of 109 Priority Compounds Listed in the 76/464/CEE Council Directive Using Solid-Phase Extraction and GC/EI/MS. *Anaytical Chemistry* 72, 2000, 1430-1440.

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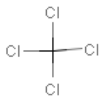
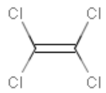
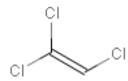
[5] C. Planas, A. Puig, J. Rivera, J. Caixach, Analysis of pesticides and metabolites in Spanish surface waters by isotope dilution gas chromatography/mass spectrometry with previous automated solid-phase extraction; Estimation of the uncertainty of the analytical results. *Journal of Chromatography* A, 1131, 2006, 242–252.

[6] http://www.accustandard.com/asi/pdfs/epa_methods/508_1.pdf

[7] E. Pitarch, C. Medina, T. Portolés, F.J. López, F. Hernández, Determination of priority organic micro-pollutants in water by gas chromatography coupled to triple quadrupole mass spectrometry. Analytica *Chimica Acta* 583, 2007, 246–258.

Compound

Carbontetrachloride	*Tetrachloroethylene*	*Trichloroethylene*
		

CAS Number		**Log K_{OW}**	**Water Solubility [mg/L]**
Carbontetrachloride	56-23-5	2.83	1160
Tetrachloroethylene	127-18-4	3.4	100
Trichloroethylene	79-01-6	2.42	1100

	AA-EQS [µg/L]		**MAC-EQS [µg/L]**	
	Inland Surface Waters	**Other Surface Waters**	**Inland Surface Waters**	**Other Surface Waters**
Carbontetrachloride	12	12		
Tetrachloroethylene	10	10	*not applicable*	*not applicable*
Trichloroethylene	10	10		

Available Standard Method

EN ISO 10301:1997

Determination of highly volatile halogenated hydrocarbons - Gas-chromatographic methods

Matrix Drinking, ground, surface and waste waters

Sampling

Pretreatment

Storage

Method Description

EN ISO 10301:1997 specifies two methods for the determination of highly volatile halogenated hydrocarbons in water using gas chromatography with e.g. electron capture detector after: a) the extraction by an organic solvent or using, b) a head-space method.

Limit of Quantification (LOQ [µg/L]):

	Solvent	**Headspace**
Carbon tetrachloride	0.01-0.1	0.1
Tetrachloroethylene	0.1	0.2
Trichloroethylene	0.05-0.1	0.2

Method Validation

l Number of laboratories
n_{AP} percental rate of outliers
$\bar{\bar{x}}$ Total mean after elimination of outliers
s_R standard deviation between the laboratories
CV_R reproducibility variation coefficient

Interlaboratory study

Wastewater	***l***	***n_{AP} in %***	***$\bar{\bar{x}}$ in ng/L***	***s_R in µg/L***	***CV_R in %***
Solvent Extraction:					
Carbon Tetrachloride	18	0	76.2	7.2	9.4
Tetrachloroethylene	18	0	81.3	6.4	7.8
Trichloroethylene	18	6	74.7	7.3	9.7
Headspace:					
Carbon Tetrachloride	10	0	0.29	0.05	17.6
Tetrachloroethylene	17	0	27.63	0.62	2.3
Trichloroethylene	23	5	41.07	1.226	3.0

Other Analytical Methods

EPA method 502.2 - Purge and Trap concentration with photoionisation and electrolytical conductivity detection [1]. GC/MS confirmation can also be used.

EPA method 524.2 – Purge and Trap concentration with GC/MS analysis [2].

Comments Modern GC/MS instrumentation may allow the use of full scan mass spectra for identification and quantification of these substances at levels below EQS.
References [1] http://www.accustandard.com/asi/pdfs/epa_methods/502_2.pdf [1] http://www.accustandard.com/asi/pdfs/epa_methods/524_2.pdf

ANNEX III: Existing certified reference materials[25]

Table 1: Reference materials producers

BAM, Germany	http://www.bam.de/
CMI, Czech Republic	http://www.cmi.cz/
EUROFINS, Denmark	http://www.eurofins.dk/
GUM, Poland	http://www.gum.gov.pl/pl/site/
IAEA, Austria	http://www.iaea.org/programmes/aqcs/
IPO, Poland	http://www.ipo.waw.pl/
IRMM, European Commission	http://www.irmm.jrc.be
LGC, GB	http://www.lgcstandards.com/home/home_de.aspx
NIST, USA	http://www.nist.gov/
NRC-CNRC, Canada	http://inms-ienm.nrc-cnrc.gc.ca/
National Institute of Metrology, China	http://www.en.nim.ac.cn/
National Measurement Institute, Australia	http://www.measurement.gov.au/
SMU, Slovakia	http://www.smu.gov.sk/

[25] EAQC-WISE project, funded under the 6th RDT Framework Programme, European Commission

Table 2: Certified reference materials related to the WFD priority substances
P – Pure compounds or solutions

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
Alachlor	**P**	SRM-3070	NIST	24.0 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Anthracene	**P**	DPAC-1	NRC-CNRC, Canada	13 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	48.7 µg/g	http://www.comar.bam.de/
	P	SRM-1647d	NIST	20.77 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	3.231 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Atrazine	**P**	SRM-3070	NIST	39.2 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Benzene	**P**	7141-95M/1	GUP TSIKV	0.99 g/L	http://www.comar.bam.de/
	P	7141-95M/2	GUP TSIKV	0.495 g/L	http://www.comar.bam.de/
	P	7141-95M/3	GUP TSIKV	0.097 g/L	http://www.comar.bam.de/
	P	7141-95M	GUP TSIKV	99.87 %	http://www.comar.bam.de/
	P	C03	SMU	99.9 %	http://www.comar.bam.de/
	P	GBW 06104	Tian Jin Institute of Metrological Technology	99.95 %	http://www.comar.bam.de/
Cadmium and its compounds	**P**	6690-93/1	GUP TSIKV	1 g/L	http://www.comar.bam.de/
	P	7325-96	GUP TSIKV	0.0101 %	http://www.comar.bam.de/
	P	DMR-85c	CENAM, Mexico	1001.0 mg/L	http://www.comar.bam.de/
	P	DMR-8i	CENAM, Mexico	1 mg/L	http://www.comar.bam.de/
	P	GBW-08602	National Institute of Metrology, China	0.100 µg/kg	http://www.comar.bam.de/
	P	GBW-08607	National Institute of Metrology, China	0.100 µg/g	http://www.comar.bam.de/
	P	GBW-08608	National Institute of Metrology, China	10.0 µg/kg	http://www.comar.bam.de/
	P	JK-0012 Cd 1000	CERI, Japan	0.1 %	http://www.comar.bam.de/
1,2-Dichloroethane	**P**	7332-96	GUP TSIKV, Russia	99.76 %	http://www.comar.bam.de/
	P	SRM-3012	NIST	0.010039 g/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Endosulfan	**P**	SRM-3069	NIST	4.66 mg/kg (I) 5.29 mg/kg (II)	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2275	NIST	2.880 mg/kg (I) 2.943 mg/kg (II)	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Hexachlorobenzene	**P**	SRM-1492	NIST	308 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2261	NIST	1.968 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-3069	NIST	4.39 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Hexachlorocyclohexane gamma-isomer	**P**	SLRM-10-2-08	Slovak Institute of Metrology, Slovakia	0.1 %	http://www.comar.bam.de/
	P	SRM-1492	NIST	310 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2261	NIST	1.972 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-3069	NIST	4.22 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-8466	NIST	99.9 weight %	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Lead and its compounds	**P**	7012-93/1	GUP TSIKV	1.01 g/L	http://www.comar.bam.de/
	P	DMR-63c	CENAM, Mexico	1002.1 mg/L	http://www.comar.bam.de/
	P	DMR-8i	CENAM, Mexico	10 mg/L	http://www.comar.bam.de/
Naphthalene	**P**	DPAC-1	NRC-CNRC, Canada	116 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	49.8 µg/g	http://www.comar.bam.de/
	P	SRM-1586-1	NIST	126.5 µg /g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-1586-2	NIST	126.6 µg /g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-1647d	NIST	20.13 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2270	NIST	77.0 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Nickel and its compounds	**P**	DMR-8i	CENAM, Mexico	1 mg/L	http://www.comar.bam.de/
Pentachlorophenol	**P**	SRM-1584	NIST	15.4 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-3066	NIST	100.7 mg/L	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
PAHs benzo[a]pyrene	**P**	DPAC-1	NRC-CNRC, Canada	35 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	GBW-08701	Beijing Municipal Environmental Monitoring Centre, China	5.75 µg/g	http://www.comar.bam.de/
	P	GBW-08702	Beijing Municipal Environmental Monitoring Centre, China	10.0 µg/g	http://www.comar.bam.de/
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	49.4 µg/g	http://www.comar.bam.de/
	P	SRM-1586-1	NIST	49.2 µg /g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-1586-2	NIST	44.1 µg /g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-1647d	NIST	4.91 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	4.07 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2270	NIST	37.3 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
fluoranthene	**P**	DPAC-1	NRC-CNRC, Canada	116 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	DPAC-2	NRC-CNRC, Canada	117 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	SRM-1647d	NIST	7.64 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	7.200 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2269	NIST	62.6 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterial

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
					s/232.cfm
benzo[b]fluoranthene	P	BCR-048R	EC-JRC-IRMM	0.995 g/g	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	P	DPAC-1	NRC-CNRC, Canada	35 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	SRM-1647d	NIST	4.17 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	6.80 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	49.9 µg/g	http://www.comar.bam.de/
benzo[k]fluoranthene	P	BCR-048R	EC-JRC-IRMM	0.995 g/g	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	P	SRM-1647d	NIST	4.72 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	2.979 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	49.9 µg/g	http://www.comar.bam.de/
indeno[1,2,3-*cd*]pyrene	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	49.5 µg/g	http://www.comar.bam.de/
	P	SRM-1647d	NIST	4.28 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
benzo*[g,h,i]*perylene	P	BCR-052	EC-JRC-IRMM	0.990 g/g	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	P	DPAC-1	NRC-CNRC, Canada	23 µg/g	http://inms-ienm.nrc-cnrc.gc.ca/calserv/crm_e.html
	P	SIRM 10-2-30s	Q-chem Ltd., Slovakia	48.8 µg/g	http://www.comar.bam.de/
	P	SRM-1647d	NIST	3.68 µg /mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2260a	NIST	4.904 µg/mL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM-2270	NIST	35.34 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Simazine	P	SRM-3070	NIST	49.4 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Trichloromethane (Chloroform)	P	7288-96	GUP TSIKV, Russia	99.88 %	http://www.comar.bam.de/
		SRM-1639	NIST	6235 ng/µL	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm

Table 3: Certified reference materials related to the WFD priority substances
Matrix: S – Sediment; W – Water; A – Aquatic plant or animal

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
Anthracene	**S**	EC-1	National Water Research Institute, Canada	1.2 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	41 µg/kg	http://www.comar.bam.de
	S	IAEA-383	IAEA Analytical Quality Control Services	0.03 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.0098 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	630 ng/g	http://www.comar.bam.de
	S	HS-3B	NRC-CNRC, Canada	2.76 µg/g	http://www.comar.bam.de
	S	HS-4B	NRC-CNRC, Canada	0.46 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	0.38 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	1.1 µg/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	184 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	1.77 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1974b	NIST	0.527 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.014 mg/kg	http://www.comar.bam.de
	A	IAEA-432	IAEA Analytical Quality Control Services	1.5 ng/g	http://www.comar.bam.de
Benzene	**S**	PR 9584	RIZA QA and Interlaboratory studies	7.62 µg/kg	http://www.comar.bam.de/
Cadmium and its compounds	**W**	BCR-505	EC-JRC-IRMM	0.80 nmol/kg	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	W	BCR-403	EC-JRC-IRMM	0.175 nmol/kg	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	W	BCR-609	EC-JRC-IRMM	0.164 µg/kg	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	W	BCR-610	EC-JRC-IRMM	2.94 µg/kg	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	W	BCR-713	EC-JRC-IRMM	5.1 µg/L	http://http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm/html/reference_materials_catalogue/index.htm
	W	BCR-714	EC-JRC-IRMM	19.9 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-715	EC-JRC-IRMM	40 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	QC LL2	EUROFINS (DK)	2 µg/L	http://www.eurofins.dk
	W	CASS-4	NRC-CNRC, Canada	0.026 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	LGC-6016	LGC-Promochem	101 µg/kg	http://www.comar.bam.de/
	W	LGC-6017	LGC-Promochem	0.13 µg/L	http://www.comar.bam.de/
	W	LGC-6019	LGC-Promochem	0.11 µg/L	http://www.comar.bam.de/
	W	NASS-5	NRC-CNRC, Canada	0.023 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLEW-3	NRC-CNRC, Canada	0.048 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLRM-12-3-10	Research Institute for Irrigation, Slovakia	0.005 µg/g	http://www.comar.bam.de
	W	SLRS-4	NRC-CNRC, Canada	0.012 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SRM-1640	NIST	22.79 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	SRM-1643e	NIST	6.408 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	TM-23.2	NRC-CNRC, Canada	2.6 µg/kg	http://www.comar.bam.de/
	W	TM-24	NRC-CNRC, Canada	12.5 µg/kg	http://www.comar.bam.de/
	W	TM-26.2	NRC-CNRC, Canada	6.8 µg/kg	http://www.comar.bam.de/
	W	TM-27	NRC-CNRC, Canada	1.0 µg/kg	http://www.comar.bam.de/
	W	TM-27.2	NRC-CNRC, Canada	1.2 µg/kg	http://www.comar.bam.de/
	W	TM-28	NRC-CNRC, Canada	1.2 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-51.2	NRC-CNRC, Canada	25.1 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-52.2	NRC-CNRC, Canada	91.4 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-53.2	NRC-CNRC, Canada	122 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-54.2	NRC-CNRC, Canada	185 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-95	NRC-CNRC, Canada	0.48 µg/kg	http://www.comar.bam.de/
	S	GBW-07314	NRCCRM, China	0.20 µg/g	http://www.comar.bam.de/
	S	GBW-08301	Institute of Environmental Chemistry, China	2.45 µg/g	http://www.comar.bam.de/
	S	HISS-1	NRC-CNRC, Canada	0.024 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	IAEA-SL-1	IAEA, Austria	0.26 mg/kg	http://www.comar.bam.de/
	S	MESS-3	NRC-CNRC, Canada	0.24 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	NIES-2	NIES, Japan	0.82 µg/g	http://www.comar.bam.de/
	S	NIES-9	NIES, Japan	0.15 µg/g	http://www.comar.bam.de/
	S	PACS-2	NRC-CNRC, Canada	2.11 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	SRM-1646a	NIST	0.148 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	8.8 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-2702	NIST	0.817 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	DORM-2	NRC-CNRC, Canada	0.043 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	LUTS-1	NRC-CNRC, Canada	2.12 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	DOLT-3	NRC-CNRC, Canada	19.4 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	TORT-2	NRC-CNRC, Canada	26.7 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	GBW-08571	Institute of Environmental Chemistry, China	4.5 µg/g	http://www.comar.bam.de/
	A	LGC-7160	LGC-Promochem	1.85 mg/kg	http://www.comar.bam.de/

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
	A	SLRM-12-2-02	Institute of Radioecology and Applied Nuclear Techniques, Slovakia	44.8 µg/kg	http://www.comar.bam.de/
	A	SRM-1566b	NIST	2.48 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2976	NIST	0.179 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	0.82 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	ERM-CE278	EC-JRC-IRMM	0.348 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-279	EC-JRC-IRMM	0.274 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-060	EC-JRC-IRMM	2.20 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-414	EC-JRC-IRMM	0.383 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-422	EC-JRC-IRMM	0.017 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
Hexachlorobenzene	**S**	EC-2	National Water Research Institute, Canada	200.6 µg/kg	http://www.comar.bam.de
	S	EC-3	National Water Research Institute, Canada	279 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	98 µg/kg	http://www.comar.bam.de
	S	SRM-1941b	NIST	5.83 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	6.03 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1945	NIST	32.9 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1946	NIST	7.25 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	BCR-598	EC-JRC-IRMM	55.7 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	IAEA-432	IAEA Analytical Quality Control Services	0.2 ng/g	http://www.comar.bam.de
	A	SRM-1588	NIST	157.8 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Hexachlorobutadiene	**S**	EC-2	National Water Research Institute, Canada	21.3 µg/kg	http://www.comar.bam.de
	S	EC-3	National Water Research Institute, Canada	61 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	21 µg/kg	http://www.comar.bam.de
	A	SRM-1945	NIST	32.9 µg /kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Hexachlorocyclohexane gamma-isomer	**S**	IAEA-408	IAEA Analytical Quality Control Services	0.00019 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	0.54 ng/g	http://www.comar.bam.de
	A	BCR-598	EC-JRC-IRMM	23.0 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	SRM-1588	NIST	24.9 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1945	NIST	3.30 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1946	NIST	1.14 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Lead and its compounds	**W**	7272-96	GUP TSIKV	0.103 g/L	http://www.comar.bam.de/
	W	BCR-403	EC-JRC-IRMM	0.117 nmol/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-609	EC-JRC-IRMM	1.63 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-610	EC-JRC-IRMM	7.78 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-713	EC-JRC-IRMM	47 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-714	EC-JRC-IRMM	145 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-715	EC-JRC-IRMM	0.49 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	QC LL2	EUROFINS (DK)	20 µg/L	http://www.eurofins.dk
	W	CASS-4	NRC-CNRC, Canada	0.0098 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	NASS-5	NRC-CNRC, Canada	0.008 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLEW-3	NRC-CNRC, Canada	0.0090 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLRS-4	NRC-CNRC, Canada	0.086 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	GBW-08601	NRCCRM, China	1.0 µg/g	http://www.comar.bam.de/
	W	GBW-08607	National Institute of Metrology, China	1.0 µg/g	http://www.comar.bam.de/
	W	GBW-08608	National Institute of Metrology, China	50 µg/kg	http://www.comar.bam.de/
	W	LGC-6016	LGC-Promochem	196 µg/kg	http://www.comar.bam.de/
	W	LGC-6017	LGC-Promochem	1.0 µg/L	http://www.comar.bam.de/
	W	LGC-6019	LGC-Promochem	5.2 µg/L	http://www.comar.bam.de/
	W	ERML-CA010a	LGC	95 mg/L	http://www.lgcpromochem.com
	W	SIRM 12-3-10	Research Institute for Irrigation, Slovakia	0.029 µg/g	http://www.comar.bam.de/
	W	SLRM-12-3-10	Research Institute for Irrigation, Slovakia	0.029 µg/g	http://www.comar.bam.de
	W	SRM-1640	NIST	22.79 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	SRM-1643e	NIST	19.45 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	TM-23.2	NRC-CNRC, Canada	3.8 µg/kg	http://www.comar.bam.de/
	W	TM-24	NRC-CNRC, Canada	7.3 µg/kg	http://www.comar.bam.de/
	W	TM-26.2	NRC-CNRC, Canada	9.9 µg/kg	http://www.comar.bam.de/
	W	TM-27	NRC-CNRC, Canada	4.9 µg/kg	http://www.comar.bam.de/
	W	TM-27.2	NRC-CNRC, Canada	3.2 µg/kg	http://www.comar.bam.de/
	W	TM-28	NRC-CNRC, Canada	3.0 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-51.2	NRC-CNRC, Canada	72.9 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-52.2	NRC-CNRC, Canada	368 µg/kg	http://www.comar.bam.de/

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
	W	TMRAIN-53.2	NRC-CNRC, Canada	360 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-54.2	NRC-CNRC, Canada	531 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-95	NRC-CNRC, Canada	0.29 µg/kg	http://www.comar.bam.de/
	S	GBW-07314	NRCCRM, China	25 µg/g	http://www.comar.bam.de/
	S	GBW-08301	Institute of Environmental Chemistry, China	79 µg/g	http://www.comar.bam.de/
	S	HISS-1	NRC-CNRC, Canada	3.13 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	MESS-3	NRC-CNRC, Canada	21.1 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	PACS-2	NRC-CNRC, Canada	183 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	IAEA-SL-1	IAEA, Austria	37.7 mg/kg	http://www.comar.bam.de/
	S	NIES-2	NIES, Japan	105 µg/g	http://www.comar.bam.de/
	S	NIES-9	NIES, Japan	1.35 µg/g	http://www.comar.bam.de/
	S	SRM-1646a	NIST	11.7 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	330 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-2702	NIST	132.8 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	BCR-060	EC-JRC-IRMM	63.8 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-279	EC-JRC-IRMM	13.48 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-414	EC-JRC-IRMM	3.97 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-422	EC-JRC-IRMM	0.085 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	ERM-CE278	EC-JRC-IRMM	2.00 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	DOLT-3	NRC-CNRC, Canada	0.319 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	DORM-2	NRC-CNRC, Canada	0.065 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	GBW-08571	Institute of Environmental Chemistry, China	1.96 µg/g	http://www.comar.bam.de/
	A	SLRM-12-2-02	Institute of Radioecology and Applied Nuclear Techniques, Slovakia	1.23 µg/g	http://www.comar.bam.de/
	A	SRM-1566b	NIST	0.308 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2976	NIST	1.19 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	2.27 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	LUTS-1	NRC-CNRC, Canada	0.010 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	TORT-2	NRC-CNRC, Canada	0.35 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
Mercury and its compounds	W	8004-93/1	GUP TSIKV	1.01 g/L	http://www.comar.bam.de/
	W	BCR-579	EC-JRC-IRMM	1.85 ng/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	ORMS-3	NRC-CNRC, Canada	12.6 pg/g	http://inms-ienm.nrc-cnrc.gc.ca
	W	SIRM 12-3-10	Research Institute for Irrigation, Slovakia	0.0011 µg/g	http://www.comar.bam.de/
	W	SRM-1641d	NIST	1.590 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	QC LL3	EUROFINS (DK)	5 µg/L	http://www.eurofins.dk
	W	QC LL3A	EUROFINS (DK)	0.5 µg/L	http://www.eurofins.dk
	S	ERM-CC580	EC-JRC-IRMM	132 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	GBW-07314	NRCCRM, China	0.20 µg/g	http://www.comar.bam.de/
	S	GBW-08301	Institute of Environmental Chemistry, China	0.048 µg/g	http://www.comar.bam.de/
	S	MESS-3	NRC-CNRC, Canada	0.091 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	PACS-2	NRC-CNRC, Canada	3.04 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	SRM-2702	NIST	0.4474 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	WQB-1	NRC-CNRC, Canada	1.09 µg/g	http://www.comar.bam.de
	S	WQB-3	NRC-CNRC, Canada	2.75 µg/g	http://www.comar.bam.de
	A	BCR-060	EC-JRC-IRMM	0.34 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-414	EC-JRC-IRMM	0.276 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-422	EC-JRC-IRMM	0.559 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	BCR-463	EC-JRC-IRMM	2.85 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	DOLT-3	NRC-CNRC, Canada	3.37 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	DORM-2	NRC-CNRC, Canada	4.64 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	ERM-CE278	EC-JRC-IRMM	0.196 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	ERM-CE464	EC-JRC-IRMM	5.24 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	GBW-08571	Institute of Environmental Chemistry, China	0.067 µg/g	http://www.comar.bam.de/
	A	LGC-7160	LGC-Promochem	0.096 mg/kg	http://www.comar.bam.de/
	A	SRM-1566b	NIST	0.0371 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1946	NIST	0.433 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1974b	NIST	17.0 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2976	NIST	61.0 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	TORT-2	NRC-CNRC, Canada	0.27 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
Naphthalene	S	EC-8	National Water Research Institute, Canada	10 µg/kg	http://www.comar.bam.de
	S	IAEA-383	IAEA Analytical Quality Control Services	0.096 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.027 mg/kg	http://www.comar.bam.de
	S	HS-3B	NRC-CNRC, Canada	2.14 µg/g	http://www.comar.bam.de
	S	HS-4B	NRC-CNRC, Canada	0.22 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	0.25 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	4.1 µg/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	848 µg/kg	http://ts.nist.gov/MeasurementServices/Ref

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
					erenceMaterials/232.cfm
	S	SRM-1944	NIST	1.65 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.017 mg/kg	http://www.comar.bam.de
	A	SRM-1974b	NIST	2.43 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Nickel and its compounds	W	7272-96	GUP TSIKV, Russia	0.102 g/L	http://www.comar.bam.de/
	W	8001-93/1	GUP TSIKV, Russia	1.00 g/L	http://www.comar.bam.de/
	W	SIRM 12-3-10	Research Institute for Irrigation, Slovakia	0.061 µg/g	http://www.comar.bam.de/
	W	BCR-403	EC-JRC-IRMM	4.4 nmol/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-505	EC-JRC-IRMM	24.1 nmol/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-713	EC-JRC-IRMM	30 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-714	EC-JRC-IRMM	108 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	BCR-715	EC-JRC-IRMM	1.20 µg/L	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	W	QC LL1	EUROFINS (DK)	15 µg/L	http://www.eurofins.dk
	W	SRM-1643e	NIST	60.89 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	W	GBW-08607	National Institute of Metrology, China	0.500 µg/g	http://www.comar.bam.de/
	W	GBW-08608	National Institute of Metrology, China	60 µg/kg	http://www.comar.bam.de/
	W	LGC-6016	LGC-Promochem	186 µg/kg	http://www.comar.bam.de/
	W	LGC-6017	LGC-Promochem	1.6 µg/L	http://www.comar.bam.de/
	W	LGC-6019	LGC-Promochem	2.6 µg/L	http://www.comar.bam.de/
	W	ERML-CA010a	LGC	48 mg/L	http://www.lgcpromochem.com
	W	CASS-4	NRC-CNRC, Canada	0.314 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLEW-3	NRC-CNRC, Canada	1.23 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	SLRS-4	NRC-CNRC, Canada	0.67 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	NASS-5	NRC-CNRC, Canada	0.253 µg/L	http://inms-ienm.nrc-cnrc.gc.ca
	W	TM-23.2	NRC-CNRC, Canada	5.3 µg/kg	http://www.comar.bam.de/
	W	TM-24	NRC-CNRC, Canada	3.5 µg/kg	http://www.comar.bam.de/
	W	TM-26.2	NRC-CNRC, Canada	9.9 µg/kg	http://www.comar.bam.de/
	W	TM-27	NRC-CNRC, Canada	2.7 µg/kg	http://www.comar.bam.de/
	W	TM-27.2	NRC-CNRC, Canada	2.5 µg/kg	http://www.comar.bam.de/
	W	TM-28	NRC-CNRC, Canada	19.3 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-51.2	NRC-CNRC, Canada	66.7 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-52.2	NRC-CNRC, Canada	268 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-53.2	NRC-CNRC, Canada	319 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-54.2	NRC-CNRC, Canada	325 µg/kg	http://www.comar.bam.de/
	W	TMRAIN-95	NRC-CNRC, Canada	0.80 µg/kg	http://www.comar.bam.de/
	S	SRM-1944	NIST	76.1 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-2702	NIST	75.4 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	GBW-07314	NRCCRM, China	34.3 µg/g	http://www.comar.bam.de/
	S	HISS-1	NRC-CNRC, Canada	2.16 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	IAEA-SL-1	IAEA, Austria	44.9 mg/kg	http://www.comar.bam.de/
	S	MESS-3	NRC-CNRC, Canada	46.9 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	NIES-2	NIES, Japan	40 µg/g	http://www.comar.bam.de/
	S	PACS-2	NRC-CNRC, Canada	39.5 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	S	WQB-3	NRC-CNRC, Canada	52.0 µg/g	http://www.comar.bam.de
	A	DOLT-3	NRC-CNRC, Canada	2.72 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	DORM-2	NRC-CNRC, Canada	19.4 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	LUTS-1	NRC-CNRC, Canada	0.2 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	TORT-2	NRC-CNRC, Canada	2.50 mg/kg	http://inms-ienm.nrc-cnrc.gc.ca
	A	GBW-08571	Institute of Environmental Chemistry, China	1.03 µg/g	http://www.comar.bam.de/
	A	BCR-414	EC-JRC-IRMM	18.8 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	A	SRM-2977	NIST	6.06 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	LGC-7160	LGC-Promochem	0.23 mg/kg	http://www.comar.bam.de/
Pentachlorobenzene	S	EC-2	National Water Research Institute, Canada	48.6 µg/kg	http://www.comar.bam.de
	S	EC-3	National Water Research Institute, Canada	65 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	30 µg/kg	http://www.comar.bam.de
Pentachlorophenol	S	BCR-530	EC-JRC-IRMM	0.47 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
PAHs benzo[*a*]pyrene	S	BCR-535	EC-JRC-IRMM	1.16 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	EC-1	National Water Research Institute, Canada	5.3 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	1.21 µg/g	http://www.comar.bam.de
	S	EC-3	National Water Research Institute, Canada	386 µg/g	http://www.comar.bam.de
	S	EC-5	National Water Research Institute, Canada	449 µg/kg	http://www.comar.bam.de/
	S	EC-8	National Water Research Institute, Canada	207 µg/kg	http://www.comar.bam.de
	S	IAEA-383	IAEA Analytical Quality Control Services	0.12 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.048 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	2800 ng/g	http://www.comar.bam.de
	S	HS-3B	NRC-CNRC, Canada	5.80 µg/g	http://www.comar.bam.de
	S	HS-4B	NRC-CNRC, Canada	1.55 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	1.7 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	2.2 µg/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	358 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
	S	SRM-1944	NIST	4.30 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.02 mg/kg	http://www.comar.bam.de
	A	IAEA-432	IAEA Analytical Quality Control Services	0.9 ng/g	http://www.comar.bam.de
	A	SRM-2977	NIST	8.35 µg/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1974b	NIST	2.80 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
fluoranthene	**S**	EC-1	National Water Research Institute, Canada	23.2 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	3.55 µg/g	http://www.comar.bam.de
	S	EC-3	National Water Research Institute, Canada	558 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	462 µg/kg	http://www.comar.bam.de
	S	HS-3B	NRC-CNRC, Canada	25.33 µg/g	http://www.comar.bam.de
	S	HS-4B	NRC-CNRC, Canada	3.33 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	8.4 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	3.54 µg/g	http://www.comar.bam.de
	S	IAEA-383	IAEA Analytical Quality Control Services	0.29 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.084 mg/kg	http://www.comar.bam.de
	S	SRM-1941b	NIST	651 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	8.92 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.088 mg/kg	http://www.comar.bam.de
	A	IAEA-432	IAEA Analytical Quality Control Services	12 ng/g	http://www.comar.bam.de
	A	SRM-1974b	NIST	17.1 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	38.7 µg/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
benzo[*b*]fluoranthene	**S**	BCR-535	EC-JRC-IRMM	2.29 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	IAEA-383	IAEA Analytical Quality Control Services	0.15 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.046 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	4100 ng/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	453 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	3.87 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	EC-8	National Water Research Institute, Canada	208 µg/kg	http://www.comar.bam.de
	S	EC-1	National Water Research Institute, Canada	7.9 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	2.48 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	2.0 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	2.8 µg/g	http://www.comar.bam.de
	A	IAEA-432	IAEA Analytical Quality Control Services	4.8 ng/g	http://www.comar.bam.de
	A	SRM-1974b	NIST	6.46 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	11.01 µg/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
benzo[*k*]fluoranthene	**S**	BCR-535	EC-JRC-IRMM	1.09 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	IAEA-383	IAEA Analytical Quality Control Services	0.073 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.046 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	2000 ng/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	225 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	EC-8	National Water Research Institute, Canada	294 µg/kg	http://www.comar.bam.de
	S	EC-1	National Water Research Institute, Canada	4.4 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	1.93 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	1.0 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	1.43 µg/g	http://www.comar.bam.de
	S	SRM-1944	NIST	2.30 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-432	IAEA Analytical Quality Control Services	1.9 ng/g	http://www.comar.bam.de
	A	SRM-1974b	NIST	3.16 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
indeno[1,2,3-*cd*]pyrene	**S**	BCR-535	EC-JRC-IRMM	1.56 mg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	EC-1	National Water Research Institute, Canada	5.7 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	1.55 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	34 µg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	2700 ng/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	1.3 µg/g	http://www.comar.bam.de

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
	S	HS-6	NRC-CNRC, Canada	1.95 µg/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	341 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	2.78 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.033 mg/kg	http://www.comar.bam.de
	A	SRM-1974b	NIST	2.14 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	4.84 µg/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
benzo[*g,h,i*]perylene	**S**	EC-1	National Water Research Institute, Canada	4.9 µg/g	http://www.comar.bam.de
	S	EC-2	National Water Research Institute, Canada	1.47 µg/g	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	176 µg/kg	http://www.comar.bam.de
	S	IAEA-383	IAEA Analytical Quality Control Services	0.19 mg/kg	http://www.comar.bam.de
	S	IAEA-408	IAEA Analytical Quality Control Services	0.038 mg/kg	http://www.comar.bam.de
	S	IAEA-417	IAEA Analytical Quality Control Services	2300 ng/g	http://www.comar.bam.de
	S	HS-3B	NRC-CNRC, Canada	3.88 µg/g	http://www.comar.bam.de
	S	HS-4B	NRC-CNRC, Canada	1.23 µg/g	http://www.comar.bam.de
	S	HS-5	NRC-CNRC, Canada	1.3 µg/g	http://www.comar.bam.de
	S	HS-6	NRC-CNRC, Canada	1.78 µg/g	http://www.comar.bam.de
	S	SRM-1941b	NIST	307 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	S	SRM-1944	NIST	2.84 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1974b	NIST	3.12 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	9.53 µg/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.02 mg/kg	http://www.comar.bam.de
Tributyltin compounds	**S**	BCR-462	EC-JRC-IRMM	54 ug/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	BCR-646	EC-JRC-IRMM	480 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
	S	HIPA-1	NRC-CNRC, Canada	78 ng/g	http://inms-ienm.nrc-cnrc.gc.ca
	S	PACS-1	NRC-CNRC, Canada	890 ng/g	http://inms-ienm.nrc-cnrc.gc.ca
	S	PACS-2	NRC-CNRC, Canada	0.890 mg/kg (Tri-)	http://inms-ienm.nrc-cnrc.gc.ca
	S	SOPH-1	NRC-CNRC, Canada	125 ng/g	http://inms-ienm.nrc-cnrc.gc.ca
	A	NIES-11	NIES, Japan	1.3 µg/g	http://www.comar.bam.de/
Trichlorobenzenes (1,2,4-trichlorobenzene)	**S**	EC-2	National Water Research Institute, Canada	80.7 µg/kg	http://www.comar.bam.de
	S	EC-8	National Water Research Institute, Canada	67 µg/kg	http://www.comar.bam.de

Table 4: Certified reference materials related to other pollutants
P - Pure compounds or solutions

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
DDT p,p'-DDT	**P**	SRM 1492	NIST	302 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM 2261	NIST	3.004 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM 2273	NIST	2.862 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM 2275	NIST		http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Dieldrin	**P**	SRM 1492	NIST	307 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	P	SRM 2261	NIST	3.012 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Endrin	**P**	SRM 2275	NIST	2.908 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Carbontetrachloride	**P**	SRM 3006	NIST	0.010099 g/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
Tetrachloroethylene	**P**	SRM 3010	NIST	0.009772 g/g	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm

Table 5: Certified reference materials related to other pollutants
Matrix: S – Sediment; W – Water; A – Aquatic plant or animal

Priority substance	Matrix	CRM-Identifier	Producer	Certified value	Reference
DDT p,p'-DDT	**S**	IAEA-408	IAEA Analytical Quality Control Services	0.0014 mg/kg	http://www.comar.bam.de
	S	SRM-1944	NIST	199 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1974b	NIST	3.91 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.0022 mg/kg	http://www.comar.bam.de
	A	SRM-1945	NIST	245 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1946	NIST	37.2 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-1588b	NIST	570 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	1.28 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	BCR-598	EC-JRC-IRMM	179 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm
Dieldrin	**S**	IAEA-408	IAEA Analytical Quality Control Services	0.0003 mg/kg	http://www.comar.bam.de
	A	IAEA-140/OC	IAEA Analytical Quality Control Services	0.0017 mg/kg	http://www.comar.bam.de
	A	SRM-1588b	NIST	156 µg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	SRM-2977	NIST	6.04 mg/kg	http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm
	A	BCR-598	EC-JRC-IRMM	59 µg/kg	http://www.irmm.jrc.be/html/reference_materials_catalogue/index.htm

ANNEX IV: Case Studies

Background information
Title/Name of case study: Pesticides in Surface Water Bodies from Agricultural Sources (Pesticide Program).
Type of case study: Monitoring to check the chemical and ecological status compliance (operational and investigative monitoring).
Reporting Institution: Ministry of the Environment (Spain).
Web-Link: www.mma.es
Main sources for further information; literature: *Analysis of pesticides and metabolites in Spanish surface waters by isotope dilution gas chromatography/mass spectrometry with previous automated solid-phase extraction. Estimation of the uncertainty of the analytical results.* Planas et al. Journal of Chromatography A, 1131 (2006) 242-252.
Objective of case study - background information: Development of the methodology for monitoring the pollution caused by pesticides from agricultural sources. Analysing pesticides is necessary to check the good chemical and ecological status compliance. The pesticides included in the monitoring program must be all the priority substances discharged and "other pesticides" discharged in significant quantities. It is not easy to select the "other pesticides" to analyse due to high number of possible compounds, changes in pesticides use, pesticide fate, etc. To solve this, the surveillance of pesticide pollution from agricultural activities may combine 2 types of analytical methodologies. Type 1: Standardized techniques with high level of QA/QC to monitor EQS compliance (legally binding EQSs or calculated EQSs). Type 2: MS characterization to determine new pesticides not included in common lists in order to incorporate them in the selected compounds to monitor in the future. This combined methodology is used to monitor pesticides in water bodies potentially at risk of failing to meet the pesticides EQS due to pressure from agricultural sources.
Contribution to…
Specific contribution linked to WFD monitoring programmes Operational and investigative monitoring design.
Description *Monitoring points*: water bodies potentially at risk of pesticides pollution from agricultural sources. *Matrix:* Water *Frequency*: 8 sampling/year *Methodology and substances* Using Isotope dilution GC/MS with previous automated SPE 10 pesticides from Priority Substances List , 04 pesticides from List II with national legally binding EQSs 05 metabolite pesticides 13 pesticides commonly used or detected in waters Using MS characterization of the all the pollutants present in the sample Unknown pesticide presents in the sample

Experiences gained - Conclusions - Recommendations **Experience gained:** Determination of the level of pollution from pesticides of water bodies at risk due to agricultural pressures. Development of a Methodology with high QA/QC data. Determination of new pollutants to be included in the Pesticides Program. **Conclusion**: A method based on isotope dilution GC/MS with automated SPE extraction was developed for the analysis of 32 pesticides and metabolites in surface water samples. Trueness was in the range 80-120% for 29 pesticides, precision below 15% for 25 compounds, method detection limit ranged from 1 to 9 ng/g and expanded uncertainties were < 40% for 24 pesticides. 93 Spanish surface water samples collected during summer and autumn 2004. Highest concentration and occurrence were found for atrazine, simazine, alachlor, terbutylazine and metoachlor included in the Priority List and/or Spanish Relevant List. New pesticides were detected using MS characterization technique, the pollutant molinate and imazalil and are included in the future pesticide program. Pesticides concentrations and occurrence are higher in the summer than in the autumn period. In summer, four pesticides were found in more than 50% of the analysed samples and four compounds were detected above the concentration level of 1 µg/l (atrazine, terbutylazine, 3,4-dichloroaniline and fenitrothion), while in autumn percentage of detection was bellow 50% for all pesticides, only one compound (terbutylazine) exceeded 1 µg/l. **Recommendations**: The surveillance of pesticides in water from agricultural activities needs the combination of 2 types of techniques. Standardized analytical methods with a high level of QA/QC to monitor specific pesticides, at least all the pollutants included in the Priority List and/or other National Relevant List in order to monitor the EQS compliance, and hence Chemical status. And the application of screening techniques to detect new pesticides from diffuse sources not included in common Lists in order to monitor ecological status compliance.
Outlook - Next steps – Accessibility of results/information

Background information
Title/Name of case study: Conversion of pollutant concentrations measured in suspended particulate matter (SPM) into total concentrations in the whole water sample.
Type of case study: Routine operation since 1990 in the water quality monitoring program of the international Rhine Commission (ICPR) for compliance checking of annual data of lipophilic pollutants with water quality targets.
Reporting Institution: International Commission for the Protection of the Rhine (ICPR)
Web-Link: http://www.iksr.de/fileadmin/user_upload/Dokumente/Berichte/IKSR_Bericht_Nr_143d.pdf
Objective of case study - background information – In surface waters a number of the priority substances are adsorbed to SPM from 50 close to 100 percent. The water quality targets of the ICPR (analogous the EQS) for organic priority substances are expressed as total concentrations, that is the dissolved portion plus adsorbed portion of the substance in the whole water sample. For some organic priority substances the AA-EQS are very low, and the respective detection limits of the recommended analytical methods are insufficient. The objective is to support compliance checking with whole water EQS (or ICPR water quality targets) by conversion of SPM determinand concentration.
Contribution to support compliance checking with EQS
Specific contribution linked to WFD monitoring programmes Surveillance monitoring design; specific monitoring of pollutants adsorbed to suspended particulate matter; compliance checking of SPM determinand concentration with whole water EQS.
Characterisation For organic micropollutants like PCB, TBT, PAH or hexachlorobenzene, the ICPR had developed water quality targets for whole water. For reasons of the analytical method, surveillance of the quality targets was performed by sampling and analyzing these pollutants in suspended particles. Sampling by centrifuge allows collecting the suspended material from several 1,000 litres of water within a few hours. Thus, a sufficient amount of SPM can be gained for chemical analysis, what corresponds to an enrichment from several 100 (or 1,000) litres of water. The amount of water centrifuged is recorded. **Course of procedure:** The concentration of contaminants is determined in µg/kg dw and converted to whole water by means of the SPM content (in mg/L): $C_{Ti} = (Si \times C_{si}) \times 10^{-6}$ C_{Ti} = total contaminant content on the day of sampling in µg/L Si = SPM content on the day of sampling in mg/L C_{si} = contaminant content in SPM on the day of sampling in µg/kg. This applies to substances that are adsorbed at SPM by more than 90 %. For substances that are adsorbed by 50 % at SPM, the value is multiplied by the factor 2: $C_{Ti} = 2\,(Si \times C_{si}) \times 10^{-6}$

Other factors might be selected for a particular substance, if the partition coefficient is known. The mean value (50- or 90-percentile in ICPR procedure) is calculated from the C_{Ti} values. Values below the limit of detection (limit of quantification) are included in the mean-value calculation (arithmetic mean) by the numerical value of the limit of detection. Then, the value of the arithmetic mean is indicated as “less than”.
Experiences gained - Conclusions - Recommendations **Experience gained:** The ICPR member states have successfully applied this method at selected sampling sites since 1990. The error that results from the arbitrary definition of the conversion factor for adsorption between 50 and 90 percent is negligible against the other errors in trace analyses. But for EQS compliance checking procedure it is possible to define the adsorbed portion for each priority substance in 10-percent steps (50, 60, 70, 80, 90 or 100 percent). **Conclusion**: The collection of the SPM from several 100 (or 1,000) litres of surface water allows the compliance checking of the EQS for priority substances, which are partially or not dissolved in the water because of their hydrophobic and lipophilic properties. Sampling by centrifuge is time- and labour-intensive and should be applied in surveillance monitoring only at selected sampling sites at large rivers. But it is no problem to meet the minimum performance criteria for the quality of analytical results – also for low EQS values (e.g. tributyl tin). The results of the contaminant concentrations in SPM can be used for comparisons with the EQS, and - after a hydrological interpretation - they are also suitable for trend analyses. **Recommendations**: - For selected priority substances and for selected monitoring sites at large rivers the described procedure is suitable for compliance checking with EQS and for trend analyses. Special attention should be given to the following micropollutants: Pentabromodiphenylether, C10-13 chloroalkanes, Fluoranthene, Hexachlorobenzene, Pentachlorobenzene, PAH (Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Indeno(1,2,3-cd)pyrene), Tributyltin and Trifluralin. - the result of each measurement (spot sample) is converted into the total determinand concentration by means of the SPM content of the water and according to the percent factor of the adsorbed portion of contaminants; - No further effort is necessary for analytical techniques to obtain a limit of quantification half of the EQS.
Outlook - Next steps – Accessibility of results/information

Background information
Title/Name of case study: Comments Concerning the National Swedish Contaminant Monitoring Programme in Marine Biota
Type of case study: Monitoring activities within the Swedish contaminant programme in marine biota
Reporting Institution: Environmental Protection Agency (Sweden)
Web-Link: www.naturvardsverket.se
Main sources for further information; literature: Comments Concerning the National Swedish Contaminant Monitoring Programme in Marine Biota, 2006
Objective of case study - background information: The data of concern in this report represent the bioavailable part of the investigated contaminants i.e. the part that has virtually passed through the biological membranes and may cause biological effects. The main objectives of the monitoring program in marine biota could be summarised as follows: - to estimate the levels and the normal variation of various contaminants in marine biota from several representative sites, uninfluenced by local sources, along the Swedish coasts. The goal is to describe the general contaminant status and to serve as reference values for regional and local monitoring programmes - to monitor long term time trends and to estimate the rate of found changes. - to estimate the response in marine biota of measures taken to reduce the discharges of various contaminants - to detect incidents of regional influence or widespread incidents of 'Chernobyl'- character and to act as watchdog monitoring to detect renewed usage of banned contaminants. - to indicate large scale spatial differences - to explore the development and regional differences of the composition and pattern of e.g. PCB's, HCH's and DDT's as well as the ratios between various contaminants.
Contribution to…
Specific contribution linked to WFD monitoring programmes Surveillance monitoring design and operational monitoring design as soon as EQS are developed for biota.
Description Substances monitored: Metals, for example Hg, Cd, Pb and Cu and organic substances, for example PCB, DDT, Lindane, brominated flameretardants and dioxins. Sampling area: The sampling sites are located in areas regarded as locally uncontaminated and, as much as possible, uninfluenced by major river outlets or ferry routes and not too close to heavy populated areas. Collected specimens: For many species adult specimens are less stationary than sub-adults. To increase comparability between years, young specimens are generally collected. Only healthy looking specimens with undamaged skin are selected. The collected specimens are placed individually in polyethene plastic bags, deep frozen as soon as possible and transported to the sample preparation laboratory.

Number of samples and frequency: In general 20 individual specimens from the Baltic sites (reported to HELCOM) and 25 from the Swedish westcoast sites (reported to OSPARCOM) are analysed annually from each site/species. For guillemot eggs and perch, 10 individual specimens are analysed. Organo-chlorines in blue mussels are analysed in pooled samples containing about 50 individual specimens in each pool. Since 1996, samples from 12 individual specimens are analysed which is proposed in the revised guidelines for HELCOM and OSPARCOM.

Experience gained:
Continuous development of design for both a spatial and temporal monitoring programme and also increased knowledge of choice of matrix. The importance of quantifying objectives.

Conclusion:
Herring is the most commonly used indicator species for monitoring contaminants in biota within the BMP (Baltic Monitoring Programme) in the HELCOM convention area and is sampled by Finland, Estonia, Poland and Sweden. Herring muscle tissue is fat and thus very appropriate for analysis of fatsoluble contaminants i.e. hydrocarbons.

Cod is among the 'first choice species' recommended within the JAMP (Joint Assessment and Monitoring Programme) and BMP (Baltic Monitoring Programme). The cod liver is fat and organic contaminants are often found in relatively high concentrations. For that reason, it is also a very appropriate matrix for screening for 'new' contaminants.

Mussels are one of the most common used organisms for monitoring contaminants in biota. Adult mussels are sessile and hence it is easier to define the area the samples represent, compared to fish.
Blue mussel is among the 'first choice species' recommended within the JAMP (Joint Assessment and Monitoring Programme).

Recommendations:
It is very important that the objectives of the monitoring are quantified before designing a monitoring programme. When the objectives are defined the choice of sampling location, matrix, sampling method and analytical procedure could cause problems if the proper guidelines are not followed.

Outlook - Next steps – Accessibility of results/information

Background information
Title/Name of case study: Screening of Industrial and Consumer Chemicals in Finland (VESKA 1)
Type of case study: Screening to select sites and substances for surveillance monitoring of WFD
Reporting Institution: Finnish Environment Institute SYKE
Web-Link: http://www.ymparisto.fi
Main sources for further information; literature:
Objectives of case study: To study the occurrence and concentrations of the substances chosen by risk assessment in the aquatic environment close to emission sources To produce information for the purpose of emission source identification. To develop the analytics used to examine harmful substances and to build up cooperation network between laboratories. To develop a risk assessment method that can be used to estimate the circulation of the studied compounds in nature and to minimize the expenses needed for their monitoring. To set a criterion that could be used to preclude or add substances to a more detailed monitoring plan.
Contribution to…
Specific contribution linked to WFD monitoring programmes Supply data for national surveillance monitoring programme 2006-2008
Description The study was carried out in the vicinity of twelve industrialized cities in Finland, in water systems downstream municipal sewage treatment plants. Concentrations were measured in sludge and waste water samples (1-3 occasions) and surface water (1-3 occasions), sediment (once, surface 2-3 cm) and fish (4-10 specimen pooled, Northern pike, *Esox lucius*) muscle samples. Organotin compounds (both butyl and phenyl –forms) were found in all matrices, often exceeding EQS or "benchmark" values. This will trigger more research, monitoring and management activities MBT and DBT were found in sediments also below inland sewage treatment plants, indicating sources other than antifouling paints (stabilizer in plastics). TPhT indicated bioaccumulation: found less than TBT in sediments but more in fish Alkylphenols, phthalates, organotin compounds, HCH, HCB and VOC-compounds were found in treated sewage water. Out of these, only DEHP and alkylphenols were found in excess of surface water EQS proposals. In surface waters, only nonylphenol ethoxylates were found at the (national) EQS-level. Several substances were not detected (other alkylphenols, chlorobenzenes and volatile organic compounds). PAHs, PBDE, organotins and phthalates were, however, not measured in surface water phase. In sediments, organotins, PAHs, HCHs and dibutylphthalate were most commonly found.
Experience gained:

Conclusion: Simultaneous screening of several substance groups might not be cost-efficient for industrial and household chemicals with several, poorly known sources. On national level, surveillance monitoring will be started for alkylphenols, phthalates and PAHs in water (10 sites/year). First year (mid 2007- mid 2008) results will determine the need of continuation (rotation, cessation). Sediment and biota monitoring continues (5-15 sites, 2-6 yr rotation) for lipophilic substances. **Recommendations**: In addition to analytical problems at low concentrations, natural conditions in Northern Europe (lake-richness, low temperature, low particulate matter, low degradation, low population/water volume) would favour sediment and/or biota over water, in monitoring many industrial and household chemicals presently on the Priority Substances list (e.g. PBDE, HCB, SCCP, some PAHs, DEHP, TBT). Effect-based monitoring should be developed and brought into the guidance for impact monitoring locations.
Outlook - Next steps – Accessibility of results/information New groups of substances will be screened in sewage effluents and waste deposit leachates. The impact monitoring of selected compounds will start gradually along source identification and the renewal process of the permissions (industrial and municipal STPs) with statutory monitoring.

Background information
Title/Name of case study: Pesticide Screening in Finnish Surface Waters (VESKA 2)
Type of case study: Screening to select sites and substances for surveillance monitoring of WFD
Reporting Institution: Finnish Environment Institute (SYKE)
Web-Link: http://www.ymparisto.fi/download.asp?contentid=49817&lan=EN
Main sources for further information; literature:
Objectives of case study: To study the occurrence and concentrations of agricultural pesticides in Finnish surface waters. To produce information for identification of emission source. To develop a risk assessment method that can be used to minimize the expenses of later monitoring.
Contribution to…
Specific contribution linked to WFD monitoring programmes Supply data for national surveillance monitoring programme 2006-2008
Description *Monitoring points*: water bodies (streams and rivers) potentially at risk of pesticide pollution from agricultural sources *Matrix*: surface water and the top of bottom sediment (0-1 cm) *Duration:* 2004 - 2005 *Frequency* - at one intensive site: weekly (May-Oct 2004) + monthly in winter (2004-2005) - intermediate sites: monthly (Apr/May-Sep/Oct) - areal screening sites: twice (Jun/Jul + Jul/Aug in 2005). *Analysed substance*: - 100 compunds from water samples using :multi-residue methods (GC-MS and LC-MS-MS) (including all pesticides in the EU Priority list and four of the six pesticides in the national list of pesticides) - Tribenuronmethyl (a low-dose herbicide in the national list) from part of water samples using a specific analysing method - The 14 pesticides analysed from sediment samples were selected basing on partitioning coefficients (from the EU and national lists of priority substances and other potential pesticides). *Number of samples:* 190 water samples + 31 sediment samples The study was carried out in two parts. The objective of the pilot year 2004 was to find the best timing for surface water sampling and to assist in the selection of the sampling sites for a survey for following year. In the second year (2005) the main objective was areal representativeness, but most of the sites were sampled only twice at the time of expected high concentrations. In 2004 the focus was in upstream sites (catchment areas: 1-100 km^2) close to fields. Surface water was collected in an intensive site and in 6 other agricultural streams. Additional samples were collected once from 6 rivers (Sep/Oct). The pilot year indicated that agricultural land use percent was more important factor to explain pesticide detections than catchment area. In 2005, sampling sites were selected from watershed register using agricultural land use percent as the

main criterion: 35 agricultural sites and five reference sites from non-agricultural areas (catchment areas of the sampling points: .50 - 37 000 km^2). In addition, six rivers and two of the smaller streams sampled during the pilot year were sampled monthly (May-Oct) in 2005.

Pesticides in water samples (70 (in 2004) + 120 (in 2005) + quality assurance samples):
The number of different pesticides detected was 24 in 2004 and 46 in 2005. Detected concentrations were mainly low (traces). In 2005, one or more herbicides were detected in 90% of water samples. Phenoxy acid herbicides were most frequently found compounds. This may be explained by the volume of they use in Finland. Only following few exceedings of EQS values were observed during the screening, although the sampling was focused in the expected concentration peaks and in the areas of high pesticide loadings:

- Endosulfansulphate was detected in one site (3 detections /3 sampling times) (max 0.02 µg/l = quantification limit), while suggested EQS-value is 0.005 µg/l.
- The detected peaks of MCPA concentration exceed national EQS value (1.6 µg/l) in several sites (max 8.8 µg/l), but concentrations were still lower than MacQS (15 µg/l).
- In single samples the concentrations of low-dose herbicides (thifensulfuronmethyl, tribenuronmethyl) were higher than Swedish "target values". However, the Finnish national EQS of tribenuronmethyl was not exceeded.
- Insecticides were detected seldom, which is inline with the sold amounts of them. Pirimicarb was found in one site and its concentration was higher than Norwegian limit value.

Pesticides in sediment samples (31 + a parallel sample):
In 2005, the top of bottom sediment (in all sites where possible) was sampled and 14 substances were analysed and 6 detected from sediment samples samples. Atrazine (forbidden in 1991) was detected in more than half of the sediment samples, prochloraz in every third sample, and the others in single samples. Currently there are no confirmed sediment EQS values for pesticides, but the earlier proposed values were exceeded in case of atrazine, prochloraz, endosulfan and its metabolite endosulfansulphate.

Conclusion:
Simultaneous screening of several substances was cost-efficient for pesticides. High number of different pesticide compounds, mainly herbicides and their metabolites were detected. Concentrations exceeded seldom levels of potential environmental threat.

The time and site of sampling have significant effects on the results. No watershed specific information about pesticide usage is available. Agricultural land use percent was a good tool in selecting sampling sites, but further information about the type of agriculture (e.g. typical crops) would help in finding the risky sites.

The intensive agricultural land use fraction is usually rather low in big Finnish catchments and pesticides are diluted in water from non-agricultural areas in big rivers while pesticides may occasionally pose local problems in some small streams close to fields.

Outlook - Next steps – Accessibility of results/information
For year 2007 the statutory pesticide monitoring is planed to be performed in 8 rivers and in one stream (10-12 samples/site). Later (in 2008-) it will be reasonable to include some upstream sites to monitoring program.

Background information
Title/Name of case study: French National Monitoring Network (RNO) Réseau National d'Observation de la qualité du milieu marin
Type of case study: A 30 years Chemical monitoring network (surveillance and operational monitoring)
Reporting Institution: **IFREMER** (Institut français de recherche pour l'exploitation de la mer) French Research Institute for Exploitation of the Sea
Web-Link: www.ifremer.fr and www.ifremer.fr/envlit/surveillance/rno.htm
Main sources for further information; literature: Annual bulletin may be downloaded at : **www.ifremer.fr/envlit/surveillance/rnopublis.htm**
Objective of case study - background information: 1. Assessment of the levels and trends of the chemical contamination of the French coastal seas. 2. To meet OSPAR and Barcelona Conventions monitoring obligations
Contribution to…
Specific contribution linked to WFD monitoring programmes Surveillance and Operational Monitoring
Description **Chemical contaminants monitored :** - metals : Ag, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn - organochlorinated compounds: DDT compounds, HCH isomers, PCB congeners - PAH's : 16 US-EPA PAH's and some alkylated PAH's **Strategy of monitoring :** The RNO is largely based on bivalve molluscs (mussels and oysters) which are used as quantitative indicators of contamination. **Some 90 sampling points are sampled twice a year for metals and once a year for organic contaminants**. Analyses are carried out at a single laboratory, the Ifremer Center of Nantes. An aliquot of the samples is systematically archived for possible controls at a later date or the retrospective search of other contaminants (the bank contains more than 8000 samples, since 1981). The contaminants are also measured in the sediments. The first centimetre of the surface sediments can integrate several years of contamination. A yearly sampling cruise is carried on 1/10 of the French maritime frontage, the whole French littoral being covered every 10 years. The contaminants measured are the same than in biota, in addition to descriptive and normalization parameters (grain size, organic carbon, carbonates, aluminium, iron, lithium and manganese). Some sediment cores are collected to reconstruct the history of the contamination over several decades.
Experience gained: Direct monitoring in water is not used any longer because it is too expensive and not reliable. Indeed, the operational difficulties to collect valid samples (i.e. uncontaminated and representative) for analyses of substances present in water at trace levels are too great. First, collecting uncontaminated samples needs a care difficult to reach in routine monitoring. Secondly, the spatial and temporal representativeness of samples collected in Water Bodies affected by tides and currents, are too low. This is our first-hand

experience of direct measurements of contaminants in water which was carried out between 1979 and 1984 and abandoned for the reasons above. This is coherent with the OSPAR Convention monitoring programme which is also based on biota and sediment.

Conclusion:

To assess the levels of contamination by metals and organic hydrophobic substances, it is highly preferable to use accumulative matrixes that present higher levels and allow temporal integration of the natural water variability.

Recommendations:

Within the frame of the WFD, Surveillance Monitoring should be advantageously carried out in sediments for the metals and hydrophobic substances. One survey by Management Plan (6 years) would be sufficient to assess the quality of the Water Bodies.

Operational Monitoring needs to assess temporal trends of the contamination and should be carried out in biota (mussels as a first choice). One survey per year (synchronous with biological life cycle of the biota) would make possible to evaluate the trends.

Outlook - Next steps – Accessibility of results/information

Ifremer developed a Web site including a broad section devoted to marine monitoring (**www.ifremer.fr/envlit/surveillance**). It is possible to view and to download the data of contaminants in molluscs for each sampling point.

Background information
Title/Name of case study: What Concentrations of Hazardous Substances Do We Find in the Environment? Results from the Swedish Screening Programme 2003-2004
Type of case study: Screening
Reporting Institution: Environmental Protection Agency (Sweden)
Web-Link: www.naturvardsverket.se
Main sources for further information; literature: What concentrations of hazardous substances do we find in the environment? Results from the Swedish Screening Programme 2003-2004 Report 5524, February 2006.
Objective of case study - background information: For the purpose of obtaining information regarding the concentrations of newly discovered persistent organic pollutants (POPs), as well as other potential problem substances used in society, the national environmental monitoring scheme was supplemented by a screening programme a few years ago. In this programme, one or more selected substances are measured on one or more occasions during a single year and in different media, such as sewage, fish or air. Screening was initiated on a small scale in 1996-97 and has gradually increased in scope since then. The reason for including a substance in the screening programme may be that it is used on a large scale, that it has been prioritized in various international contexts, or that it has attracted national attention for other reasons.
Contribution to…
Specific contribution linked to WFD monitoring programmes Data for substances those are not included in the regular monitoring programme.
Description The screening studies have been modelled on the **DPSIR** strategy. This strategy analyses environmental problems based on **D**rivers such as those created by industry, **P**ressures on the environment such as polluting discharges that harm the **S**tate of the environment, which in turn results in an **I**mpact on human health and the environment, whereby we try to find **R**esponses or actions to deal with the problems. *A screening study consists of the following closely-connected parts:* Choice of substance Preparatory theoretical study Measurement study Evaluation
Experience gained: The primary purpose of the screening is not to support research on new POPs, but to comply with requirements on reporting of certain substances in various EU directives and international conventions. Many of these substances are of no relevance for Sweden, and the screening could help to show this so that resources do not have to be wasted on measurement of these substances.

Draw attention to new environmental pollutants. Informing the public without frightening them is important, but perhaps even more important is furnishing data to those who work with chemical risk reduction, i.e. various public authorities.

Conclusion:
Further studies should be made of the following substance groups
Organophosphates
Bisphenol A
α- and β-endosulfan
Siloxanes
Chloro- and bromostyrenes

The following substance group should be subjected to another screening study in a few years
Adipates

The following substance groups do not have to be followed regularly
Chlorinated paraffins
Limonene
Mirex
Isocyanates

Recommendations:
Will be based on the results obtained for each substance/group.

Outlook - Next steps – Accessibility of results/information
Data are available on the Internet from the environmental monitoring scheme's data host for screening.
http://www.ivl.se/english/ivlstartpage/rightmenu/environmentaldata.4.360a0d56117c51a2d30800064209.html

Background information
Title/Name of case study: Monitoring Using Passive Sampling Devices to Improve Trace Metal-Related Risk Assessments
Type of case study: Complementary monitoring by *in-situ* deployment of passive sampling to help reduce the uncertainty associated with infrequent grab sampling for compliance monitoring
Reporting Institution: University of Portsmouth (UK), Bureau de Recherche Géologique et minière (Fr) As part of the EU-funded FP6 project *Screening Methods for Water Data information in support of the implementation of the WFD (SWIFT-WFD)*
Web-Link: none
Main sources for further information; literature: *Evaluation of the performance of the Chemcatcher and DGT passive sampling devices for monitoring heavy metals in water* Allan IJ, Knutsson J, Guigues N, Mills GA, Fouillac A-M and Greenwood R, (in preparation) *(2007)*
Objective of case study - background information: Demonstration of the applicability of passive sampling to increase confidence in measures of water quality provided by infrequent spot (bottle) sampling campaigns. Grab or bottle sampling followed by filtration at 0.45µm is to be used for compliance checks (AA-EQS & MAC-EQS). Whilst monthly spot samples provide a precise estimate of concentrations of contaminants at the time of sampling, there is uncertainty concerning conditions prevailing in the periods between sampling events. This is of particular concern where concentrations are known to fluctuate or where there are significant or potential natural or anthropogenic pressures. One possible solution to this problem is to deploy passive samplers to provide time-weighted average (TWA) concentrations of concentrations of contaminants in the period between grab samples. This may confirm or contradict the data from the routine monitoring campaigns, and should help to reduce the possibility of making erroneous decisions in risk assessments required in the implementation of the WFD. In this application the TWA concentrations of metals estimated using DGT and Chemcatcher samplers were compared with estimates based on spot sampling in the Meuse River (Eijsden, The Netherlands). In this trial 2 different grab sampling procedures were used at relatively high frequencies (one to three times per week) and metal analyses conducted in two different laboratories in a pilot-scale inter-organisational comparison that incorporated both the analytical determination and the sampling step.
Contribution to…
Specific contribution linked to WFD monitoring programmes Surveillance and operational monitoring tasks
Description *Matrix:* Water *Passive sampling:* Use of the Diffusive Gradient in Thin Film (DGT) and Chemcatcher sampling devices following guidelines provided in the BSI Publicly Available Specification 61, and analysis of sampler extracts by ICP-MS in an university research laboratory. *Sampler exposure:* Consecutive and/or overlapping 7, 14, 21 and 28 day periods *Grab sampling protocol 1:* Routine weekly sampling, transport of the sample to the laboratory followed by filtration (0.45 µm) and ICP-MS analysis. *Grab sampling protocol 2:* Sampling every two or three days, on-site filtration (0.45 µm) and analysis by ICP-OES in an accredited laboratory.

Experience gained:
There was good agreement between the results for cadmium, copper, nickel and zinc provided by the two types of samplers, despite differences in their working principles. High and fluctuating concentrations of cadmium (between proposed MAC-EQS and AA-EQS thresholds) were detected by passive sampling during the first 14 day exposure period. This was confirmed by the relatively high frequency of grab sampling used in this trial, but may have been missed if only conventional sampling rates had been used. Extra information, on speciation of the metals, was provided by the samplers, and this was consistent with predictions obtained using equilibrium speciation modelling with visual MINTEQ (NICA-Donnan model).

Conclusion:
Reliability and consistency of TWA metal concentrations measured by passive sampling were shown when compared with 2 distinct grab sampling protocols in a procedure that included uncertainty both on the sampling and analytical measurement steps. This provided representative information on average concentrations. On the other hand an estimate based on a single grab sample could have provided misleading information since for instance levels of Cd varied over a factor of five during the trial.

Recommendations:
Passive sampling devices should be deployed following BS PAS 61 guidelines and manufacturer's specifications for period up to 14 to 20 days to achieve representative sampling. This should be combined with grab sampling to reduce monitoring uncertainty to manageable levels.

Outlook - Next steps – Accessibility of results/information
These results will be published in detail in a peer-reviewed scientific journal.

A desirable extension of this work would be to increase the duration of the trial to two or three years in order to provide a reliable, long-term comparison between the average concentrations of contaminants estimated by routine grab sampling, and passive sampling. This would establish the utility of the two methods either on their own or in combination to quantify trends in trace metal concentrations over time. Since the two methods measure different (operationally defined, and water body specific) fractions of metals, relationships between the concentrations in filtered bottle samples and those measured by passive samplers need to be established.

Other future developments may include testing and optimising combinations of grab and passive sampling in order to improve sampling representativeness while ensuring a reduction in monitoring costs.

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 20

GUIDANCE DOCUMENT ON EXEMPTIONS TO THE ENVIRONMENTAL OBJECTIVES

EUROPEAN COMMISSION

environment

Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

Activities to support the implementation of the Water Framework Directive are under way both in Member States and in the European Commission. The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. The focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In the context of this common implementation strategy (CIS), a series of working groups and joint activities have been launched for the development and testing of non-legally binding Guidance Documents. A strategic co-ordination group oversees these working groups and reports directly to the Water Directors of the European Union and Commission that play the role of the overall decision body for the Common Implementation Strategy.

As a result of a four year discussion initiated by the Water Directors and assisted by a Drafting Group, several documents have been prepared to identify some key issues and make recommendations related to environmental objectives and exemptions.

Now this previous work is brought together in one consolidated document to give a full overview on the issue of environmental objectives and exemptions. This document compiles previously agreed interpretations on issues related to environmental objectives and exemptions and does not add any new issues. The previously agreed documents will stay available on Circa[1] as background documents for this consolidated guidance document.

1 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/environmental_objectives

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1 INTRODUCTION - A GUIDANCE DOCUMENT: WHAT FOR?

On 23 October 2000, the "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" or, in short, the **EU Water Framework Directive** (or even shorter the WFD) was adopted. By means of this Framework Directive, the EU provides for the management of inland surface waters, groundwater, transitional waters and coastal waters in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.

The environmental objectives are defined in Article 4 - the core article - of the Water Framework Directive (WFD). The aim is long-term sustainable water management based on a high level of protection of the aquatic environment. Article 4.1 defines the **WFD general objective** to be achieved in all surface and groundwater bodies, i.e. good status by 2015, and introduces the principle of preventing any further deterioration of status. There follow a number of **exemptions** to the general objectives that allow for less stringent objectives, extension of deadline beyond 2015, or the implementation of new projects, provided a set of conditions are fulfilled.

As for many of the challenging concepts under the WFD, the text of the directive provides the framework and gives the general orientation but there is scope for differences in understanding and application. So from the first day of the implementation it was clear that the use of exemptions needed to be explained further and the rules for application had to become clearer.

Under the Common Implementation Strategy (CIS) of the WFD several working groups for various topics have been set up[2]. The issue of exemptions was firstly addressed in the working group on economics (WATECO) where a first indication of how to deal with exemptions related to disproportionate costs is given. The WATECO guidance document, endorsed by the Water Directors, in particular started to discuss exemptions in the light of disproportionate costs.

In June 2005, the Water Directors (WD) endorsed a paper on the environmental objectives under the WFD (WFD). This document introduced key elements regarding the environmental objectives of the WFD. At the end of 2006, the Water Directors endorsed a Policy Paper on the application of Article 4.7 for new modifications. In November 2007, a third document dealing with the exemptions on extension of deadlines (4.4), the setting of less stringent objectives (4.5) and temporary deterioration (4.6) was endorsed by the Water Directors. Finally, a specific paper with conclusions on disproportionate costs was endorsed by the Water Directors in June 2008[3].

In addition to the agreed documents, information on case studies and practical examples was exchanged at various occasions. Information related to a workshop held in Berlin in 2005 and in Copenhagen in 2008 can be found at the Circa website[4].

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[2] See http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents

[3] All papers can be found at http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/environmental_objectives

[4] See http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/objectives_exemptions and http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/disproportionate

After this, all existing earlier agreed papers are brought together into one consolidated document, resulting in this guidance document. Chapter 2 recalls the requirements of the WFD related to the environmental objectives and the exemptions. Chapter 3 reflects on key issues for the interpretation of the exemptions. In paragraph 3.2, horizontal issues which are applicable to two or more exemptions are addressed. In addition to these horizontal issues, paragraph 3.3 until 3.5 included address some specific issues related to each exemption.

This guidance document intends to provide earlier agreed information in a complete way, and may be useful for water managers involved in preparing the river basin management plans, as well as to the public interested in the (draft) river basin management plans (RBMP) and the related process of objectives setting.

2 RECALL OF WFD REQUIREMENTS IN RELATION TO ENVIRONMENTAL OBJECTIVES

2.1 General introduction

The environmental objectives and the exemptions are set under Article 4 of the WFD. The subsequent paragraphs aim at describing Article 4, mainly the exemptions, in a summarised way and in the order presented in the Directive.

Article 4 WFD sets out the **"environmental objectives"** mainly in Article 4.1. The **main environmental objectives** in the Directive are manifold and include the following elements (for details see Article 4.1, (a) surface waters, (b) groundwaters and (c) protected areas):

- ***No deterioration*** of status for surface and groundwaters and the protection, enhancement and restoration of all water bodies;
- Achievement of *good status* by 2015, i.e. good ecological status (or Potential) and good chemical status for surface waters and good chemical and good quantitative status for groundwaters;
- ***Progressive reduction of pollution*** of priority substances and ***phase-out*** **of** priority hazardous substances in surface waters[5] and prevention and limitation of input of pollutants in groundwaters;
- ***Reversal*** of any significant, upward ***trend*** of pollutants in groundwaters;
- Achievement of Standards and objectives set for ***protected areas*** in Community legislation.

It is important to note that where more than one of the objectives relates to a given body of water, the most stringent shall apply (Art. 4.2), irrespective of the fact that all objectives must be achieved.

It is important to understand that the normative definitions for the environmental objective of "good status" are described in the Directive in great detail in Annex V. However, the development of specific numerical criteria and classification schemes including class boundaries is described only as regards the process. Taking into account the results of the intercalibration exercise Member States are obliged to set detailed values defining the status for each water body.

For **heavily modified and artificial water bodies**, Article 4.1 point (a) indent (iii) sets out "specific objectives" for these specific water bodies. In Article 4.3, strict criteria for the designation of artificial or heavily modified water bodies are described.

In order to achieve the specific objectives for heavily modified and artificial water bodies (i.e. good ecological potential and good chemical status), the provisions for designation (see Article 4.3), contain elements of comparing the consequences of achieving the 'good ecological status' to a number of aspects including economic considerations. Moreover, the assessment of "good ecological potential" is linked to the possible mitigation measures[6].

There has been a debate whether these requirements should be interpreted as "alternative objectives" or "exemptions". **It has been agreed that artificial and heavily modified water bodies do not constitute a conventional objective or exemption. They are a**

[5] Pollution of "other pollutants" than PS and PHS need to be reduced by Member States in accordance with Article 11 (3) (k) WFD.

[6] See Guidance Document No. 4 on "Identification and Designation of HMWB and AWB" for more detail. http://europa.eu.int/comm/environment/water/water-framework/guidance documents.html

specific water body category - with its own classification scheme and objectives - which is related to the other exemptions in requiring certain socio-economic conditions to be met before it comes to play.

An integral part of the environmental objectives set out in Article 4 are the so-called exemptions. Article 4.4, 4.5, 4.6 and 4.7 describe the conditions and the process in which they can be applied. These exemptions range from small-scale temporary exemptions to mid- and long term deviations from the rule "good status by 2015[7]", and include the following aspects:

- **the extension of the deadline** , in other words, good status must be achieved by 2021 or 2027 at the latest (Article 4.4) or as soon as natural conditions permit after 2027;
- the achievement of **less stringent objectives** under certain conditions (Article 4.5);
- the **temporary deterioration** of the status in case of natural causes or "force majeur" (Article 4.6);
- **new modifications** to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater, or failure to prevent status deterioration of a body of surface water (including from high status to good status) as a result of new sustainable human development activities (Article 4.7).

Common to all these exemptions are strict conditions to be met and a justification to be included in the River Basin Management Plan.

Comparing the criteria for applying the various exemptions (or "exemption tests"), there are some similarities between them. Thus, it should be discussed how and when to apply particular exemptions and whether there is a certain sequence or hierarchy when applying them together (see chapter 3 for more details).

Finally, paragraphs 8 and 9 of Article 4 introduce two principles applicable to all exemptions,

- first, exemptions for one water body must not permanently exclude or compromise achievement of the environmental objectives in other water bodies
- second, at least the same level of protection must be achieved as provided for by existing Community law (including those elements to be repealed).

2.2 Scope of article 4.4 and 4.5

Under certain conditions, the WFD permits the assignment of a less stringent objective or the extension of the timescales for achieving a particular objective:

Art 4.4
The deadlines established under paragraph 1 may be extended for the purposes of phased achievement of the objectives for bodies of water, provided that no further deterioration occurs in the status of the affected body of water when all of the following conditions are met:

(a) Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales set out in that paragraph for at least one of the following reasons:

(i) the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;
(ii) completing the improvements within the timescale would be disproportionately expensive;
(iii) natural conditions do not allow timely improvement in the status of the body of water.

[7] or "good ecological potential by 2015 " for HMWB and AWB.

(b) Extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan required under Article 13.

(c) Extensions shall be limited to a maximum of two further updates of the river basin management plan except in cases where the natural conditions are such that the objectives cannot be achieved within this period.

(d) A summary of the measures required under Article 11 which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, the reasons for any significant delay in making these measures operational, and the expected timetable for their implementation are set out in the river basin management plan. A review of the implementation of these measures and a summary of any additional measures shall be included in updates of the river basin management plan.

Art 4.5
Member States may aim to achieve less stringent environmental objectives than those required under paragraph 1 for specific bodies of water when they are so affected by human activity, as determined in accordance with Article 5(1), or their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive, and all the following conditions are met:

(a) the environmental and socioeconomic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs;

(b) Member States ensure,
— for surface water, the highest ecological and chemical status possible is achieved, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution,
— for groundwater, the least possible changes to good groundwater status, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution;

(c) no further deterioration occurs in the status of the affected body of water;

(d) the establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the river basin management plan required under Article 13 and those objectives are reviewed every six years.

2.3 Scope of article 4.6

Article 4.6 differs from articles 4.4 and 4.5 in that it relates to events which "could not reasonably have been foreseen".

Art 4.6.
Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause or force majeure which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents which could not reasonably have been foreseen, when all of the following conditions have been met:

(a) all practicable steps are taken to prevent further deterioration in status and in order not to compromise the achievement of the objectives of this Directive in other bodies of water not affected by those circumstances;

(b) the conditions under which circumstances that are exceptional or that could not reasonably have been foreseen may be declared, including the adoption of the appropriate indicators, are stated in the river basin management plan;

(c) the measures to be taken under such exceptional circumstances are included in the programme of measures and will not compromise the recovery of the quality of the body of water once the circumstances are over;

(d) the effects of the circumstances that are exceptional or that could not reasonably have been foreseen are reviewed annually and, subject to the reasons set out in paragraph 4 (a), all practicable measures are taken with the aim of restoring the body of water to its status prior to the effects of those circumstances as soon as reasonably practicable, and

(e) a summary of the effects of the circumstances and of such measures taken or to be taken in accordance with paragraphs (a) and (d) are included in the next update of the river basin management plan.

Hence it is not used for setting alternative objectives during the improvement planning process - rather it is used after the event, as a "defence" to justify why an objective which was set in a river basin management plan has not been met. This justification must be provided in the following (update of the) river basin management plan. Details are discussed in section 3.4.

2.4 Scope of article 4.7

Article 4.7 sets out circumstances in which failure to achieve certain of the WFD objectives are permitted.

Art 4.7.
Member States will not be in breach of this Directive when:

- failure to achieve good groundwater status, good ecological status or, where relevant, good ecological potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of new modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater, or

- failure to prevent deterioration from high status to good status of a body of surface water is the result of new sustainable human development activities

and all the following conditions are met:

(a) all practicable steps are taken to mitigate the adverse impact on the status of the body of water;
(b) the reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years;
(c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, and
(d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

Note that Article 4.7 does not provide an exemption if deterioration caused by inputs of pollutants from point or diffuse sources drives the water body to a status below good.

If the resulting development is not causing a deterioration of status on the water body scale, art. 4.7 does not have to be used (for example if replacing one activity by another).

Details on how Art 4.7 can be applied are provided in section 3.5.

3 KEY ISSUES IN THE PROCESS OF JUSTIFYING EXEMPTIONS

3.1 General Introduction

When discussing exemptions it should be taken into account that the WFD is an environmental directive and exempting from its objectives should not be the rule but exceptional. It is important that before considering the application of exemptions for a certain water body, all relevant requirements from existing EU legislation for the protection of water have to be fulfilled. Nevertheless "exemptions" are an integral part of the environmental objectives set out in Article 4 and the planning process.

Member States are encouraged to keep the analysis for applying exemptions as simple as possible, but as detailed as necessary. The level of information should be determined by the complexity of the decision and the possible consequences of taking the wrong decision.

When consensus is reached between all relevant stakeholders in an early stage of the decision-making process, the efforts for data gathering may be reduced. Thus, early consensus may help to reduce analytical efforts but does not replace an economic analysis.

In the following section the key issues to use exemptions are outlined in more detail. First, some horizontal issues related to the exemptions in general are set out (in paragraph 3.2), followed by specific issues for Article 4.4 and 4.5 (in paragraph 3.3), Article 4.6 (in paragraph 3.4) and Article 4.7 (paragraph 3.5).

3.2 Horizontal issues

3.2.1 Scale

Member States have to set objectives for individual water bodies. As reflected in the 2010 reporting sheets, Member States are asked to report each water body for which the objective will not be good status by 2015; the alternative objective related to the affected quality element, and the reasons for this.

It is however recognised that different scales (national, basin, sub-basin, water body) may be appropriate for different assessments or different aspects of the same assessment. For example, transboundary issues have to be assessed on a transboundary scale. However, the choice of the scale should be justified by the provisions of the WFD and if the information used to justify an exemption is gathered at a more aggregated level it needs to be clear that the aggregated information is relevant for the concerned water body or group of water bodies.

Furthermore, Article 4.8 specifies that when applying an exemption to a water body, "a Member State shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation." Regarding the link between water bodies, it is clear that there cannot be an automatic mechanism for justifying exemptions in an adjacent water body on the basis of an assessment carried out for another water body. This does not necessarily imply that the reasons (e.g. water uses or significant pressures) for justifying an exemption must always be located within the water body for which the exemption is sought for.

3.2.2 Protected areas

It is generally understood that the exemptions in Article 4.4 and 4.5 and 4.6 are applicable to all environmental objectives in Article 4.1, thus also to Article 4.1(c), which describes the objectives for protected areas. But Article 4.9 is clear in its obligation that when applying the exemptions of Article 4, the same level of protection should be given as in existing Community legislation. This means that exemptions from the WFD environmental objectives cannot be used to deviate from objectives and obligations set by other pieces of EU legislation.

For example, a new development is proposed that would cause deterioration of status and a failure to achieve the objectives for a Natura 2000 site. In such a case, in order to fulfil both the WFD and the Habitats Directive:

- The relevant conditions set out in Article 4.7 of the WFD for allowing deterioration of status would have to be met to the extent that it is a water body; and
- The conditions set out in Article 6 of the Habitats Directive (92/43/EEC) for allowing a failure to achieve a Natura 2000 site's objective would have to be met.

3.2.3 Management of uncertainties

Uncertainty is an inevitable feature of objective setting in general, and will therefore be a feature of the first set of river basin plans[8]. Uncertainties should be taken into account in deciding the appropriate action. This action may include further investigation, monitoring and assessment to reduce uncertainties and this could contribute to the justification for the phasing of measures across cycles. Uncertainty will reduce over the medium to long term but will always be present. There can be uncertainty about:

- Whether, and to what extent, a water body is adversely impacted and what and/or who causes the impact;
- The impact of policies already in place or planned and various trends and developments, including innovation and technical change;
- The effectiveness of measures in addressing an adverse impact on a water body (note that this will have an effect on the certainty of the benefits as well);
- The assessment of the achievement of good status[9];
- The costs associated with measures;
- The benefits resulting from improvements to the status of water bodies, particularly the calculation of the non-marketable benefits.

These uncertainties will also relate to the analysis for applying exemptions, and will have substantial impact on cost and benefit estimates. There are a number of things which can be done, and should be done, to reduce uncertainties or to deal with them in the decision-making process. For example:

- Choose reversible measures, measures that can be easily adapted, measures that can be carried out iteratively or measures with low risk and costs, and high return[10]. Where

[8] See also Guidance nr 13 on Classification of Ecological Status on: http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents

[9] A number of uncertainties are addressed by the Directive's requirements to apply the 'one out - all out' principle and to set physico-chemical Standards characterising the good Status and to use hydro-morphological parameters to define the high Status. The pressure - Status - impact relations are well researched and understood for most of those non-biological parameters. Furthermore, uncertainties associated with the assessment of water body Status are addressed in the CIS ECOSTAT work programme 2007-2009.

[10] These measures are often referred to as 'no-regret measures'.

there is significant uncertainty, the risk of incurring disproportionate costs can be reduced by choosing measures that can be readily and iteratively added to, or adapted, in the future on the basis of information on their effects and the associated benefits. However, these kinds of measures are not necessarily the ones that are most acceptable to stakeholders.

- Estimating and recording the level of uncertainty is needed to take into account uncertainty in objective setting.
- Weigh the benefits in such a way that the additional uncertainty of benefits relative to costs is taken into account. The same logic should apply where costs are more uncertain than benefits, though this is likely to be less common in practice.
- Actions need to be taken to reduce uncertainty (e.g. by research programmes), although these actions need to be proportional. The findings of the Article 5 reports are an important basis for addressing knowledge gaps and identifying follow-up actions.
- Efforts to reduce uncertainty should be proportional to the difficulty of the decision at hand and the implications of making a wrong decision. However, there is no point attempting to reduce uncertainty if doing so does not clarify the decision at hand. It may be better to act on the basis of principle, for example the precautionary principle and/or the polluter pays principle and/or, where possible, on the basis of consensus.
- There needs to be a balance between the risk of failing to meet objectives and the risk of failing to use the most cost-effective means of achieving those objectives, with priority being given to minimising the risks of the first.

For example, the effectiveness of diffuse pollution measures may be more uncertain than the effectiveness of point source pollution measures. Conversely, the costs of diffuse pollution measures may be less than the costs of point source pollution measures.

3.2.4 Technical infeasibility

In principle, only issues of a technical nature should be taken into account in applying the technical infeasibility test - as referred to in Article 4.4 and 4.7 - and not cost issues. Although cost savings may be associated with extending the deadline for achieving good status, such savings are not relevant in deciding whether making the improvements by the deadline would be technically infeasible.

Technical infeasibility is justified if:

- No technical solution is available;
- It takes longer to fix the problem than there is time available;
- There is no information on the cause of the problem; hence a solution cannot be identified.

In practice, the greater the effort expended in trying to overcome practical issues of a technical nature, the greater the likelihood that technically feasible ways of making the improvements will be found. This means that consideration of the costs and benefits will need to be considered alongside technical feasibility. Where the benefits resulting from an improvement would be substantial, a much higher degree of effort to find a technically feasible option is likely to be appropriate than where the benefits of an improvement are expected to be low.

Further guidance can be provided by the term 'best available technique (BAT)' which is defined in the IPPC-directive (96/61/EC)[11], although in the cases where going beyond BAT might be technically feasible, these options should be explored.

Article 4.5 refers to the term 'infeasible', which includes technical infeasibility, but which could also refer to situations where addressing a problem is out of the control of a Member State.

3.2.5 Disproportionate costs

The term disproportionate costs (or disproportionately expensive) is used in Article 4.4, 4.5 and 4.7 of the WFD. Below, some principal issues related to these terms are addressed.

3.2.5.1 General introduction of the terms 'disproportionate costs'

'Disproportionality', as referred to in Article 4.4 and 4.5, is a political judgement informed by economic information, and an analysis of the costs and benefits of measures is necessary to enable a judgement to be made on exemptions. It was already concluded in the WATECO guidance that, given the uncertainty around estimates of costs and benefits one should bear in mind that,

- Disproportionality should not begin at the point where measured costs simply exceed quantifiable benefits;
- The assessment of costs and benefits will have to include qualitative costs and benefits as well as quantitative;
- The margin by which costs exceed benefits should be appreciable and have a high level of confidence;
- In the context of disproportionality the decision-maker may also want to take into consideration the ability to pay of those affected by the measures and some information on this may be required.

From the logic of the WFD is becomes clear that an assessment of disproportionate costs only makes sense after a combination of the most cost-effective solutions has been identified. Most importantly, for all cases where an exemption is applied, all measures that can be taken without involving disproportionate costs should still be taken to reach the best status possible.

In cases where exemptions are considered the consequences of non-action (i.e. foregone benefits) need to be weighed against the specific costs of the measures.

3.2.5.2 Costs of measures required under other Community legislation

The costs of measures required under existing Community legislation already agreed at the time of the adoption of the Directive cannot be considered when deciding on disproportionate costs. Without prejudice to the transitional arrangements in the Accession Treaties, this also applies to Member States which joined the EU in 2004 and 2007.

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[11] 'best available techniques' shall mean the most effective and advanced stage in the development of activities and their methods of Operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole. For further details, see http://ec.europa.eu/environment/air/legis.htnrfstationary

3.2.5.3 Affordability issues

Affordability (or ability to pay for a certain measure) can be one element for justifying the decision on a time extension (i.e. application of Article 4.4), if based on a clear explanation:

- of the non-availability of relevant alternative financing mechanisms which would not result in affordability issues,
- of the consequences of non-action in deciding on an extension of the deadline,
- of steps to resolve the affordability issues in the future.

Non-action by one player does not automatically lead to non-action by other players within the same sector.

Furthermore, Member States may phase the implementation of measures to spread the costs of the implementation, but there is the need for clear and demonstrable action in the first cycle.

When affordability arguments are used to extend the deadline, the possibility to use relevant **alternative financing mechanisms** should be fully considered. The alternative financing mechanisms could include distribution of costs among polluters and users, use of the public budget (at different levels), private investment, EU and international funds, etc. These relevant alternative financing mechanisms should be considered at the appropriate scale.

On the role of affordability in setting less stringent objectives, no guidance can be provided at this stage. For some Water Directors affordability could play a role in setting less stringent objectives, as both Article 4(4) and 4(5) use the same terminology 'disproportionately expensive'. They indicated that in practice affordability arguments may be used less frequently in Article 4(5) than in Article 4(4). Some other Water Directors argued that affordability can not be used as an argument for setting less stringent objectives as the context of 'disproportionate expenses' is different in 4(5) from the context in Article 4(4) as it concerns setting lower objectives permanently (subject to revision every 6-years). These Water Directors consider that application of this provision requires it to be set out clearly that the costs outweigh the benefits of achieving the targets.

On the role of constraints of the public budget as a reason for extending the deadline, no guidance can be provided at this stage either. Most Water Directors indicated that constraints of the public budget may be used as a reason for extending the deadline as there are limits to the available budget for water management. The Commission indicated that in its views the adoption of the WFD by the Council and the European Parliament entails obligations for Member States to make available the necessary means for its implementation.

3.2.5.4 Prioritisation approaches in the context of disproportionate costs

The Water Directors agreed that a proportionate selection of the different analyses (cost-benefit analysis, benefits assessment, assessment of the consequences of non-action, distribution of costs, social and sectoral impacts, affordability, cost-effectiveness etc) is useful to inform decision making.

It was also agreed by the Water Directors that prioritisation approaches for ranking measures that are considered technically feasible can be the first operational steps in the assessment of cost disproportionality, but that a justification of an extension of the deadline following these approaches should respect the relevant provisions of the WFD. The results of prioritisation have to be developed on or transformed to the water body level when relevant.

It was emphasised that prioritisation takes place on different geographic / administrative levels (e.g. MS, River Basin, Region, sub unit, water body) and should consider the different basic conditions in the area. The prioritisation process should take into account a set of relevant criteria, for example:

- synergies with other directives, e.g. habitat directive, flood risk management directive
- cost-efficiency / benefits of measures
- consequences of non-action
- certainty / uncertainty ("no regret measures")
- measures which could be implemented short term
- urgency of problem to be solved(severe consequences/high cost of non action: e.g. protection of drinking water supplies)
- existence of available financing mechanisms
- acceptance by the public

Prioritisation criteria and results should be transparent and should be disclosed to the public. The prioritisation approach should also give information on the further timescale to reach the environmental objectives.

3.2.6 Alternative means

In both Article 4.5 and Article 4.7, the necessity is mentioned to assess 'alternative means'. In Article 4.5 this refers to alternatives to serve the environmental and socioeconomic needs served by a certain human activity, which are a significantly better environmental option not entailing disproportionate costs. In Article 4.7 it is indicated that it is necessary to demonstrate that the beneficial objectives served by the modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

Those means or alternatives solutions could involve alternative locations, different scales or designs of development, or alternative processes. Alternatives should be assessed in the early stages of development and at the appropriate geographical level (EU, national, RBD) against a clear view of the beneficial objectives provided by the modification.

For projects under its scope, the use of the requirements of the EIA Directive can help to assess the different possible alternatives.

3.2.7 Transboundary context

In international river basin districts within the EU, exemptions need to be coordinated. This obligation to coordinate the requirements for the achievement of the environmental objectives is indicated in Article 3.4 and 3.5.

Exemptions can be applied in cases where a certain Member State cannot resolve the reasons for not achieving the environmental objectives because they lay outside the competence and jurisdiction of the Member State. In these cases, a country causing the problem should be obliged to provide enough information for justification of the application of exemptions for the affected Member State.

Frequent information exchange between Member States, and between an EU Member State and a country outside the EU, is crucial when applying exemptions in a transboundary context. This includes information on intermediate objectives and the expected evolution for the water bodies where exemptions are applied. This enables affected Member States to adapt their own planning process.

In cases where the reasons for not achieving good status cannot be resolved by a Member State since they are outside the competence and jurisdiction of the Member State, the WFD includes the provision of Article 12 on the involvement of the Commission to solve the issue.

The key issue in both applying the exemption and invoking Article 12 is the demonstration of evidence that Member States have taken all reasonable actions to fulfil the legal obligations.

More information on the transboundary context is included in Annex II: Exemptions in a transboundary context

3.2.8 Public participation and transparency

Active participation at an early stage should be encouraged not only because of legal requirements, but it can also be used to get a better insight in factors influencing the application of exemptions (such as costs and benefits and technical feasibility). Further, it might also give an early indication of acceptability and create a basis of understanding of a certain decision on objective setting. However, public information and consultation do not guarantee acceptance of a range of (feasible) measures.

As a minimum, the public should be given insight in the reasons for applying exemptions (eg. as mentioned in Article 4(a) i, ii and iii) per water body for which an exemption is applied.

Public information and consultation is not only an obligation of WFD Article 14 and other legislation, also Article 4(4) and 4(5) and the related recitals require that the following information should be provided in the river basin management plans[12]:

- the reasons for an extension of the deadline should be specifically set out
- the reasons for the establishment of less stringent environmental objectives should be specifically mentioned;
- a summary of the measures to bring the bodies of water *progressively* to the required status;
- the reasons for any significant delay in making the measures operational;
- the expected timetable for the implementation of the measures (that are delayed);
- the appropriate, evident and transparent criteria used for applying exemptions

It is agreed that:

- there is the need for clear and demonstrable action in the first cycle;
- when applying the 'disproportionality justification', the reasons, underlying data and assessments should be made public;
- if affordability arguments are used, an explanation that there are no relevant alternative financing mechanisms available;
- an explanation of how consequences of non-action are taken into account and what action will be taken to address these reasons, so that in the future a time extension is no longer needed.

[12] See 4.4(b):'Extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan required under Article 13' and 4.4(d):' A summary of measures required under Article 11 which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, the reasons for any significant delay in making these measures operational, and the expected timetable for their implementation are set out in the river basin management plan.' and 4.5(d):' the establishment of less stringent environmental objectives and the reasons for it, are specifically mentioned in the river basin management plan required under Article 13 and those objectives are reviewed every six years', including reasons why 'the environmental and socioeconomic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs' (4.5(a)).

3.2.9 Link with Strategic Environmental Assessment and Environmental Impact Assessment

Both in applying Article 4.4/4.5 and in applying Article 4.7, the question may arise regarding how a link to the Environmental Impact Assessment (EIA)[13] and/or Strategic Environmental Assessment (SEA)[14] can be best made.

Some measures to improve status may fall within the scope of the EIA Directive and hence require an EIA (see Figure below). Furthermore, the EIA Directive gives a list of some of the environmental factors to consider in assessment of environmental costs and benefits which should be a starting point.

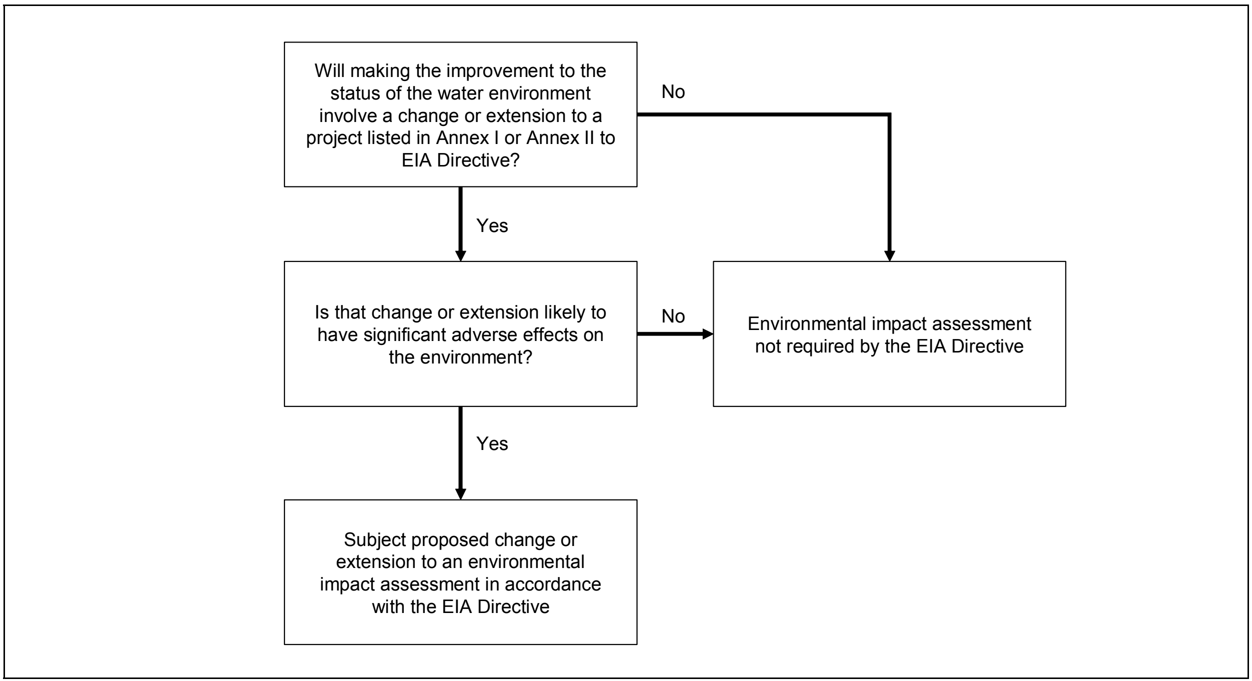

Figure 0: Link between EIA and measures under the WFD

Information from an already carried out SEA or EIA should be used as much as possible in exemptions tests. However, a formerly carried out EIA is not a blank cheque for application of the WFD exemptions.

The assessment of whether the criteria and conditions set out in **Article 4.7** are met needs to be carried out in the planning stage. Thus, it makes sense to incorporate such an evaluation into the environmental impact assessment which has to be done for most of these types of projects. However, even if certain projects are not covered by the EIA Directive, article 4.7 may apply. For plans and programmes affecting the environmental objectives of the WFD, the evaluation in accordance to 4.7 should be incorporated into the SEA[15].

In summary, the planning of "new modifications" requires the carrying out of an assessment of the environmental impacts which demonstrates, at least, that the criteria and conditions of Article 4.7, but also 4.8 and 4.9, are met.

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[13] Directive 85/337/EEC

[14] Directive 2001/42/EC

[15] See guidance document on the implementation of the SEA Directive, available at http://europa.eu.int/comm/environment/eia/sea-support.htm

3.3 Key issues for Article 4.4 and 4.5

3.3.1 Relationship between Article 4.4 and 4.5

The relationship between Article 4.4 and Article 4.5 is not a hierarchy in the sense that Member States must prove that one is ruled out before considering another. Member States are free to apply either exemption, provided the relevant exemption tests are met. However, the conditions for setting less stringent objectives require more information and in-depth assessment of alternatives than those for extending the deadline. For this reason, there should be a stepwise thinking process for considering what sort of exemption may be most appropriate (see Figure 1).

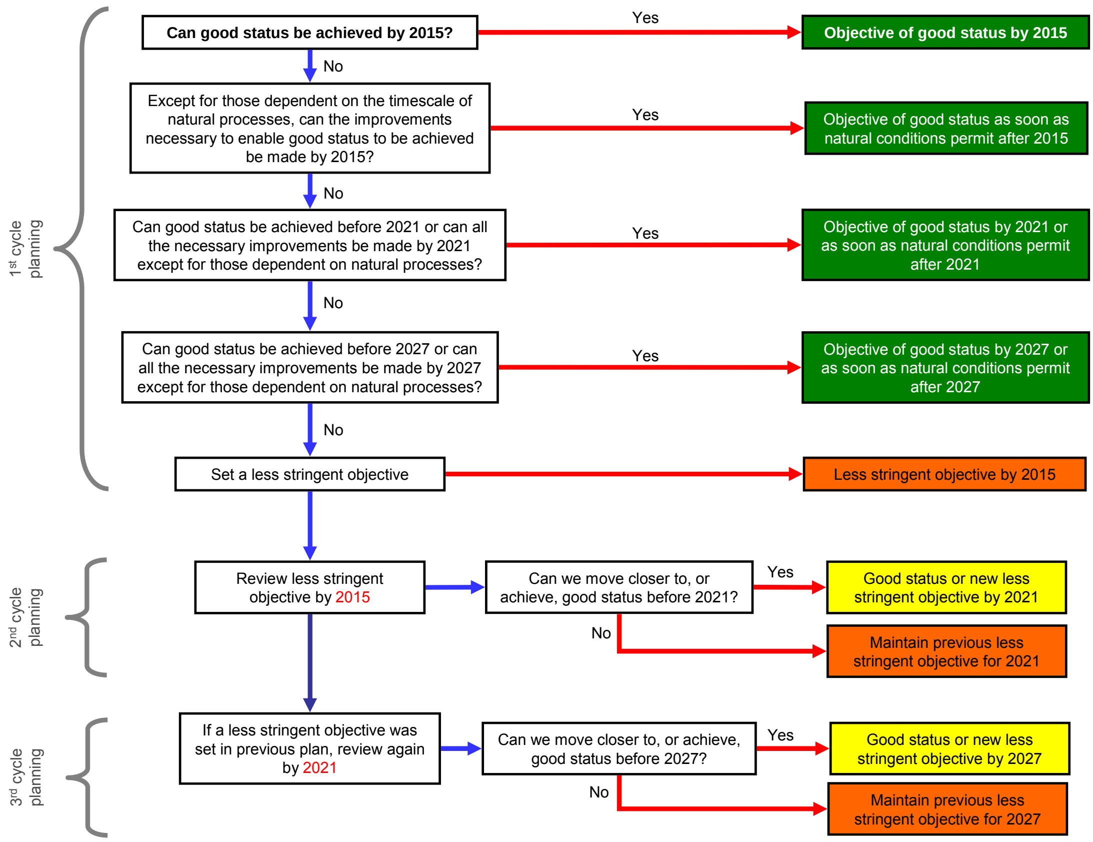

Figure 1: Stepwise thinking process for the considerations of exemptions from good status. The orange boxes refer to Art 4.5, the green except the first box to Art 4.4. For water bodies designated as heavily modified or artificial, references in the Figure to 'good status' should be taken to mean 'good ecological potential and good surface water chemical status[16]. Note, if the objective of "good status" is aimed for (green boxes), the achievement of "good status" needs to be confirmed by monitoring data.

[16] All information needed for the decision on exemptions should be on the desk before starting the stepwise process, especially the economic data and assessments, as these make it possible to test the proportionality of costs, which is one assumption for the achievement of good status

3.3.2 Internal logic of Article 4.4

Figure 2 summarises the principal tests involved in deciding whether the application of an extended deadline is appropriate. Other tests also need to be considered before applying an extended deadline. These include meeting the conditions specified in paragraphs 8 and 9 of Article 4 of the Directive.

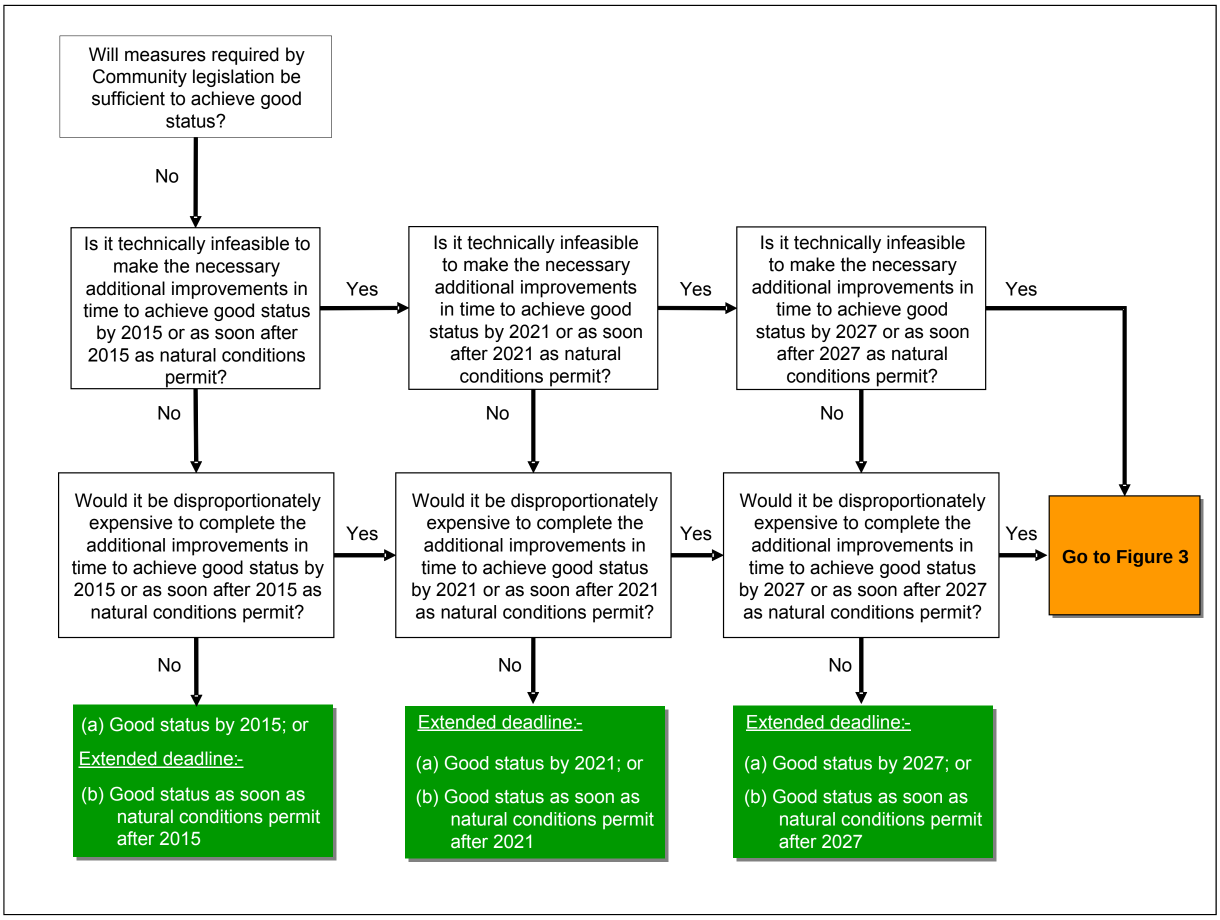

Figure 2: Internal logic of Article 4.4 - References in the Figure to good status should be interpreted as references to good ecological potential and good chemical status when dealing with heavily modified or artificial water bodies.

The Figure represents the internal logic of Article 4.4 as a step-wise linear process. However, in practice Member States may apply the process in a more iterative manner. For example, where it is technically infeasible to achieve good status by 2015 because there is no known technique for doing so (see above), consideration of the other tests illustrated in Figure 2 will not be relevant. Instead, the application of a less stringent objective (see Figure 3 below) could be considered. In contrast, if achieving good status by 2015 is technically infeasible because of technical constraints on the timing of making the measure operational, consideration of whether the measure could be implemented in time to achieve good status by 2021 or 2027 would be relevant in order to decide if an extended deadline might be applicable.

The tests should not be applied in relation to any improvements to the status of water bodies that are required by other Community legislation (see above). Exemptions may only be applied in relation to the additional improvements that would be necessary to achieve good status once compliance with relevant Community legislation has been achieved.

Where an exemption for an extended deadline is applied, a summary of the measures envisaged as necessary to achieve good status by the extended deadline and the expected timetable for their implementation must be set out in the RBMP. A review of the implementation of these measures and a summary of any additional measures must be included in updates of the RBMP. In the second and third planning cycle, Figure 2 should be used by leaving out the first column boxes referring to 2015.

The tests require consideration of the measures needed to address the pressures on the water body and so create the conditions necessary for the achievement of good status. It should be borne in mind that the rate of recovery of the water body to good status once such conditions have been established may be delayed because of natural conditions. Where natural conditions are preventing the timely achievement of good status by 2015, Article 4.4 provides that the deadline may be extended until such time as the water body recovers to good status.

Some changes of the institutional framework for putting alternative financing mechanisms in place, or addressing other administrative or legal constraints, may need time. In some cases, pursuing these changes within the first management cycle may lead to disproportionate costs. In cases where certain procedural requirements need to be fulfilled to take measures, the deadline for achieving the environmental objectives may need to be extended. In all cases where administrative or legal constraints occur, a description of the constraints has to be given in the RBMP as well as an explanation of how these constraints will be addressed in the future.

3.3.3 Internal logic of Article 4.5

Figure 3 is intended to illustrate the process of checking whether a less stringent objective is applicable and, if so, the process for identifying what the less stringent objective should be.

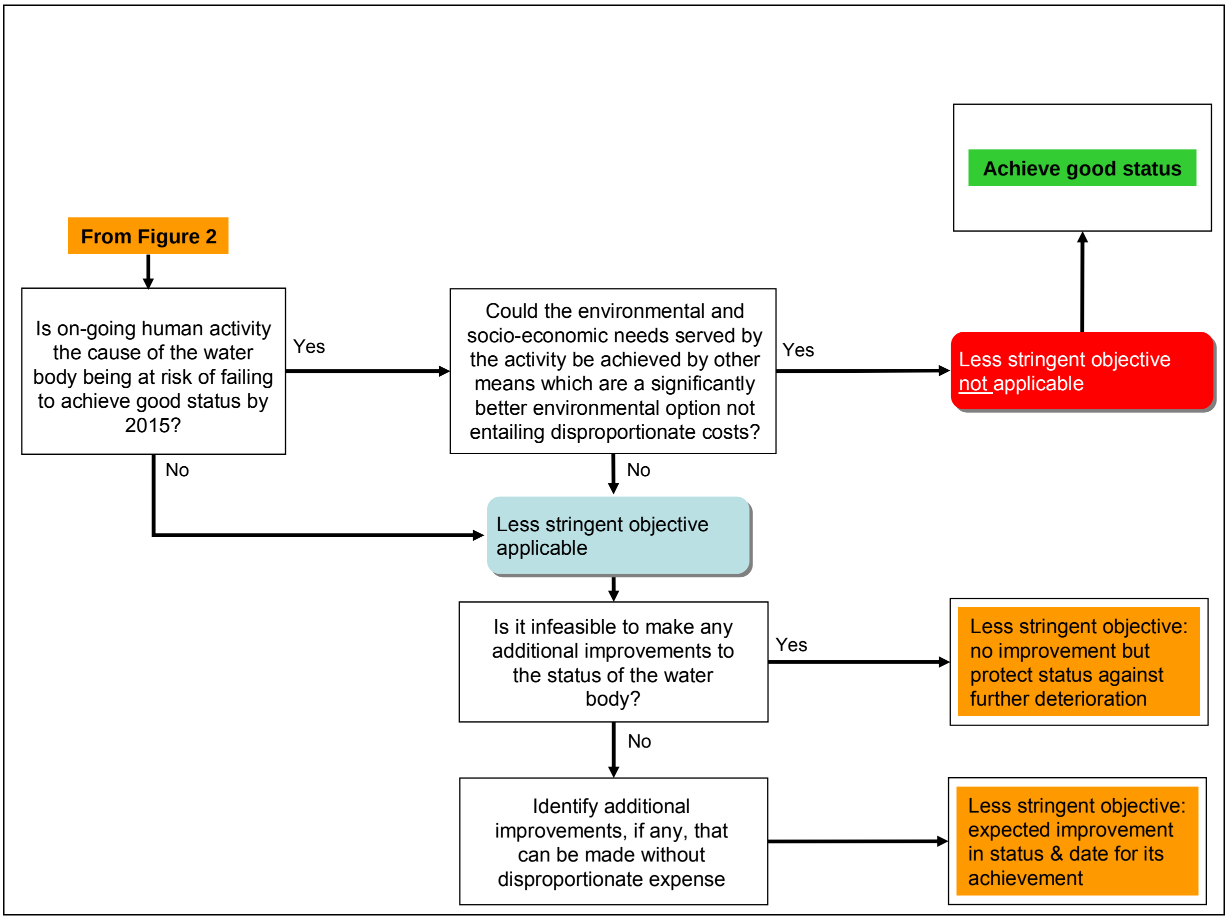

Figure 3: Internal logic of Article 4.5 - References to status should be interpreted as references to ecological potential and chemical status when dealing with heavily modified or artificial water bodies.

Figure 3 should be read in conjunction with Figure 2. According to the step-wise approach, it assumes that the tests indicated in Figure 2 have already been applied.

The Figure illustrates the process for the first cycle. The application of any less stringent objective must be reviewed in each subsequent planning cycle. When reviewing a less stringent objective, the internal logic illustrated in Figure 3 still applies. However, references in the Figure to 2015 should be treated as references to the deadline relevant to the planning cycle concerned (e.g. 2021; 2027; etc).

Before setting a less stringent objective, Member States must decide whether the environmental and socio-economic needs served by any activity that is preventing the achievement of good status could instead be provided by other means which are a significantly better environmental option not entailing disproportionate costs. Where the achievement of good status is being prevented by impacts resulting from human activities which have now ceased (e.g. historically contaminated land or sediment), this test will not be relevant.

If the test for other means is failed (i.e. if an 'other means' exists), an exemption cannot be applied and the objective for the water body will remain to aim to achieve good status. Member States are free to choose how they then achieve good status. They are not obliged to implement the identified other means of providing the benefits served by the activity as part of those measures.

In principle, a less stringent objective should represent the condition expected in the water body once all measures that are feasible and not disproportionately expensive have been taken. For example, this could mean that a less stringent objective is for the majority of the quality elements to be protected at, or restored to, values consistent with good status even though the overall status may be worse than good because of remaining impacts on other quality elements. A 'less stringent objective' does therefore not mean that (a) the other quality elements are permitted to deteriorate to the status dictated by the worst affected quality element or (b) the potential for improvement in the condition of other quality elements can be ignored.

In some cases it may be technically infeasible or disproportionately expensive to make any improvements in the status of a water body within the period covered by the relevant river basin management plan or update. In such cases, Member States must nevertheless prevent further deterioration of status, subject to the application of paragraphs 6 or 7 of Article 4 of the Directive. It should be noted that the term "infeasible" used in Article 4 (5) is broader than the term "technical feasibility" used in Article 4 (4).

The achievement of a so called "less stringent objective" may require the implementation of measures that are as stringent, if not more so, than the measures that are required for water bodies for which the objective is good status.

3.3.4 Application of new exemptions in subsequent planning cycles

On the basis of new knowledge gathered in the subsequent planning cycle, it may be necessary and appropriate in some cases to apply a new exemption under article 4.4 or 4.5 in the next update of the river basin management plan. For example, suppose a Member State finds that a water body will not achieve the objective set for it because the measures the Member State implemented are proving less effective than expected. If bringing the achievement of the objective back on track would be infeasible or disproportionately expensive, an extended deadline up to 2027 or a less stringent objective may be applied, as appropriate. Along the same lines, it is possible to apply a less stringent objective in a subsequent planning cycle for a water body for which an extension of the deadline was applied in an earlier planning cycle or it could be concluded that an exemption is not necessary anymore for the second or the third planning cycle.

The internal logic of Article 4.4 and 4.5 illustrated in Figures 2 and 3 above applies equally where the application of new exemptions is being considered in subsequent planning cycles. However, references in the figures to the deadlines for achieving objectives will change accordingly.

3.3.5 Natural conditions

The term 'natural conditions' is used both in Article 4.4 and 4.5 and refers to the conditions which dictate the rate of natural recovery. It recognises that it may take time for the conditions necessary to support good ecological status to be restored and for the plants and animals to recolonise and become established. It also recognises that due to varying natural hydrogeological conditions, groundwater bodies may take time to reach good chemical status. Climate change can also change the natural conditions over time.

3.4 Key issues for Art 4.6

Article 4.6 provides, under certain conditions, an exemption for temporary deterioration of the status of bodies of water in certain circumstances, which are exceptional or could not reasonably have been foreseen. In order to apply Art 4.6 a common understanding of the different terms below is needed, as well as a common understanding of the terms extreme floods and prolonged droughts.

- *Temporary deterioration:* The length of a temporary deterioration (Article 4.6) is linked to the length of the circumstances of natural cause, which are exceptional or could not reasonably have been foreseen and the practicability[17] of the measures that can be taken to restore the status of the water bodies.
- *Natural cause:* 'Natural cause' refers to events like floods and droughts which give rise to situations which cause us to make use of the water environment in ways that results in its deterioration of status (e.g. by taking emergency action to save life and property during floods; by supplying the public with drinking water during prolonged drought; by having pollutants to be washed into the water environment by floods). It is essential for proper river basin management planning and the application of Article 4(6) to make a distinction between the natural cause itself and the effects of management practices. WFD Article 4.6 deals with circumstances of natural cause which are exceptional or could not reasonably have been foreseen.

3.4.1 Extreme floods

The term 'extreme floods' recognises that, whilst it is possible to have some knowledge of the quantitative range of numerical flows and levels that might occur and the possible frequency of flood events, it will not be possible to foresee all flood events or to extrapolate all of their consequences in terms of environmental and other impacts.

The new Flood Risk Management Directive[18] introduces a EU-wide *"framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity".* This includes the setting up of preventive measures which can contribute to the prevention of deterioration of status as provided for by the WFD. Thus, a closely coordinated and coherent implementation of both Directives will maximise synergies in the achievement of their objectives.

Despite all required preventive measures, however, some flood events will lead to "temporary deterioration" for which it is justified to apply the exemption set out by Article 4.6 WFD[19]. The identification of such an event can finally only take place after its occurrence. However, Member States should have assessment strategies in place in which they make use, to the maximum possible extent, of the implementation of the Floods Directive.

For example, the Floods Directive introduces three categories in Article 6.3 for the purposes of mapping floods:

a) floods with a low probability, or extreme events scenarios;
b) floods with a medium probability (likely return period > 100 years);
c) floods with a high probability, where appropriate.

It is most likely that "extreme flood" events falling under category (a) will require the application of a "temporary deterioration". However, floods with a higher probability of

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[17] Practicable is related to 'technical feasible, not disproportionately expensive and without natural conditions preventing the improvements' (Article 4.4(a)).

[18] Directive 2007/60/EC of 23 October 2007 of the European Parliament and of the Council on the assessment and management of flood risks.

[19] This does not, however, include those cases of coastal flooding where deterioration, as a result of coastal erosion, may be permanent.

occurrence may also be regarded as "extreme floods" in circumstances where the impacts of such floods are equally exceptional or reasonably unforeseen.

In no way does the application of exemptions under the WFD give a Member State a possibility to make an exemption from the obligation of implementing all aspects of the Directive on the assessment and management of flood risks.

3.4.2 Prolonged droughts

A drought - contrary to water scarcity- is a natural unpredictable phenomenon. The appearance of a drought is not generated by human activities. However, the impacts of a drought episode may be exacerbated by mismanagement practices. Mitigation and prevention measures can be taken in order to reduce, and potentially avoid, the consequences of a drought when it occurs, but no measures can avoid a drought.

Although not always easy in practice, Member States will have to differentiate between the effects of prolonged droughts, which are purely natural phenomena, and the effects of human activities.

'Prolonged' droughts should be clearly distinguished from non-prolonged droughts. The conditions of a prolonged drought, i.e. the circumstances that are exceptional or that could not reasonably have been foreseen, should be demonstrated, as normal dry hydrological conditions should be addressed in the reference conditions. Relevant indicators identified at EU level are necessary to facilitate the common understanding of a 'prolonged drought', similar to criteria to define 'extreme floods'. More information is provided in Annex III.

3.5 Key issues for Art 4.7

Under Art 4.7 exemptions can be applied for **new modifications** and **new sustainable human development activities.** Before explaining the main principles of applying Art 4.7 some common definitions are provided:

- New modifications: Article 4.7 has a considerable impact on new developments and modifications. Modifications to the physical characteristics of water bodies mean modifications to their hydro-morphological characteristics. The impacts may result directly from the modification or alteration or may result from changes in the quality of water brought about by the modification or alteration. For example, hydropower plants, flood protection schemes and future navigation projects are covered by this provision. Also the hydro-morphological characteristics of impoundment created for hydropower and water supply can dictate the oxygen and temperature conditions resulting in a deterioration of ecological status in the impounded water and in the downstream river. These may be different from those in a natural water body.

  The impacts of those modifications and alterations may be limited to the water bodies in which modification works are undertaken; or extend to water bodies beyond those in which the modification works are undertaken. For example, the abstraction of water from a body of groundwater may cause adverse impacts in an associated surface water body.

- New sustainable human development activities: The Directive does not give a definition of those activities. In general, such activities cannot be defined per se through a set of criteria or policies but are framed by the relevant decision making process requirements within an open ended and iterative procedure. The exact definition for an activity falling under sustainable development will thus depend on the time, scale, involved stakeholders and information available. Relevant process requirements are provided in the WFD itself, the Strategic Environment Assessment, Environmental Impact Assessment and "Aarhus" Directives and should be guided by the principles of the EC Treaty, being the *"polluter pays principle, the precautionary principle and preventive action, and the principle of rectification of pollution at source"'.* Guiding principles on sustainable development can be found in the Renewed EU Sustainable Development Strategy (EU SDS), which was adopted by the Council in June 2006[20]. Furthermore, the decision making process should follow the principles of "good governance", including policy coherence, social inclusion and transparency and make best use of the availability of alternatives. A generic approach for small business developments affecting the same water body may be considered when applying the second point of 4.7.

- Deterioration of status or potential: The ecological status (or the potential) of a water body is expressed in terms of “classes” (e.g. high, good, moderate, poor or bad). Ecological status and potential classes are established on the basis of specific criteria and boundaries in accordance with the annex V of the WFD. In the context of Article 4.7, the objectives of preventing deterioration of ecological status (or the potential) refer to changes between classes rather than within classes. Member States do not, therefore, need to use article 4.7 for negative changes within a class.

- Temporary effects: Fluctuations in the condition of water bodies can sometimes occur as a result of short-duration human activities, such as construction or maintenance works. If the condition of each affected water body is adversely affected for only a short period of time and recovers within a short period of time[21] without the need for any restoration measures, such fluctuations will not constitute deterioration of status. The application of Article 4.7 will not be required.

  For example, temporary impacts due to the establishment of the modification during the building phase are not required to be addressed if no deterioration of status or potential could be expected thereafter in the water body or parts of the water body.

  Article 4.6 provides, under certain conditions, an exemption for temporary deterioration of the status of bodies of water in certain circumstances, which are exceptional or could not reasonably have been foreseen. An exemption under Article 4.7 will be unnecessary in those cases in which an Article 4.6 exemption is applicable.

- Small size projects: The size of the project is not the relevant criteria to trigger article 4.7. The relevant approach is to assess if a given project, whatever its importance is, will result in deterioration of the status of a body of surface water or groundwater or prevent the achievement of good ecological status, good ecological potential or good groundwater status or from high status to good status of a body of surface water. Thus, projects of any size may fall under article 4.7. However, for small projects not falling within the scope of the EIA Directive (85/337/EEC) a generic approach can be used in order to reduce the assessment burden.

In addition to the explanations above, the conditions under which Article 4.7 can be applied are presented in the figure below in a stepwise approach. This flow chart aims to be a practical tool when considering application of Article 4.7.

In comparison to the exact text of the Directive (art 4.7) c), the order of Box 3 and 4 have been changed. This is done for two reasons. Firstly, the considerations in Box 2 and 3 may result in adaptations of the project. This is not the case for the considerations from Box 4 onwards.

[20] Available at: http://register.consilium.europa.eu/pdf/en/06/stlO/stl0117.en06.pdf

[21] No definition will be given of 'short period of time'. However, the frequencies mentioned for the monitoring programmes (Annex V 1.3.4 and 2.2.3) can serve as an indication.

Secondly, Box 3 refers to the process of looking for alternatives, which should be done at an early stage of drafting the project, when better alternatives are available.

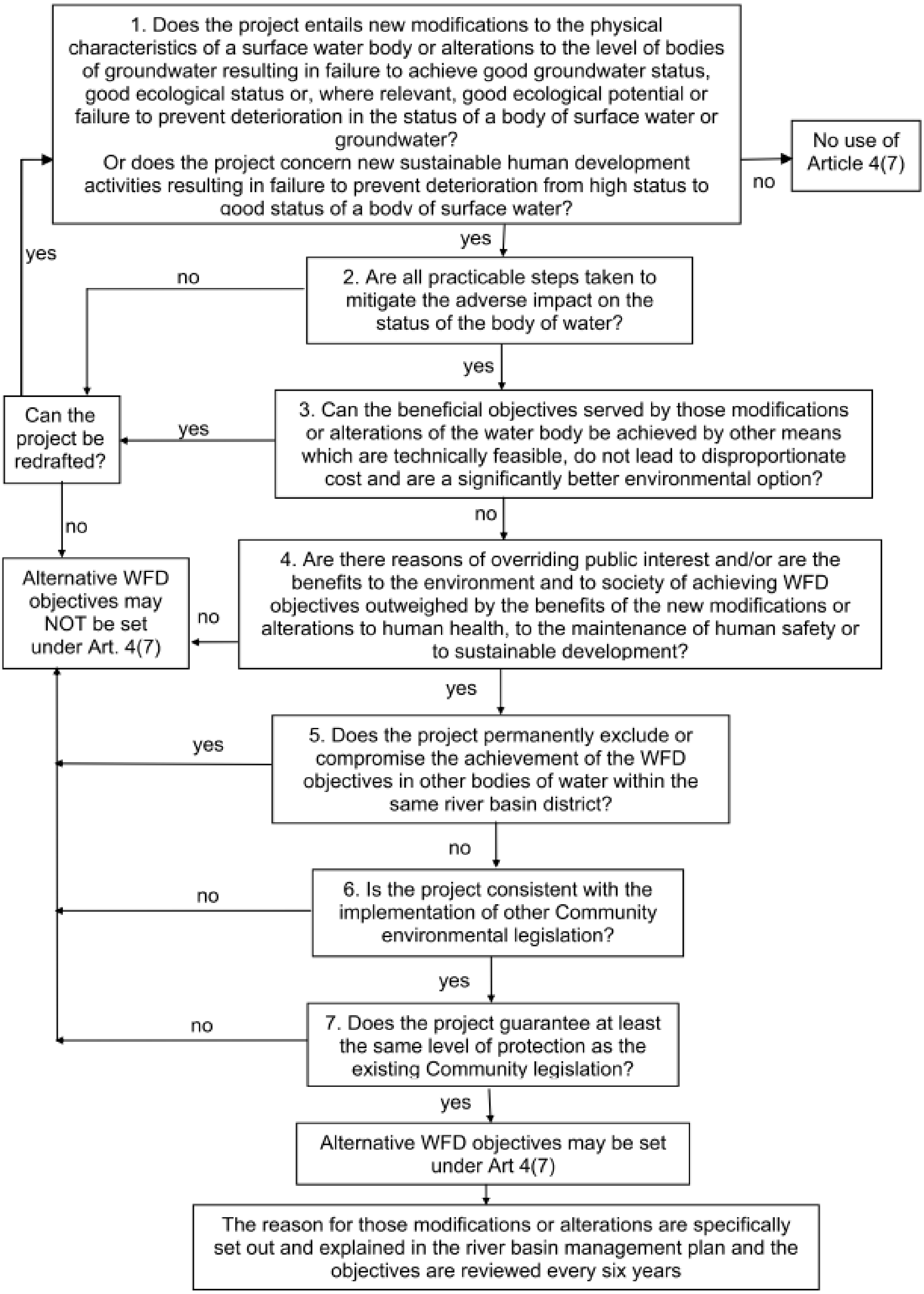

Figure 4: Example for an iterative approach, which should allow the re-assessment of the potential identification of a sustainable development activity done at the beginning.

Like all WFD exemptions, article 4.7 does not apply when the provisions of articles 4.8 and 4.9 are not fulfilled. In other words, use of the exemptions is allowed when they guarantee at least the same level of protection as existing Community legislation and provided that they do not permanently exclude or compromise the achievement of the wider objectives of the WFD under Article l in other bodies of water within the same river basin district.

In the following paragraphs, the different conditions of the Article 4.7 assessment are explained in more detail.

3.5.1 Practicable steps to mitigate adverse impacts

As indicated in box 2 in figure 5, all practicable steps have to be taken to mitigate the adverse impact on the status of the water body. As article 4.7 requires only mitigation, it is at first important to make a clear distinction between:

- Mitigation measures, which aim to minimise or even cancel the adverse impact on the status of the body of water, and
- Compensatory measures, which aim is to compensate in another body of water the "net negative effects" of a project and its associated mitigation measures.

Article 4.7 does not require compensatory measures.

The notion of "steps" addresses potentially a wide range of measures in all phases of development, including maintenance and operation conditions, facilities' design, restoration and creation of habitats.

The wording "all practicable steps", in analogy with the term "practicable" used in other legislation, suggests those mitigation measures should be technically feasible; do not lead to disproportionate costs; and are compatible with the new modification or sustainable human development activity.

3.5.2 Overriding public interest

As indicated in box 4, when applying Article 4.7, the reasons for those modifications or alterations are of overriding public interest. This concept is also used in the Habitats Directive (92/43/EEC) and other EC law. Though there is no case law from the European Court of Justice on the application of this concept to the Habitats Directive, the European Commission's "Methodological guidance on the provisions of Article 6.3 and 6.4 of the Habitats Directive 92/43/EEC: Assessment of plans and projects significantly affecting Natura 2000 sites"[22], may bring some clarification. It is reasonable to consider that the reasons of overriding public interest[23] refer to situations where plans or projects envisaged prove to be indispensable within the framework of:

- Actions or policies aiming to protect fundamental value for citizen's lives (health, safety, environment);
- Fundamental policies for the state and the society;
- Carrying out activities of an economic or social nature, fulfilling specific obligations of public services.

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[22] Some consideration to defining "Overriding public interest" can be found at http://europa.eu.int/comm/environment/nature/nature_conservation/eu_nature_legislation/specific_articles/art6/index_en.htm

[23] Note that the consideration of "overriding public interest" only applies to the first part of Article 4.7 c, not to the second part.

Furthermore, public participation will contribute considerably in determining overriding public interest[24].

3.5.3 Benefits of the new modification versus benefits to the environment

In Box 4, it is asked whether the benefits to the environment and to society of achieving the objectives set out in paragraph 4.1 (of the Directive) are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development. The benefits of achieving the environmental objectives of Article 4 include:

- In case of deterioration of status, those benefits and opportunities foregone as a result of the deterioration of status (e.g. loss of biodiversity); and
- In case of failure of reaching good status or potential, those benefits that would be provided if the achievement of good status or good ecological status were not prevented (e.g. drinking water supply is not longer possible).

The "water costs" (negative benefits) have to be put in balance with the potential benefits and other costs (increased use of other natural resource, including global impacts) of the new modifications and alterations to human health, to the maintenance of human safety or to sustainable development. Thus, other categories of possible benefits and costs will have to be considered and -if possible- calculated.

In conclusion, an analysis of the costs and the benefits of the project adapted to the needs of the Directive is necessary to enable a judgement to be made on whether the benefits to the environment and to society of preventing deterioration of status or restoring a water body to good status are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development.

This does not mean that it will be necessary to monetise or even quantify all costs and benefits to make such a judgement. The appropriate mix of qualitative, quantitative and, in some cases, monetised information should depend on what is necessary to reach a judgement and what is proportional and feasible to collect.

3.5.4 Article 4.7 and the designation of heavily modified water bodies (HMWB)

After a new hydro-morphological alteration has occurred, it may be that the water body qualifies for designation as a heavily modified water body in accordance with Article 4.3 in the next planning cycle. There is no requirement that the designation has to wait until the publication of the next River Basin Management Plan. However, **water bodies cannot be designated as HMWBs before the new modification has taken place** because of the anticipation of the significant hydro-morphological alteration.

After the application of article 4.7 and in case of designation of new HMWBs, the step by step approach developed within the HMWB guidance document should be applied without the "provisional identification-step".

[24] See Guidance Document No 8: Public Participation in relation to the Water Framework Directive on http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents

3.5.5 Reporting article 4.7 in the RBMP and public consultation

Annex VII of the WFD describes the information that should be included in the RBMP. Under point A.4, the current status of the water bodies must be assessed as a result of the monitoring programmes. Under point A.5, the environmental objectives established for surface waters and groundwaters must be listed, including identification of the use of the exemptions and the associated information required under Article 4.

The risk of deterioration of status occurring should be assessed at the time a new modification or alteration is being considered. The assessment of risk should be based on the best information available on the status of those water bodies whose status is likely to be affected by the proposed project. Such information should include the latest information from the monitoring programmes required under Article 8 and information obtained from any environmental impact assessment undertaken for the project.

Further, under article 4.7 (b), there is a general provision that "the reasons for those modifications and alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years". This is a reporting obligation and does not mean that Member States must wait until the publication of the River Basin Management Plan before allowing a new physical modification or new sustainable development activity to proceed. In many cases projects will be developed within the RBMP six-year cycle.

For modifications and alterations within the scope of the Environmental Impact Assessment Directive, Member States must ensure that the public concerned is given the opportunity to express an opinion before the project is initiated.

Even if timing of a project is such that consultation on the RBMPs will not provide the opportunity for interested parties to express their views in advance of those decisions, Article 14 requires Member States to encourage the active involvement of all interested parties in the implementation of the Directive. It is recommended that Member States ensure that such opportunities are provided in relation to projects that are outside the scope of the Environmental Impact Assessment Directive but likely to result in deterioration of status or to prevent the achievement of good ecological Status, good ecological potential or good groundwater status.

The information provided through such consultations will help Member States in reaching a judgement on whether the exemption conditions are met and will reduce the likelihood that interested parties will challenge the subsequent decision.

If a modification or alteration goes ahead in the middle of a river basin planning cycle, the reason for that modification or alteration must be set out in the subsequent (update of the) RBMPs.

4 Conclusions

The work on environmental objectives and exemptions has started in 2005 and has progressed significantly over the past years. It has become evident that Article 4 of the WFD is the heart of this legislation and the crucial element to achieve a high level of protection of our waters as part of a sustainable water management, which also takes account of the social and economic needs and realities. This document brings together the fruitful work under the WFD Common Implementation Strategy on exemptions.

In the mean time, Member States are gaining practical experience with the application of Article 4 and are preparing for the necessary discussions as part of the public consultation. Whilst it is recognised that starting points, strategies and approaches differ across Europe, it is important to make transparent the underlying reasons and data for decision-making and to not use the exemptions as a blanket excuse. In many cases it may be more effective to discuss in a proactive way what measures can be taken to improve the current situation, rather than what arguments and administrative effort can be made to avoid taking any measures.

Thus, where "good status" may not be achieved or "deterioration of the current status" is possible, no action is not an option! This document aims at contributing towards this positive and proactive attitude when implementing the WFD and thereby contributing to sustainable water management.

The process of objective setting does not stop after the first planning cycle but is dynamic and iterative which means that it should be further developed and improved on the basis of experiences in the first RBMP. It is likely that the number of water bodies for which exemptions are applied will be decreasing within the second and third planning cycle but the application will have to be adapted each time.

It may be necessary to continue the work on exemptions in the next years, focusing on practical experiences and cases from the first planning cycle.

ANNEXES

Annex I: Costs & Benefits

An analysis of the costs and the benefits of measures to achieve the objectives of the WFD may be necessary to support the judgement to be made on exemptions from these objectives. Reasonable efforts should be made to collect information on different types of costs and benefits, including the appropriate mix of qualitative, quantitative and monetised information. In addition, available information, for example from the cost-effectiveness assessment, should be used. In all cases, the data should be used in a transparent way showing how the assessments and calculations have been carried out.

Below, more specific information is given on benefits and costs in the framework of the WFD. Useful guidance on types of costs and benefits and how to assess them was also made in the **WATECO guidance**. Please see Section 2 and 3 and Annex D of this guidance document[25].

In addition to the WATECO guidance, **the study on Costs and Benefits associated with the implementation of the Water Framework Directive of** 2007[26] provides useful information on types of costs and benefits and methodology for Cost-Benefit Analyses (CBAs) (mainly Chapter 3). Currently used methodologies for estimating the total costs and benefits of the implementation of the WFD were studied, and recommendations were made on which costs and benefits to include and how to evaluate them. Issues relating to comparison and aggregation of costs and benefits were also outlined.

I.1 Benefits

The environmental objectives set in the WFD shall ensure the long-term protection and the sustainable use of the water resources and prevent further deterioration. The achievements of these objectives will have numerous benefits and socio-economic gains for this and coming generations. When examining the proportionality of costs required for achieving the objectives, these benefits can and should be taken into account. Some examples of such benefits are listed below:

- Protection and enhancement of health and biodiversity of the aquatic ecosystem (in particular since good ecological status requires good quality of the structure and the functioning of this ecosystem).
- Protection of human health through water-related exposure (e.g. through drinking, drinks and food production, bathing and consumption of fish, shellfish and seafood).
- Lower costs for water uses, e.g. water supply or fisheries and more cost effectively achieved improvements by reducing treatment and remediation costs (e.g. drinking water supply, Sediment pollution).
- Improvement of efficiency and effectiveness of water policy based on the "polluters-pays principle" (in particular by adequate water pricing policies and cost-effectiveness assessment of measures, example: reduction of amount of water use per capita).
- Increased cost-effectiveness of water management, in particular of measures to implement and apply, for example the Nitrates, Urban Wastewater Treatment and IPPC Directives.

25 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos1seconomicss/_EN_1.0_&a=d

26 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/economic_issues/benefits_implementation/report_septl2pdf/_EN_1.0_&a=d

- Integrated river basin management - as introduced by the WFD – should help authorities to maximise the economic and social benefits derived from water resources in an equitable manner instead of repeating the mistaken and fragmented approaches of the past, which dealt with problems in a local, and usually temporary, basis. This should translate, *inter alia,* in designing more cost-effective measures to meet the environmental objectives of other EU legislation (see above). Especially for new Member States, the cost-saving potential is great the lessons from the experiences in EU15 are learnt[27].
- Improvement of the quality of life by increasing the amenity value of surface waters (e.g. for visitors, tourists, water-sports users, conservationist) and by increasing its non-use value and all non-market benefits associated.
- Mitigation of impacts from **climate change and security of water supplies** (e.g. by forward planning in river basin management, water demand and supply management and mitigation of flood and drought events)
- Mechanisms to address **conflicts and regional disadvantages** by balancing interests of different water users and creating a level playing field for water users across the EU[28] (in particular by addressing and managing all demands on water resources from drinking water supply, agricultural and industrial uses, navigation, hydropower, etc. in a consistent and comparable way).
- Promotion of sustainable uses thereby **creation of new jobs** (e.g. in ecotourism, fisheries, environmental technologies and nature conservation sector).

Some of these benefits are financial like e.g. the saving of costs for water supply (economic benefits) and therefore can be expressed in monetary terms, or, if the acquisition of the corresponding data requires a disproportionate effort, can at least be estimated. However, on the basis of existing methodologies, it is difficult to attribute a monetary value to many types of environmental and social benefits. The existing Information Sheet on "Environmental and Resource Costs" clarifies many concepts and outlines a few examples of how to measure them in monetary terms. Another useful tool is the "Millennium Ecosystem Assessment Report"[29] which includes substantial information on freshwater ecosystem values as well as more recent study on The Economics of Ecosystems and Biodiversity (TEEB)[30] which quantified the costs of in-action for many ecosystem services. Member States need to make an effort to value or assess social and environmental benefits/costs more appropriately than in the past. Without this, it is likely that many assessments of disproportionate costs, taking place as part of the WFD implementation, will be incorrect.

However, it will not always be necessary to place a monetary value on all costs and benefits. Member States will need to collect sufficient information on costs and benefits to support good decision making, taking into account the costs associated with the collection of the relevant information. There is a need for pragmatic approaches in order to be able to take benefits into account if this monetary information is incomplete or not fully available. Some of these benefits may be assessed by using qualitative information. In other cases, an appropriate alternative may be the application of the "precautionary principle" or it might be possible to make a qualitative assessment of the benefits and to weigh them up against the costs.

More work is required to achieve full assessment of benefits (monetary or not) derived from the implementation of measures under the WFD. It is expected that, e.g. the ongoing

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[27] See e.g. EEA report on "Effectiveness of urban wastewater treatment policies in selected countries: an EEA pilot study". Final draft of 19 April 2005.

[28] and with non-EU countries sharing a river basin with the EU.

[29] http://www.maweb.org//en/index.asp

[30] http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm

work on environmental costs (both within the WFD implementation as well as in a wider context) will improve this situation.

I.2 Costs

While recognising the considerable benefits, achieving the environmental objectives may have additional costs on those water uses or "driving forces" which have a negative impact on the aquatic environment or beneficiaries from improvements and which have not - up until now - contributed to address such impacts (e.g. not paying for the water use). At the moment, these potential costs are not known for various reasons. First, it is impossible to determine the costs before criteria for the environmental objectives are available. The water quality has to be monitored in accordance with the Directive. Only when comparing the monitoring results with the environmental standards (as defined through Annex V WFD) will it be possible to assess the "distance to target" and thereby the required investments. Second, the costs are largely dependent on the choices of instruments and combination of measures that Member States will use. Third, application and enforcement of other water protection legislation, in particular the Urban Waste Water Directive, the Nitrates Directive and the Drinking Water Directive, are inadequate in a number of countries and, thus, costs related to implementing those are easily, but wrongly, added to the costs of implementing the WFD. In the end, it is not always possible to distinguish between the water management costs incurred due to the implementation of the WFD, and the costs which would have been incurred in the absence of the WFD. However, this distinction is crucial for performing the different analysis of costs. The costs of basic measures according to existing EC water related directives (UWWD, IPPC, Nitrate etc.) can not be included in the analysis for justification of exemptions.

Independent of the lack of concrete cost-estimates, the WFD incorporates mechanisms that the socio-economic impacts are properly addressed in the decision-making and that the least cost option is selected. The way that such considerations are addressed in the directive is mainly through the above-mentioned exemptions and the development of the programme of measures as an integral part of the planning process.

If there is sufficient evidence that costs seem to be disproportionate, careful assessment and balanced decision-making on benefits and costs is an integral part of the WFD, in particular through the "exemptions" tests.

Further to the considerations in the objectives, the socio-economic aspects and, in particular the **cost-effectiveness,** is a central part in the development for the Programme of Measures. The Member States should attempt to ensure that the combination of measures for achieving the environmental objectives is resulting in the least cost option after giving sufficient attention and consideration to environmental and resource costs. Such approaches, which should be applied on national or river basin, sub-basin or water body level, leave enough flexibility in order to address issues of concern.

Furthermore, the proposed options including the use of certain exemptions and the proposed programme of measures must be subject to **public participation** in which all interested stakeholders are encouraged to be involved.

The WFD provides for environmental objectives which should be achieved by the most cost-effective combination of measures. Cost-effectiveness assessment and public participation of proposed choices are the key instruments in this process.

Annex II: Exemptions in a transboundary context

II.1 Principles for applying exemptions in a transboundary context

Exemptions may be applied in cases where a certain Member State cannot resolve the reasons for not achieving the environmental objectives because they lay outside the competence and jurisdiction of the Member State. When applying such an exemption, the following principles should be taken account of.

The coordination mechanisms as mentioned in WFD Article 3.4 or Article 3.5 or covered by other pieces of legislation (e.g. air quality) should be in place and have been exploited to the fullest extent to resolve the problem. In this context, the Member States concerned should coordinate their efforts to apply the most cost effective solution to solve the environmental issue for which an exemption may be required. - Furthermore, the Member State has to take all measures on its own territory that will contribute to achieving good status, and that are not disproportionate expensive or technically infeasible.

Finally, the Member State has to demonstrate that the reasons for not achieving the environmental objectives are outside its jurisdiction and its competence. This could for example be done by information provided by the other Member State, and/or by information provided by a monitoring point at the border between the Member States concerned or by other means.

II.2 Reasons for applying exemptions in a transboundary context

Exemptions in a transboundary context could relate to transboundary pollution, but also to hydro-morphological alterations or other transboundary ecological impacts or in the case of extreme events.

Transboundary pollution was specifically discussed in the context of the negotiations of the Commission proposal on environmental quality Standards (EQS) for priority substances[31], in particular for the following issues:

- where EQS are exceeded because the pollution load which is transported from an upstream country (whether this country is a EU Member State or not) through transboundary rivers;
- where EQS are exceeded because long-range transboundary air pollution transports high loads of pollutants (in particular heavy metals and PAHs) into the Member State concerned[32];

In both cases, the exceedance of the EQS *"cannot be resolved by that Member State"* since the sources of pollution are outside the competence and jurisdiction of the Member State. So it appears most likely that in these cases of transboundary pollution, the exemptions (Article 4.4, 4.5 and 4.6) would be applicable. Countries receiving transboundary pollution via marine currents or by atmospheric deposition are also considered downstream (or affected) countries in the context of Section 3.2.7 and this Annex.

[31] COM(2006) 397 final of 17.7.2006; 2006/0129 (COD)

[32] It should be noted that other EU or international legislation or agreements might be applicable to this issue, for example the protocols under the UNECE Convention on Long-range Transboundary Air Pollution.

II.3 Conditions of the exemptions in transboundary context

Similar to applying exemptions in a national context, it needs to be demonstrated if the conditions of Article 4.4 and 4.5 are met. Subparagraph 4.5(a) needs special attention in this case: the application of sub-paragraph (a) is clear in cases where human activities are carried out within a Member State and where an assessment of the environmental and socio-economic needs of the human activities and its alternatives is carried out. In case of transboundary effects, there is no human activity within the Member States' competence that can be compared with another. The human activity causing the pollution or the ecological impacts is outside the jurisdiction of the Member State. Thus, this condition does not apply in case of transboundary pollution or transboundary ecological impacts.

<u>WFD Article 3</u>

WFD Article 3.4 requires Member States to ensure coordination of the requirements for the achievement of the environmental objectives for international river basin districts within the territory of the EU. For international river basin districts partly outside the territory of the EU, the requirement is to 'endeavour to establish appropriate coordination'. It is obvious that this includes the coordination of the application of exemptions. It is of particular relevance that the coordination ensures that all relevant information and data are being exchanged between the Member States and/or other countries. For example, if the upstream Member State intends to apply an exemption on its territory, the downstream country should be informed as soon as possible and access to all information should be guaranteed. The international river conventions and other relevant international agreements play an important role in fostering and improving this information exchange.

<u>WFD Article 12</u>

In case the reasons for not achieving good status cannot be resolved by a Member State since they are outside the competence and jurisdiction of the Member State, the WFD includes the Provision of Article 12 ***"Issues which cannot be dealt with at a Member State level".*** Article 12 provides for:

"1. Where a Member State identifies an issue which has an impact on the management of its water but cannot be resolved by that Member State, it may report the issue to the Commission and any other Member State concerned and may make recommendations for the resolution of it.

2. The Commission shall respond to any report or recommendations from Member States within a period of six months."

Article 12 might be invoked for various situations related to exemptions. It might for example be applied in cases where no information on exemptions is provided, or it might be applied to solve the issue for which an exemptions needs to be applied by a neighbouring Member State. Article 12 could be invoked at the same time when applying the exemption in the drafting phase of the river basin management plan.

The possible reaction by the Commission will vary depending on the issue.

<u>Demonstration of evidence</u>

The key issue in both applying the exemption and invoking Article 12 is the **demonstration of evidence** that Member States have taken all reasonable actions to fulfil the legal obligations.

When applying exemptions, the reasons for this need to be mentioned in the river basin management plan. Furthermore, it is important to inform neighbouring countries as soon as possible on intermediate Steps related to the evidence, the intermediate objectives and the expected evolution, in order to enable the neighbouring country to adapt their own river basin management.

When a Member State is reporting to the Commission under Article 12, it will have to provide information which support their argument and allow the Commission to verify that the non-achievement of an objective is clearly linked to the transboundary pollution or other transboundary effects. In general, such demonstration of evidence can be achieved through an appropriate and targeted monitoring strategy or a comprehensive risk analysis in accordance with Article 5 and Annex II WFD.

Annex III: Background information on prolonged droughts

The 'Drought Management Plan Report, including Agriculture, Drought Indicators and Climate Change' (also DMP report) of the Water Scarcity and Drought Expert Network notes that there are various types of droughts. For the application of exemptions according to WFD Article 4(6), the term to be used is "prolonged droughts". Whilst it will be difficult to find an all encompassing definition for what a "prolonged drought" is, it would be beneficial to enhance the common understanding for the application of the term in the context of the WFD exemptions.

As the WFD indicates in Article 4.6, the Member State may declare a "temporary deterioration" to achieving the objectives of Article 4.1 on the basis of the following conditions:

- It is a result of natural causes or *force majeure* which are exceptional or which could not reasonably be foreseen and which are reviewed periodically (e.g. through a follow up of the Programme of Measures (PoM) and/or Drought Management Plan);
- All practicable Steps are taken to avoid further deterioration (Article 4.6(a));
- Measures taken during the prolonged drought do not compromise the recovery of the water body after the prolonged drought and are included in the PoM (Article 4.6(c));
- Measures to restore the water body are taken as soon as reasonably practicable and are included in the next update of the River Basin Management Plan; (Article 4.6(c) and 4.6(d))
- A summary of effects of the prolonged droughts is included within the RBMP (Article 4.6(e)).

Section 10 of the Paper "Exemptions to the Environmental Objectives under the Water Framework Directive, Article 4(4), 4(5), and 4(6)" already highlights a few issues regarding the exemption under 4(6).

First, 'prolonged droughts' are one of the natural causes for which the exemptions under Article 4(6) may be applied. It is highlighted again that a **drought - contrary to water scarcity - is a natural and unpredictable phenomenon[33].** The appearance of a drought is not generated by human activities. However, the impacts of a drought episode depend on the degree of use of the resource in a particular river basin and may be exacerbated by mismanagement practices (i.e. water resource management that is not sustainable). Some mitigation and prevention measures can be taken in order to (partially) reduce the effects of a drought when it occurs, but no measures can avoid a drought.

Secondly, it is already recognised that Member States will have to differentiate between the effects of prolonged droughts, which are purely natural phenomena, and the effects of human activities, although not always easy in practice. It is essential for proper river basin management planning and the application of Article 4.6 to make a distinction between the natural cause itself and the effects of management practices.

Thirdly, the Exemptions Paper indicates that for the distinction between a "non prolonged drought" and a "prolonged drought", the conditions of a prolonged drought, i.e. the circumstances of natural causes or "force majeure" which are exceptional or could not reasonably have been foreseen should be demonstrated in order to qualify as "prolonged". Normal dry hydrological conditions should be addressed in the ecological reference conditions set by the WFD. The river basin management plans should be able to

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[33] See also the Communication 'Addressing the challenge of water scarcity and droughts in the European Union' (COM(2007) 414)

cope with non prolonged droughts without resorting to the exemption in article 4(6). Relevant criteria are necessary to facilitate the common understanding of a 'prolonged drought' through an agreed set of indicators (see below), similar to criteria to define 'extreme floods'.

III.1 Identification of a "prolonged drought"

Characteristics of droughts can vary significantly from country to country and between regions and therefore it is not possible to agree on common values of indicators that can be used in all cases.

As the circumstances to declare prolonged drought relate to a natural cause, indicators for prolonged droughts should relate to natural parameters (see 4.6(b)). Although there might be a time lag between the lack of precipitation and decreased water levels, e.g. due to retention effects of soil and vegetation and inertial effects on aquifers, the main parameter to define prolonged drought should be related to lack of precipitation (minus evapotranspiration) during a particular period with respect to average, and should take into account aspects like intensity and duration. It is necessary to distinguish between the drought itself and the effects of water use and management practices.

The drought events that are part of the normal dry hydrological conditions cannot be considered a "prolonged drought" since they are not "circumstances of natural cause *or force majeure* which are exceptional or could not reasonably have been foreseen". Any indicator used to define a prolonged drought and hence to allow triggering the exemption in article 4(6) should be based on a statistical analysis of the deviation of precipitation from the average situation (including intensity and duration), to prove that the circumstances are those of a prolonged drought.

III.2 Management of a prolonged drought

The reason for invoking an exemption under Article 4.6 is that a prolonged drought may affect the status of a water body considerably and during a significant period of time, so that a temporary deterioration may be inevitable even with the application of the best water management practices.

In the case of a prolonged drought, it may be necessary to take exceptional measures, but they must not compromise the recovery of the quality of the water body when the prolonged drought is over. These measures need to be included in the programmes of measures and/or the Drought Management Plan. They also do not exempt from taking all practicable steps to prevent further deterioration in status of the water body (see 4.6 paragraphs (a) and (c)).

Furthermore, during the prolonged drought and afterwards, all measures have to be taken with the aim of restoring the water body to its prior status as soon as reasonably practicable. In this context, practicable measures are those that are technically feasible and not disproportionately expensive. Restrictions on water use by different sectors might be an example of measures that have to be taken.

Managing prolonged droughts implies making decisions on the allocation of reduced resources to both environmental and human activity needs. Unlike in non prolonged droughts, during which the environmental needs should be respected at all times so that the WFD environmental objectives are met, during a prolonged drought, and provided the conditions on article 4.6 are respected, priority needs related to human activity (e.g. drinking water supply) can be temporarily met at the expense of the environmental needs, i.e.

allowing a temporary non- achievement of the environmental objectives. Such decisions have to carefully consider the environmental and socioeconomic aspects in accordance with the conditions in paragraphs 4.6 (a) to (d).

Besides the potential impacts on drinking water, prolonged droughts may cause significant impacts on all water uses, in particular irrigation, hydropower generation, supply of cooling water and other industrial uses, navigation and domestic uses other than drinking water (such as garden sprinkling). Thus, a clear prioritisation of main uses should be established[34] in advance where use restrictions are imposed step-by-step with increased duration, intensity and impact of the drought event. Essential drinking water supplies will be considered a high priority during periods of prolonged droughts, and this should be combined with high priority for an ecological minimum flow.

All drought situations other than a prolonged drought need to be managed without the use of article 4.6, i.e. for water bodies where non-prolonged droughts occur, the environmental objectives should be achieved and no deterioration must take place. Hence the water uses need to be brought in balance with the water availability under these dry hydrological conditions. The impacts of non prolonged droughts need to be taken into account in the definition of the environmental objectives of the RBMP and need to be addressed in the programme of measures and/or the Drought Management Plan. The iterative process of the WFD includes a periodical review of these objectives and associated measures in order to take into account the evolving impacts of these events in time.

In case of water bodies where the extent of human activity is such as to produce a permanent imbalance between available resources and demands, and if the achievement of environmental objectives would be infeasible or disproportionately expensive, the possibility to apply an exemption in article 4.4 or 4.5 might be explored, provided the conditions set out in these articles are fulfilled

III.3 Drought impacts on ecology and other water uses

For management of droughts and for determining if a temporary deterioration occurs in case of a prolonged drought, the impacts of this extreme phenomenon need to be investigated, both on ecology and on different human water uses.

Some examples for impacts on the ecology at a low water level and high water temperature are, in particular:

- changes in fish development and larger numbers of deaths than normal. Some periods of the year are highly critical for fish, such as the reproduction and migration periods.
- increased algae development due to the lack of water in rivers and lakes due to the drought. However, this parameter may be difficult to distinguish from the excess of nutrient releases that cause eutrophication.

The effects of a drought could greatly vary depending on the existing scenarios: basins with storage aquifers directly linked to the water body system, and/or regulating infrastructures (e.g. reservoirs) could be less vulnerable to impacts, while basins without storage capacity could be more rapidly affected. Other factors will undoubtedly influence drought impacts, such as demands and uses of the area. Thus, the different potential impacts caused by droughts should be assessed or, at least estimated, in advance, preferably as part of a drought management plan. Such assessment should consider economic, social and

[34] See also the Communication 'Addressing the challenge of water scarcity and droughts in the European Union' (COM(2007) 414)

environmental impacts in order to inform the necessary decision-making. Such an assessment should also take into account transboundary impacts, disparities between different Member States and distortions of competition between them which may stem from restricting or stopping certain uses.

III.4 Indicators

Three types of indicators can be identified in relation to droughts:

1. Indicators to identify and demonstrate the occurrence of a prolonged drought: natural indicators based on precipitation as the main parameter (where relevant including evapotranspiration, and with statistical series) indicate that it is a 'natural cause *or force majeure',* and that the circumstances are exceptional or could have not reasonably been foreseen.
2. Indicators to prove that the prolonged drought has resulted in a temporary deterioration of one (or several) water body(-ies) as an integral part of the monitoring programmes established under Article 8 and Annex V WFD (these are indicators related to environmental impacts).
3. Indicators to illustrate the socio-economic impacts of the prolonged droughts (drinking water supply, agriculture, industry, etc).

The first and second types of indicators should be used to prove the occurrence of a prolonged droughts and the associated temporary deterioration of water bodies. The second and third types of indicators should be used:

- to take the appropriate measures in order to mitigate the impacts of the prolonged droughts
  and recover the quality of the water bodies, according to 4.6 (c) and (d),
- to draft the annual review of the effects of the prolonged droughts (4.6(d))
- to draft the summary of the effects (4.6(e))

All indicators should be used to inform the water users and the public about the occurrence of droughts, their effects and the management results.

Chapter 3 of the DMP report provides an overview of national indicators related to droughts. The development of such indicators to be used on EU level and the specification on which indicators are consistent for the purpose of applying the exemption related to "prolonged droughts" will be subject of further work carried out by the European Commission, the European Environment Agency and Member States. In all cases, it is a requirement that when applying an exemption and the related indicators that they are to be submitted to a transparent and open process through the public participation (cf. Article 14 WFD).

III.5 Measures to address "prolonged droughts"

When a prolonged drought occurs, measures need to be taken to avoid further deterioration and to restore the water body as soon as reasonably practicable. Examples of such measures could be the following:

- develop early warning System and public Information
- implement preventive measures
- promote water savings
- take all practicable measures to prevent further deterioration
- implement specific mitigation and adaptation measures of article 11 (basic and supplementary) in water management sector as well as in other water

dependant sectors (agriculture, energy, tourism, transport, urban development, industry)

- propose additional measures after the annual review of the effects of circumstances
  that are exceptional or could not have reasonably been foreseen (Article 4.6(d))

When, and where necessary, these measures can be presented in advance as part of a drought management plan (complementing the river basin management plan). Acting on a prolonged drought, requires a rapid adoption of measures, for which the course of action should also be reflected in the RBMP or directly within the specific DMP.

Measures to be taken in case of prolonged droughts as mentioned in 4.6(c) cannot adversely affect other water bodies (see Article 4.8 WFD) and must ensure that the objectives set by other Community legislation are not compromised (see Article 4.9 WFD).

Additional information on the types of measures and possible implementation strategies are described in detail in Chapter 5 of the DMP report.

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 21
Guidance for reporting under the Water Framework Directive

EUROPEAN COMMISSION

environment

Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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1 INTRODUCTION

1.1 Purpose of this document

Since 2003 several documents have been agreed defining the information that Member States (MS) should provide the Commission for the purposes of compliance checking under the Water Framework Directive (WFD). These cover the following reporting requirements:

- Article 3 (2004);
- Article 5 (2005);
- Article 8 (2007);
- Article 13 (2010).

Information has already been provided by the MS for the first three of these reporting requirements and initial compliance assessments completed. Following agreement of the Reporting sheets for the River Basin Management Plans (RBMP) (2010 reporting), the Reporting sheets for Articles 3 and 5 were reviewed and some changes agreed with the MS through Working Group D. During this review it was agreed to prepare an overall, consolidated document which would present, in a logical way, all the reporting requirements that had been agreed. This document fulfils that requirement.

1.2 Development of the Reporting Guidance

Reporting in the context of EU water legislation has been regulated and implemented in different ways over the past 30 years. For example for the remaining 'old' directives (Urban Waster Water Treatment Directive (UWWTD) – 91/271/EEC, Bathing Waters Directive (BWD) – 76/160/EEC, Nitrates Directive (NiD) – 91/676/EEC, Drinking Water Directive (DWD) – 98/83/EC) and the new Bathing Waters Directive (2006/7/EC, concerning management of bathing water quality and repealing Directive 76/160/EEC), reporting is based on several articles[1]. Some of the 'old' directives had clearly defined procedures for reporting adopted through the Committee procedures in the form of Commission Decisions (e.g. reporting on 'old' BWD is based on the provisions of Commission Decision 95/337/EC). However for the others, the reporting process had various backgrounds – sometimes through Committee procedures (e.g. reporting under Article 17 of UWWTD was set up via Commission Decision 83/481/EEC, while reporting under Article 15(4) was based on the Commission duty to issue the questionnaires (request of information) to the Member States with the duty to reply within six months.

For some other directives (stemming partially from the 1970s), streamlined monitoring was introduced with the Standardised Reporting Directive 91/692/EEC with a reporting cycle of three years. On the basis of this directive, the water questionnaire was introduced in 1992 and the latest version agreed by Committee in

[1] For UWWTD – articles 17, 16, 15(5); for 'old' BWD – article 13 and decision 95/337/EC (Annex VIII) amending decision 92/446/EEC; for 'new' BWD – article 13; for NiD (91/676/EEC) – article10; and for DWD (98/83/EC) – on article 13.

1995 (Commission Decision 95/337/EEC). The experiences from this reporting exercise are summarised as follows:

- Information was often not submitted or was incomplete;
- The format of the information provided varied (e.g. electronic vs paper copy) and often did not follow the format of the questionnaires in the 1995 Decision;
- It was not clear to MS what information had to be reported for the second reporting return, and what could be omitted and it was not clear to those carrying out the assessment what information had been submitted in previous returns;
- The quality of the information submitted by MS was very diverse and often difficult to read, validate and process;
- There were often differences between MS in the interpretation of the questions and information needs within the questionnaires. This led to information being incomparable between MS and difficulties in drawing comparisons on a year-on-year basis.

Also, for reporting for some 'old' water directives the experiences were mixed. Some of the reporting was organised without providing specifications and/or technical guidelines what to report and how. This led to a set of inconsistent, incomplete information with different levels of detail which were difficult to compare.

On the basis of all these experiences, there is a clear need to streamline the reporting exercise under the directives mentioned above along with the WFD in order to use more consistent approach, taking into account the electronic reporting foreseen under the Water Information System for Europe (WISE).

For the newer pieces of legislation, most of them have general provisions for reporting but include possibilities to specify the explicit requirements and needs in more detail. For example, Article 20 WFD stipulates in paragraph 2:

"*(2) For the purpose of transmission and processing of data, including statistical and cartographic data, technical formats for the purpose of paragraph 1 may be adopted in accordance with the procedures laid down in Article 21.*"

Once approved by the Regulatory Committee and adopted by the Commission, such formats would become legally binding. In other words, if a MS fails to submit even parts of the agreed information, it is not compliant with the Directive. Moreover, the procedures to develop such formats are time consuming and lack flexibility in case adaptations and improvements should be introduced on short notice. Furthermore, the agreement on the required specifications for reporting may be driven by the lowest common denominator and may not have been able to incorporate a feedback and testing process as applied now.

For these reasons, no such legally binding reporting formats have yet been developed. Even if they had been considered, the ambitious deadlines for implementation of the WFD would have made it difficult to publish legally binding reporting formats with sufficient lag time to allow MS to implement the system. Any delays would have triggered complex legal and formalistic discussions rather than focusing on the implementation of the Directive.

The past experience demonstrated that reporting without any detailed specifications and guidelines results in a diverse set of documents with different levels of details and with information which is poorly comparable. Furthermore, the development of the WISE requires some form of agreement on the contents and the technical specifications of data exchange. Therefore, and having the successful consensus-based cooperation under the Common Implementation Strategy (CIS) in mind, it was decided to prepare and agree guidance documents for the different reporting requirements using the format of Reporting sheets. These Reporting sheets have been prepared by a drafting group of the Working Group on Reporting (Working Group D), agreed by the Group and endorsed by the Water Directors on a consensus basis. These Reporting sheets therefore are informal arrangements between the MS and the Commission and thus are not legally binding. It is a voluntary commitment, agreed at high level, by the MS to submit this information to WISE. Current experiences show that this approach results in a higher success rate in reporting in comparison to the legally binding reporting requirements of the past.

Figure 1 below shows the Reporting sheets developed for surface water and the relationships between them. Similar sheets were developed for groundwater. Whilst the Reporting sheets were a useful tool for the development of the reporting requirements on an Article by Article basis, it is no longer necessary, or indeed helpful, to present the information requirements in this way. This consolidated guidance document contains all the information originally in the Reporting sheets but presented in a clearer, object-related way with the ultimate focus being on fully reported and comparable RBMP.

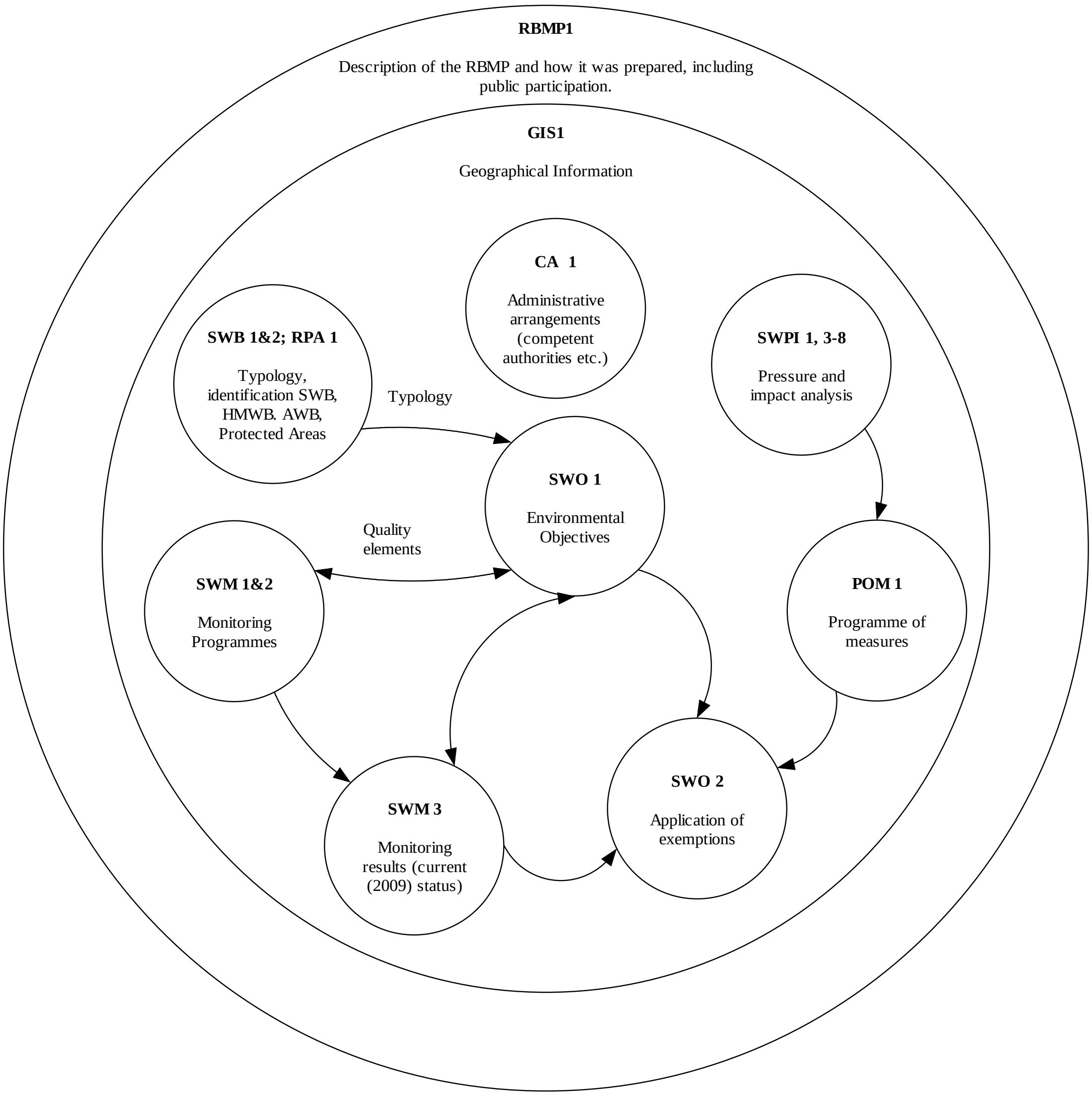


Figure 1 Relationships between Reporting sheets on surface waters

2 REPORTING REQUIREMENTS OF THE WATER FRAMEWORK DIRECTIVE

The reporting requirements of the WFD are specified in Articles 3 and 15. Article 3 requires MS to provide information to the European Commission on the identification of River Basin Districts and Competent Authorities, whilst Article 15 requires information to be provided to the Commission on:

- The analysis carried out according to Article 5;
- Monitoring programmes;
- River Basin Management Plans.

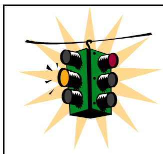
Article 18 of the Directive requires the Commission to publish reports on the implementation of the Directive and to submit them to the European Parliament and to the Council.

The first reports by MS were made in 2004 (for Article 3) and 2005 (for Article 5). The Commission has used the information provided to make reports to the European Parliament and Council as required under Article 18 of the Directive.

The first report on monitoring programmes was made by the MS in 2007 and the Commission will publish a report to the European Parliament and Council in early 2009. The first report by MS on the RBMPs will be made in 2010.

In addition to the specific requirements of the Directive, the Commission, as “Guardian of the Treaties”, also has a duty to ensure that the regulations and directives adopted by the Council and Parliament are being implemented in the MS. The Commission uses the information provided by the MS to carry out this compliance assessment and to ensure that the Directive is being applied consistently throughout the EU. The Commission has developed a concept for compliance checking for the WFD, and papers have been presented to the Member States specifying how the compliance check will be carried out. These have been completed for Articles 3, 5 and 8 and are currently being developed for Article 13. One of the key concepts used by the Commission is that of compliance indicators which are used for screening assessments to identify where a more detailed examination of compliance may be required. Compliance indicators may be simple (for example: have Competent Authorities been identified?– yes, no, to a certain extent, unclear – not sufficient information) or more complex and numeric indicators (for example: percentage of water bodies per water body category). The information requirements for these indicators have been identified as part of the reporting requirements. More detail on the Commission approach to compliance checking for the WFD can be found in the following documents:

- Questionnaire for the assessment of Compliance of WFD Article 3 Reports (discussed at the Working Group D meeting March 2006);
- Preliminary Screening For Compliance Checking Of Article 5 Reports (2005 Reporting) (discussed at the Working Group D meeting March 2006);
- “Use of information reported for Article 8 – concept paper on compliance checking” (presented at the Working Group D meeting March 2008);
- Concept paper on compliance checking on RBMP – currently being prepared.

	**Look Out!** Information that has already been reported for other purposes (e.g. UWWT Directive to the EEA under WISE-SoE reporting) does NOT have to be provided again.

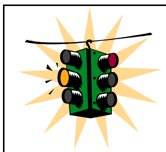
3 REPORTING REQUIREMENTS FOR RIVER BASIN MANAGEMENT PLANNING

3.1 Introduction

Article 13(1) of the WFD requires MS to ensure that a River Basin Management Plan (RBMP) is produced for each River Basin District (RBD) within their territory. Article 13(4) requires that the RBMP includes the information laid down in Annex VII of the Directive. Paragraph 8 of Annex VIIA requires MS to include a register of detailed programmes and management plans for the RBD in the RBMP.

Article 14 of the WFD requires MS to encourage the active involvement of all interested parties in the implementation of the Directive, and in particular in the production of the RBMP. For further information in relation to public participation in accordance with the WFD, refer to the Public Participation Guidance Document (WFD CIS Guidance Document 8)[2].

Article 3 of the WFD requires MS to ensure the appropriate administrative arrangements, including the identification of the appropriate Competent Authority, for the application of the rules of this Directive within each RBD lying within their territory. This will include Competent Authorities for the portion of any international RBD lying within its territory. The Directive requires Competent Authorities to be put be in place by 2003 and first reported in June 2004. Annex I of the WFD lays down the information that must be provided.



Look Out!

Member States first reported under Article 3 in 2004. In 2010, data should only be resubmitted if any was missing from the original submission or if any of the information has since changed.

3.2 How will the Commission use the information reported?

The Commission will use the information reported to ensure that the Member State has properly implemented the Water Framework Directive; ensuring that a register of more detailed programmes and management plans[3] is in place and that information has been provided to the public in accordance with the Directive. In particular, the information provided will be used to check the consistency of approach between Member States.

The following compliance indicators will be used:

- Have the Member States prepared a comprehensive River Basin Management Plan including all elements of and being consistent with the Directive and having been consulted with the public? (Possible answers: Yes / No / To a certain extent/ Unclear – not sufficient information).

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[2] http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos8spublicspar/_EN_1.0_&a=d

[3] Dealing with particular sub-basins, sectors, issues or water types.

- A check list will be developed to ensure that every point in Annex VII and other relevant aspects are covered in some place of the RBMP. This check list will build on compliance indicators from other sheets.

Compliance of information provided by Member States on Competent Authorities will not be assessed in 2010. However, the provision of data will allow the Commission to ensure that all roles required by the WFD are being fulfilled within the RBD, making it unnecessary to seek further information from Member States at a later date. The data may be used for presentation to the European Parliament and will be provided to the public through WISE.

3.3 Information to be provided

The following information should be provided for each RBD (including national portions of international RBDs).

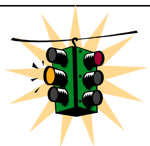
Data

For the RBMP the dates of publication of the:

- Timetable, work programme and consultation measures;
- Interim overview of significant water management issues;
- Draft copies of the RBMP;
- Final RBMP.

For each Competent Authority:

- The official name, acronym and Competent Authority Code[4];
- The full address and web-site.



Look Out!

Definition of a Competent Authority:

The various possible roles/responsibilities of a Competent Authority might be discharged at different levels in different MS. This could result in a large number of Competent Authorities in some MS. To circumvent any difficulties that this situation may cause, for reporting purposes a Competent Authority will be defined as having the following **core roles**:

A. Coordination, preparation and production of RBMPs;

B. Reporting (including of reporting on Article 5 requirements, monitoring requirements, establishment of programmes of measures, regulation and authorisation of surface water activities, regulation and authorisation of groundwater activities and public information and consultation).

[4] A Competent Authority may be associated with many RBDs, and may have different address and contact details for each association. A general/main address and specific addresses for RBDs should be provided if appropriate.

Summary text

Summary text should be provided covering the following items:

- A description of the (international) RBMP, including;
    - A table of contents of the plan;
    - Reference to any supporting documents that form part of the plan;
    - Reference to databases/repositories of information that support the plan;
    - A summary of the process and procedures used to develop the plan, and the main institutions involved in the planning process.
- The register of the programmes and management plans for the RBD, including sub-basins, Sub-units, sectors, issues or water types, and the information held within it (as specified in Article 13(5) and Paragraph 8 of Annex VIIA);
- **Only if it has not been possible** to produce an international RBMP for any RBD falling entirely within the Community, a justification for why this has not been possible;
- **Only if it has not been possible** to produce a single RBMP for any RBD that extends beyond the boundaries of the Community, a justification for why this has not been possible;
- **Only if any RBMP does not include the information detailed in Annex VII**, a justification for why this is the case;
- **Only if any RBMPs have not been published by 2009**, a justification for why publication is delayed;
- The public participation activities in place to encourage the active participation of the interested parties and consultation of the public in the development of the RBMP; including information on how the consultation on the RBMP was managed (including response periods); and including the arrangements in place to allow members of the public access to the background documents;
- A brief assessment of the experiences of the public participation activities carried out and what could be done in the RBMP to address these issues;
- The planned process of preparation of the first update of the RBMP;
- The legal status of each Competent Authority including:
    - The legislation establishing the Competent Authority;
    - The legislation laying down the duties of the Competent Authority in relation to the WFD;
    - The legislation laying down other duties of the Competent Authority relevant (but not directly related) to the WFD.
- The institutional relationships established in order to:
    - ensure co-ordination where the Competent Authority acts as a co-ordinating body for other Competent Authorities. This should include a list showing the co-ordinating body and the relationship between the co-ordinating body and the authorities whose activities it is co-ordinating;

    - ensure co-ordination where a RBD covers the territory of more than one MS or includes the territory of non-Member States.

- The core responsibilities of the relevant Competent Authority. If other relevant roles are fulfilled by organisations not defined as Competent Authorities for the purposes of reporting, a summary should be provided identifying these authorities and the roles that they perform.

References/Hyperlinks to more detailed supporting documents (e.g. methodology documents, documents provided as part of the public participation, statutes, founding treaty or equivalent legal documents) should be provided for each of the above-mentioned summaries, if available.

4 REPORTING REQUIREMENTS FOR GEOGRAPHICALLY REFERENCED INFORMATION

4.1 Introduction

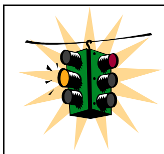
Water Framework Directive

Articles 3 and 15 of the WFD require MS to provide information to the European Commission on the identification of RBDs and of the results of the analysis carried out under Article 5, including specific requirements to report geographic information. The first reports were made in 2004 (for Article 3) and 2005 (for Article 5).

In 2010 MS will be required to provide information on the RBMPs. According to Annex VII these should include information on the general characteristics of the RBDs. This section identifies the *geographic elements* of this information that should be provided to the Commission. The *data and textual aspects* of the information required are identified in other sections of this document.

Guidance on how this information should be provided can be found in WFD CIS Guidance Document No. 9[5] and Guidance Document No.22 - Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water policy[6]. The Commission will use the information to prepare European wide maps for the assessment of compliance and to present information to the European Parliament, Council and general public. In some cases, reference data sets will be created to provide a common basis for assessments across the EU.

Annex V of the WFD specifies how Member States are to monitor and present "status" classification. For groundwater, the detailed provisions and criteria for the respective assessments of chemical and quantitative status are laid down in the Groundwater Directive 2006/118/EC.

	**Look Out!** Member States first reported under Article 5 in 2005 and under Article 8 in 2007. In 2010, data should only be resubmitted if any was missing from the original submission or if any of the information has since changed.

[5] Guidance Document No. 9 has been revised and replaced by Guidance Document No. 22 - Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water policy. Future reporting of geographical information should be in accordance with the specifications agreed in the context of this process.

[6] Guidance Document No. 22 has been endorsed by the SCG and Water Directors and is available from:
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents&vm=detailed&sb=Title.
The appendices are available from:
http://eea.eionet.europa.eu/Public/irc/eionet-circle/eionet-telematics/library?l=/technical_developments/wise_technical_group/updated_2nd-edition/appendices_updated&vm=detailed&sb=Title
.

4.2 How will the Commission use the information reported?

The Commission will use the information to prepare European wide maps for the assessment of compliance and to present information to the Parliament, Council and general public. In some cases, reference data sets will be created to provide a common basis for assessments across the EU.

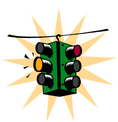
For further information on how the Commission will use the information reported on surface water bodies, see Chapter 5.

For further information on how the Commission will use the information reported on groundwater bodies, see Chapter 6.

For further information on how the Commission will use the information reported on pressures, impacts and Programmes of Measures, see Chapter 7.

4.3 Information to be provided

Data

	**Look Out!** The geographic information below should be harmonised to national and coastal boundaries. The technical specifications of such harmonisation are to be agreed in the context of the development of the updated GIS guidance.

For each **RBD** the data are required to enable the following maps to be produced:

- The RBDs;
- All river basins which have either been combined with larger river basins, or joined with neighbouring small basins to form individual RBDs as allowed under Article 3.1;
- Sub-units;
- The main rivers within the RBDs of a catchment area of, at least, 500 km²;
- The lakes which have been assigned to the RBDs;
- Transitional waters relating to the main rivers within the RBD;
- Coastal waters which have been assigned to the RBDs;
- Transboundary groundwaters which have been assigned to the RBDs;
- Other contextual data including:
    - River length;
    - Area of lakes, transitional and coastal waters.

For each **RBD/Sub-unit,** data will be required to enable the following maps of surface water status to be produced (reflecting the status as reflected in the RBMP). The maps shall present the following quality elements (QE):

- Map 1: Ecological status class of natural water bodies including data at a water body level, on which Biological QEs the assessment is based (default setting "unknown status" is applied if no class and BQE-specific data are provided)[7];

- Map 2: Ecological potential class for HMWB - MS should specify BQE concerned (default setting "unknown potential" is applied if no class and BQE-specific data are provided);
- Map 3: Status for protected areas – if not, specify reasons for failure **(if reported for other Directives (e.g. BWD, NiD, Habitats etc.) this information will not need to be reported again**. Reporting **will be required** for Article 7 protected areas as these are not defined under any other Directive);
- Map 4: Achievement/exceedance of EQS for **heavy metals[8]** out of list of Priority Substances;
- Map 5: Achievement/exceedance of EQS for **pesticides[9]** out of list of Priority Substances;
- Map 6: Achievement/exceedance of EQS for **industrial pollutants[10]** out of list of Priority Substances;
- Map 7: Achievement/exceedance of EQS for **other pollutants[11]** out of list of Priority Substances;
- Map 8: Achievement/exceedance of EQS for **other (national) pollutants**;
- Application of exemption for Water Bodies (by QE (to level 2 as defined in the 2007 monitoring Reporting sheets) and the target class)[12], which illustrates the envisaged/agreed objective for 2015.

Annex V of the WFD specifies how Member States are to monitor and present "status" classification. For surface water it has been agreed that the overall ecological status class of the waterbody will be reported using the defined colour codes. In addition, the following information should be provided[13]:

- An indication of which quality elements have been used in the classification;
- An indication of the status class indicated by the quality elements used;
- An indication of where information for a quality element is not available or not applicable;

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[7] The WFD requires to determine the ecological status/potential class of every water body, but not to monitor all quality elements of all water bodies. Furthermore, some MS may not have appropriate monitoring for all BQE in place. The map should enable to create a disaggregated picture where only selected information is shown. It may be necessary to describe more detailed data and reporting needs to fulfil this aim.

[8] Cadmium, lead, mercury, nickel.

[9] Alachlor, atrazine, chlorpyriphos, chlorvenfinphos, diuron, endosulfan, isoproturon, HCH, pentachlorobenzene, simazine, trifluralin.

[10] Anthracene, Benzene, C_{10-13}-chloroalkanes, Naphthalene, Nonylphenol, octylphenol, chlorinated organics (incl. SCCP, TRI, PER, DCM, Chloroform, 1,2-Dichloroethane...), PentaBDE, DEHP.

[11] DDT, HCB, HCBd, TBT, PAHs (including Fluoranthene), PCP, TCB, drins.

[12] Default status “good status” unless water body is already at “high status” according to 2009 monitoring data and classification.

[13] Agreed at the SCG on 14-15 May 2008 (see document WGD/SCG14150508-13, "Reporting WFD ecological status of water bodies at European level", version 2).

- An indication of confidence in the ecological status class for the water body on a qualitative scale from 1 (Low confidence) to 3 (High confidence).

When monitored, monitoring data (disaggregated or aggregated) will be supplied for WISE-SoE reporting at the monitoring site level.

Data will be required to enable the following groundwater-related maps to be produced at **RBD** level (reflecting the status with data available in 2009). The maps shall present the following information:

- Map 1: Quantitative status – Identification of bodies that are at “good quantitative status” and those that are at “poor quantitative status”;
- Map 2: Achievement/exceedance of standard for **nitrates** (value in Annex 1 of GWD or set according to paragraph 3 of Annex 1 GWD, and according to status assessment procedure in Article 4 of GWD);
- Map 3: Achievement/exceedance of standard for **pesticides** (combined total and individual value in Annex 1 of GWD or set according to paragraph 3 of Annex 1 GWD, and according to status assessment procedure in Article 4 of GWD);
- Map 4: Achievement/exceedance of threshold values set by Member States for **other pollutants** (considering in this category the list of substances as contained in Part B of Annex II of GWD and more generally any other pollutants contributing to the characterisation of groundwater bodies as being 'at risk', and according to status assessment procedure in Article 4 of GWD);
- Map 5: Trends - Identification of: (a) groundwater bodies with environmentally significant and sustained upward trends in pollutant concentrations, and (b) groundwater bodies in which trends have been reversed[14];
- Application of exemption for WB (by QE (to level 2 as defined in the 2007 monitoring reporting sheets) and the target class)[15], which illustrates the envisaged/agreed objective for 2015.

For each **surface water body** the following data are required:

- Water body code;
- Water body name;
- Shapefile/GML file:
  - Rivers: for water bodies on rivers with catchments>500 km^2;
  - Lakes: for all lakes identified as water bodies by Member States;
  - Coastal and transitional waters: for all water bodies identified.
- Centroid (for all surface WBs) (technical specification for the calculation of the centroid to be developed in the context of the updated GIS guidance);
- Size (total length or area) at 1:250 000;

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[14] For further information see Document No. 18 - Guidance on groundwater status and trend assessment.

[15] Default status “good status” unless water body is already at “high status” according to 2009 monitoring data and classification.

- Whether the water body (WB) is heavily modified (HMWB) or artificial (AWB);
- Type;
- Significant point source discharges to surface waters:
  - ID of significant point sources where data already available;
  - Latitude and longitude of each significant point source (if possible);
  - Type of point source (see SWPI3).
- Significant diffuse source pollution to surface waters:
  - WB Affected? (Y/N);
  - Type of source (see SWPI4).
- Significant water abstractions from surface waters:
  - WB Affected? (Y/N);
  - Latitude and longitude of each abstraction (if possible);
  - Type of abstraction (see SWPI5).
- Water flow regulations and morphological alterations:
  - WB Affected? (Y/N);
  - Type of Regulation/Alteration (see SWPI6).
- Significant saltwater or other intrusion:
  - WB Affected? (Y/N).
- Other pressures:
  - WB Affected? (Y/N);
  - Type of Pressure (to be specified see SWPI7).
- Impacts:
  - Type of impact identified (see SWPI8).
- Protected areas
  - Water body within or overlapping with a protected area (Y/N);
  - Type of protected area (**provide a Shapefile/GML file only where information is NOT reported under any other Directive. Where information has been provided under other Directives provide the unique identifier (code) of the appropriate protected area**):
    - WFD Article 7;
    - Sites for the protection of economically significant aquatic species;
    - Bathing Water Directive sites (Directives 76/160/EEC and 2006/7/EC);
    - Nitrate vulnerable zones (Directive 91/676/EEC);
    - Sensitive Areas (91/271/EEC);
    - Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites (Directive 92/43/EEC and 79/409/EEC);
    - Other protected areas defined under national legislation (specify – see also RPA1);
    - Other protected areas defined under regional/local legislation (specify – see also RPA1).

For each **groundwater body (GWB)** the following data are required:

- Water body code;
- Water body name;
- Shapefile/GML file:
    - Groundwaters: boundaries of groundwater bodies or groups of groundwater bodies larger than 100 km^2.[16]
- Centroid (for all groundwater bodies) (technical specification for the calculation of the centroid to be developed in the context of the updated GIS guidance);
- For groundwater bodies or groups of groundwater bodies, if available:
    - Layered (Y/N);
    - Average depth to groundwater body (m);
    - Average thickness of groundwater body (m);
    - Assignment to a depth range where the main part of the GWB is situated in (depth ranges: 0-20m, 20-50 m, 50-200 m, >200m);
    - Directly dependent aquatic ecosystems (Y/N);
    - Directly dependent terrestrial ecosystems (Y/N);
    - Geological formation – aquifer type (according to a predefined typology);
    - Type of vertical orientation of GWB (indicated by category and visualised by symbols);
    - Volume of aquifer (m^3) (if possible).
- Relevant point source discharges to groundwater:
    - ID of significant point sources where data already available;
    - Latitude and longitude of each relevant point source (if possible);
    - Type of point source (see GWPI3).
- Relevant diffuse source pollution to groundwater bodies:
    - WB Affected? (Y/N) ;
    - Type of source (see GWPI4).
- Relevant abstractions from groundwater:
    - WB Affected? (Y/N);
    - Latitude and longitude of each abstraction (if possible);
    - Type of abstraction (see GWPI5).
- Relevant artificial recharge of groundwater:
    - WB Affected? (Y/N);
    - Type of Regulation/Alteration (see GWPI6).
- Significant saltwater or other intrusion:
    - WB Affected? (Y/N).
- Other pressures:
    - WB Affected? (Y/N);
    - Type of Pressure (to be specified see GWPI8).

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[16] When providing all GWB boundaries in one file please take care that the GWBs are not intersected. Alternatively provide separate files for each GWB horizon.

- Impacts:
    - Type of impact identified (see GWPI9).

- Protected areas:
    - Water body within or overlapping with a protected area (Y/N);
    - Type of protected area (**provide a Shapefile/GML file only where information is NOT reported under any other Directive. Where information has been provided under other Directives provide the unique identifier (code) of the appropriate protected area**):
        - WFD Article 7;
        - Nitrate vulnerable zones (Directive 91/676/EEC);
        - Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites (Directive 92/43/EEC and 79/409/EEC);
        - Other protected areas defined under national legislation (specify – see also RPA1);
        - Other protected areas defined under regional/local legislation (specify – see also RPA1).

For each **surface water monitoring site**, the following data are required:

- Site name;
- Is the site a surveillance monitoring or operational monitoring site, or both?;
- Unique site identifier;
- Link to the code/s of WB or WBs reported under Article 5 to which the site is associated (1 to 1-, 1 to many- or many to 1-relationship possible);
- X/Y co-ordinates (latitude/longitude) of the site;
- Identify if the site located in protected areas (Y/N). If so, the type of the protected areas (in accordance to Annex IV WFD) is required;
- Identify if the site is part of the intercalibration network (in accordance with Decision 2005/646/EC) or the national network of reference sites (i.e. determining reference conditions);
- Identify if the site is part of existing international monitoring networks (e.g. TNMN of the Danube river basin or WISE-SoE site);
- QE identifiers[17].

For each **groundwater monitoring site**, the following date are required:

- Unique site identifier;
- Identify the type of monitoring site:
  a) Is the site a well or a spring?;
  b) Is the site a quantitative or chemical monitoring site, or both?

[17] Development of an identifier system for QEs should be developed.

- Identify the use of monitoring site:
  Is the site used for monitoring, drinking water supply, industrial supply, irrigation or others?
- Unique code of GWB or group of GWBs to which the site is associated (1 to 1-, 1 to many- or many to 1-relationship possible);
- X/Y co-ordinates (latitude/longitude) of the site;
- Identify if the site is part of existing international monitoring networks (e.g. TNMN of the Danube river basin or WISE-SoE site);
- Information on sampling depth (site allows for sampling of upper, medium or deeper layer of the GW-body or for mixed samples);
- Parameter identifier.

5 REPORTING REQUIREMENTS FOR SURFACE WATER BODIES

5.1 Introduction

Identification and Characterisation of Water Bodies

Article 5 of the WFD requires Member States (MS) to identify surface water bodies that will be used for assessing progress with, and achievement of the WFDs environmental objectives. In addition, under certain conditions, Article 4(3) of the WFD permits MS to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB). HMWB and AWB are required to achieve Good Ecological Potential by 2015.

Identifying the size of water bodies was an important parameter that had implications on the design of the monitoring programmes and on the development of appropriate programmes of measures. A stepwise process for the identification of HMWB resulted in a provisional identification by 2004. Full identification should be completed by 2010 for publication in the RBMP.

Article 5 of the WFD also requires MS to analyse the characteristics of surface water bodies and provide a summary report on surface water characterisation including general information on their typology.

Article 6 of the WFD requires that a register of the water-related protected areas lying within each RBD be established. This will help to ensure that the management of the relevant water bodies also ensures the objectives of these protected areas are achieved. Annex IV of the WFD specifies what types of protected areas should be included in the register and specifies what the summary of the register, which should be part of the RBMP should include.

Classification and Monitoring of Water Bodies

Annex V of the WFD specifies how MS are to monitor and present "status" classification. The Commission needs to ensure that "good status/potential" has been defined according to the provisions of the Directive, and in a consistent and comparable way throughout the EU. The status requirements refer to all QEs in the Directive, chemical and biological. The normative provisions of Annex V provide a starting point. However, interpretation and application of these definitions may differ, which may lead to a wide range of variation between the MS. In this respect, it is important to compare the criteria and thresholds that MS have set. Whilst it is recognised that the intercalibration exercise has set out to ensure that the definition of high and good ecological status is consistent, the intercalibration exercise will not result in the findings of whether the Member States have followed the results of intercalibration or whether class boundaries have been established for all required water body types and quality elements. However, the intercalibration exercise has provided a useful template for the collection of such information which has been used in the development of this reporting guidance.

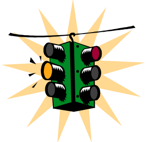
Article 8 of the WFD requires MS to ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each RBD. Monitoring programmes should be in place by 2006 and reported in March 2007.

Investigative monitoring is reactive in nature and, as such, differs from the more routine surveillance and operational programmes. No detailed site specific information can be provided up front in relation to investigative monitoring. However, methodologies/strategies can be put in place detailing how each MS will investigate exceedances, reasons for likely failure to meet the environmental objectives and pollution incidents.

Strategies may include:

- Implementation of early warning systems (e.g. alert systems, public enquiries, pollution incident helplines etc);
- Procedures for dealing with individual exceedances (e.g. maximum allowable concentrations) and long-term exceedances (e.g. likelihood of non-compliance);
- Procedures for dealing with pollution incidents (e.g. incident notification, site visits, monitoring, reporting and action such as fines, clean-up etc).

In order to assess compliance with the requirements for *investigative monitoring*, MS are requested to provide an overview of the methodology/strategies that have been put in place at an RBD level to address the above issues.



Look Out!

Member States first reported under Article 5 in 2005 and under Article 8 in 2007. In 2010, data should only be resubmitted if any was missing from the original submission or if any of the information has since changed.

5.2 How will the Commission use the information reported?

The Commission will use this information to assess progress with, and achievement of, the WFD's environmental objectives. This information will be provided to the public through WISE.

The following compliance indicators, for the identification of surface water bodies will be used:

- Average size of river water bodies: as the total river water body length (km)/number of river water bodies;
- Average size of lake water bodies: total lake surface area (km^2)/number of lake water bodies (by Sub-unit);
- Average size of transitional water bodies: total area of transitional water bodies (km^2)/number of transitional water bodies (by Sub-unit);
- Average size of coastal water bodies: total surface area of coastal waters (km^2)/number of coastal water bodies/ (by Sub-unit);
- Minimum and maximum size (define dimensions) of water body in the Sub-unit per water category;

- Number and combined surface area (km^2) of lakes that are below the threshold (0.5 km^2). If no accurate figures are available then an estimate should be provided.

The following compliance indicators, for the identification of AWBs and HMWBs will be used for each water category (rivers, lakes, transitional waters, coastal waters):

- Number of artificial water bodies/Sub-unit – calculated by MSs;
- Number of heavily modified water bodies/Sub-unit;
- Percentage of water bodies per water body category.

With regard to the typology of surface waterbodies, the key issue for compliance will be identifying whether the level of typology is comparable. The information will be used to ensure that if System B has been followed, it provides at least the same level of differentiation as would be provided by System A and that type specific reference conditions can be adequately defined. It is also important for the Commission to check how the International River Basin District (IRBD) have co-ordinated their typology, and if not, the reasons why it was not coordinated, the steps that have been taken to address this shortcoming and by when co-ordination will be achieved.

For information relating to the typology of surface waters in accordance with the WFD, refer to the REFCOND, COAST and Waterbodies Guidance Documents (WFD CIS Guidance Document Nos 10, 5 and 2, respectively).

WFD Article 8 requires that monitoring programmes be established for each RBD and made operational by December 2006, and must be implemented in accordance with Annex V.

While Annex V sets out the minimum requirements for establishment of surface water surveillance, operational and investigative monitoring programmes, it is up to individual MS to develop the programmes, ensuring that the network of sites, parameters indicative of the QEs and monitoring frequencies are sufficient to provide a comprehensive and coherent overview of surface water status within each RBD.

A summary report of the monitoring programmes was reported to the Commission by March 2007. This summary should be sufficient to enable the Commission to carry out screening to ensure that the monitoring networks established for each purpose will be adequate to provide a comprehensive and coherent overview of surface water status for each RBD within each MS.

The Commission will check comparability of the monitoring programmes between Member States and consistency with the requirements of Annex V WFD and the outcome of the Article 5 analysis. Moreover, the Commission will use this information to inform the European Parliament and the public about the implementation progress in the Member States. Finally, some of the base data are necessary to establish a reference dataset with which monitoring results can be related and exchanged between the Member States and the European bodies more easily at a later stage.

WFD Annex V 1.3 requires that, under certain circumstances and to supplement surveillance and operational monitoring, MS may need to establish an investigative monitoring programme. The purpose of investigative monitoring is to determine:

- Reasons for exceedances, where these are unknown;

- Reasons for the likely failure to achieve the environmental objectives and where operational monitoring has not already been established; and,
- The magnitude and impacts of accidental pollution.

The outcomes of investigative monitoring will be used to inform the programme of measures.

Annex V 1.3.3 sets out the objectives and requirements for investigative monitoring. Additional monitoring requirements for protected areas and standards for monitoring are set out in Annex 1.3.5 and 1.3.6, respectively. No specific guidance is provided on selection of sites and monitoring frequencies. However, the number of sites and monitoring frequencies must be sufficient to determine the magnitude and impacts of accidental pollution and to achieve acceptable levels of confidence and precision.

For further information in relation to the establishment of monitoring programmes in accordance with the WFD, refer to the Monitoring Guidance Document (WFD CIS Guidance Document No. 7)[18].

Although compliance of information provided by Member States on the results of surface water monitoring programmes (status of surface waterbodies) will not be assessed in 2010, a key indicator will be percentage of moderate, poor or bad water bodies in the River Basin District or Sub-unit (i.e. those not of good ecological status and potential). Therefore, the main part of the reported information will be used for visualisation and for providing information to the public through WISE. Furthermore, the data and maps will provide a baseline or starting point for the implementation of the WFD (e.g. answering the question: how was the water quality before the programme of measures required by the WFD was implemented?). This means that the requested data and maps will be essential for trend analysis, for policy development and for the assessment of policy effectiveness. However, if Member States provide some of this information through the WISE-SoE reporting to the EEA, the Commission will use those data for its own purposes.

The following compliance indicator will be used:

- No compliance check will be carried out on 2009 monitoring results. However, for the purposes of illustrating the current status of water bodies to the public the indicator percentage of the water bodies being in different status classes specified for different quality elements (based on available maps) will be used.

Information provided by Member States on will be used to establish whether Member States have established a status classification scheme in accordance with the Directive, and to determine whether status classes are consistent with the Directive, comprehensive and comparable between Member States and River Basin Districts. The comparison of assessment criteria and thresholds will make the level and ambition of environmental protection more transparent and will allow to identification of differences in assessment methods, in terms of whether they are comprehensive and comparable.

[18]http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos7smonitoring/_EN_1.0_&a=d

The following compliance indicator will be used:

- Did Member States set a comprehensive set of criteria for assessing "good status/potential" (and other required boundaries) which is consistent with the Water Framework Directive and comparable throughout the EU? (Possible answers: Yes / No / To a certain extent / unclear – not sufficient information).

The Commission will use the information provided by Member States on protected areas to ensure that a register of protected areas has been established in the RBD.

The following compliance indicator will be used:

- Has information relating to protected areas been provided?

5.3 Information to be provided

Data

For each **RBD/Sub-unit** the following data are required:

- Total river water body length/total number of water bodies including artificial water bodies;
- Total lake water body surface area (km^2)/number of lake water bodies;
- Total area of transitional water bodies (km^2)/number of transitional water bodies;
- Total surface area of coastal waters (km^2)/number of coastal water bodies;
- Maximum and minimum size of water body (by water body category);
- Total number of HMWBs and AWBs.

The size of water body should be calculated at the scale of 1:250 000. If this is not possible then the scale at which the calculations have been made should be stated.

For each **category of water body** (rivers, lake, transitional and coastal waters) the following data are required:

- Number of types per water category (national or RBD);
- A list of types and a short description (<300 characters) of each type.

For each **surveillance and operational monitoring programme and for each surface water category** (rivers, lakes, coastal and transitional), the following data are required:

- Intended start date (if it differs from 22 December 2006);
- Total number of monitoring sites and frequency to be (or expected to be) monitored for each QE (see Table 1 below);
- List of Priority Substances and other substances discharged in significant quantities to be monitored.

Table 1 Information required for surveillance and operational monitoring programmes

Category	River		Lake		Coastal		Transitional	
	No. sites	Freq	No. sites	Freq	No. sites	Freq	No. sites	Freq
QE1 -Parameter 1 -Parameter 2 -Etc								
QE2 -Parameter 1 -Parameter 2 -Etc								
*QE (priority substances) -Parameter 1 (if applicable) -Parameter 2 (if applicable) -Etc								
*QE (other substances -Parameter 1 (if applicable) -Parameter 2 (if applicable) -Etc								

*Note: If individual substances are monitored at different frequencies, then the monitoring frequency for each substance/group of substances should be reported.

The following data on investigative monitoring should **only be provided as an illustration of how the system of investigative monitoring has been implemented – it can only be provided if an incident requiring investigative monitoring has occurred.**

- Type of investigative monitoring programme (e.g. incident response, unknown exceedances, likely failure of objectives);
- QEs and parameters monitored;
- Number of monitoring stations for each programme;
- Number of monitoring occasions (e.g. 1 off, monthly for 1 year etc).

No specific monitoring results per monitoring station in water bodies will be required at this stage. For the purpose of plausibility and consistency checking with the assessment of status, other data submitted to WISE (e.g. WISE-SoE reporting) may be used. If the Commission requires additional monitoring data for an in-depth analysis, a specific data request will be issued.

For each **surface water type and relevant QE,** the status/potential class boundaries should be reported (see Table 2):

Table 2 Reporting of Classification boundaries

Water category	QE or parameter code (Reported under Article 8)	National method in use (hyperlink) (Reported under Article 8)	National type (name or code) (Reported under Article 5)	Short description of national type (Reported under Article 5)	Reporting units	Reference conditions (if applicable)	High-Good boundary	Good-Moderate boundary	Moderate – Poor boundary	Poor – Bad boundary	Does this boundary reflect the result of the intercalibration exercise? (For biological quality elements only) (this column may be removed depending on results of discussions ongoing in intercalibration process) Yes/No/Other (specify)	Can the Member State implement this quality element at this stage?
Rivers	Dissolved oxygen	In situ measurement	Type R1; type R2 etc.	Small, high altitude, low alkaline	5-percentile mg O_2/L	9	7,5	6				
	Soluble reactive phosphorus	CEN 11564			μg/L	25	30	50				
	…											
	Macro-invertebrates	GREB			EQR	1	0,86	0,65			Yes	
	Phytobenthos	MMPB			EQR	1	0,75	0,55			No	

Water category	QE or parameter code (Reported under Article 8)	National method in use (hyperlink) (Reported under Article 8)	National type (name or code) (Reported under Article 5)	Short description of national type (Reported under Article 5)	Reporting units	Reference conditions (if applicable)	High-Good boundary	Good-Moderate boundary	Moderate – Poor boundary	Poor – Bad boundary	Does this boundary reflect the result of the intercalibration exercise? (For biological quality elements only) (this column may be removed depending on results of discussions ongoing in intercalibration process) Yes/No/Other (specify)	Can the Member State implement this quality element at this stage?
	…											
	Priority substances (specify)(1) – CAS number	….			…..	NA	NA	[means EQS]	NA	NA	NA	
	Other pollutants– CAS number					NA	NA	[means EQS]	NA	NA	NA	
	Supporting parameters (hydromorphology and physico-chem			…								

Water category	QE or parameter code (Reported under Article 8)	National method in use (hyperlink) (Reported under Article 8)	National type (name or code) (Reported under Article 5)	Short description of national type (Reported under Article 5)	Reporting units	Reference conditions (if applicable)	High-Good boundary	Good-Moderate boundary	Moderate – Poor boundary	Poor – Bad boundary	Does this boundary reflect the result of the intercalibration exercise? (For biological quality elements only) (this column may be removed depending on results of discussions ongoing in intercalibration process) Yes/No/Other (specify)	Can the Member State implement this quality element at this stage?
Lakes, transitional, coastal and territorial waters												

Summary text

Summary text should be provided for each RBD covering the following items:

- The methodology/criteria used to:
  - delineate each category of surface water bodies such as size, river confluence, etc;
  - identify HMWB and AWB;
  - identify and characterise small water bodies less than the threshold;
  - determine the QEs and the class boundaries for natural waters;
  - determine the QEs and the class boundaries for artificial and heavily modified water bodies;
  - combine QEs to define the final status class;
  - assess the "no deterioration" objective (Art. 4.1.a). The information should demonstrate on how the assessment is carried out (including: baseline, trend analysis etc.).
- **If System B has been used** for the characterisation of water bodies, a list of those factors (obligatory and optional) listed in Annex II 1.2 of the WFD that have been used for the definition of typology of water bodies should be provided;
- The coordination for international RBDs to:
  - designate water bodies;
  - characterise water bodies;

  If no co-ordination has been achieved, give reasons why not and details of what has been put in place to overcome this situation.
- A list of any legislation identifying additional national, regional or local water related protected areas other than those identified in EU legislation.

Summary text for each monitoring programme and for each surface water category should be provided covering the following items:

- The methodology/criteria used to:
  - select sites;
  - select monitoring frequencies for each QE.
- The sampling and analysis methodology to be used for each QE and details of any relevant national or international standards (e.g. CEN/ISO);
- The extent of where any monitoring deviates from what is outlined in the monitoring programme overview above (e.g. frequency, QEs) and number or percentage of sites that is affected (in particular for surveillance monitoring and where possible/applicable also for operational monitoring);
- Information on the levels of confidence and precision expected to be achieved from the results of monitoring;
- Any additional monitoring requirements for waters used for the abstraction of drinking water in relation to Article 7[19];

[19] Monitoring requirements for protected areas (other than for the abstraction of drinking water) identified in Annex IV will be incorporated into WISE and are not required to be reported here.

- If the monitoring programmes will start later than 22 December 2006, a justification of why the monitoring programme/s are delayed;
- If the monitoring programme includes the identification of sub-sites[20], a summary of the extent and how the concept of sub-sites has been applied;
- The investigative monitoring strategy, including an example of where the strategy has been implemented, if available;
- Whether a paper-based report, e.g. for national consultation, international co-ordination, public information or other purposes, to describe the establishment of the monitoring programmes in accordance to Article 8 WFD (e.g. in PDF- or DOC-format) was produced. If yes, the report should be provided or uploaded.

References/Hyperlinks to more detailed supporting documents (e.g. methodology documents, documents provided as part of the public participation, statutes, founding treaty or equivalent legal documents) should be provided for each of the above-mentioned summaries, if available.

5.4 Reporting on specific initiatives and management objectives

If Member States choose to set operational management objectives they will be asked to report those in a generic form. In order to communicate such information to the public it would be beneficial to provide detailed, geographically referenced information on specific management measures taken and the management objectives put in place. At the highest level this could be provided for each RBD or Sub-unit. The information that would need to be provided to enable data to be displayed visually would be:

- The RBD (code);
- The Sub-unit (code);
- For nutrient load (if objectives set) the current nutrient load, the target nutrient load for the Sub-unit (for 2015) and the load reduction required for the impacted groups of water bodies;
- For connectivity (if objectives set), current status of connectivity of the Sub-unit (yes, no, partial). This question should be answered for 2009, 2015, 2021, 2027 and the target date by which the Sub-unit will be connected to the river network;
- MS may report information on other management objectives that they have set for other parameters;
- A textual summary of what measures are being put in place to achieve this (e.g. dam removal and target dates).

If this is not possible, summary text with hyperlinks to more detailed information may be provided. The summary should include the targets that have been set, the deadlines

[20] It may be necessary to monitor parameters at a number of sub-sites within a single monitoring site (E.g. to determine profiles of stratification in lakes/reservoirs, transitional and coastal waters or in large rivers (e.g. temperature, oxygen, nutrient or phytoplankton conditions) or to monitor chemical and biological QEs at different points in one site).

by which they should be achieved, the measures in place to achieve the targets and the resulting improvements in water quality that would result. Given the generalised nature of this information it should be reported at a RBD level.

On the basis of this information, data should be provided to allow maps to be produced along the lines of the examples presented by Germany (see presentation at http://circa.europa.eu/Members/irc/env/wfd/library?l=/working_groups/new_wg_reporting/meetings/meeting_1718_october/reporting_janningppt/_EN_1.0_&a=d#261,1,Reporting 2010).

6 REPORTING REQUIREMENTS FOR GROUNDWATER BODIES

6.1 Introduction

Identification and Characterisation of Water Bodies

Article 5 and Annex II of the WFD requires MS to identify the location and boundaries of groundwater bodies. The Commission will use the information provided on the level of subdivision of groundwater to ensure that this is adequate to describe the status of groundwater bodies.

Article 6 of the WFD requires that a register of the water-related protected areas lying within each RBD be established. This will help to ensure that the management of the relevant water bodies also ensures the objectives of these protected areas are achieved. Annex IV of the WFD specifies what types of protected areas should be included in the register and specifies what the summary of the register, which should be part of the RBMP, should include.

Classification and Monitoring of Water Bodies

Annex V of the Water Framework Directive specifies how Member States are to monitor groundwater, present chemical and quantitative status classification results and identify groundwater bodies with significant and sustained upward trends[21] in pollutant concentrations. The detailed provisions and criteria for status and trend assessments are laid down in the Groundwater Directive.

In addition to the WFD reporting requirements, the Groundwater Directive introduces several additional reporting requirements to ensure that groundwater body status and trends have been defined according to the provisions of the Directive, and in a consistent and comparable way across the EU.

The reporting requirements include threshold values (groundwater quality standards set by Member States). These have to be reported along with a summary of the methodology used for identifying the pollutants (or their indicators) and deriving the threshold value(s). The criteria for establishing threshold values are included in Article 3 and Annex I and II of the GWD (reporting obligations in GWD Article 3.5 and Annex II Part C). This is linked to the pressure and impact analysis required by Article 5 of the WFD and Article 17 of the WFD relating to strategies to prevent and control pollution of groundwater. According to Article 3.1(b) of the GWD, threshold values have to be established for pollutants, groups of pollutants and indicators of pollution – the relevant parameters – which have been identified as contributing to the characterisation of groundwater bodies as being at risk of not meeting the WFD Article 4 objectives, taking into account at least the list of the GWD Part B Annex II).

Article 8 of the WFD requires MS to ensure the establishment of groundwater programmes for the monitoring of water status (quantitative and chemical), including the assessment of the available groundwater resource, in order to establish a coherent

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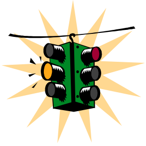
[21] In this reporting sheet the term 'significant and sustained upward trends' refers to the definition in Article 2.3 of GWD.

and comprehensive overview of water status within each RBD. Monitoring programmes should be in place by 2006 and reported in March 2007.

The GWD requires that the results of both chemical and quantitative status assessment and the methodology used to classify groundwater bodies are reported. The requirements are laid down in WFD Annex V, GWD Article 4, and Annex III (reporting requirements in GWD Article 4.4 and Annex III point 5).

In addition, the GWD requires that the results of trend assessment and the method used for trend assessment, including the way in which results from monitoring at individual points has been used, must be reported. The starting point for trend reversal and the reasons for selecting the starting point must also be reported. Requirements for the identification of upward trends and the definition of starting points for trend reversal are laid down in GWD Article 5 and Annex IV (reporting requirements in GWD Article 5.4, 5.5 and Annex IV, Part A point 3).



Look Out!

Member States first reported under Article 5 in 2005 and under Article 8 in 2007. In 2010, data should only be resubmitted if any was missing from the original submission or if any of the information has since changed.

6.2 How will the Commission use the information reported?

The Commission will use the information provided on the level of subdivision of groundwater to ensure that this is adequate to describe the status of GWB. The following compliance indicators will be used:

- Number of groundwater bodies per RBD/Sub-unit;
- Average size of groundwater body per RBD/Sub-unit.

WFD Article 8 requires that groundwater monitoring programmes be established for each RBD and made operational by December 2006, and must be implemented in accordance with Annex V.

WFD Annex V (2) requires that MS must establish a groundwater monitoring programmes (quantitative and chemical status). The groundwater network must be designed in order to provide a reliable assessment of the status of all GWBs or groups of GWBs, including the assessment of the available groundwater resource.

For further information in relation to the establishment of monitoring programmes in accordance with the WFD, refer to the Monitoring Guidance Document (WFD CIS Guidance Document No. 7).

A summary report of the monitoring programmes was reported to the Commission by March 2007. This summary should be sufficient to enable the Commission to carry out screening to ensure that the monitoring networks established for each purpose will be adequate to provide a comprehensive and coherent overview of groundwater status for each RBD within each MS.

The Commission will check comparability of the monitoring programmes between Member States and consistency with the requirements of Annex V WFD and the outcome of the Article 5 analysis. Moreover, the Commission will use this information to inform the European Parliament and the public about the implementation progress in the Member States. Finally, some of the base data sets (such as geographic information) are necessary to establish a reference dataset with which monitoring results can be related and exchanged between the Member States and the European bodies more easily at a later stage.

Information provided by Member States under the Groundwater Directive will be used to ascertain whether they have established and applied methodologies, in accordance with the WFD and GWD, for: deriving threshold values; assessing status (chemical and quantitative) and; identifying environmentally significant pollutant trends (and starting points for trend reversal).

The Commission will determine whether the methods applied are comparable between Member States and River Basin Districts. The comparison of assessment criteria and thresholds will make the level and ambition of environmental protection more transparent and will allow any differences to be identified. Information on threshold values and the substances for which such values have been established will be summarised and analysed.

Although compliance will not be assessed in 2010, a key indicator will be number of poor status groundwater bodies per River Basin District (i.e. those not of good status). This information will be provided to the public through WISE. Appropriate explanation will accompany the information on status noting that an overall result of poor status could reflect problems that are very different in severity and character (i.e. the problems can exist throughout the whole groundwater body or only in part of the body and the gap between the WFD objectives and the actual state of the groundwater can be large or small).

The following compliance indicators will be used:

- It will be analysed whether threshold values have been established in accordance with the Groundwater Directive. Did Member States set a comprehensive set of criteria for assessing "good status" which is consistent with the WFD and comparable throughout the EU? (Possible answers: Yes / No / To a certain extent / unclear – not sufficient information);
- No compliance check will be carried out on status and trends results. However, for the purposes of illustrating the current status of water bodies to the public the indicator percentage of the groundwater bodies being of good and poor chemical and quantitative status (based on available maps) will be used.

The Commission will use the information provided by Member States on protected areas to ensure that a register of protected areas has been established in the RBD.

The following compliance indicator will be used:

- Has information relating to protected areas been provided?

6.3 Information to be provided

Data

For each **RBD** the following data are required:

- Total number of groundwater bodies;
- Average area (m^2) of the groundwater bodies;
- Number of groundwater bodies for which there are directly dependent surface water or terrestrial ecosystems.

For each **surveillance and operational monitoring programme**, the following data are required:

- Intended start date (if it differs from 22 December 2006);
- Total number of monitoring sites to be (or expected to be) monitored;
- Total number of protected areas used for drinking water abstraction (from groundwater) for which there are groundwater monitoring sites associated;
- List of parameters (mainly level and pollutants) expected to be monitored.

For sites that are located in drinking water abstraction areas, the following data are required:

- Any additional monitoring requirements in relation to drinking water abstraction areas, over and above those already provided;
- Detailed site-specific information on monitoring frequencies is only required where monitoring deviates from the general programme outlined above.

No specific monitoring results per monitoring station in water bodies will be required at this stage. For the purpose of plausibility and consistency checking with the assessment of status, other data submitted to WISE (e.g. WISE-SoE reporting) may be used. If the Commission requires additional monitoring data for an in-depth analysis, a specific data request will be issued.

The following information on the **classification used for groundwater bodies** should be reported for each RBD:

- The Threshold Values (TV) established in accordance to Article 3 of the GWD and the level at which TV are established (Member State level / international RBD / national part of RBD / GWB level)[22];
- The Threshold Values established for nitrates and pesticides, only if more stringent than the groundwater quality standards identified in Annex 1 of GWD;
- The starting point for trend reversal, and reasons for their definition where they are different from 75% of the applicable TV.

Table 3 summarises the information requested.

[22] All TVs that are relevant for the RBD should be reported, including those developed at MS or GWB level.

Table 3 Information required on Groundwater Classification

Pollutants / Indicators	Threshold Value (or range)[2, 4]	Level on which the TV is established (Member State / international RBD / national part of RBD / GWB)	Starting point for trend reversal (in % of TV)[3, 4]
Nitrates			
Active substance in pesticides			
Pesticides total			
Parameter 1[1]			
Parameter 2[1]			
…[1]			
Parameter n[1]			

[1]) Considering at least the list of substances as contained in Part B of Annex II of GWD and extended by further relevant parameters/indicators as appropriate.
[2]) For nitrates and pesticides, only if different from those in Annex I to GWD.
[3]) Only if different from 75%.
[4]) Insert the range of TVs respectively the range of starting points if different TVs or starting points are applied at GWB-level within the RBD.

The following should be reported on **groundwater chemical status**, background levels and trends for each **groundwater body or group of groundwater bodies**:

- The result of the chemical status assessment (good/poor);
- If the GWB is identified as poor status;
  - The relevant pollutants / indicators for the GWB as referred to in Annex II Part A of GWD including the observed concentration values; and
  - The reason(s) for failing to achieve good chemical status, including the threshold values or quality standards that have been exceeded:
    - Multi-selection of reasons:

      a) Saline or other intrusions;
      b) Exceedance of one or more quality standard or threshold value;
      c) Failure to meet environmental objectives in associated surface water bodies or significant diminution of the ecological or chemical status of such bodies;
      d) Significant damage to terrestrial ecosystems which depend directly on the groundwater body;
      e) Deterioration in quality of waters for human consumption;
      f) Significant impairment of human uses;
      g) Significant environmental risk from pollutants across the groundwater body.
- The background level for those substances that occur naturally in the groundwater body and for which threshold values have been established;

- Information on significant and sustained upward trends including the pollutants for which trend assessment has been required.

The following should be reported on **quantitative status for each groundwater body or group of groundwater bodies**:

- The results of quantitative status assessment (good/poor);
- If the GWB is identified as poor status;
    - The reason(s) for failing good quantitative status:
        - Multi-selection of reasons:

        a) Exceedance of available groundwater resource by long-term annual average rate of abstraction that may result in a decrease of groundwater levels;
        b) Failure to achieve environmental objectives (Article 4 WFD) for associated surface waters;
        c) Significant diminution of the status of surface waters;
        d) Significant damage to terrestrial ecosystems directly depending on groundwater;
        e) Saline or other intrusion.

Summary text

Summary text should be provided for each RBD covering the following items:

- The methodology/criteria used to delineate GWBs;
- A list of any legislation identifying additional national, regional or local water related protected areas other than those identified in EU legislation;
- The establishment of groundwater threshold values (GWD Annex II Part C) covering the following items:
    - The way the procedure set out in Annex II Part A of the Groundwater Directive has been followed to derive threshold values;
    - The relationship between threshold values and background levels for naturally occurring substances;
    - The relationship between threshold values and environmental quality objectives and other standards for water protection that exist at national, Community or international level.
- The assessment of groundwater chemical and quantitative status describing the following methodologies:
    - The assessment of groundwater chemical status to cover an explanation of how exceedances of groundwater quality standards or threshold values at individual monitoring points have been taken into account in the final assessment, including the indication of what option from GWD Article 4.2 has been used (GWD Article 4.4);
    - The assessment of groundwater quantitative status.
- The assessment of trends and trend reversal (GWD Article 5.4) describing:
    - The way in which the trend assessment at individual monitoring points within a body or a group of bodies of groundwater, has contributed to identifying that those bodies are subject to a significant and sustained upward trend;

  - The way in which the trend assessment at individual monitoring points within a body or a group of bodies of groundwater has contributed to identifying that those bodies are subject to a reversal of that significant and sustained upward trend;
  - The reasons to establish starting points for trend reversal where they are different from 75% of the parametric value of the threshold value or groundwater quality standards (see GWD Article 5.4 and Annex IV, Part B, point 1).

- The results of any existing assessments of the impacts of relevant (expanding) plumes (GWD Article 5.5) in particular, verification by additional trend assessments that existing plumes from contaminated sites do not expand, do not deteriorate the chemical status of groundwater bodies and do not present a risk for human health and the environment;

- For transboundary groundwaters, a summary of the steps put in place to co-ordinate the objectives (establishment of threshold values, status and trend assessment).

Summary text for **quantitative and chemical monitoring programmes** should be provided separately covering the following items:

- The methodology/criteria used to;
  - select sites;
  - select monitoring frequencies.

- The sampling and analysis methodology to be used and details of any relevant national or international standards (e.g. CEN/ISO);

- The extent of where any monitoring deviates from what is outlined in the monitoring programme overview above (e.g. frequency, QEs) and number or percentage of sites that is affected (in particular for surveillance monitoring and where possible/applicable also for operational monitoring);

- If the monitoring programmes will start later than 22 December 2006, a justification of why the monitoring programme/s are delayed;

- If the monitoring programme includes the identification of sub-sites[23], a summary of the extent and how the concept of sub-sites has been applied.

References/Hyperlinks to more detailed supporting documents (e.g. methodology documents, documents provided as part of the public participation, statutes, founding treaty or equivalent legal documents) should be provided for each of the above-mentioned summaries, if available.

[23] It may be necessary to monitor parameters at a number of sub-sites within a single monitoring site (E.g. to determine profiles of stratification in lakes/reservoirs, transitional and coastal waters or in large rivers (e.g. temperature, oxygen, nutrient or phytoplankton conditions) or to monitor chemical and biological QEs at different points in one site).

7 REPORTING REQUIREMENTS FOR PRESSURES, IMPACTS AND PROGRAMMES OF MEASURES

7.1 Introduction

Article 5 of the WFD requires MS to identify the key pressures present in the RBD likely to cause water bodies to be of less than good status. It also requires MS to assess the impacts on water bodies to support the determination of status.

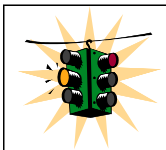
Article 11 of the WFD requires MS to ensure the establishment of a programme of measures for each RBD, or part of international RBDs within its territory to achieve the objectives laid down in Article 4 of the Directive. The programme of measures should take account of the analyses carried out according to Article 5 and the subsequent monitoring results collected with the network established under Article 8.

For each RBD, the programme of measures must include “basic” and, where required, “supplementary measures”. Basic measures are listed in Article 11(3) of the Directive. The basic measures are divided into those measures which are regulated in other EU directives (Article 11 (3)(a)) (including those listed in Annex VI, part A) and those measures additionally introduced by the WFD (Article 11 (3), sub-paragraphs (b) to (l)).

A tentative list of supplementary measures (Article 11 (4)) are listed in Annex VI, part B.

Article 4(4-9) of the WFD allows MS to extend the deadlines for the achievement of good status/potential or to set other objectives under certain specified circumstances. Additional information can be found in the CIS Paper on "Environmental Objectives" agreed in 2005[24].

Article 4(4-9) goes on to require MS to provide information regarding such extensions or other objectives and the reasons for it in the River Basin Management Plan.

	**Look Out!** Member States first reported under Article 5 in 2005 and under Article 8 in 2007. In 2010, data should only be resubmitted if any was missing from the original submission or if any of the information has since changed.

7.2 How will the Commission use the information reported?

The purpose of the collection of the information is to identify the main pressures within the RBD. The summary information will be used to compile maps at a European level of relevant pressures and to ensure that relevant pressures have been identified at RBD level. Statistics and information will be provided to the European Parliament at EU wide level. Information will be provided to the public through WISE.

[24] http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/environmental_objectives/environmental_20605pdf/_EN_1.0_&a=d

The following compliance indicators relating to surface waters will be used:

- Number of water bodies failing to reach good status/potential as a result of each pressure;
- Number of water bodies or river length etc/Sub-unit "not in good status/potential" as a result of point sources (either as a result of point sources only or in combination with other pressures);
- Whether information has been provided on the substances discharged from point sources and the load of those substances;
- Number of water bodies/Sub-unit "not in good status/potential" as a result of diffuse sources (either as a result of diffuse pollution only or in combination with other pressures);
- Whether information has been provided on the substances discharged from diffuse sources and the load of those substances;
- Whether information has been provided on the number of abstraction points and the volumes abstracted;
- Number of water bodies/Sub-unit "not in good status/potential" as a result of water abstractions (wholly or partially);
- Whether information has been provided on the water flow regulations and morphological alterations;
- Number of water bodies/Sub-unit "not in good status/potential" as a result of water flow regulations and morphological alterations, either as a result of water flow regulations and morphological alterations only or in combination with other pressures;
- For each pressure type (point sources, diffuse sources, water abstractions, and water flow regulations and morphological alterations) is “significance” defined in a way that is comparable with the approach used in other RBDs/Member States;
- Number of water bodies/Sub-unit "not in good status/potential" as a result of unknown pressures;
- Whether information has been provided on the actions to be taken to identify the unknown pressures;
- Whether information on the impacts on surface water bodies has been provided;
- Whether information on the impacts on uncertainties and data gaps have been provided;
- Whether sufficient steps have been taken since 2005 to address the uncertainties and data gaps;
- Whether future plans have been put in place to address any continuing uncertainties and data gaps;

The following compliance indicators relating to groundwaters will be used:

- Number of groundwater bodies failing to reach good status as a result of each pressure or combination of pressures (depending on the information provided);
- Number of GWBs/RBD "not in good status" as a result of point sources (either as a result of point sources only or in combination with other pressures);
- Whether information has been provided on the substances discharged from point sources and the load of those substances;
- Whether information has been provided on the substances discharged from diffuse sources and the loads of those substances;
- Number of GWB/RBD "not in good status" as a result of water abstractions only or in combination with other pressures;
- Whether information has been provided on the number of abstraction points and the volumes abstracted;
- Number of water bodies/RBD "not in good status" as a result of artificial recharge only or in combination with other pressures;
- Whether information has been provided on the number of artificial recharges and the volumes concerned;
- Number of GWBs/RBD "not in good status" as a result of saltwater intrusion (either as a result of saltwater intrusion only or in combination with other pressures);
- Whether information has been provided on the number of groundwater bodies affected by saltwater intrusion;
- Number of groundwater bodies/RBD "not in good status" as a result of pressures not covered by other reporting sheets or unknown pressures;
- Whether information has been provided on the actions to be taken to identify the pressures;
- Whether information on the further characterisation/assessment of human impacts on GWBs has been provided;
- What level of further characterisation of groundwater has been carried out and what plans are in place to complete the work in preparation for the publication of the draft River Basin Management Plans in 2010;
- Whether information on the impacts on uncertainties and data gaps has been provided;
- Whether sufficient steps have been taken since 2005 to address the uncertainties and data gaps;
- Whether plans have been put in place to address any continuing uncertainties and data gaps.

Information provided by Member States on the summary of steps and measures taken to meet the requirements of Article 11 will be used by the Commission to ensure that the provisions of Article 11 have been properly and consistently applied according to the Directive, and to provide information to the Parliament and public on the relevant measures. A screening assessment will be made on the basis of the compliance indicator which builds on an approach based on pressures.

The following compliance indicators will be used:

- For every significant pressure that has been identified, the Commission will check that Member States have ensured that measures are in place to address that pressure or that exemptions are applied and justified. An aggregated compliance indicator will be developed. (Possible answers: Yes / No / To a certain extent/unclear – not sufficient information);
- A check list will be developed to ensure that every point in Article 11 and any other relevant aspects is covered in some place of the Programme of Measures and to ensure that every pressure identified has been adequately addressed.

The Commission will use information provided by Member States on the classification of status to give summary statistics to the European Parliament and the public and assess whether the level of exemptions is comparable and justified. The comparative screening assessment will be based on the compliance indicators (see below). Taking account also the summary text provided, the screening assessment will be used to determine whether more detailed analysis is required.

The Commission will use the geographic information provided to produce a map for the Parliament and the Public to show the distribution of water bodies across the EU where Article 4(4-7) has been used and also to create a map showing the status of water bodies. This information will be made available through WISE.

The following compliance indicator will be used to prioritise those River Basin Districts where the use of Article 4 (4-7) requires further investigation:

- Percentage of surface water bodies where each exemption per Article 4 (4, 5, 6 and 7) has been used/River Basin District (per (national part of international) River Basin District or Sub-unit), as a proportion of all SWBs and the SWBs not achieving good status as reported in the River Basin Management Plan.
- Percentage of groundwater bodies where each exemption per Article 4 (4, 5, 6 and 7) has been used/River Basin District (per (national part of international) River Basin District or Sub-unit), as a proportion of all GWBs and the GWBs not achieving good status as reported in the River Basin Management.

7.3 Information to be provided

A list of pressures is given below. This is indicative and it is not expected that all these pressures will be significant for all RBDs:

- Point sources including:
  (to surface water)
  - UWWT plants;
  - Storm overflows;
  - IPPC plants (EPRTR);
  - Other industrial plants outside the IPPC Directive not covered in EPRTR;
  - Additional point sources (e.g. small agglomerations) that may cause a significant impact in the status of water body or water bodies.

  (to groundwater)
  - Leakages from contaminated sites;

  - Leakages from waste disposal sites (landfill and agricultural waste disposal);
  - Leakages associated with oil industry infrastructure;
  - Mine water discharges;
  - Discharges to ground such as disposal of contaminated water to soakaways;
  - Other relevant point sources.

- Diffuse sources including:
  (to surface water)
  - Via storm overflows (if data not available to allow this to be treated as a point source) or the built environment (urban run-off);
  - Due to agricultural activities (via leaching, erosion, spills, direct drainage discharges,);
  - Due to transport and infrastructure without connection to canalisation/sewers (ships, trains, automobiles and airplanes and their respective infrastructures outside the urban area);
  - Abandoned industrial sites;
  - Releases from facilities for the storage and/or treatment of domestic effluent in areas without sewerage networks (e.g. leaks from septic tanks etc.);
  - Other diffuse sources not listed above.

  (to groundwater)
  - Due to agricultural activities (e.g. fertilizer and pesticide use, live stock etc.);
  - Due to non-sewered population;
  - Urban land use.

- Water Abstractions including
  (from surface water)
  - Abstractions for irrigation in agriculture;
  - Abstractions for public water supply;
  - Abstractions by manufacturing industry;
  - Abstractions for the production of electricity (cooling);
  - Abstractions by fish farms;
  - Abstractions by hydro-energy (not for cooling);
  - Abstractions by quarries/open cast coal sites;
  - Abstractions for navigation (e.g. supplying canals);
  - Abstraction for water transfer;
  - Other major abstractions.

  (from groundwater)
  - Abstractions for agriculture;
  - Abstractions for public water supply;
  - Abstractions by industry;
    - IPPC industries;
    - Non-IPPC industries;
  - Abstractions by quarries/open cast coal sites;
  - Other major abstractions.

- Water flow regulations and morphological alterations of surface water including:

  - Water Flow Regulations;
  - Groundwater re-charge;
  - Hydroelectric dams;
  - Water supply reservoirs;
  - Flood defence dams, dykes and channels;
  - Diversions;
  - Locks;
  - Weirs.

- River management including:
  - Physical alteration of channel;
  - Engineering activities;
  - Agricultural enhancement;
  - Fisheries enhancement;
  - Land infrastructure (road/bridge construction);
  - Dredging.

- Transitional and coastal water management including:
  - Estuarine/coastal dredging;
  - Marine constructions, shipyards and harbours;
  - Land reclamation and polders;
  - Coastal sand suppletion (safety);
  - Tidal barrages including those for flood defence and power generation.

- Other morphological alterations or surface waters including:
  - Barriers;
  - Land sealing in riparian area/zones and flood plains.

- Artificial recharge of groundwater including:
  - Discharges to groundwater for artificial recharge purposes;
  - Returns of groundwater to GWB from which it was abstracted (e.g. for sand and gravel washing);
  - Mine water rebound;
  - Other major recharges.

- Saltwater intrusion of groundwater including:
  - Saltwater intrusion;
  - Other intrusion.

- Other pressures not covered by the list above.

Data

- The number of water bodies in each Sub-unit or RBD failing to reach good status as a result of each pressure type (point sources, diffuse sources, water abstractions etc.) for each water body category (rivers, lakes, transitional waters, coastal waters, groundwaters). This will result in some water bodies being counted more than once;

- Number of significant point sources in the Sub-unit (UWWT plants, storm overflows, IPPC Plants (EPRTR), other industrial plants outside the IPPC Directive not covered in EPRTR);

- Number of other significant point sources that are relevant in the Sub-unit (e.g. small agglomerations);
- Number of relevant point sources in the RBD causing groundwater bodies to be "not in good status";
- Loads (monitored, calculated or estimated) of pollutants (COD, nutrients, priority substances, other pollutants, saline discharges)25 discharged to surface waters (total for Sub-unit) (if not provided to the EEA under WISE-SoE Reporting);
- Number of significant abstractions and volumes abstracted/year or in different seasons by category of abstraction (see list in the introduction to this section) and per Sub-unit;
- Number of relevant abstractions in a RBD and volumes abstracted (annual average) by category of abstraction (if not provided to the EEA under WISE-SoE Reporting);
- Water balance (as defined in the guidance on the assessment of groundwater status) (or groundwater exploitation index);
- Number of relevant recharges and volumes recharged by category of recharge (see list in the introduction to this sheet) and per RBD.

Provide data on basic measures (Article 11(3)(a) and (b-l)), supplementary measures (Article 11(4)) and additional measures (Article 11 (5)) according to the templates provided in Tables 3 - 5.

Table 4 Basic Measures required by Article 11(3)(a) and listed in Annex VI Part A

Directive listed in Annex VI Part A	**Measures implemented in Member State (self assessment) – tick if yes**	**Additional comments or if no, additional explanations (<2000 characters)**
Bathing Water Directive (76/160/EEC and 2006/7/EC)		
Birds Directive (79/409/EEC)		
Drinking Water Directive (80/778/EEC) as amended by Directive (98/83/EC)		
Major Accidents (Seveso) Directive (96/82/EC)		
Environmental Impact Assessment Directive (85/337/EEC)		
Sewage Sludge Directive (86/278/EEC)		
Urban Waste-water Treatment Directive (91/271/EEC)		
Plant Protection Products Directive (91/414/EEC)		

[25] Specification of detailed pollutant lists and units when preparing the schemas.

Directive listed in Annex VI Part A	Measures implemented in Member State (self assessment) – tick if yes	Additional comments or if no, additional explanations (<2000 characters)
Nitrates Directive (91/676/EEC)		
Habitats Directive (92/43/EEC)		
Integrated Pollution Prevention Control Directive (96/61/EC)		

Table 5 Other basic measures as required by Article 11(3)(b-l)

Measure (Article 11(3))	Implemented in Member State (self assessment) – tick if yes	Reference to legislation or other document (hyperlink or document)	Description of measure (<500 characters)	Additional comments or if no, additional explanations (<2000 characters)
Measures for the recovery of cost of water services (Article 9)				
Measures to promote efficient and sustainable water use				
Measures for the protection of water abstracted for drinking water (Article 7) including those to reduce the level of purification required for the production of drinking water (note: these basic measures may not apply to the whole territory)				
Controls over the abstraction of fresh surface water and groundwater and impoundment of fresh surface waters including a register or registers of water abstractions and a requirement for prior authorisation of abstraction and impoundment				

Measure (Article 11(3))	**Implemented in Member State (self assessment) – tick if yes**	**Reference to legislation or other document (hyperlink or document)**	**Description of measure (<500 characters)**	**Additional comments or if no, additional explanations (<2000 characters)**
Controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies.				
Requirement for prior regulation of point source discharges liable to cause pollution				
Measures to prevent or control the input of pollutants from diffuse sources liable to cause pollution.				
Measures to control any other significant adverse impact on the status of water, and in particular hydromporphological impacts.				
Prohibition of direct discharge of pollutants into groundwater				
Measures to eliminate pollution of surface waters by priority substances and to reduce pollution from other substances that would otherwise prevent the achievement of the objectives laid down in Article 4				
Any measures required to prevent significant losses of pollutants from technical installations and to prevent and/or reduce the impact of accidental pollution incidents				

Table 6a Need for Supplementary/Additional Measures (Article 11(4) and 11(5))

Estimated % of SW bodies (as a proportion of river length/surface area) within the basin that may fail to reach GES/GEP (by 2015)	What is the nature of the pressure that will prevent the water bodies from reaching good status or potential by 2015 (chemical pollution, hydromorphology etc.)	Will the basic measures identified above be sufficient to address this (Y/N)	Comments

Estimated % of GW bodies within the basin that may fail to reach good status (by 2015)	What is the nature of the pressure that will prevent the water bodies from reaching good status or potential by 2015 (chemical pollution, hydromorphology etc.)	Will the basic measures identified above be sufficient to address this (Y/N)	Comments

Table 6b Significant Pressures and Measures Checklist – incl. Supplementary Measures (only to be completed if table 5.a indicates that supplementary measures are required. INFORMATION SHOULD ONLY BE PROVIDED FOR THOSE PRESSURES THAT ARE RELEVANT – IT IS NOT NECESSARY TO PROVIDE INFORMATION FOR THOSE PRESSURES THAT ARE NOT RELEVANT OR WHERE BASIC MEASURES ARE SUFFICIENT) Information can be provided at different levels if required.

Significant Pressure	**Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)**		**Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)**		**Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)**	**Comments**
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Point sources:						
To surface water						
UWWT plants						
Storm overflows						
IPPC plants (EPRTR)						
Other industrial plants outside the IPPC Directive not covered in EPRTR						
Additional point sources (e.g. small agglomerations) that may cause a significant impact in the status of a water body or water bodies						
To groundwater						
Leakages from contaminated sites						
Leakages from waste disposal sites (landfill and agricultural waste disposal)						

[26] Pick list to include: revision of permits; establishment of stricter environmental standards.

Significant Pressure	**Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)**		**Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)**		**Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)**	**Comments**
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Leakages associated with oil industry infrastructure						
Mine water discharges						
Discharges to ground such as disposal of contaminated water to soakaways						
Other relevant point sources						
Diffuse sources:						
To surface water						
Via storm overflows (if data not available to allow this to be treated as a point source) or the built environment (urban run-off)						
Due to agricultural activities (via leaching, erosion, spills, direct drainage discharges)						
Due to transport and infrastructure without connection to canalisation/sewers (ships, trains, automobiles and airplanes and their respective infrastructures outside the urban area)						
Abandoned industrial sites;						

Significant Pressure	Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)		Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)		Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)	Comments
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Releases from facilities for the storage and/or treatment of domestic effluent in areas without sewer networks (e.g. leaks from septic tanks etc.)						
Other diffuse sources not listed above						
To groundwater						
Due to agricultural activities (e.g. fertilizer and pesticide use, livestock etc.)						
Due to non-sewered population						
Urban land use						
Water Abstractions:						
From surface water						
Abstractions for irrigation in agriculture						
Abstractions for public water supply						
Abstractions by manufacturing industry						
Abstractions for the production of electricity (cooling)						
Abstractions by fish farms						
Abstractions by hydro-energy (not for cooling)						
Abstractions by quarries/open cast coal sites						

Significant Pressure	**Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)**		**Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)**		**Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)**	**Comments**
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Abstractions for navigation (e.g. supplying canals)						
Abstraction for water transfer						
Other major abstractions						
From groundwater						
Abstractions for agriculture						
Abstractions for public water supply						
Abstractions by industry: IPPC activities						
Abstractions by industry: Non-IPPC activities						
Abstractions by quarries/open cast coal sites						
Other major abstractions						
Water flow regulations and morphological alterations of surface water						
Water Flow Regulations						
Groundwater re-charge						
Hydroelectric dams						
Water supply reservoirs						
Flood defence dams, dykes and channels						
Diversions						

Significant Pressure	**Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)**		**Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)**		**Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)**	**Comments**
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Locks						
Weirs						
River management including:						
Physical alteration of channel						
Engineering activities						
Agricultural enhancement						
Fisheries enhancement						
Land infrastructure (road/bridge construction)						
Dredging						
Transitional and coastal water management including:						
Estuarine/coastal dredging						
Marine constructions, shipyards and harbours						
Land reclamation and polders						
Coastal sand suppletion (safety)						
Tidal barrages including those for flood defence and power generation						
Other morphological alterations including:						
Barriers.						
Land sealing in riparian area/zones and flood plains						

Significant Pressure	**Where relevant give details of supplementary measures (Art 11(4)) put in place (including hyperlink)**		**Where relevant give details of additional measures (Art 11(5)) put in place (including hyperlink)**		**Geographic coverage of measure (RBD, part-RBD, Water Body, National etc.)**	**Comments**
	Type of measure (from pick list of Annex VI Part B)	Details including hyperlink	Type of measure (from pick list[26])	Details including hyperlink		
Artificial recharge of groundwater						
Discharges to groundwater for artificial recharge purposes						
Returns of groundwater to GWB from which it was abstracted (e.g. for sand and gravel washing)						
Mine water rebound						
Other major recharges						
Saltwater intrusion of groundwater						
Saltwater intrusion						
Other intrusion						
Other pressures not covered by the list above						

Data on the costs of measures should be provided as detailed in Table 7.

Table 7 Costs of measure (per MS or RBD as available)

Type of measure	**Total cost of measures (€)**	**Comments**
Basic measures (Article 11(3)(a) (Table 1)		
Basic measures (Article 11(3)(b-l) (Table 2)		
Supplementary and additional measures (Article 11(4-5) (Table 3b)		

Note: The figures should be based on readily available administrative budgetary allocations (not private) or alternatively official or informal estimations. The method for estimation is left to the MS. If possible, it should refer to the total costs of the programme of measures during **one** entire RBMP. If not, annual or otherwise aggregated figures can be provided. A pick list should allow classifying the costs (e.g. pick list on methods for calculation, reference years, etc.). Where available, reference to relevant documents should be provided. If it is not possible to provide the costs disaggregated by the type of measure, a total cost should be provided:

- The percentage of water bodies per Sub-unit where each exemption under Article 4(4-7) applies and the main justifications for each exemption and the quality elements concerned;
- Statistics on the water bodies where an exemption applies under Article 4(4-7) and the justification for the exemption (Table 8).

Table 8 Data to be provided on exemptions

Exemption	%age of the total river length/surface area of water bodies in Sub-unit to which exemption applies %age of the total number of GWBs in Sub-unit to which exemption applies	Justification (from a pick list to be defined – multiple selections to be allowed – examples given below)	%age of exempt (by river length/surface area) WBs where this justification applies (total may be above 100%) %age of exempt GWBs where this justification applies (total may be above 100%)	Further comments or explanation
Article 4(4)		1) Technical feasibility 2) disproportionate cost 3) natural conditions	1) x% 2) y% 3) z%	
Article 4(5)		1) Technical feasibility 2) disproportionate cost	1) x% 2) y%	
Article 4(6)		1) Natural causes (a-floods, b-droughts) 2) *Force majeure* 3) Accidents	1) x% 2) y% 3) z%	
Article 4(7)		1) New modifications to physical characteristics of surface water 2) New sustainable human development activities	1) x% 2) y%	

Summary Text

Summary text should be provided for each RBD covering the following items:

- For surface water the methodology and criteria provided in 2005 for identifying the following should be updated:
  - Significant point sources;
  - Significant diffuse sources. Loads (calculated or estimated) of pollutants (nutrients, priority substances, other pollutants, temperature, saline discharges)[27] discharged (total for Sub-unit) if available (**if not provided to the EEA under WISE-SOE reporting**);
  - Significant abstractions;
  - Significant morphological alterations;
  - Other significant pressures.

- For **groundwater** the methodology and criteria provided in 2005 for identifying the following should be updated:
  - Relevant point sources including a list of pollutants discharged to the GWBs from the relevant point sources where thresholds have been established and, where available, an indication of the loads of those pollutants discharged. Loads, if available, (monitored, calculated or estimated) of pollutants (NO3, As, Cd, Pb, Hg, NH4, Cl-, SO4, Trichloroethylene, Tetrachloroethylene) discharged (total for RBD) if not already provided to the EEA under WISE-SoE reporting;
  - Relevant diffuse sources including a list of pollutants discharged to the GWBs in the RBD from the relevant diffuse sources where thresholds have been established and an indication of the loads of those pollutants discharged where available;
  - Relevant abstractions;
  - Relevant artificial recharge;
  - Relevant saltwater intrusions;
  - Other relevant pressures.

- The plan of actions to be put in place to identify any unknown pressures to surface waters or groundwaters;

- The main environmental impacts on **surface waters** occurring in the RBD as a result of significant pressure. This should include the following if appropriate:
  - Nutrient enrichment (at risk of becoming eutrophic) (unless information already provided under UWWTD);
  - Organic enrichment;
  - Contamination by priority substances or other specific pollutants;
  - Contaminated sediments;
  - Acidification;
  - Saline intrusion;
  - Elevated temperatures;
  - Altered habitats as a result of hydromorphological alterations.

[27] Specification of detailed pollutant lists and units when preparing the schemas.

- The methodology and criteria used for identifying significant impacts on **surface waters** should be provided. This should include a description of the following where appropriate:
    - Numerical models;
    - Quantification tools;
    - State assessment tools;
    - Data sources (e.g. whether existing data were used or whether data was collected specifically for the purpose);
    - Expert judgment;
    - Legal status of the assessment criteria;
    - Role of supporting quality elements in the assessment of significance of impacts.
- The main impacts on groundwaters occurring in the RBD as a result of relevant pressures should be provided. This should include the following if appropriate:
    - Anthropogenic alterations of the level of groundwater leading to significant diminution of the ecological and qualitative status of associated surface water bodies;
    - Chemical composition of groundwater leading to significant diminution of the ecological and qualitative status of associated surface water bodies;
    - Anthropogenic alterations of the level of groundwater leading to significant damage to terrestrial ecosystems which depend directly on the GWB;
    - Chemical composition of groundwater leading to significant damage to terrestrial ecosystems which depend directly on the GWB;
    - Altered habitat in dependent surface water or terrestrial ecosystems;
    - Substitution of populations.
- The methodology and characteristics assessed in the further characterisation of GWBs;
- The description of progress to resolve uncertainties and data gaps since 2005;
- A list of uncertainties and data gaps;
- A list of planned actions to address uncertainties and data gaps.

References/Hyperlinks to more detailed supporting documents (e.g. methodology documents, documents provided as part of the public participation, statutes, founding treaty or equivalent legal documents) should be provided for each of the above-mentioned summaries, if available.

8 REPORTING REQUIREMENTS FOR ECONOMIC DATA[28]

8.1 Introduction

Economic Analysis of Water Use

Article 5 of the Water Framework Directive (WFD) requires Member States to undertake an economic analysis of water uses according to the specifications of Annex III. Article 13 and Annex VII requires Member States to send summary reports of the analyses required under Article 5 and Annex II as part of the first river basin management plan.

Annex III of the WFD Directive stipulates that the economic analysis of water uses should contain enough information in sufficient detail (taking account of the costs associated with collection of relevant data) in order to:

- Make the relevant calculations necessary for taking into account the principle of recovery of the costs of water services under Article 9, taking into account long term forecasts of supply and demand for water in the river basin district and where necessary:
  - estimates of the volume, prices and costs associated with water services; and
  - estimates of the relevant investment including forecasts of such investments.
- Make judgements about the most cost-effective combination of measures with respect to water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures.

The Commission has found that at the time the Article 5 reports were submitted in 2005 the information reported was often not sufficient, taking account of the costs associated with collection of the relevant data, to fulfil these requirements. Several years later additional data may have been collected in order to update the economic analysis and to close the gaps of 2005.

Summary of Steps and Measures Taken to Recover the Costs of Water Services (Article 9)

Article 9 of the Water Framework Directive (WFD) requires that Member States take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the Annex III economic analysis and in accordance with the polluter pays principle.

According to Article 9.1 Member States shall ensure by 2010:

[28] Disclaimer: WFD reporting on economics expressed in this chapter (previously consulted and agreed as Reporting sheets ECO1 and ECO2) represents an informal arrangement between the Member States and the Commission. The information reported is without prejudice to any related infringement procedures.

- That water pricing policies provide adequate incentives for users to use water resource efficiently, and thereby contribute to the environmental objectives of this Directive;
- An adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services.

Member States have the possibility to account for social, environmental and economic effects in defining pricing policy.

Under Article 9.2 Member States shall report in the river basin management plans on the planned steps towards implementing paragraph 1 that will contribute to achieving the environmental objectives of this Directive and on the contributions made by the various water uses to the recovery of the costs of water services.

According to Article 9.4 Member States can indicate that they will not apply the provisions of Article 9.1, 2nd indent and the relevant parts of Article 9.2 for specific water use activities, if this does not compromise the purposes and achievements of the objectives of the WFD. This paragraph refers to "established practices" meaning at the time of adoption of the WFD in the year 2000. The Member States should report the reasons for doing so in the river basin management plans.

8.2 How will the Commission use the information reported?

The Commission will use this information to ensure that the Member States have carried out an economic analysis consistent with the requirements of Article 5 and Annex III and also that the provisions of Article 9 WFD have been properly and consistently applied according to the Directive. The information will also be used to provide statistics and information on a EU wide level to the European Parliament and the general public. A screening assessment will be made on the basis of the compliance indicators which builds on an approach based on the three main elements of Article 9: i) incentive pricing; ii) adequate cost-recovery; and iii) polluter pays principle.

In addition information on gaps will be collected in order to take further action and to plan future activates in order to support Member States in the further use of Article 9.

The following compliance indicators will be used:

- Have Member States prepared a comprehensive economic analyses including all elements of and being consistent with the Directive? (Possible answers: Yes/No/To a certain extent/Unclear – not sufficient information);
- Where necessary, have estimates of the volume, prices and costs associated with water services been provided;
- Where necessary, have estimates of the relevant investment including forecasts of such investments been provided;
- How has long term forecasts of water supply and water demand been taken into account in the principle of the recovery of the costs of water services;
- Have approaches been identified showing that the economic analysis was used to assist in judging cost effectiveness;

- What progress that has been made since 2005 to address the uncertainties and data gaps in the economic analysis;
- Have Member States have ensured that the measures to implement Article 9 address all three main elements of Art 9: i) incentive pricing; ii) adequate contribution to cost-recovery including environment and resource costs, iii) polluter pays principle. (Possible answers: Yes/No/To a certain extent/Unclear – not sufficient information);
- How has the definition of water services and uses been implemented in practice;
- How water pricing policies provide adequate incentives for users to use water resources efficiently;
- Which approach was taken to ensure that water uses are providing an adequate contribution to the recovery of the costs of water services;
- Whether future plans have been put in place to address any continuing uncertainties and data gaps on the recovery of the costs of water services.

8.3 Information to be provided

Data

Member States should provide the information set out below, where it was included in the economic analysis, for each River Basin:

- Volumes abstracted/discharged per water service;
- Estimated investments for water services[29] in Euro per year (2009 to 2015) or as available for the period;
- Costs of water services (Euro per m3 or other relevant unit), with an indication if environmental and resource costs are included or not and the share they have in the overall costs;
- Level of cost recovery in % per water service;
- Water prices per water service in Euro per m3 or other relevant unit;
- Information relating to measures to comply with Article 9 will be reported as described in Chapter 7, Table 5: Measures for the recovery of cost of water services.

Summary text

In order to better understand the data above, summary text should be provided (max 5000 characters) covering the following items:

- Where relevant, provide a summary of the cases and reasons why estimates on volume, prices and costs of water services and estimates of relevant

[29] Where this information is not collected separately, the aggregated data should be reported and clearly marked as such.

investments including forecasts of such investment were not included in the economic analysis;

- Summary of the methodology (eg aggregation) and assumptions used to estimate the costs of investments for the period 2009 to 2015[30];
- Summary of the methodology (eg aggregation) and assumptions used to estimate the volume, costs and prices associated with water services[31];
- Summary of the methodology used for calculating the cost recovery rate for water services;
- Summary of how the issue of cross-subsidies is handled in cost recovery calculations;
- Approach to estimate the costs of future investments[32], as well as how the baseline scenario has been considered/developed;
- For international RBDs, has there been any coordination of economic analysis? If yes, provide reference. If no, please provide additional explanations;
- For international RBDs, has the judgement of cost effectiveness of measures been coordinated? If yes, provide reference. If no, please provide additional explanations;
- Summary of how the economic analysis has been considered when making judgement about cost effectiveness of measures;
- How has the definition of water services and uses been applied in practice;
- Summary on the planned steps towards implementing Article 9.1 that will contribute to achieving the environmental objectives of this Directive (Article 9.2);
- Summary of how environmental and resource costs were considered and estimated;
- Where applicable, report the reasons for not fully applying paragraph 1, second sentence, to be reported in the River Basin Management Plans (Article 9.4). (This exemption possibility is only possible to apply for "a given water-use activity", so Member States must specify which water uses are considered. It also needs to be transparently explained by Member States that applying the specific exemption does not compromise the purposes and the achievement of the objectives of the Directive);
- How has the Member State ensured that “water-pricing policies provide adequate incentives for users to use water resources efficiently, thereby contributing to the environmental objectives of the Directive” (Article 9.1);

[30] In cases where estimates of the relevant investments including forecasts of such investments were not included in the economic analysis, this item does not apply.

[31] In cases where estimates on volume, prices and costs associated with water services were not included the economic analysis, this item does not apply.

[32] See footnote 30.

- How has the Member State ensured an adequate contribution of the different water uses to the recovery of the costs of water services taking account of the polluter pays principle;
- Any problems encountered in data collection or methodology used;
- Gaps in information identified that could not be closed since 2005 and planned additional data collection to fill gaps for the second implementation cycle.

Other information

- Hyperlinks to more detailed supporting documents including references to legal documents or methodology documents should be provided.

9 HOW TO REPORT

9.1 What is WISE?

The Water Information System for Europe – WISE – is comprised of data and information collected at EU level by various institutions or bodies which has previously either not been available or been stored in a number of different places. There are four EU partners developing WISE: DGs Environment, JRC and Eurostat, and EEA.

The WISE project started in 2002 and in 2003 a report on "Reporting for Water – Concept Document: towards a shared Water Information System for Europe (WISE)" defined the overall concepts of WISE which was endorsed by the Water Directors under the Italian Presidency in November 2003.[33]. The paper identified the following core objective:

"…the European Commission (DG ENV, Eurostat and JRC) and the EEA are committed to continue the development of a ***new, comprehensive and shared European data and information management system for water****, including river basins, following a participatory approach towards the Member States, in order to have it operational as soon as possible and to implement it, including all the various elements set out in this document,* ***by 2010****.*

Member States have agreed to provide data under the WFD to WISE. Rules and Procedures to do this have been agreed[34].

9.2 Reporting into WISE

The EEA has a central role in the management of WISE due to its role as EU data centre for water. The reporting services (Reportnet) of the EEA will be used and further developed towards the needs of WISE. The EEA is acting as a WISE operator (with the assistance of DGs Environment, JRC and Eurostat) and is responsible for the provision and operation of the WISE infrastructure at EU level.

The right to upload information and data for official compliance reporting needs to be thoroughly regulated and implemented. There will be a limited number of officially nominated individuals with the rights to submit, update and validate data on behalf of a Member State. The European Commission (DG Environment, unit D.2) will forward the list of the authorised WISE data providers to the EEA which is the responsible body for managing the access rights through Reportnet[35]. The EEA – through the WISE helpdesk - will contact the authorised WISE data providers to provide a

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[33] http://ec.europa.eu/environment/water/water-framework/transp_rep/pdf/2003_concept_report.pdf

[34] Guidance on practical arrangement for electronic reporting to the Water Information System for Europe (WISE), "WISE REPORTING ARRANGEMENTS " Final Document (01/03/2007).

[35] Reportnet is a system of integrated IT tools and business processes creating a shared information infrastructure optimised to support and improve European environment reporting by the streamlining, improving quality and ensuring transparency and availability of information reported by Member States and other European Countries. See: http://www.eionet.europa.eu/reportnet

username, password and relevant supporting material. Member States should take the appropriate actions to prevent any misuse of their username and password.

Data should be provided in XML format and schemas are being developed and agreed to facilitate this under the auspices of Working Group D. Geospatial data should be provided as Shapefiles or in GML format (GML is a requirement under the INSPIRE Directive[36]).

The EEA provides a content-related help desk for questions related to these rules and procedures, and for technical issues regarding WISE. (The EEA may delegate these tasks to contracted partners). The contact details of the WISE technical help desk are:

Phone: +37 2 508 4992 from Monday through Friday 09:00 to 17:00 CET

Email: helpdesk@eionet.europa.eu

Web page: http://nmc.eionet.europa.eu/

[36] http://inspire.jrc.ec.europa.eu/

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 22
Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water policy

EUROPEAN COMMISSION

environment

Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Appendices to the guidance are available on EEA CIRCA at:

http://eea.eionet.europa.eu/Public/irc/eionet-circle/eionet-telematics/library?l=/technical_developments/wise_technical_group/updated_2nd-edition/appendices_updated&vm=detailed&sb=Title

FOREWORD

The EU Member States, Norway and the European Commission in 2000 have jointly developed a common strategy for implementing Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Directive.

One of the main objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the EU water policy. These guidance Documents are targeted to those experts who are directly or indirectly implementing the WFD in the river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above mentioned strategy, a working group dedicated to the development of technical specifications for implementing a Geographical Information System (GIS) for the reporting needs of the Water Framework Directive was established in 2001 under the coordination of the Joint Research Centre. The working group, with the support of most Member States, the Commission, Eurostat and the EEA produced Guidance Document no 9 Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive, which was published in 2003.[1]

Since then, significant changes have been made to the way in which data and geographic information are gathered, reported and shared at the European level and these made it necessary for the Guidance Document to be updated and extended to the needs for EU water legislation and electronic reporting within Water Information System for Europe (WISE). A Drafting Group under the auspices of the WISE Technical Group carried out this task starting in 2007, including a number of consultations with the experts from the Member States through GIS workshops (held in January and November 2008) and via working group on reporting (WG D under CIS) and Strategic Coordination Group. In 2008, an updated WISE GIS Guidance Document was presented to the Water Directors for their approval and endorsement.

We, the Water Directors of the European Union and Norway, have examined and endorsed this updated guidance during our informal meeting under the French Presidency in Paris (24-25 November 2008). We would like to thank the Drafting Group for producing the update and we strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy play a key role in the process of implementing the Water Framework Directive.

We also commit ourselves to assess and decide upon the necessity for reviewing this Guidance Document in the future based on experiences gained during continued implementation of the Water Framework Directive and other water policies of the European Union.

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[1] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos9sgisswgs31p/_EN_1.0_&a=d

Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water legislation

The main text of the document is available on CIRCA at:
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents&vm=detailed&sb=Title

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LIST OF APPENDICES

Appendices to the guidance are available on EEA CIRCA at: http://eea.eionet.europa.eu/Public/irc/eionet-circle/eionet-telematics/library?l=/technical_developments/wise_technical_group/updated_2nd-edition/appendices_updated&vm=detailed&sb=Title

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1 Introduction

The EU Member States, Norway and the European Commission have jointly developed and followed a common strategy for supporting the implementation of Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – WFD). The main aim of the strategy is to allow a coherent and harmonious implementation of the Directive based on common understandings of the technical and scientific implications of the Directive.

One of the important tools to bring about the common understanding is the development of practical Guidance Documents on various technical issues. In this context, the development of technical specifications for implementing a Geographical Information System (GIS) for the reporting needs of the WFD was begun in 2001 by a working group of representatives of most Member States and the European Institutions under the coordination of the Joint Research Centre. At their meeting under the Danish Presidency (21-22 November 2002) the Water Directors of the EU endorsed the GIS Guidance (Guidance Document No 9)[2] which was published the following year.

After the GIS Guidance was published in 2003, a number of reporting exercises under the WFD and other water directives took place and significant improvements were made to the way in which data and geographic information were to be gathered, reported and shared at the European level.

In 2003, a report on "Reporting for water – Concept document: towards a shared Water Information System for Europe (WISE)" defined the overall concept of WISE which was endorsed by the Water Directors under the Italian Presidency in November 2003[3]. The WFD introduced a new approach to information and data collection and reporting, providing a more streamlined reporting process and a clearer distinction between the needs of different actors and different levels. WISE was to be the system that provided the streamlining and clarity. WISE had to be flexible, easy to be updated, manageable in terms of human resources and descriptive, in that textual information, data, documents, metadata, figures, graphs, maps etc, had all to be incorporated.

In July 2004, DG Environment submitted a proposal for a directive aimed at the introduction of a European spatial data infrastructure (INSPIRE) to encourage harmonisation of geographic data and information exchange leading to streamlined reporting and the common use of geographic information for different environmental policy areas. The directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) entered into force on 15 May 2007[4].

In October 2005, the Environmental Policy Review Group published a vision on reporting and monitoring around the concept of a Shared Environmental Information System (SEIS)[5].

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[2] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos9sgisswgs31p/_EN_1.0_&a=d
[3] http://ec.europa.eu/environment/water/water-framework/transp_rep/pdf/2003_concept_report.pdf
[4] http://inspire.jrc.ec.europa.eu/
[5] http://ec.europa.eu/environment/seis/index.htm

In order to improve access to environmental information and the availability of reports, the European Commission (DG Environment, Joint Research Centre and Eurostat) and the European Environment Agency (so called Group of Four, Go4) on 24 November 2006 endorsed the WISE Implementation Plan for 2006-2010[6]. On 22 March 2007, the official launch of the public WISE map viewer as "a gateway to water" at the European level took place[7]. WISE serves as a pilot for implementing the INSPIRE directive and the SEIS initiative, and currently is still at its formative phase, developing an electronic data and information system on water that will serve as an exemplar for other environmental sectors.

Following the Common Implementation Strategy for the WFD, streamlining the reporting process for all EU water sector directives (Urban Waste Water Treatment, Nitrates, Bathing Waters and Drinking Water Directives[8]) intensively started in 2007. Other newly adopted (such as the Groundwater Directive[9] and Marine Strategy Directive[10]) and upcoming directives (such as the Directive on Environmental Quality Standards in the field of water policy[11]) will follow the process of the Common Implementation Strategy as regards reporting information on water at the EU level during 2008-2015.

These major steps in the evolution of a system to improve the flow of information, to avoid duplication and to reduce the burden on Member States are described in more detail in Chapter 1.2.

1.1 Purpose of the Guidance

This document aims at guiding experts and stakeholders in the implementation of the Water Framework Directive (WFD) (2000/60/EC) and focuses on the GIS elements which will contribute to the development and understanding of all EU water related GIS reporting requirements under all water directives, as described above, including the River Basin Management Plans as required under Article 13 of the WFD by March 2010 and the revision of reporting arrangements for other water policy areas.

The original GIS Guidance (see above) required updating because of the many changes brought about by the development of the WISE, the practical experience gained from the first 4-5 years of the implementation of the WFD, the technical evolution and the need to adapt to new requirements of SEIS and INSPIRE.

The WISE Steering Group requested members of the WISE Technical Group to do the update during 2007-2008. The WISE GIS community were consulted on the drafts and their comments taken into account. The Guidance is intended not only for those who are responsible for reporting the national information but for those who use and develop it at national and European levels.

The purpose of updating the Guidance is to support the development of WISE by providing guidelines and technical specifications, IT tools, services and digital

[6] http://ec.europa.eu/environment/water/water-framework/transp_rep/pdf/wise_ip_2006_2010.pdf
[7] http://www.water.europa.eu/
[8] http://ec.europa.eu/environment/water/index_en.htm
[9] http://ec.europa.eu/environment/water/water-framework/groundwater/policy/current_framework/index_en.htm
[10] http://ec.europa.eu/environment/water/marine/index_en.htm
[11] http://ec.europa.eu/environment/water/water-dangersub/surface_water.htm

resources to be used by the data providers and WISE developers to ensure satisfaction and availability of water information at the European level for the users.

The revised Guidance is divided into two parts. The first is a set of textual documents describing the general concepts of the GIS requirements in WISE for the WFD and other EU water policy legislation, the types of WISE GIS datasets and the ways in which they are visualised and the principles of compatibility and interoperability. The second part is a set of documents which give more specific, technical details for data specifications, metadata, reference datasets, updating, coding, data exchange and harmonisation. In addition there are a number of Appendices to support and explain the Guidance and a link is provided to digital resources such as XML schemas[12]. The Appendices are living documents in the sense that when new GI layers have been specified, the details will be added to the web-based versions.

1.2 Development of WISE via implementing WFD and other EU-wide reporting on water

The following Chapters describe how WISE has grown in size and technical complexity as the reporting obligations under WISE evolve in accordance with the timetable in the directive and the schedule unfolds for incorporating reporting under other EU water directives. In addition the geographical scope and data content of WISE has increased as the EEA SoE reporting agreements with its member countries becomes fully incorporated.

1.2.1 Developing reporting obligations under WFD

The Water Directors of the European Community and Norway, at an informal meeting in Paris 23-24 October 2000, identified the following elements (*inter alia*) of a Common Implementation Strategy for the WFD[13]:

- The necessity to share information between Member States and the Commission;
- The need to ensure coherence between the implementation of the WFD and other sectoral and structural policies;
- The need to ensure coherence between the implementation of the WFD and other water directives and process and product oriented directives;
- The need to integrate activities on different horizontal issues for the effective development of River Basin Management Plan;
- The need to establish working groups and develop informal guiding and supporting documents on key aspects of the WFD.

During 2003, a Reporting for Water Concept Paper was produced and endorsed by the Water Directors in November 2003. This laid down the various purposes of reporting, i.e. to satisfy the various mandatory and voluntary information needs of the European Commission (in particular DG Environment, DG Eurostat, DG Joint Research Centre, the European Environment Agency and the Commissions and Conventions covering

[12] http://water.eionet.europa.eu/schemas/dir200060ec
[13] http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

large international rivers and European marine waters). It also described a common vision for information and data sharing and gave the principles for a shared Community data and information management system (the precursor to WISE). The paper identified the need for coherence between the reporting mechanisms and proposed the WFD as a platform for streamlining.

Since 2003, Working Group D (Reporting) has shaped the agenda for reporting under the WISE and has developed the reporting requirements, in the form of Reporting Sheets, for Articles 3 (2004), 5 (2005), 8 (2007) and 13 (2010) of the WFD. The Reporting Sheets, which may be considered as the conceptual models for specific reporting needs, are developed, debated and agreed within the Working Group and the Strategic Coordination Group before formal endorsement by the Water Directors.

Information has already been provided by the Member States for the first three of these reporting requirements and initial compliance assessments have been made for the first two. The reporting exercise for Article 8 (Monitoring Programmes) was the first fully electronic reporting exercise for the WFD and was a great success in terms of streamlining and facilitating reporting. The initial compliance assessment also indicated that good progress had been made and a more detailed assessment is currently underway.

Following agreement on the Reporting Sheets for the River Basin Management Plans, (Article 13), the Reporting Sheets for Articles 3 and 5 were fully reviewed and revised. It is the Commission’s intention to provide a consolidated Reporting Guidance document containing all the Reporting Sheets for the WFD and this is scheduled for approval by the Water directors in November 2008.

The relationship between the Reporting Sheets for WFD Articles 3, 5 and 13 is shown in Figure 1.2.1a (The Reporting Sheets for Article 8 may be considered to be a separate, but interlinked, series).

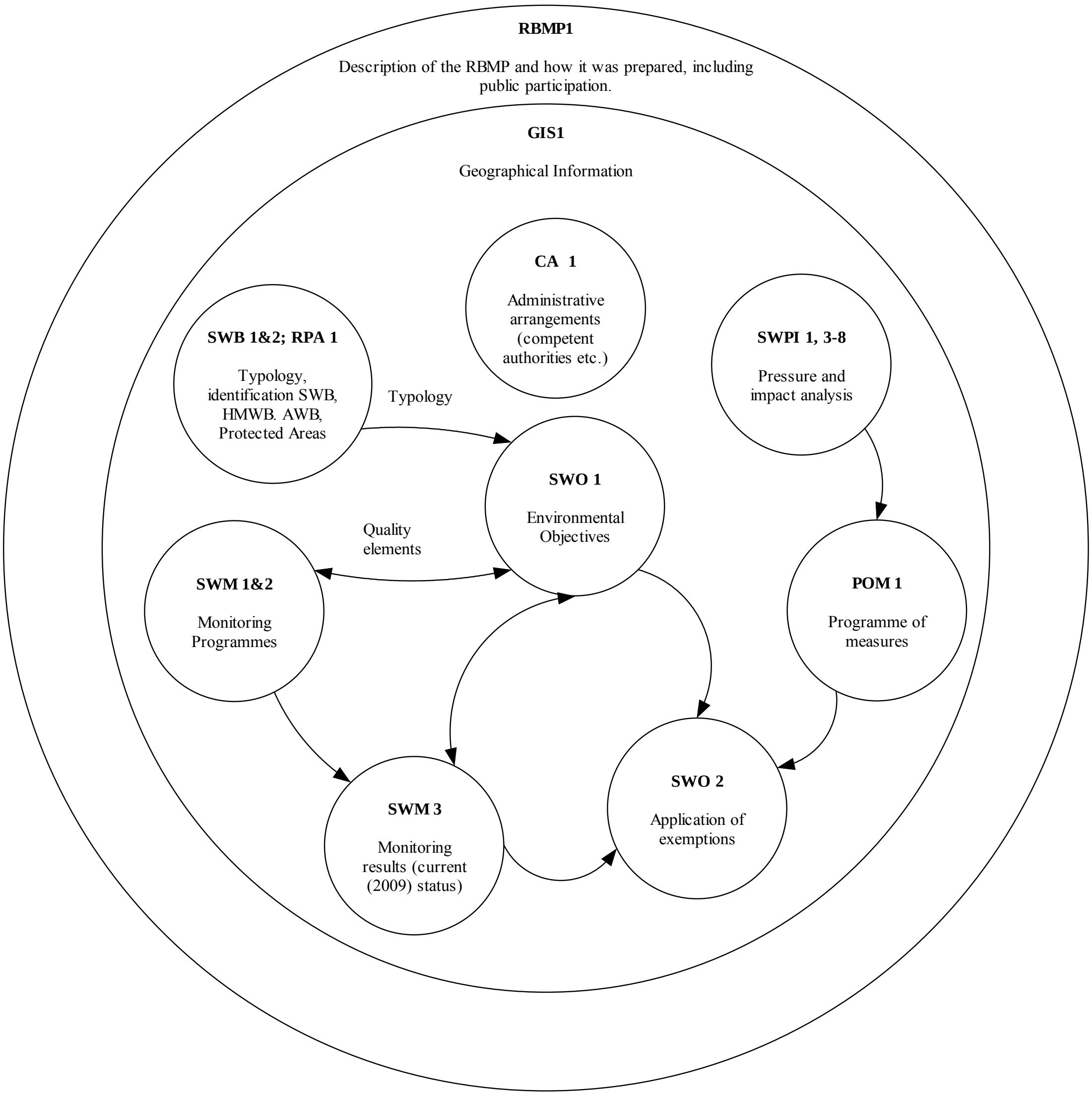

***Figure 1.2.1a Relationship between the WFD Reporting Sheets** (for surface waters only, relationship with groundwaters is virtually the same)*

Following the review, a new, generic Reporting Sheet (GIS 1) was developed to cover all the geographical information requirements for Articles 3, 5, 8 and 13.

Reporting Sheets are converted to logical models and reporting tools in the form of XML schemas which are handled by the Reportnet input tools of the WISE. The new Reporting Guidance will be tested in 2009 in good time for operational use in 2010. The WISE data flows are shown schematically in Figure 1.2.1b. A review period may follow the production of reference datasets.

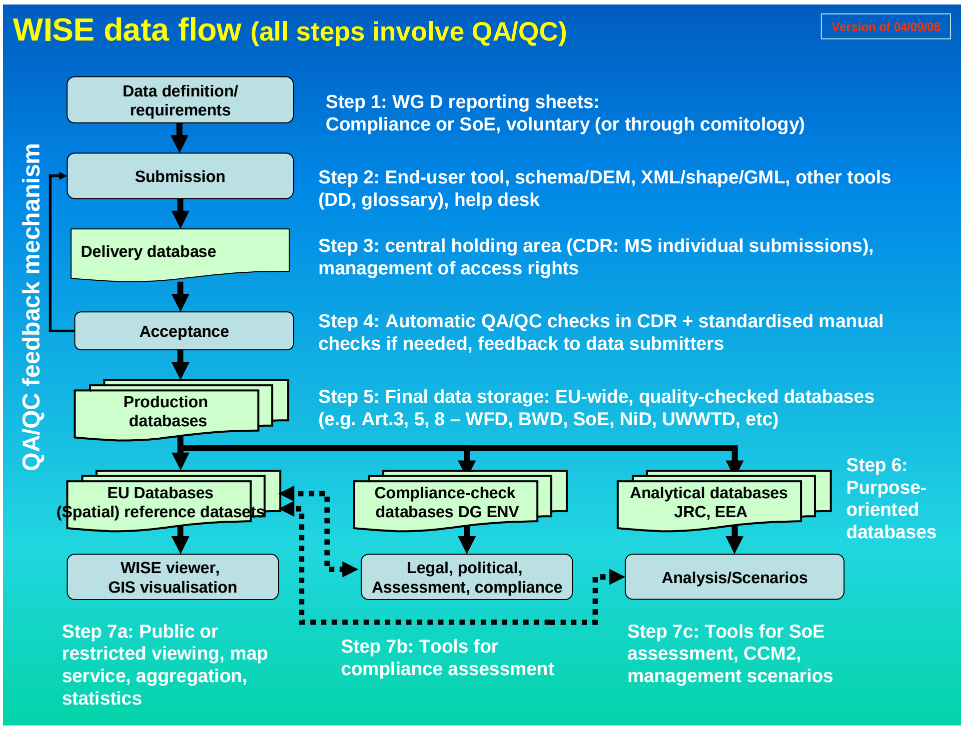

Figure 1.2.1b WISE Data flows

1.2.2 WISE – a system constantly expanding

In 2008, a communication from the Commission to the Council, European Parliament and others (COM(2008) 46 final) laid down the needs for, principles of, costs and benefits of and actions put in place for the Shared Environmental Information System (SEIS). Some of the key principles are:

- Information should be managed as close as possible to its source;
- Information should be collected once and shared with others for many purposes;
- Information should be readily available to public authorities and enable them easily to fulfil their legal reporting obligations;
- Information should be readily accessible to end-users ….. to enable them to assess in a timely fashion the state of the environment and the effectiveness of their policies and to design new policy;
- Information should also be accessible to enable end-users …… to make comparisons at the appropriate geographical scale.

At a horizontal level the INSPIRE Directive (2007/2/EC) establishing an infrastructure for spatial information in Europe entered into force in May 2007.[14] It contains provisions aiming to improve the accessibility and interoperability of spatial data. INSPIRE is based on similar principles to SEIS. Its successful implementation will go a long way towards overcoming existing inefficiencies relating to the usability and use of spatial data stored by public authorities. It is important to recognise,

[14] http://inspire.jrc.ec.europa.eu/

however, that INSPIRE will not directly address data of a non-spatial or non-numerical nature or documents, it will not by itself constitute an integrated e-reporting system related to EU environmental legislation, and will not lead directly to an improvement in the quality and comparability of data. The updated Guidance recognises that the GIS component of WISE will be a building block of the European Spatial Data Infrastructure and will be compliant with the requirements of INSPIRE.

The Global Monitoring for Environmental Security (GMES)[15] initiative aims to provide operational information services based on Earth monitoring data obtained from satellites and *in-situ* observations on water, air and land.

An integrated platform that can link all these initiatives into a shared and common system is required and SEIS aims to provide that function. With the help of Member States this new system will modernise the production, exchange and use of environmental data and information based on the latest information technology.

WISE is seen as the water pillar of SEIS. Although originally designed as a reporting tool in the context of the WFD, WISE is now being extended to integrate reporting data flows from a number of existing and upcoming water-related directives as well as water relevant statistical data. Furthermore, WISE not only relates to the reporting flow but also covers the aspect of information visualisation and dissemination through the WISE map viewer. The overall scale of WISE is shown in the following figure (Figure 1.2.2).

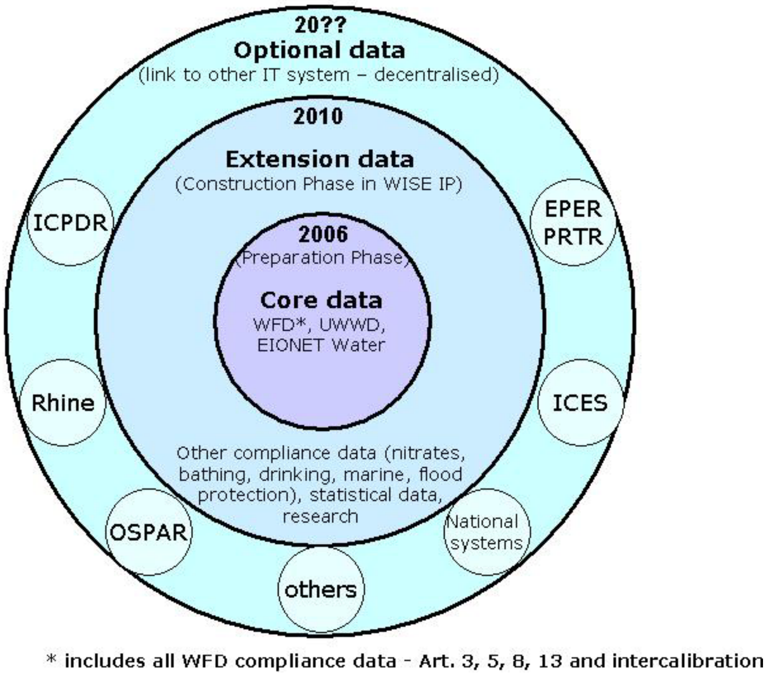

Figure 1.2.2 Planned expansion of WISE

The annual EC Bathing Water Report for the 2007 bathing season (based on Member State submissions under the Bathing Waters Directive) was made available in WISE

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[15] http://www.gmes.info/

map viewer in June 2008[16]. A further extension of the functionality was realised in July 2008, when EEA and Microsoft launched a new environmental information portal 'Eye on Earth', displaying the latest information on the water quality in bathing sites across Europe. Through its first application, 'Water Watch', the new portal allows users to rate beaches and to share their comments with others[17].

For the Nitrates Directive, the reporting process through WISE takes place in 2008 and by 2010 should be streamlined with the State of the Environment Reporting (for the EEA via the Eionet). The Reporting Sheets for the Drinking Water Directive were agreed in 2007 and the IT formats are currently being implemented into WISE with the objective reporting through WISE and visualisation of information in 2009.

The Urban Waste Water Treatment Directive (UWWTD) was reported in 2007 and improvements are underway in time for the next reporting cycle in 2009 to use Reportnet as a single entry point of information for WISE. Visualisation of reported data under UWWTD in WISE is already also available through WISE viewer.

Streamlining of reporting on the UWWTD and the requirements for the joint Eurostat/OECD Joint Questionnaire on Inland Waters (JQ-IW) is also being discussed in 2007 by the institutions (Eurostat and DG Environment) and Member States (national contact points on water statistics) and took part in 2008 by aggregating reported data for UWWTD (during the last reporting exercise) to the Member State level and pre-filling this JQ-IW. This process will be further developed in the frame of WISE by making the process more automatic.

The EEA's water data gathering system (Eionet-Water) from its Member Countries (considerably larger than the EU27) has been integrated with WISE and is now called WISE State of the Environment reporting (WISE-SoE). It is based on the Eionet and also has a planned expansion to meet the reporting ambitions of the EEA which is increasingly based on indicators.

In terms of new water policy, the reporting requirements of the Floods Directive have been described in a Floods Reporting Concept Paper and draft Reporting sheets have been produced to meet the needs of the Groundwater Directive. The concept of development WISE –marine part is also under way, and will find its place and the solution in a frame of WISE and other activities related to the marine issues within upcoming few years, with the first deadline on data reporting under the marine strategy directive being in 2010.

The Implementation Plan of WISE[18] describes this progressive expansion and the system design has to be flexible to accommodate the step by step changes.

The WISE is hosted, managed and maintained by the EEA in its capacity as the Water Data Centre based on an agreement between EEA, DG Environment, Eurostat and the Joint Research Centre. Ultimately WISE will be a distributed system and proposals have been made for the design and implementation of the distributed architecture of WISE that take account of INSPIRE guidelines and that the architecture has to be feasible with open source software. The proposed architecture makes a number of

[16] http://ec.europa.eu/environment/water/water-bathing/report_2008.html and http://www.eea.europa.eu/themes/water/status-and-monitoring/state-of-bathing-water
[17] http://www.eea.europa.eu/highlights/heading-for-your-favourite-beach-is-the-bathing-water-clean
[18] http://ec.europa.eu/environment/water/water-framework/transp_rep/pdf/wise_ip_2006_2010.pdf

assumptions: that data from the Member States should be available by both "push" and "pull"; more than one version or format of schemas can be handled; the system is backward-compatible; and countries can use the "old-style" of reporting if they wish. The definition of the service layers is relatively easy but the challenge will be in bringing together different services from all EU Member States and EEA Member Countries. Over the next 2-3 years, a number of Member States/Countries will cooperate with the EEA in exploring the technical options of how to bring that about.

1.2.3 Lessons learned from the first 4 years of WFD implementation

A number of lessons have been learned and these can be divided into five different areas as follows:

(i) The *usage of the WISE portal for reporting data* falls into two phases. In a first phase, the WISE reporting prototype at the JRC was used to store reported data on WFD Articles 3 and 5. While the data reported was stored and a certain level of quality assurance was performed, no European datasets were built at that stage. In a second phase, the reporting of data in accordance with WFD Article 8 and the hand-over of all reported data to the EEA which assumed the responsibility for managing the data marked a major change in procedures. A full quality assurance process was established for Article 8 and the first European datasets were established. Also, the production of GIS reference datasets from the Article 3 submissions on River Basin Districts has begun and, following consultation with Member States, the objective is to have an EU-wide harmonised reference dataset. The reporting as such was moved to the Reportnet system in order to have a common approach across environmental directives, and to use Reportnet as a common data entry point for reporting on water. In a later stage, most probably by 2015, when the reporting formats and data specifications will be in place and fully operational, WISE could be described as a shared and distributed system completely implementing initiative of SEIS.

(ii) In assessing the experiences with *agreed vs voluntary contributions of information* from Member States, the picture is fragmented. Reporting can be regarded as an evolutionary process where experiences have to be collected on both sides: those that do the reporting and those that receive the reports. The history of the Article 3 reporting shows that quality has been improved with the resubmission of data in a second phase. Article 5 data quality, where no resubmission has yet been initialised, suffers from various, non-matching interpretations of the reporting requirements by Member States resulting in heterogeneous data quality and quantity. Also to be taken into account is the improvement of technology e.g. the maturing of GIS systems during the past years which has improved the ability of the Member States to deliver better quality data, as well as making more clear guidelines to harmonise on the technical formats and requirements to report information (in the sense of tabular/point data as well as geographical information) in a uniform way.

(iii) The process of *validating and harmonising data from Member States* has begun with the on-going production of GIS reference datasets. This is a huge task and the available resources on the EU side and on Member States side are not always sufficient enough to lead to a timely production of quality data products. The experiences from the initial years of the WFD reporting are very useful to guide the process on the upcoming Article 13 reporting, which is of key importance in terms of implementing the WFD with a sound data and information base. This process is also serving as a guiding line on reporting and data visualisation process for other EU water directives.

(iv) The *experiences of handling resubmissions of data*, derived from the Article 3 resubmissions, show that this is an important way of improving data availability and data quality. Therefore the opportunity of improving Article 3 and in particular Article 5 data in conjunction with the Article 13 reporting will be strongly recommended. The Article 3, 5 and 13 Reporting Sheets are being amalgamated into a single consolidated Guidance and the associated XML schemas are being streamlined to avoid duplication and reduce the reporting burden on Member States. Also, Article 8 data, which is seen to be especially dynamic (changeable), will be subject to periodical updates. This is an area in which new technologies and distributed system architectures will be initially explored and applied.

(v) The *experience of provision of updated information* is derived from the fact that the Article 3, 5 and 8 data were submitted over a span of years and designed to be interlinked for the purpose of reducing duplication of reporting. The experience has shown that information inevitably changes over even a short time period and the management of versioned submissions is crucial for the correct processing and interpretation of data.

1.3 Terminology and abbreviations

Ambiguity in terms may easily evolve in a period where several related processes are taking place simultaneously in the domain of spatial data infrastructures. It has not been the intention with this document to come up with new definitions of concepts, rather we have strived for alignment with the terminology applied by INSPIRE working groups in order to improve transparency. A part of the INSPIRE terminology has been developed through the elaboration of documents from the INSPIRE Drafting team "Data Definition". The terminology may however continue to evolve until the INSPIRE process deliver a final glossary to be available from http://www.ec-gis.org/inspire/.

A wider glossary of terms can be found in Appendix 14.

1.3.1 Terminology

In order to avoid ambiguity in terms, it is important to note that the following terminology will be used throughout this document:

Code:

A rule for converting a piece of information (for example the confluence of rivers) into another form or representation, not necessarily of the same sort.

> **A**: a representation of information in a shorter alphanumerical form**.**
>
> EXAMPLE: the two letter ISO 3166 Country code (e.g. DE for Germany); acronyms and abbreviations; ASCII code.
>
> **B:** identifiers with a certain logic for which more than just the simple identification relationship can be derived.
>
> EXAMPLE: Hydrological feature code - A Pfaffstetter code describes the relative position of a river in a river network (see Chapter 5.4).

Feature:

Abstraction of real world phenomena [ISO 19101]. In this document synonymous with spatial object. Unfortunately "spatial object" is also used in the ISO 19100 series of International Standards, however with a different meaning: a spatial object in the ISO 19100 series is a spatial geometry or topology.

Feature type:

Classification of **features**.

> EXAMPLE Cadastral parcel, road segment or river basin are all examples of potential feature types.
>
> NOTE In the conceptual schema language UML a spatial object type will be described by a class with stereotype <<FeatureType>>.

GIS layer:

Identifiable collection of spatial data produced according to a data product specification, used synonymously with the "spatial data set".

Identifier:

Linguistically independent sequence of characters capable of uniquely and permanently identifying that with which it is associated (ISO 19135).

Map:

A graphical representation of a section of the Earth's surface. The Water Framework Directive refers to a number of maps, each one with a specific thematic content – a spatial data set (e.g. a map of the River Basin Districts). A map can be made up of one or many GIS layers. Using GIS software, maps can be presented in digital form from which an analogue map can be plotted.

Object:

in this document used as a generic term for abstractions, often represented as either tables or features.

River basin:

The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta. (Definition from WFD). A river basin may include sub-basins.

River basin district:

The area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins. (Definition from WFD).

River sub-basin:

The area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence). (Definition from WFD).

Table:

Most software systems require the organisation of datasets in one or more tables. In order to make information comparable between organisations, the structure of these tables must be similar. (Definition fromWFD GIS Guidance).

WISE Reference GIS dataset:

Dataset which provides a comparable basis for visualisation or assessment of geo-referenced data across Europe (for more details see Chapter 3.1).

1.3.2 Abbreviations

BWD	Bathing Waters Directive
DWD	Drinking Water Directive
CRS	Coordinate Reference System
CSL	Conceptual Schema Language
EC	European Commission
EEA	European Environment Agency
EGM	EuroGlobalMap
E-PRTR	European Pollutant Release and Transfer Register
ERM	EuroRegionalMap
ETRS89	European Terrestrial Reference System 89
EU	European Union
EUROSTAT	Statistical Office of the European Communities
EVRF2000	European Vertical Reference Frame 2000
ESDI	European Spatial Data Infrastructure
GI	Geographic Information
GIS	Geographic Information System
GML	Geography Markup Language
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
IR	Implementing Rule
ISO	International Organization for Standardization
ISO/TR	ISO Technical Report
JRC	Joint Research Centre
MS	Member State
NiD	Nitrates Directive
OCL	Object Constraint Language
OGC	Open Geospatial Consortium
RBD	River Basin District (according to the WFD definition)
RISE	Reference Information Specifications for Europe

SoE	State of Environment
UML	Unified Modelling Language
UWWTD	Urban Waste Water Treatment Directive
WCS	Web Coverage Service
WFD	Water Framework Directive
WFS	Web Feature Service
WISE	Water Information System for Europe
WMS	Web Map Service
XML	eXtensible Markup Language

CONCEPTUAL CHAPTERS

2 GIS in WISE: developing a common understanding

2.1 Scope of GIS Guidance and purpose of GIS in WISE

This Chapter introduces the general basis for the detailed specifications which are described in the following Chapters. It reflects the common understanding of the Working Group experts (and others) on the purpose and the structure of the GIS elements to be developed as a basis for the reporting obligations under the water policy domain. A common understanding is an essential pre-requisite for a consistent approach to the reporting of spatial information and it had to be achieved on issues such as the contents of the various maps, the scale and positional accuracy of the data, and the reference system and projections to use. Given the fact that the various GIS layers at national or River Basin District level will be part of a European picture, it was necessary to consider issues such as the harmonisation at boundaries and the use of common identifiers. Recommendations are given on the standards to be implemented for data exchange and data access and on the content and structure of the metadata to accompany each layer.

Technical possibilities nowadays allow the required GIS layers to be provided in two different ways. One option is to transfer them into a centralised system, where they will be stored, quality checked and analysed. The other option is to leave them at their place of origin (i.e. to store the data sets locally in each River Basin District or at national level) and to guarantee broad access to these data through common standards and protocols. While the first option is easier to implement and has been pursued as a short-term objective, the second option will reduce the burden of transferring data and the longer-term objective is for the set-up of a decentralised or distributed system and work is currently in progress on that.

In a more general context, it should also be noted that information, consultation and participation are requirements of the Directive, since they will ensure a more efficient and effective implementation. The *Guidance on Public Participation*[19] provides more detail about these forms of participation. In particular WFD Article 14 promotes the active participation of all interested parties in the development of River Basin Management Plans and requires Member States to inform and consult the public. The latter can most efficiently be done through maps, GIS technology and web mapping.

2.1.1 GIS guidance – a necessity for streamlining reporting

Building on the common understanding, further consistency is achieved through the processes of the Common Implementation Strategy where the conceptual aspects of reporting are described in the WFD Reporting Concept report which was developed and agreed by Working Group D (Reporting) and the Strategic Coordination Group (SCG) and endorsed by the Water Directors on behalf of the EU Member States. Detailed specifications were then drafted in the form of Reporting Sheets by a Drafting Group of Working Group D and subsequently discussed and agreed by the main Working Group and the SCG with final endorsement by the Water Directors. The Reporting Sheets were converted into XML Schemas (or other Reportnet tools) which were used by the Member States for their formal reporting to WISE.

[19] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos8spublicspar/_EN_1.0_&a=d

For the reasons explained in Chapter 1.2.1 it has become necessary to re-assess Reporting Sheets for reporting the information required under WFD Articles 3 and 5 that were developed over a number of years, in accordance with the reporting deadlines, and to streamline and update them while the reporting for Article 13 (River Basin Management Plans) is under consideration. The task is to produce a streamlined, consolidated Reporting Guidance to Member States (and other WISE users) and gain the endorsement of the Water Directors by the end of 2008. Contemporaneous with this, the XML schemas for Article 13 reporting will be streamlined to allow Article 3 and 5 information to be resubmitted if it is out of date (in accordance with Article 3.9 and Article 5.2) while recognising that if RBMP information has been reported under other directives (see Chapter 1.2.2), it need not be reported again. The aim is to eliminate duplication and achieve the objective of "report once, use many times".

2.1.2 The role of GIS in WISE

Even though only Annex I (Competent Authorities) and Annex II (Surface Waters) of the WFD explicitly state that the respective maps should as far as possible be available for introduction into a GIS, it is obvious that the best way to provide most of the requested information will be in the form of GIS layers. This is due to the fact that most of the data is to be presented in its spatial context and that questions like 'where are the critical areas?', 'how much area is involved?', or 'which points are in a designated area?' can easily be answered when the data are kept in their spatial context and when the background database has the appropriate design.

The provision of (or access to) the requested GIS layers will not only facilitate reporting by the Member States themselves; it will also facilitate the further compilation and analysis of the information as a basis for the Commission's own reporting obligations under the WFD in accordance with the requirements of Article 18. Such development is also in line with current efforts under the INSPIRE (Infrastructure for Spatial Information in Europe) initiative of the Commission and the Member States, aiming at the development of a harmonised European spatial data infrastructure (see Chapter 1.2.2). Many parties are involved in the implementation of the WFD, ranging from local water authorities to the European Commission. Regarding this wide range of parties, having different practices for water management, different reporting obligations and different levels of technical abilities, this Guidance Document strives to keep specifications as simple as possible, based upon standards where feasible, and according to best current technical options.

The agreed Reporting sheets for WFD (Articles 3, 5, 8 and 15) require that Member States report a considerable amount of information in the form of spatial data. This is especially so for the reporting of the River Basin Management Plans where the results of the surface water monitoring programmes have to be reported to enable the following maps to be produced:

- Map 1: Ecological status class of natural water bodies;
- Map 2: Ecological potential class for Heavily Modified Water Bodies;
- Map 3: Status for Protected Areas;

- Maps 4-8: Achievement or exceedance of Environmental Quality Standards for heavy metals; pesticides; industrial pollutants; other pollutants (all from the list of Priority Substances) and, other (national) pollutants.

For groundwater bodies, (or group of Groundwater Bodies), Member States are required to provide the information necessary to produce the following maps:

- Map 1: Achievement/exceedance of good quantitative status;
- Map 2: Achievement/exceedance of good chemical status for nitrates;
- Map 3: Achievement/exceedance of good chemical status for pesticides;
- Map 4: Achievement/exceedance of good chemical status based on national thresholds for other pollutants;
- Map 5: Identification of Groundwater bodies where a significant and sustained upward trend (notifying the relevant substances) has been identified.

The implementation of the WFD therefore requires the handling of spatial data both for the preparation of the River Basin Management Plans and for the reporting to the Commission. In the first case GIS techniques will be essential for the derivation of various information layers (e.g. on the characteristics of river basins and water bodies, on the chemical and ecological status of water bodies and potentials of various management measures), while in the second case GIS will be the tool for the preparation and delivery of the GIS layers required for the reporting.

2.1.3 Member State GIS submissions and WISE Reference GIS datasets

There are two main types of spatial datasets involved in WISE:

- Spatial data submitted by MS according to Directives:
  - Named by the Directive e.g. “WFD River Basin Districts”.
- WISE Reference GIS datasets:
  - Aggregated from MS submissions;
  - Prenfix “WISE” e.g. “WISE River Basin Districts”.

The basic concepts for the GIS layers are as follows:

- All the GIS layers described in this guidance are vector data (point, line or polygon datasets);
- The WISE GIS reference layers are made available through WISE;
- All GIS layers will have associated attribute information which can be accessed as required or used to derive maps;
- In certain circumstances WISE layers are to be made available for download;
- It is the responsibility of the Member States to collect and compile GIS layers conforming to requested precision, quality and content for use within WISE under an agreed format (developed/clarified through recommended guidance for each layer), including metadata and data IT formats to ensure that an EU-wide harmonised layer will be available in WISE;

- It is the responsibility of the EEA and/or third parties to compile and maintain Reference, Background and External GIS layers within WISE;
- It is recognised that for data collection an input scale of 1:250,000 or better should be a common goal;
- All data will be harmonised to enable analysis and subsequent dissemination at the European level using WISE Water Reference and Background / External datasets (which should be provided by the Member States under agreed technical/IT formats).
- It should be noted that a map derived from GIS layers relating to datasets in WISE (e.g. a map of ecological potential) is not a GIS layer in itself as it is based on the attribution of one or more other layers, and is transient over time as that attribution changes or the rules for creating the map change.

2.2 GIS data requested from Member States under WISE

The reporting of spatial information under the water-related directives function as a reference frame for other documentation of the implementation of the directives. The form of reporting has, as a consequence of the Common Implementation Strategy, shifted from specific map products into spatial data that may be further processed in a GIS environment. The table below (Table 2.2) provides an overview of the data layers that have currently been defined and requested for the water-related directives and voluntary agreements.

Table 2.2 is provided as an overview; details can be found in subsequent Chapters, in particular Chapter 5.2 and Appendices 05 and 06.

Table 2.2 Overview of GIS data requested from Member States

Policy area	Feature group	Data layers
WFD	Management units	River Basin Districts
		Sub-units
		Competent Authorities
		Water bodies categorised by: Lake, River, Transitional, Coastal, and Groundwater
		Drinking water protected areas
		Economically significant aquatic species protected areas
		Recreational waters protected areas

		Nutrient-sensitive protected areas
		Habitats protected areas
		Birds protected areas
	Infrastructure layer	River Basins, Sub-basins
		Main Rivers
		Main Lakes
		Transitional waters
		Coastal waters
		Main artificial waters
		Groundwaters
	Measurement features	Surface water monitoring stations
		Groundwater monitoring stations
	Background features	Eco regions
WISE-SoE	Management units	WISE-SoE Groundwater bodies
	Measurement features	WISE-SoE River stations
		WISE-SoE Lake stations
		WISE-SoE Water quantity stations
		WISE-SoE Transitional, Coastal and Marine water stations
		WISE-SoE Transitional, Coastal and Marine water flux stations
		WISE-SoE Groundwater sampling sites
	Influencing features	WISE-SoE Groundwater saltwater intrusion

UWWTD	Management units	Receiving areas
		Sensitive area – River, Lake Transitional water,, Coastline, Coast area, Catchment
		Less sensitive area – Transitional water; Coastline
	Influencing features	Agglomeration
		Urban waste water treatment plants
		Discharge points

Bathing Water Directive	Management units	Bathing Water
	Measurement features	Sampling points inland and coastal
Drinking Water Directive	Management units	Water Supply Zones
Nitrates Directive	Management units	Nitrate Vulnerable Zones
	Measurement features	Monitoring zones on surface water
E-PRTR	Management units	Location of sites

3 Definition of derived products (maps)

3.1 Types of WISE GIS datasets

There are various types of dataset in WISE:

- **Member State submitted GIS datasets:** these may be relatively dynamic, such as the point locations of monitoring stations. Others may be relatively stable over time, such as UWWT agglomerations, UWWT plants and discharge points from UWWT plants. Datasets may be points as described above or polygons, such as Protected Areas and Nitrate Vulnerable Zones. These datasets may be considered candidate WISE Reference GIS datasets to be further developed in the future;
- **WISE Reference GIS datasets:** these are relatively stable over time. There are currently five WISE Reference GIS datasets. The WISE Reference GIS datasets are created using detailed digital spatial data provided by Member States and other sources, generalised for the purposes of visualisation and assessment of geo-referenced data across Europe. Thematic data can be attached or linked to WISE Reference GIS datasets;
- **Background GIS datasets:** refer to datasets such as administrative borders of the Member States, coastline, main cities/towns and roads. They provide the background and context for mapping the WISE Reference GIS datasets;
- **External GIS datasets:** these can be used to support further analysis and the visualisation of the WISE Reference GIS datasets, such as CCM2, Corine Land Cover and EEA European River Catchments.

All WISE Reference GIS datasets will fulfil standard quality criteria and will be made available to all WISE stakeholders and, wherever possible, made publicly available through official outlets e.g. through the EEA or GISCO.

All WISE Reference GIS datasets will be managed and maintained within WISE by the EEA. Background and External GIS datasets will be maintained by their data owners. Other GIS datasets will be managed and maintained by the EEA water data centre as they become integrated with WISE Reference GIS datasets.

The WISE Reference GIS datasets and the Member State submitted GIS datasets can be categorised into two different application types:

- Hydrological infrastructure layers describe the features of the physical hydrological system, e.g. rivers, lakes and river basins. The hydrological infrastructure layers can respond to questions such as “which areas contribute to flow of water at this point?”
- Water management layers describe the hydrological features from a management perspective that allow the aggregation of features across river basin boundaries, e.g. River Basin Districts and water bodies. The water management layers can respond to questions such as “who is responsible for the water quality in this area?” or “which water features are affected by similar pressures, have a similar status and may be managed in a similar fashion?”

More detailed information on all datasets in WISE can be found in Appendix 05.

3.1.1 WISE Reference GIS datasets

The current WISE Reference GIS datasets are:

- Large Rivers and Large Lakes;
- Main Rivers and Main Lakes;
- Water Bodies;
- River Basin Districts;
- Sub-units.

The River Basin Districts and Sub-units WISE Reference GIS datasets will support the visualisation and analysis of the Large Rivers and Large Lakes, Main Rivers and Main Lakes, and Water Bodies WISE Reference GIS datasets. The Main Rivers and Main Lakes WISE Reference GIS dataset will be the primary reference dataset used to present information at the European scale.

Additional information concerning each WISE Reference GIS dataset is provided in the following Table 3.1.1.

Table 3.1.1 Description of WISE GIS Reference datasets

WISE Reference GIS dataset	Description
1. Large Rivers and Large Lakes	Large Rivers is dataset with two feature types: a) Rivers with a catchment area > 50,000 km^2 and b) rivers and main tributaries that have a catchment area between 5,000 km^2 and 50.000 km^2 Large Lakes are lakes that have a surface area > 500 km^2. Large Rivers and Large Lakes are based on GISCO data at a scale of 1:10,000,000, supplemented by WFD Article 3 submissions. The data set is intended for visualisation only.
2. Main Rivers and Main Lakes	Main Rivers are rivers that have a catchment area ≥ 500 km^2. Main Lakes are lakes that have a surface area ≥ 10 km^2. Main Rivers and Main Lakes are based on WFD Article 3, Article 5 submissions and when needed ERM (EuroRegionalMap) or CCM2 v2.1 have been used to complement the layer.
3. Water Bodies	Water Bodies are based on WFD Article 5 submissions of Surface Water Bodies and Groundwater Bodies. River water bodies have a catchment area > 10 km^2, lake water bodies have a surface area > 0.5 km^2, all transitional and coastal water bodies are included.
4. River Basin Districts	River Basin Districts are based on WFD Article 3 submissions.
5. Sub-units	Sub-units are based on the submission of Sub-units by Member States at the request of the European Commission. Sub-units are defined by the national Competent Authorities of the River Basin Districts for management purposes where the River Basin Districts are very large. Sizes can vary between 5,000 and 50,000 km^2.
6. WISE-SoE stations	WISE-SoE stations are based on Eionet-Water and WFD Article 8 stations. The WISE-SoE stations have a history of more than 10

	years being annually reported and used for EEA SoE assessments.

Details regarding the production of WISE Reference GIS datasets can be found in Chapter 6.2.

3.1.2 Purpose of the WISE Reference GIS datasets

WISE Reference GIS datasets provide the basis against which comparable statistics and indicators are calculated. WISE Reference GIS datasets are based on nationally reported data from the Member States for use at different scales. Features at European, national and regional levels are linked through vertical integration using coding.

The WISE Reference GIS datasets have three main purposes:

- ***Visualisation:*** through the WISE Viewer it is possible to display features reported by Member States, the results of any analysis of the data, or a combination of any information available.
- ***Analysis:*** the data reported by Member States and contained in WISE can be used for analysis and assessment (compliance checking, policy effectiveness, modelling of scenarios for policy development, etc). Indicators can be determined at various levels. They should be produced using methodologies that are robust and transparent in agreement with the Member States.

  The visualisation and analysis of indicators at different scales can be achieved by linking the WISE Reference GIS datasets, either by code or spatially (see Figure 3.1.2a below). At the most detailed level, actual values may be visualised and analysed using the geometry defined for the feature against which the values were reported. Alternatively, reported values may be aggregated to a different spatial unit. For example, heavily modified river water bodies could be visualised and analysed at the individual water body level. Alternatively, a percentage of heavily modified river water bodies within a River Basin District or Sub-unit could be calculated by aggregating values within the spatial unit, or the heavily modified river water bodies could be related to their associated Main River stretch.

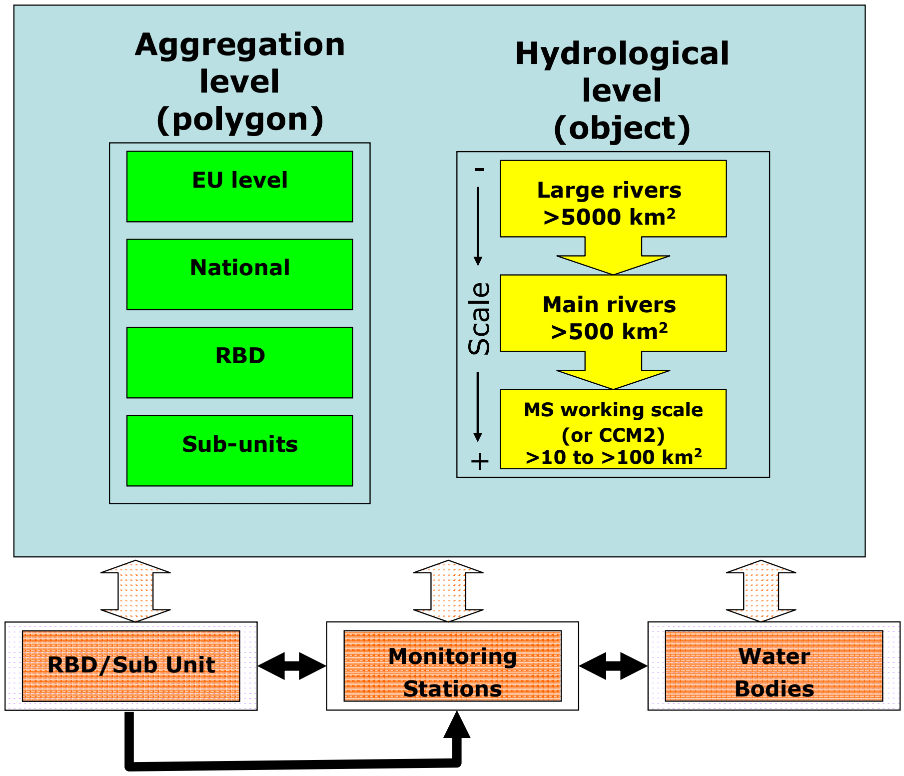


Figure 3.1.2a Visualisation of WISE Reference GIS datasets at different scales

- ***Reporting:*** future reporting exercises should be linked with the WISE Reference GIS datasets. Integrity and consistency of codes should be maintained. For example, whenever a Member State reports a river monitoring station, it should be located on and linked by code with its associated river water body (for more detailed information see Chapter 5.4).

3.2 Policy implementation visualisation

The implementation of European legislation is often divided into phases where Member States gradually implement the approaches and obligations specified in the directives. The phases cover a time span of several years. The European Commission, as a guardian of the EU legislation, is obliged to monitor the progress of implementation of the EU water legislation and to inform the European Parliament and the European Council, national governmental institutions, all interested groups and stakeholders as well as European citizens on the progress made by the Member States. The EC also informs the European Water Directors as part of the Common Implementation Strategy. The monitoring of progress, and the review and compliance checking of information related to it, has several key objectives:

- To have a general overview at the EU level on the status of the implementation of the EU water legislation;
- To identify early and resolve general problems related to the Member States' ability to implement the directive in question;

- To stress the importance of all Member States fulfilling the requirements of the European environmental legislation;
- To assess policy effectiveness.

The focus of the information on the progress of water policy implementation in the EU will, by its nature, be an overview based on simple high level indicators and map representations of key aspects of implementing water directives at the EU level, for example:

- Transposition of directives into national legislation;
- Implementation of key features of a particular legislation (e.g. establishment of River Basin Districts and identification of Competent Authorities, designation of water bodies, designation of sensitive areas and Nitrate Vulnerable Zones, establishment of a Register of Protected areas, etc);
- Establishment of monitoring programmes;
- Establishment of programmes of measure;
- Reporting to the Commission.

It should be underlined that for some water directives the requirements to show the status or progress of the implementation of a directive are rather straight forward, simply presenting and visualising the raw data reported by Member States.

Some of these data, e.g. bathing water quality monitoring sites and the status of bathing water quality, can be directly (after certain QA/QC procedures), be presented at the EU level on interactive maps using the WISE map viewer. For example, Figures 3.2.1a and 3.2.1b represent the status of implementation of the bathing water directive showing bathing water quality of inland and coastal waters at the EU as well as the MS level.

For other reported information, some aggregation, selection or clustering of reported data should be done and compliance or performance indicators derived. Visualisation of the status and performance of the implementation of a directive can be achieved using the WISE map viewer or they may be static presentations available for download (e.g. from the EEA's Atlas). Examples of such maps of indicators are:

- Overview map of WFD River Basin Districts (see Figure 3.2.1c and 3.2.1d);
- Density of monitoring stations (e.g. number of stations per 1000 km^2) visualised by Member State or River Basin District (see Figure 3.2.1e);
- Density of surveillance monitoring as reported by Member States under WFD Article 8 (see Figure 3.2.1f);
- Percentage of heavily modified water bodies visualised by River Basin District (see Figure 3.2.1g).

Development of each selected indicator and/or map will need to be clearly defined in terms of:

- The context of the directive;
- Data sources, particularly where data from different directives and/or sources are combined within an indicator;

- Derivation, presentation and visualisation.

Textual explanations of the rationale, limitations and assumptions made in the processing of the original data reported by Member State to develop indicators and present and visualise this derived information in maps will be elaborated to ensure valid interpretation.

3.2.1 Compliance assessments visualisation

In addition to the information directly requested by the EC and reported by Member States, and its visualisation using the WISE map viewer, a legal compliance assessment of the data reported against the directive requirements will be made.

The purpose of the compliance assessment is to evaluate in quantitative and qualitative terms whether a Member State has fulfilled its obligation of implementing the European legislation in accordance with the specifications and the sentiments of the legislation in question. Therefore, compliance assessment is performed by using certain methodologies and rules. The outcome or results of the compliance checking can also be visualised and presented on maps, such as displaying the status of how a Member State is implementing a certain directive.

The visualisation of the results of compliance checking can be done in two ways: by directly presenting the results of the compliance check on maps, or by developing certain indicators derived or based on the results of the compliance check.

In some cases, the outputs (maps) of the results of compliance assessments can be considered information elements in the assessment process and can provide a useful means of visually communicating the outcome of the assessments. The maps of indicators presenting results of compliance checking are used to inform EU services, European politicians, national governments of Member States and the public about the level of compliance of implementation of the water related policies.

The focus on visualising information reported on the status of implementation and compliance of directives will be as European overviews and individual country representations (using maps) with the use of derived and detailed indicators of key aspects and issues associated with implementing water directives. Examples of such compliance indicators are:

- Numbers of identified and designated water bodies in relation to the size of Member States and River Basin Districts;
- Identification of significant pressures, numbers/areas/proportion of affected waters and water bodies at risk;
- Numbers and types of monitoring sites in relation to the size of Member States and River Basin Districts;
- Numbers and types of parameters and quality elements used in monitoring;
- Frequency of monitoring;
- Level of urban waste water treatment against required designated sensitive areas and requirements for treatment based on the sensitivity of these areas;
- Bathing water quality status per bathing water against water quality requirements/thresholds for certain parameters.

It should be noted that in the compliance assessment process the EC is not limited to the information directly reported by the Member States but may apply information as deemed relevant.

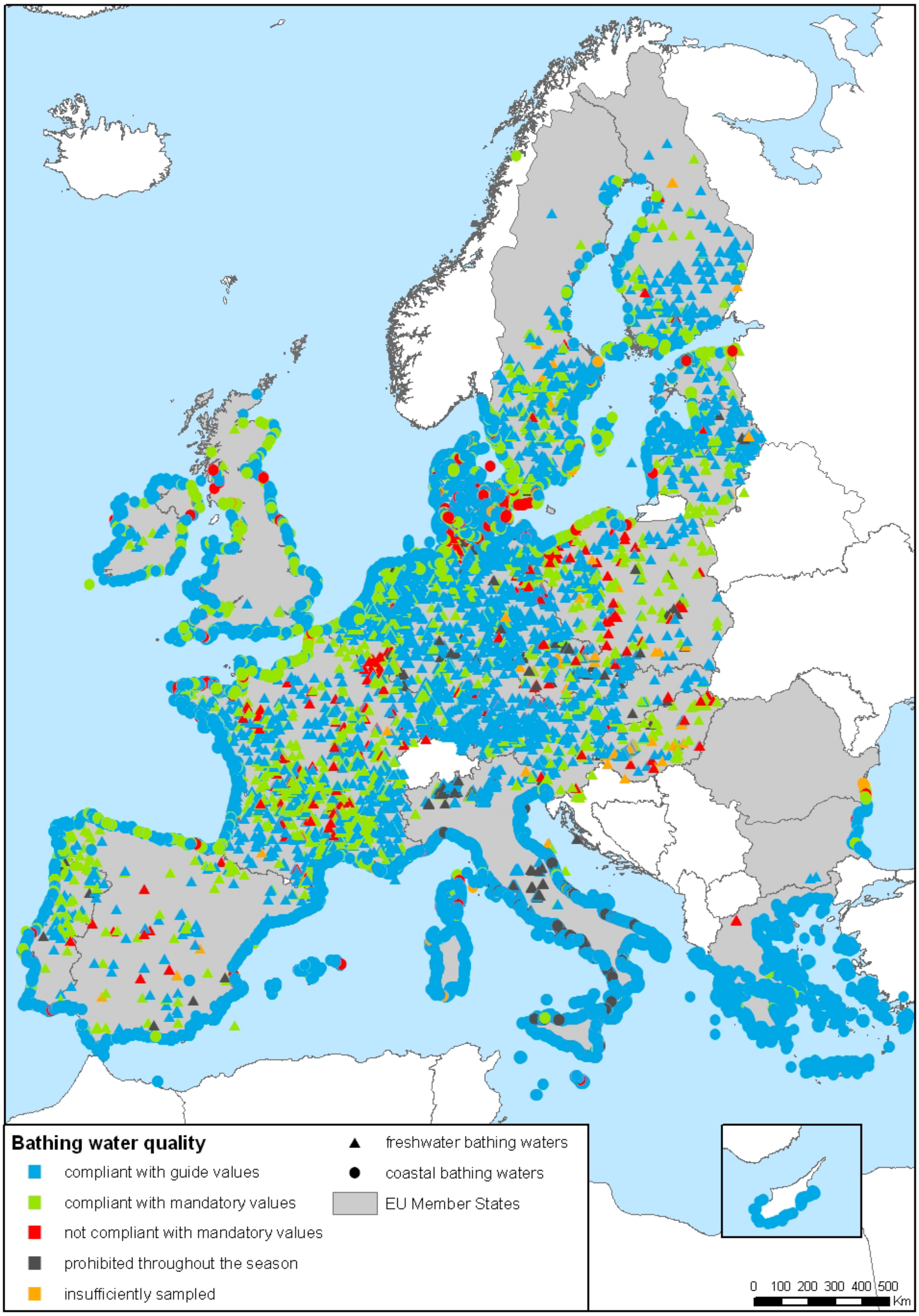


Figure 3.2.1a Bathing water monitoring stations with quality classification as reported by Member States

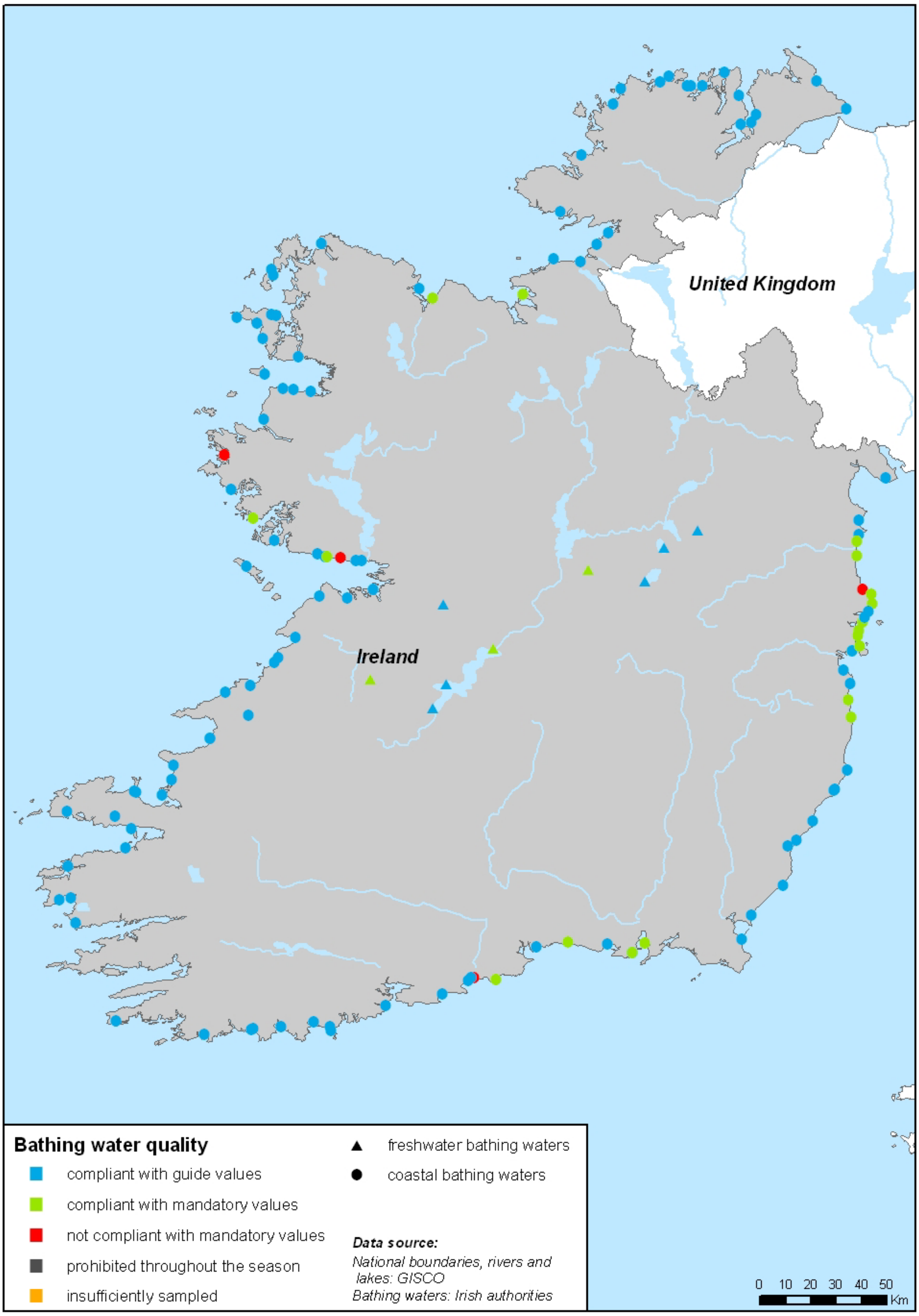
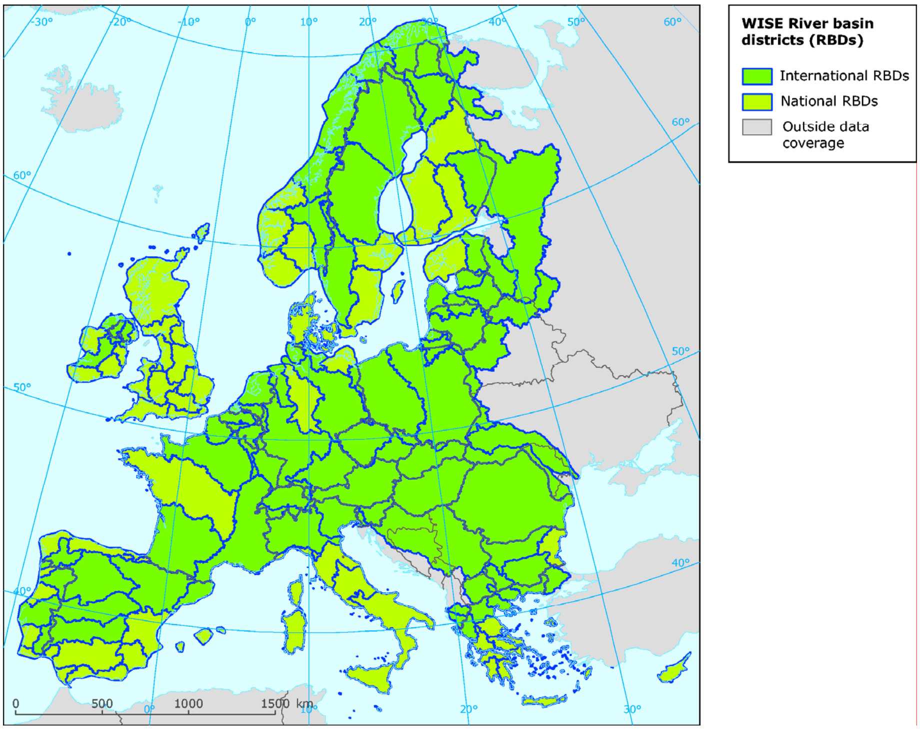
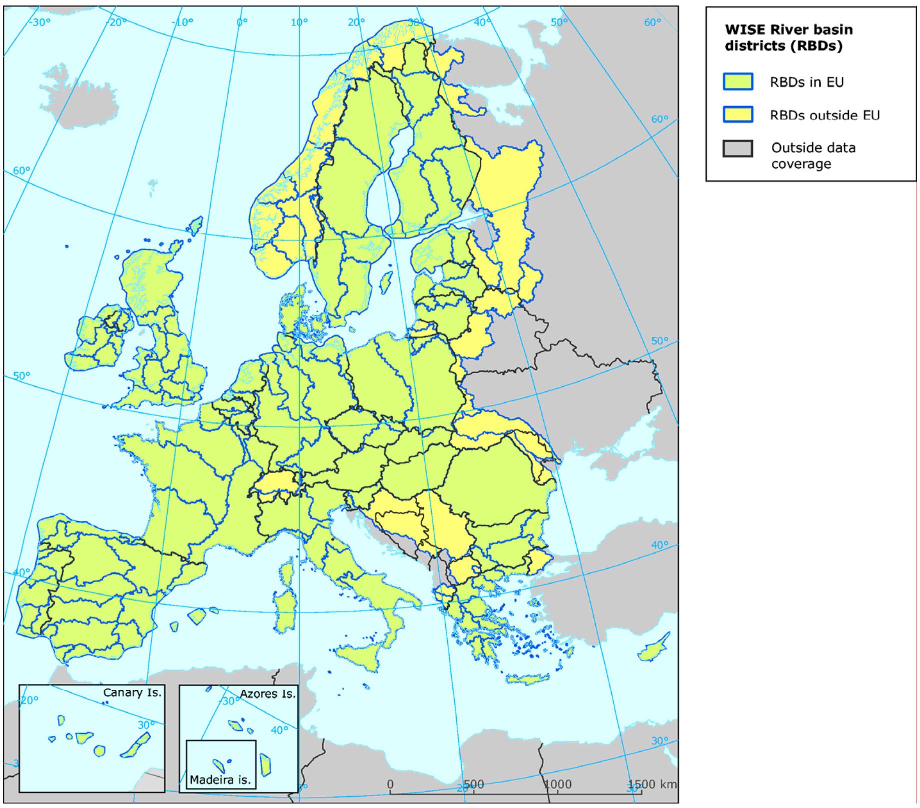


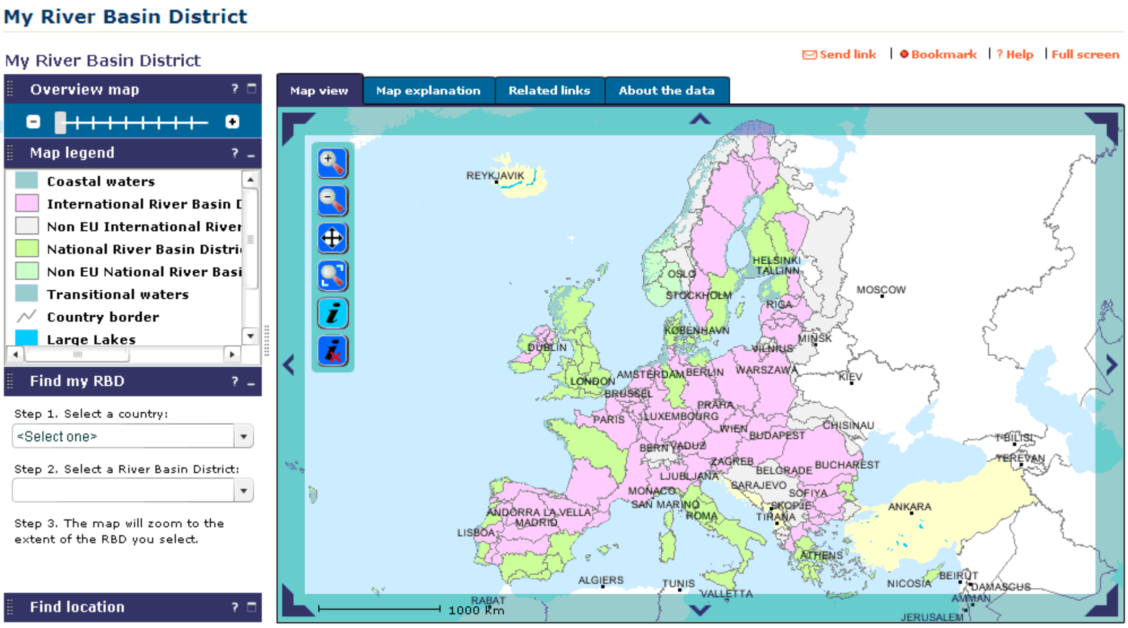
Figure 3.2.1b Detailed view into BWD stations reported by Ireland





Source: http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3687

Figure 3.2.1c Map of River Basin Districts available for download

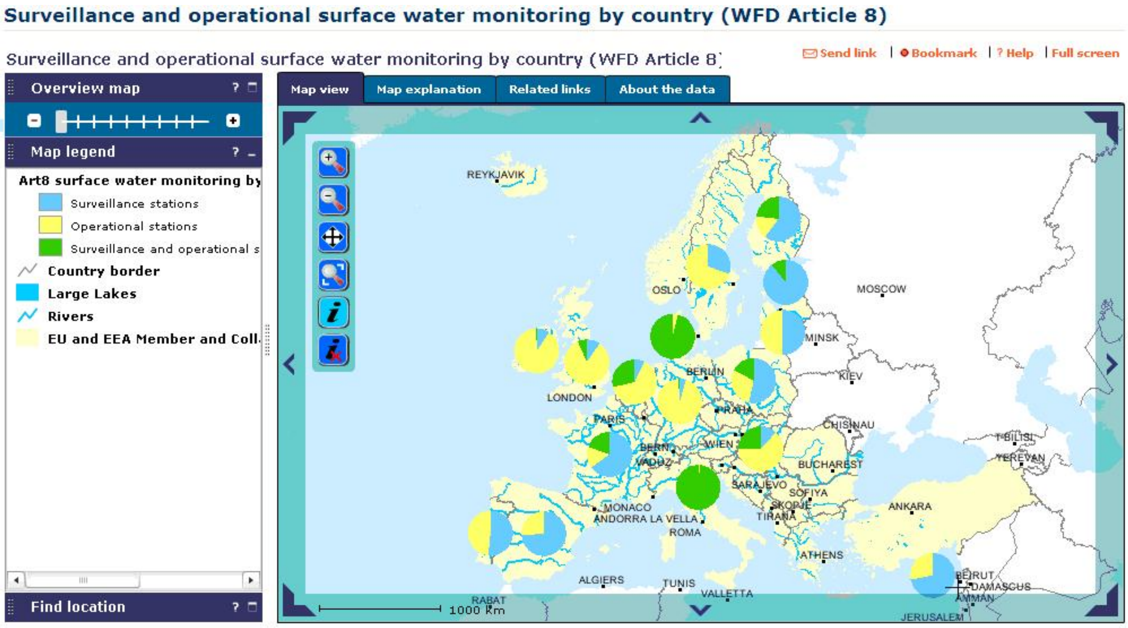


Source: http://www.eea.europa.eu/themes/water/mapviewers/myRBD

Figure 3.2.1d Interactive map of River Basin Districts

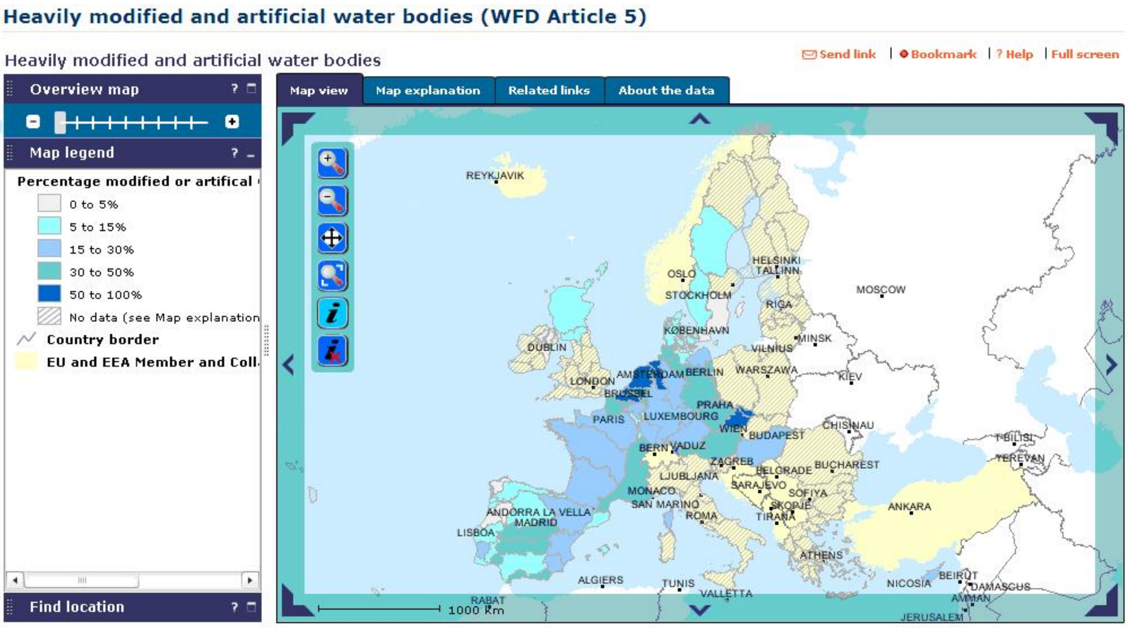
Source: http://www.eea.europa.eu/themes/water/mapviewers/art8-sw

Figure 3.2.1e Interactive map of Surface water monitoring (WFD Article 8)



Source: http://www.eea.europa.eu/themes/water/mapviewers/art8-sw-sur

Figure 3.2.1f Interactive map of Surveillance and operational surface water monitoring by country (WFD Article 8)



Source: http://www.eea.europa.eu/themes/water/mapviewers/art5-hmwb

Figure 3.2.1g Interactive map of Heavily modified and artificial water bodies (WFD Article 5)

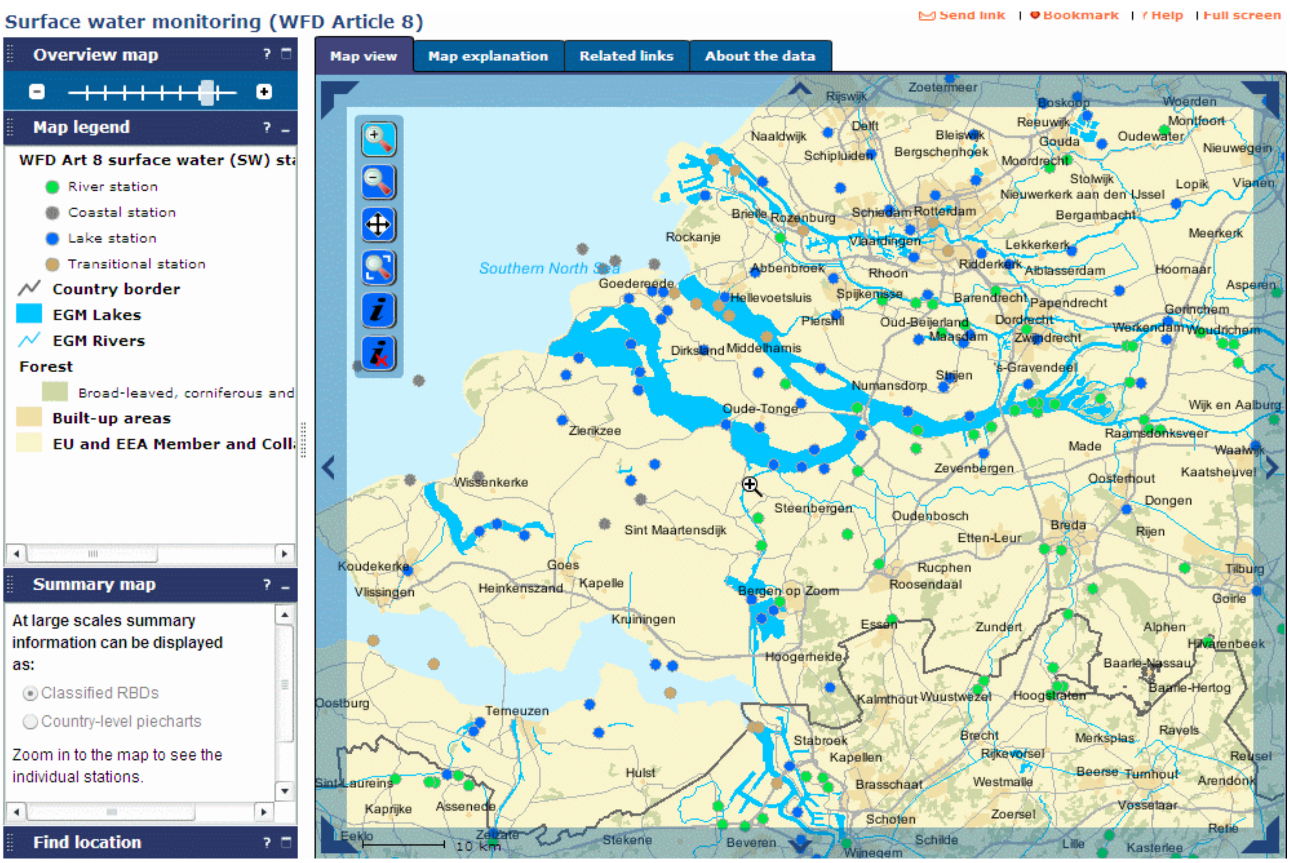
3.3 Overview of WISE map viewer application

3.3.1 Purpose and concept of the WISE map viewer

The WISE system building started in summer 2006 after a user requirement study was undertaken and an architecture document was consequently developed. From the user requirement study and from the political commitment to make data and information from the Water Framework Directive available to the general public, the development of a map viewer became a key priority.

The WISE map viewer allows the user to explore and query data presented on maps, an example of which is shown below in Figure 3.3.1.

The WISE map viewer is hosted by the European Environment Agency (EEA), in its role as water data centre. It has been developed by the EEA in consultation with the European Commission and other institutions, in accordance with specified user requirements. The WISE map viewer and a list of the interactive thematic maps that are currently available can be found at the following location: http://www.eea.europa.eu/themes/water/mapviewers/.



Source: http://www.eea.europa.eu/themes/water/mapviewers/art8-sw

Figure 3.3.1 WISE map viewer

The concept of the WISE map viewer is to package pre-defined maps and queries within a web-based interactive interface. The default view of each map is at European level, typically showing data aggregated to either Member State or River Basin

District. The pre-defined maps and queries present the information submitted by Member States as a single merged dataset at European level.

As the user zooms in the classified features (e.g. monitoring stations) are shown and the user can click on them to retrieve further information. Information is output either through a map pop-up or a table in a separate tab. Context for the map is provided in a ‘Map explanation’ tab, giving a short textual explanation of the definition and background to the map, and a ‘Related links’ tab. It is possible to search different features on the map through a search box on different layers.

Additionally, experts in each theme (e.g. relating to the Water Framework, Urban Wastewater Treatment or Bathing Water Directives, WISE-SoE, etc) have specified how data can be aggregated to either the Member State or River Basin District levels, adding value to this comparable European view. These experts are also responsible for ensuring the data displayed in the WISE map viewer has been through a quality checking procedure.

3.3.2 Technical Architecture of the WISE map viewer

After a review of the available technology options and bridging between security requirements, usability concerns and performance aspects, the WISE map viewer has been developed by the EEA for the integration and display of water related European datasets.

The WISE map viewer interface is intended to provide a rich application experience for the user when exploring the maps and data. The WISE map viewer is also designed to present the information in a readily accessible manner, hence the building of separate viewers around each map. The technology is also utilised across other of the EEA’s map-based interfaces.

The data behind the client interface is currently stored in a database spatially enabled with ESRI ArcSDE technology and delivered via an ESRI ArcIMS web map service to bring the selected data to the client.

The detailed internal functionality of the WISE map viewer falls outside of the scope of this document but the viewer should be seen as a black box which controls the interaction with the user and the response and request cycle to the data services.

3.3.3 Specification of a map and its cartography

Maps displayed in the viewer have been subject to consultation, their presentation format agreed and they conform to the needs of the user. They are first prototyped by the thematic experts in a standalone ArcMap document with the available data and the user interaction described with use cases. The technical specification for each map is then documented and the WISE map viewer application is developed and tested according to the specification. The following is a list of the typical information to be included in the technical specification:

- Data preparation – aggregation and other pre-processing tasks for data display;
- Define the display – background layers, reference and other GIS datasets to be used;
- Display scale specifications – what should be shown at different zoom levels;

- Data attribute explanation;
- Visualisation of map and legend at different scales – RBG values for legend and text for legend. Value thresholds for WISE data;
- Map interaction description – pre-conditions, triggers, post-conditions e.g. output to pop-up, table or graph;
- Map explanation text and related links.

Classification of points and colouring are important elements in helping the user quickly understand what they are looking at. Within WISE, many of the datasets have precedents set on their display. Data relating to the Bathing Water, Urban Wastewater Treatment and Water Framework Directives are displayed according to the classification and colouring specified in their respective directive text. The background to the WISE maps is a set of layers developed at the EEA from various sources, optimised for web display.

3.3.4 Alternative and future map viewing options

With the development of WISE into a distributed system using service oriented architecture (SOA) principles, more ways of serving maps and visualising data will become available. The next steps of serving maps to other machines are explained further in Chapter 5.7.

The EEA will further develop map viewing options, in particular user-friendly ways to serve a wider group of users which are not specialised in GIS and who may not be familiar with the currently used viewing tools. Within the WISE website, the theme of bathing water serves as an example for more flexible ways of presenting data: see http://www.eea.europa.eu/themes/water/status-and-monitoring/bathing-water-data-viewer for more information. This includes the display in Google Earth™ or Microsoft Virtual Earth™ as well as the possibility to download data in KML format. This flexible line, supporting multiple tools will be supported in the future and will be based on open standards wherever possible.

3.4 State of the Environment visualisation

At the core of any water related State of Environment (SoE) assessment is the need to quantify and identify the current state of, and impacts on, the water environment - how these are changing in time and whether the measures taken at different levels are effective.

Such an assessment should:

- Provide the basis for identification and assessment of environmental problems and the dominant threats at regional and European levels;
- Provide information necessary to enable actions/policies to be taken to improve the environmental state of the water bodies and to ensure sustainable development;
- Be based at the most relevant time and spatial scales to meet the two objectives stated above.

The European information needed in relation to water quantity can generally be described as:

- How much is there (runoff, availability, etc)?
- What is the state of the water quality (nutrients, hazardous substances) and ecological quality?
- Is the situation getting better or worse?
- What are the pressures on the environment (abstraction and water use by sectors)?
- Are there targets in place, such as are water-pricing policies used to provide adequate incentives for users to use water resources efficiently?

The EEA bases its water quality data on a representative sub-sample of national monitoring results, which EEA member countries report voluntarily each year to the EEA. The EEA has mainly collected annual values (e.g. average, median, minimum and maximum).

In the context of the implementation of the Water Framework Directive (WFD), the EEA's Eionet-Water annual data flow for waters is in the process of being transferred into the WISE-SoE (State of the Environment) voluntary data flow. The transition from Eionet-Water to WISE-SoE reporting has already been done for water quality related determinands for rivers, lakes and groundwater. In developing this transition, there was a clear principle that there should be no double reporting. The aim is a delivery of one dataset that might be useful for both WFD compliance by the European Commission services and EEA SoE assessments.

Data from WISE-SoE reporting are stored in Waterbase (a series of SoE databases within WISE) found at: http://dataservice.eea.europa.eu/dataservice/available2.asp?type=findkeyword&theme=waterbase.

At the end of 2007, Waterbase contained water quality information on:

- More than 6000 river stations in 35 countries;
- More than 2200 lake stations;
- Quality data from around 1100 groundwater bodies.

In the future the monitoring stations reported to the EEA will be similar to, or a subset of, the monitoring stations reported by countries under Article 8 of the WFD.

The data stored in Waterbase are visualised and communicated to the public using the WISE map viewer at http://www.eea.europa.eu/themes/water/mapviewers/ (see Chapter 3.3 for more information) and in the future will be supplemented by tabular data extraction templates. The freshwater water quality Waterbase databases consist of three main tables. For rivers, for example, the number of records stored in the database are:

- Waterbase-Rivers: **Stations** (6369 records);
- Waterbase-Rivers: **Pressures** (2876 records);
- Waterbase-Rivers: **Quality** (637344 records).

In addition, there is a fourth table containing **hazardous substances** (>300,000 records, not publicly available).

In 2008, the EEA and its European Topic Centre on Water began test data collections of data on water availability and water abstraction, and emissions to water. During 2009, these data collections will be established as annual WISE-SoE water quantity and emissions reporting. Work is also underway to develop data flows on biological and hydromorphological indicators.

In addition, the EEA bases its SoE reporting and indicators on data collected through the reporting of the Urban Wastewater Treatment, Nitrates, and Bathing Water Directives, as well as Eurostat's collection of data via the OECD/Eurostat questionnaire on environmental data on water availability, water abstraction, water use and wastewater treatment.

The data stored in the different databases form the basis of the EEA's water indicators. The EEA has the following core set of indicators relating to water:

- Use of freshwater resources (CSI 018);
- Oxygen consuming substances in rivers (CSI 019);
- Nutrients in freshwater (CSI 020);
- Nutrients in transitional, coastal and marine waters (CSI 021);
- Bathing water quality (CSI 022);
- Chlorophyll in transitional, coastal and marine waters (CSI 023);
- Urban waste water treatment (CSI 024).

In the near future the data behind the EEA indicators will be available via WISE.

3.4.1 Visualisation of State of the Environment (SoE) data in WISE

Data stored in Waterbase (on water quality) and collected via Member States reporting (Bathing Water, Urban Wastewater Treatment and Nitrates Directives) are visualised in the WISE map viewer.

During the visualisation process, different formats are used depending on the scale of the map:

- Often, for the scale 1:5,000,000 and less detailed (European overview), data are aggregated by country or national River Basin District (RBD) level;
    - For countries: pie charts of percentage of the variable (e.g. BOD, Bathing water quality or wastewater treatment type) classification by country is displayed;
    - The national RBDs are coloured according to the average of all the stations located within the RBD, falling within defined classes.
- For the scale more detailed than 1:5,000,000, individual station points are visible instead of a classified cartogram, and these are coloured according to the variable classification. Symbol size depends on the map scale (the more detailed the map, the bigger the symbol).

An updated list of SoE maps available via the WISE map viewer can be found at the following location: http://www.eea.europa.eu/themes/water/mapviewers.

In the future, additional maps will be added, which may include:

- Maps on diffuse nutrient pollution;
- Maps illustrating groundwater water quality;
- Water availability per River Basin District;
- Water abstraction by main sectors per River Basin District;
- Water exploitation index (available water resource divided by water abstraction) per River Basin District.

4 Principles of WISE compatibility and interoperability

4.1 What is WISE compatible?

As described in Chapter 1.2 WISE may, depending on the context, be seen as an initiative, a concept, a process, an information system, a set of rules or tools for reporting, a dataset or component or something else.

If WISE is referred to as an information system, it includes all possible WISE nodes, data and viewer providers as well as the common WISE public web site and their interactions. It is not a central "mega-database" but rather a decentralised system at EU level which will have capabilities to interoperate with existing national systems.

It is intended that WISE will cover all water-related information arising from EU water policy (e.g. Water Framework, Urban Waste Water Treatment, Nitrates, Bathing Waters, Drinking Water and Floods Directives) as well as the upcoming Marine Strategy Directive. In addition, WISE will include other water-related datasets such as Eionet-Water (now known as WISE-SoE) developed by EEA and those arising from relevant water research projects.

Because of the extent of themes and the number of stakeholders involved in developing WISE, guiding principles are required to be followed during development and implementation. The guiding principles for WISE compatibility are elaborated in the following text.

4.1.1 Standards applicable to WISE

WISE is a system merging spatial and non-spatial data from various physical locations. In this respect, an important aspect is the hosting of geo-referenced data, making WISE a building block for INSPIRE. WISE will build on the service-oriented architecture, applying the appropriate standards and specifications from the Open Geospatial Consortium (OGC), the International Standards Organisation (ISO) and the European Committee for Standardisation (CEN). The application of standards does on one hand ensure that the process takes on board experiences gained from other information management communities, and on the other hand that specifications are written so that they may be implemented by different developers and data managers independently of a specific technical solution or software.

- The OGC has developed a family of technical documents - OpenGIS® Specifications[20]. These specifications cover a wide range of aspects from the specification of how to encode spatial data for exchange to specification for various web-services needed for discovering, accessing and visualising spatial data. The OpenGIS® specifications build on other standards such as the family of XML standards. The application of the OpenGIS® standards is described in detail in Chapters 5.6 and 5.7;
- ISO has developed the ISO 19100 family of standards for geographic information (e.g. ISO 19115/119 covers metadata and services) and the specific adaptation of this is described in further detail in Chapter 5.5. CEN

[20] The OGC specifications and best practices may be found at http://www.opengeospatial.org/standards

have adopted a number of standards. An overview of the appropriate standards and status can be found in Appendix 04;

- INSPIRE – The ongoing INSPIRE process will lead to a binding set of implementation rules as well as a set of guiding documents specifying good practice. This document, "The WISE GIS guidance", follows the INSPIRE recommendations to the level available, and may thus be described as INSPIRE compliant given the constraint that reporting requirements have already been specified for a number of water-related directives. An overview of the INSPIRE technical architecture is shown in Figure 4.1.1.

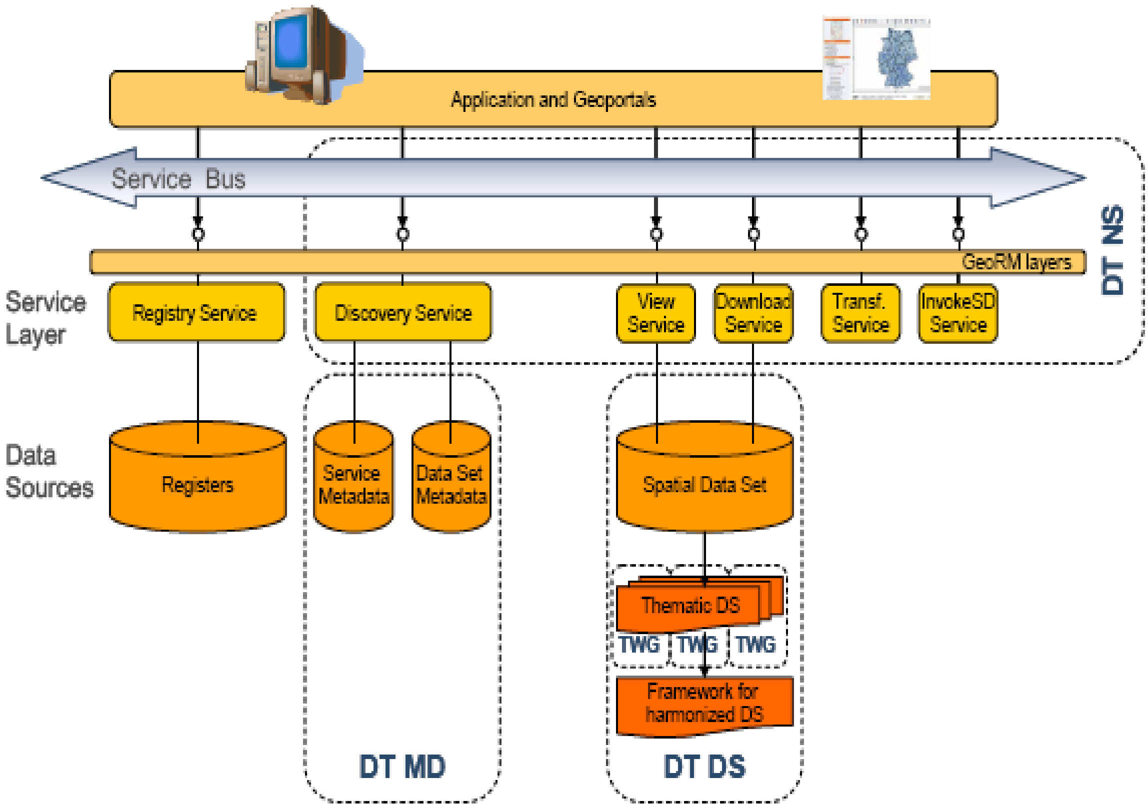


Figure 4.1.1 INSPIRE Technical Architecture overview

4.1.2 WISE compatibility

During the first 7 years of WFD implementation, a set of processes agreed by all stakeholders has been developed. WISE compatibility can be considered true when information regarding the environment is defined, gathered, exploited and disseminated as requested by the Commission. The processes follow a set of guiding principles for streamlining of reporting and the shared information system.

Streamlining reporting:

- Key principle: "Report once use many times[21] – harmonise reporting tools". This key principle overarches many of the efforts in streamlining the reporting processes between stakeholders at all levels;
- WISE will integrate State of the Environment (SoE) and compliance reporting data flows and, where appropriate, others. The principle here is a natural outcome of the key principle, as it will reduce the burden of reporting for mandatory and voluntary data flows;
- Follow the Subsidiarity Principle;
- Data should be maintained at the most appropriate level and shared between all other levels;
- To be WISE compatible means applying the collaborative processes developed as part of the WFD Common Implementation Strategy. Part of the process is to identify the most appropriate type and level of information either to be available or to be reported at the European level. Other parts of the collaborative process ensure both the sharing of good practise and common ownership of the policy implementation (see Chapter 1.2);
- Use of MS data for visualisation and analytical purposes according to the “WISE reporting arrangements”. The unrestricted use of MS data is a paramount requirement for the multiple uses of the data. MS data may be aggregated and compiled into seamless European wide layers (see Chapter 6);
- Reporting based on public schemas and multi-approach tools. The reporting is based on XML schemas which are independent of vendor specific software. MS are, to a variable degree, capable of preparing XML documents from their information systems. Tools have thus been developed to organise, validate and reformat data according to the reporting schemas. The reporting schemas themselves fit into the service-oriented architecture;
- Data processing follows an open and agreed process. The procedures for accepting, validating and exploiting the data reported by MS to WISE follow a standard procedure as illustrated in Figure 4.1.2a.

It is important to note that recommendations and specifications in this guidance build on the existing processes (reporting methods, schemas, Reporting Sheets etc). The future developments may require changes of a technical nature (reformatting of specifications etc), but the actual content will continue and be stable over time.

[21] Data should be collected once, maintained at most appropriate level and shared between all levels.

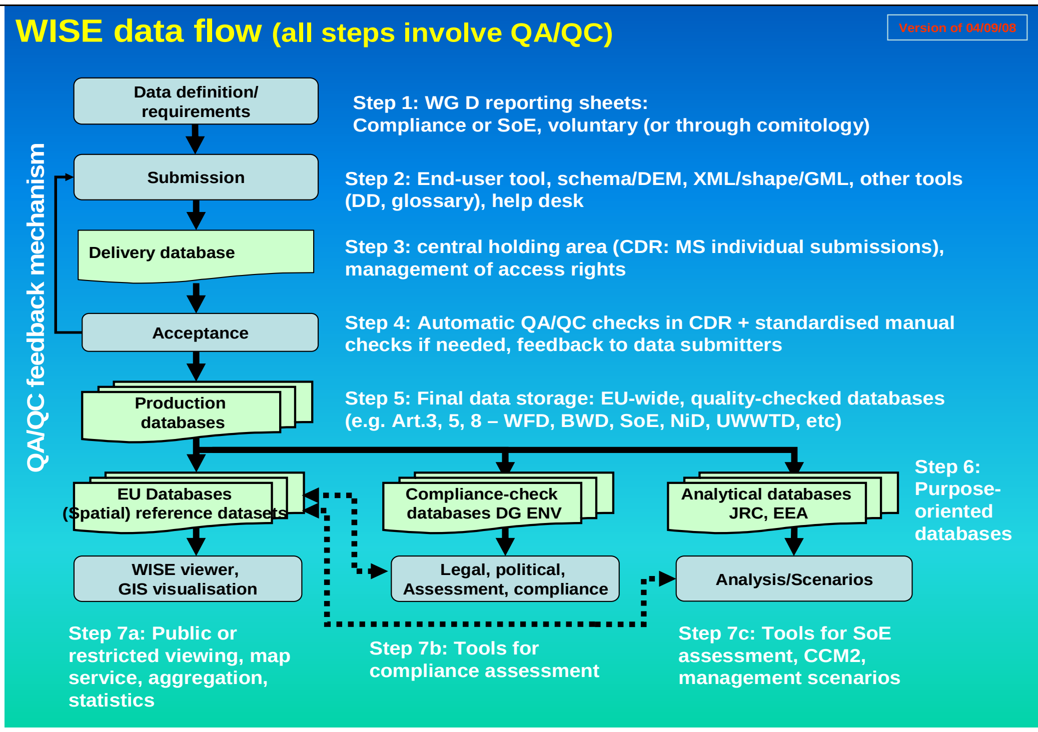


Figure 4.1.2a WISE data processing flow

Shared Information System:

- WISE is built as distributed data nodes (see Figure 4.1.2b). Data should be stored at different nodes and information should be shared between all participating nodes. It is not the intention that a data node will contain the full dataset. The distributed nodes are an application of the Subsidiarity Principle;
- Vertical integration between local, national and European levels. Vertical integration is supported by specifying spatial objects which, through stable identifiers, can serve as links to more detailed information at national / local level. These stable identifiers ease reporting provided that the spatial data is stable over time. However, an effort to maintain vertical integration is required to keep temporal track of the spatial changes;
- Interoperable system;
- For the sake of information sharing and exchange, all participating nodes must be interoperable. Data should be exchangeable and services should be able to access and process data from different nodes;
- Transparent system (open);
- It should be easy to discover data and services. Users should be able to determine fitness for purpose of data and the conditions of usage should be clearly described.

Ultimately, WISE should centralise only those data which are needed as a reference against which reporting is made. The major part of information and data will be decentralised which means that linkages between national water information systems and WISE will need to be established.

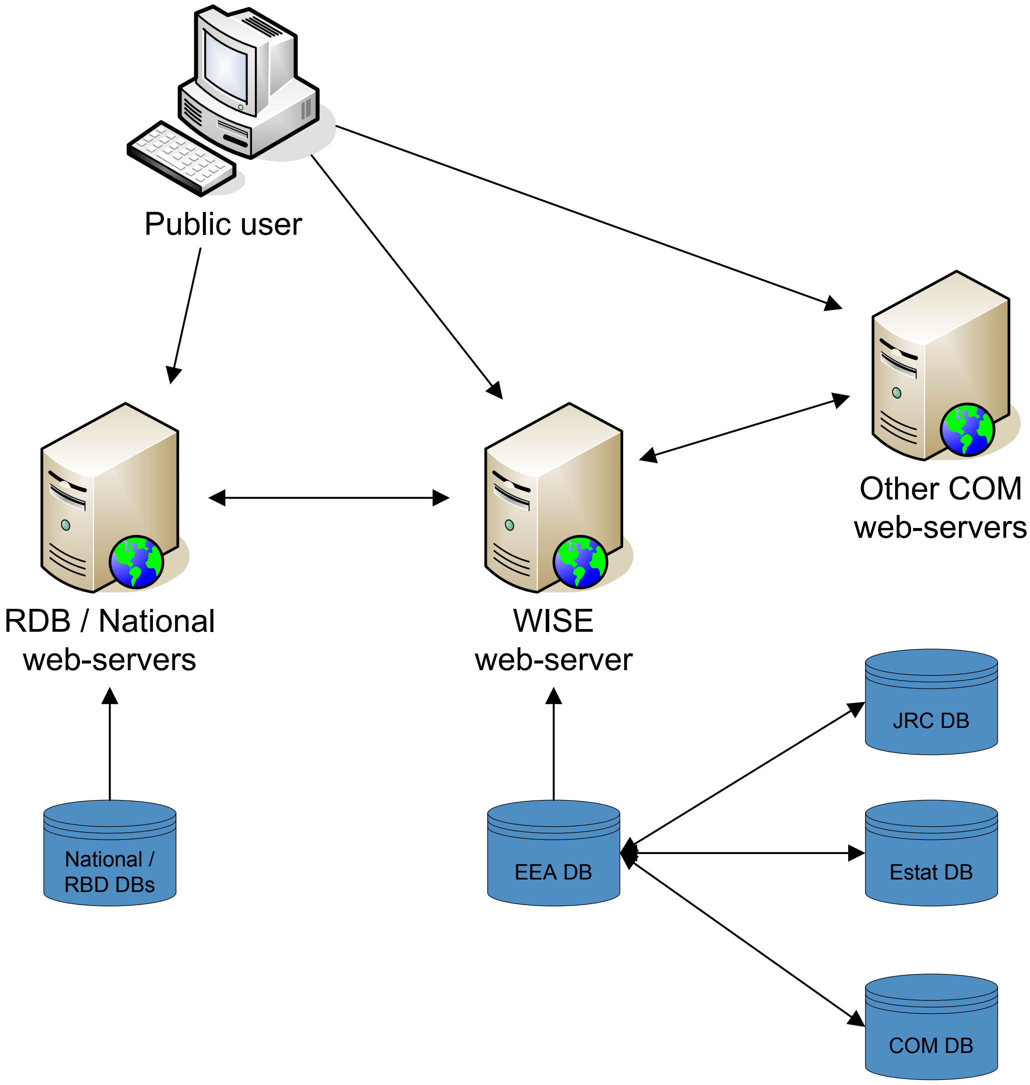


Figure 4.1.2b WISE network of databases and web-servers

4.1.3 WISE interoperability

Interoperability "is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units" (CEN Technical Report 15449[22]).

Interoperability between systems and components has other aspects:

- Network-protocol interoperability allows communication between components;

[22] CEN/TR 15449 "Geographic information – Standards, specifications, technical reports and guidelines, required to implement Spatial Data Infrastructure" CEN/TC 287.

- Standard interface specifications can enable clients to perform procedures on a remote system;
- Data transfer interoperability allows access to data, sharing of geographic databases and other services independent of the proprietary format;
- Semantic interoperability concerns the ability of an application to interpret data consistent for common representation or processing.

WISE interoperability will, in the short term, focus on the level of “data transfer interoperability” which will be based on a agreed set of public and open specifications for web services. The web services will be responding to requests that are encoded using WISE semantics and will return a WISE related dataset.

The long term recommendation for WISE interoperability aims at semantic interoperability. This level of interoperability is however not sufficiently mature neither at the technical level (tools for semantic processing) nor at the level of adequate thesauri and ontologies or the adaptation in Member States. The semantic interoperability will open for a use of the wider set of voluntary data services related to the water domain based on local requirements and priorities and disseminated by national and regional institutions. The services are already in place in several Member States but are not currently well adapted for international use.

WISE as a shared and interoperable system is reinforced by a number of decisions:

- WISE is based on open and service-oriented architecture;
- WISE web map nodes will serve the community with small scale data, whereas national and regional data nodes are expected to provide data services at a larger scale;
- Users can build own services to connect their data to WISE or access WISE data.

The service-oriented architecture implies that all the harmonisation described is performed at the “service layer” level. Any of the data sources will have full freedom to model and organise their data in their databases according to their own needs as long as the provided services correspond to the WISE data models and common agreed service specification. See Figure 4.1.2b for the INSPIRE service-oriented architecture model.

The European WISE portal serves the user community with pan-European spatial views at smaller scales. When zoom levels go beyond 1:250,000 the data sources should be from national web servers. The distributed responsibility for providing information at different scales and the freedom for users to build own services and connect their data to WISE or access WISE data require the WISE system to contain the necessary registries for:

- Data models and specifications and service specifications;
- Other WISE nodes.

Another WISE related requirement is the interest and willingness from Member States to deliver data and services prepared for pan-European viewing.

In the WISE implementation of the service-oriented architecture, the responsibility will be shared between MS and the European Institutions (DG ENV, ESTAT, JRC and EEA) in the following way:

- EEA / DG ENV have already implemented View services at the WISE portal. It is the responsibility of the EEA to develop the necessary Registry services to support the MS with data and service specifications and to develop Discovery services allowing the WISE nodes to register their data and services and allow users to discover these.
- MS can implement View services and Download services and, in the future, will be able to register the associated metadata for data and services at the WISE Discovery service.

Chapters 5.6 and 5.7 describe further details of data exchange, interoperability and web services.

4.2 Update of existing datasets

4.2.1 Introduction

The term "update" implicitly assumes that data is reported to replace earlier reported data. The following WISE reporting arrangements have been agreed:

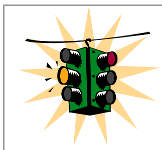
> "*Member States will be allowed to update their information and data **at any time**. Whilst the updating of information in between the reporting deadlines is voluntary, it will be beneficial always to ensure that the latest, correct information is available in WISE since that will be the one used for compliance checking and publication (adding a reference year to the data)"*. (WISE reporting arrangements[23]).

Updates can be limited to a single data object or as large as the full dataset. Under WISE two sorts of updating data are considered:

- **Data resubmission** is the update of a complete dataset. The resubmission is necessary when:
- Data is missing;
- Data is not provided according to the agreed structure, format or detail;
- Mismatch between reported data (e.g. water bodies provided for Article 5 WFD and included in the monitoring dataset reported under Article 8 WFD);
  - Resubmissions are always initiated by the European Commission (DG Environment).
- **Data update** is the submission of modified data compared to a previous submission. Updates can be either descriptive updates, geometry updates or both. A Member State can update its data at any time which helps:

[23] Guidance on practical arrangement for electronic reporting to the Water Information System for Europe (WISE); "WISE REPORTING ARRANGEMENTS "; Final Document (01/03/2007) http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/w-wise_background/arrangements_1307doc/_EN_1.0_&a=d

- Member States to avoid intensive update exercises at specific reporting deadlines because all updates are frequently submitted to WISE;
- EC/EEA to update its reference datasets more frequently;
- EC/EEA to provide the most up to date statistics.



Look out!

Data reporting is the submission of data according to deadlines defined by different reporting exercises (i.e. defined by directives as well as voluntary-based reporting such as WISE-SoE and on water statistics by Eurostat/OECD Joint Questionnaire, etc)

According to this, update of WISE geographical and descriptive data at reporting deadlines (legal or voluntary reporting) can be considered as special cases of the arrangement “at any time”.

After the first reporting date EC assumes it has the MS latest data available through regular update procedures by the next reporting date.

The procedures of the update process play an important role in the success of a reporting system. Therefore special attention has to be paid to set up a well-balanced system which includes all necessary rules to guarantee the correct use of updated data and to be able to follow developments in time. The paragraphs below will explain these procedures in more detail.

4.2.2 Technical data update flow

Due to the wide variety of data that is reported under WISE not all data can be treated the same regarding the technical update procedures. In Figure 4.2.2a, four different types of update are presented. The types are based on their update frequency and the number of objects that are reported (see also Chapter 5.7). Typical usages of each type are:

- Type I: This type could be the update of an attribute for a single object. For example when the name of a specific water body has changed;
- Type II: This type could be the update of a River Basin District. A single object is reported and it is most likely that a Member State is updating its River Basin Districts infrequently;
- Type III: This is a less common type but could be used for example to exchange aggregated datasets;
- Type IV: Some Member States may revise the complete dataset of their major rivers (new surveys). In this case the Member State reports a complete dataset on a certain topic.

	High frequency	Low frequency
Object based	Type I	Type II
Dataset based	Type III	Type IV

Figure 4.2.2a Technical update types

To organise the update procedures, all WISE data will be classified according to the technical update type, the data objects size and the need to update the data for dissemination. In the future WISE will have two methods of update flows:

- Flow 1 will use INSPIRE-like services to communicate between MS and the EC. This flow typically handles updates of descriptive data and point geometries. Flow 1 can process single data objects or lists of complete datasets;
- Flow 2 will be the reporting through Reportnet. This will allow MS to continue to use existing systems. Furthermore this flow will handle all line and polygon geometries. Flow 2 will always handle complete datasets.

Flow 1 is a new method of reporting which will require some additional explanation, as all data submitted to WISE has to undergo several processes and QA/QC procedures. In flow 1 WISE aims at near real time updates of data to be able to incorporate changes pushed by national systems and to ensure that the latest correct information is available in WISE.

Figure 4.2.2b illustrates the data flow and the QA/QC procedures after data (re)submission or update:

- On MS data submission to WISE (1) an immediate message that data are in WISE will be processed and generated (2a).
- Automatic quality checks are performed and MS will be informed when the data could not be processed correctly (2b – feedback to MS). Aspects such as formal quality, data consistency and data content checks will be taken into consideration (see also Chapter 6.1).
- The data processing will not continue until MS deliver data of sufficient quality.
- After this QA/QC feedback mechanism the data will be incorporated into WISE (3), data currently used in WISE will be updated and data will be available for several purposes and processes as mentioned above

(update/preparation of WISE reference GIS datasets (4a), compliance checks (4b), analysis, and visualisation).

- These processes will have additional QA/QC procedures and a report will go back to MS if data do not fulfil the requirements.

Data related to reporting periods (e.g. legal and voluntary reporting) or update cycles (e.g. WISE reference GIS datasets) will be tagged with the respective update or reporting period and its reference date.

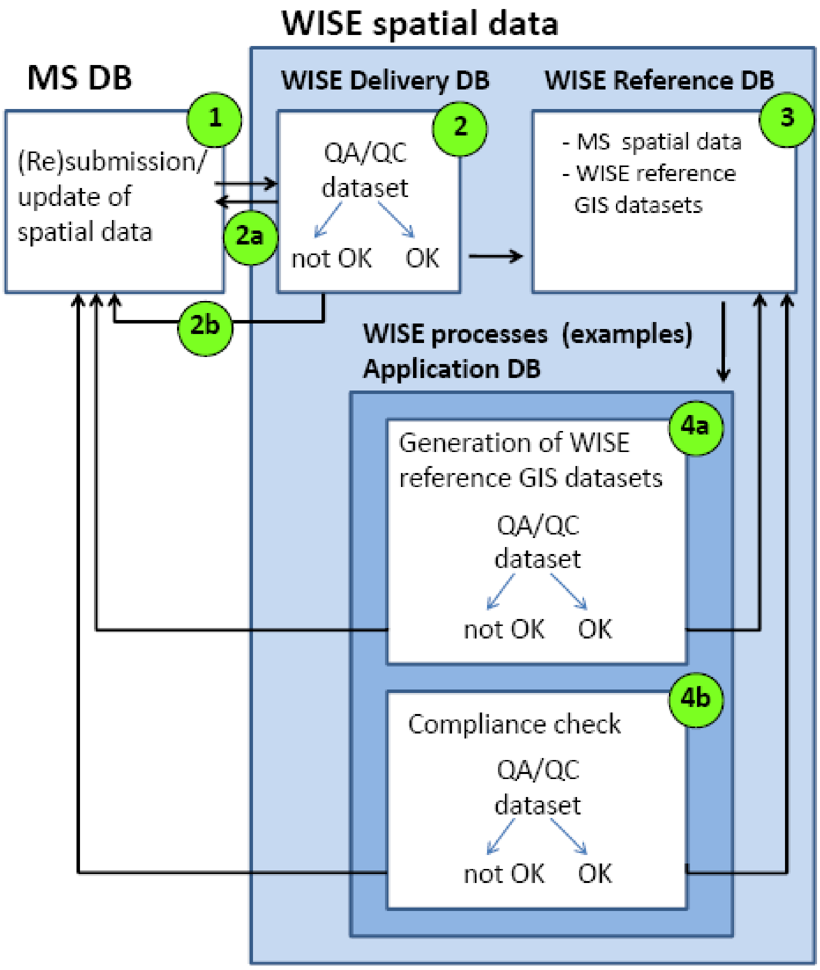


Figure 4.2.2b Submission/update of MS data: general data flow and QA/QC procedures

4.2.3 WISE update arrangements

4.2.3.1 Legal and voluntary reporting

Each water-related directive will have its own reporting deadlines. In accordance with these reporting deadlines, periods for resubmission and final deadlines will be defined. The data available at this deadline will be used for compliance checking. It will be referred to as the final dataset for the defined reporting period and tagged accordingly. Data submitted after this deadline will not be integrated into the compliance check process until the next reporting period. However, they will be available in the WISE Reference Database and can be used for the production of WISE Reference GIS datasets and integrated into the WISE map viewer.

Figure 4.2.3a illustrates possible data flows according to reporting obligations using either the possibility to update WISE GIS data at any point in time or the submission of GIS data at reporting deadlines. The update process for legal and voluntary reporting can be structured according to reporting deadlines. A submission process with a definite reporting deadline will be followed by a QA/QC period and probably resubmission of data (with a resubmission period and resubmission deadline). After this deadline, the final dataset will be included in the WISE Reference Database.

Member State GIS data already available in WISE need not be reported again. MS need only to refer to the relevant dataset, reference period and reference date. The GIS data necessary to carry out the relevant legal processes will be taken from WISE.

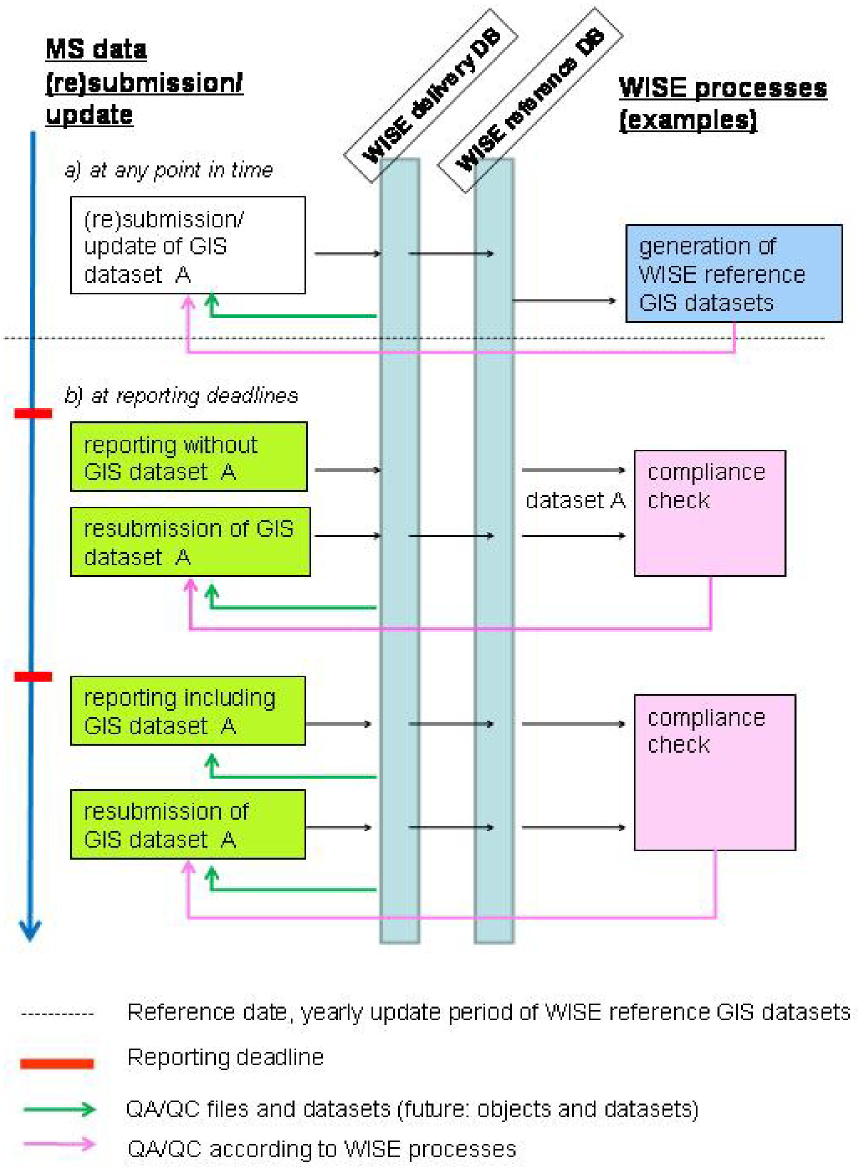


Figure 4.2.3a WISE GIS data flow and processes

4.2.3.2 Further principles:

- All submitted and resubmitted datasets will be stored in the system. The final dataset used for compliance checking will be tagged with the reference date of the reporting period;
- All datasets belonging to the reporting period have to refer to the same reference date or reference period;
- If data are submitted which are linked to already existing WISE GIS data, the proper reference to the relevant dataset has to be provided;
- Reporting cycles, the official reporting deadlines and the resubmission deadlines for each water-related directive and reporting periods within these directives will be published and made publicly available in WISE.

4.2.3.3 WISE Reference GIS datasets

As described in Chapter 3.1, there will be a set of WISE Reference GIS datasets prepared at the European level. The data source of these datasets will be:

- MS submitted GIS data:
    - Either according to the reporting obligations of the different water-related directives;
    - Or based on voluntary reporting (other GIS datasets).
- Pan-European datasets such as those from GISCO (background GIS datasets), Eurogeographics (e.g. Euro Regional Map) or JRC (CCM2). These are termed External GIS datasets.

WISE Reference GIS datasets will be **updated annually** (see Figure 4.2.3b). A near real time update will not be possible because these data will be harmonised and need an in-depth quality analysis and feedback to Member States. The update period will be closed by a defined reference date. All data submitted within the period up to the reference date will be processed. After the QA/QC period the dataset will be released and tagged with the reference date. The dataset will be available in the WISE Reference Database and the WISE web viewer.

The following principles will apply:

- The process of preparing the datasets using data provided by MS will be transparent for MS (see Chapter 6.2);
- During the time of data preparation for a WISE Reference GIS dataset and in the case of open questions, MS will be contacted to ensure the correct interpretation and use of submitted data. MS data will only be used for the compilation of WISE Reference GIS datasets if the QA/QC procedure could be finalised within a given period of time and the data are accepted and validated. All MS datasets used or not used (QA/QC not finished) for the WISE Reference GIS dataset will be marked accordingly;
- The WISE Reference GIS dataset will be released for further use by EC through the WISE portal;

- WISE Reference GIS datasets will be provided for download. They will be published with a version number and time stamp. Furthermore, detailed documentation of data sources of the respective WISE Reference GIS dataset will be available;
- WISE Reference GIS datasets will be published in the WISE viewer.

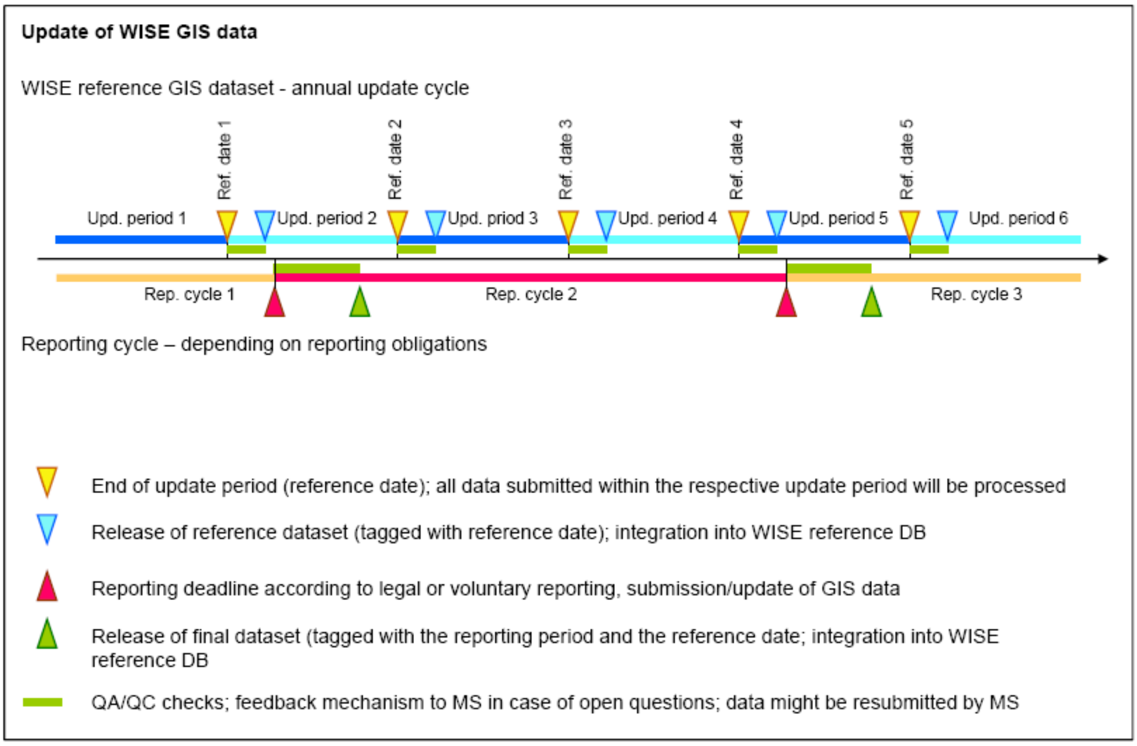


Figure 4.2.3b Update of GIS data according to the annual update cycles of WISE Reference GIS datasets or reporting cycles

4.2.4 General principles and responsibilities

The main principle of the update process should be "keep it simple". The amount of data reported under the various water-related directives is quite different. Although update of single records might be relevant it has for the time being been decided only to accept complete datasets regardless of the amount of changes.

The current decisions for WISE are:

- If data are updated/resubmitted complete datasets have to be submitted;
- All datasets related to each other will be tagged automatically at reception by EEA so that a) datasets belonging together can be easily identified and b) during an update process MS get informed which datasets are related and might need an update as well (e.g. WFD monitoring dataset includes water bodies and refer to the water body dataset);
- MS submitted data will be available in the WISE Reference Database and it will be traceable which datasets have been used for compliance checking purposes (reporting obligation, reporting period, reference date) and WISE Reference GIS datasets (update cycle reference date);

- All reporting and update cycles will be managed at EU level and published in WISE.

In future, with the realisation of the WISE distributed system architecture, update of single records or partial updates will be possible (Type I data flow).

EC and Water data centre (EEA) will be responsible:

- To set up a reporting system which allows an easy update of submitted data (and define the reporting steps and name a person responsible for each step);
- To define the reporting cycles and deadlines, the data flow and how the update has to be done in technical terms;
- To manage the reported data and update WISE Reference GIS datasets;
- To provide all relevant information and support to MS.

The **documentation of the updates** carried out for each dataset will be crucial. MS will be responsible for providing metadata describing the updated datasets (see Appendix 11 for detailed description of metadata content). EEA will be responsible for document updates of WISE Reference GIS datasets.

For various needs, in particular for QA/QC procedures carried out by WISE partners, it will be necessary to **follow changes in time and trace back information**. In several cases it might be necessary to know if all relevant features have been reported from one reporting period to the next one. This applies also for data resubmission and data update. More information about this can be found in Chapter 4.4.

Since WISE covers all water related reporting, **unique identification of spatial objects** is of fundamental importance for the reporting process. Details about identifier management are given in Chapter 4.4.

4.3 Creation of new datasets

Geo-referenced data form an important part of WISE, making WISE a building block for INSPIRE.[24] The integration of spatial information into WISE, the guidance given to Member States how to set up their water-related spatial information as regards reporting to WISE and particularly the creation of datasets for WISE should therefore be guided by INSPIRE principles.

"INSPIRE (such as WISE) *should be based on the infrastructure for spatial information that is created by the Member States and is designed to ensure that spatial data are stored, made available and maintained at the most appropriate level."*

Spatial information in WISE will be provided from several sources and will serve several purposes (see Chapter 2). The main differentiation of spatial information reported to WISE, prepared for WISE, used and visualised in WISE will be:

- Data provided by Member States (thematic data arising from reporting obligations);

[24] http://inspire.jrc.ec.europa.eu/

- Harmonised reference datasets at EU level: WISE Reference GIS datasets (see Chapter 3.1);
- Background data for visualisation (e.g. administrative boundaries, cities; to provide geographic orientation in maps);
- External GIS datasets to support further analysis and visualisation (e.g. CCM2).

The sources of spatial information and potentially new datasets are:

- Spatial information provided by Member States;
- Compilation of pan-European data from third party sources (e.g.CCM2 from JRC);
- Third party products (e.g. Eurogeographics – Euro Regional Map).

Third party products and third party sources of spatial information will not be addressed but this Chapter shall help:

- Authorities in Member States in creating water-related spatial information;
- EU bodies in compiling pan-European harmonised spatial information for WISE from Member States inputs (e.g. WISE Reference GIS datasets);
- EU bodies in planning to integrate the reporting of water-related directives into WISE.

Recommendations for the creation of new spatial information for WISE are given in Chapters 4, 5 and 6. Special attention has to be paid to the requirements given in:

- Chapters 4.4 Management of Identifiers and Codes and 5.4 European Feature Coding; set up of identifier management according to INSPIRE rules and guidance given in this document, including the specification of lifetime rules of objects and historic data management; description of object referencing between datasets and the maintenance of it;
- Chapter 5.1 General approach for the definition of datasets; development of data specification according to INSPIRE Implementing Rules;
- Chapter 5.5 Metadata;
- Chapter 6.1 Validation and harmonisation of geometry, data definitions, data models, naming.

4.3.1 GIS datasets reported by Member States

Member states will report spatial datasets to EU bodies under various articles of the WFD. These datasets come from national repositories which are not necessarily geometrically aligned across national borders or to a pan-European coastline. To connect borders of River Basin Districts or rivers across national borders, one option for Member States will be to align their data with a selection of EuroRegionalMap at scale 1:250 000. This data selection essentially comprises the national borders, the coastline and hydrological features that cut across national borders. Member States will be able to download these data sets free of charge from a dedicated section of

WISE provided they do not use these data for any other purpose. Download will be restricted to authorised persons in the water authorities.

The main concern of the Member States will be the correct use of their spatial information provided for WISE. To allow the correct:

- Use of spatial information in WISE - Member States shall provide metadata according to the WISE metadata profile (see Chapter 5.5);
- Linkage of different datasets (including non spatial data to spatial data) – Member States shall follow the principles of coding (see Chapters 4.4 and 5.4);
- Assessment of data at EU and RBD level - data should be harmonised, Member States shall follow the principles of coding and data update/resubmission (see Chapters 4.2, 4.3 and 4.4).

Furthermore, other guidelines to create and report spatial data for a specific reporting purpose have already been developed (UWWTD, NiD, BWD) and will be further developed and Member States should follow the specifications given there.

4.3.2 WISE Reference GIS datasets

The agreed WISE spatial data policy[25] allows the use of submitted data by the Commission and the EEA for deriving new geographic datasets (see Appendix 03). As described in Chapter 3.1 data provided by Member States will also be used to produce WISE Reference GIS datasets. The creation of the WISE Reference GIS datasets will follow INSPIRE principles.

In addition to the recommendations mentioned above the following specifications and descriptions for WISE Reference GIS datasets should be followed, if applicable:

- Special rules concerning the update of data (e.g. as regards ID management, development and maintenance of object referencing, historic data management, data harmonisation);
- References between the WISE Reference GIS datasets and Member State provided datasets and the maintenance of object referencing;
- Use of WISE Reference GIS datasets in WISE;
- Use of WISE Reference GIS datasets by Member States.

4.3.3 Integration of water related reporting mechanisms into WISE

The initial focus for WISE was the Water Framework Directive (WFD). However, WISE will step by step implement the data upload, sharing and analysis requirements of all water-related directives and supranational reporting. By now, in addition to the WFD, the integration of the UWWT Directive is under progress. The Bathing Water Directive will follow (see Chapter 1.2 for more detail). Guidance given to Member

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[25] Guidance on practical arrangement for electronic reporting to the Water Information System for Europe (WISE); “WISE REPORTING ARRANGEMENTS ”; Final Document (01/03/2007)
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/w-wise_background/arrangements_1307doc/_EN_1.0_&a=d

States to prepare and report the relevant spatial information should follow this WISE GIS guidance. To cover all necessary aspects a template of a short GIS guidance for specific reporting has been developed (see Appendix 13).

4.4 Management of identifiers and codes

4.4.1 Introduction

Since WISE covers all water related reporting, unique identification of spatial objects and spatial datasets is of fundamental importance for the data management in WISE. Principles of identifier management are given in the data specifications of INSPIRE[26] and also apply to WISE. This Chapter specifies the common framework for the unique identification of spatial objects and the concept for identifier management in WISE. It deals in with specific aspects of identifier management as regards reporting of spatial data by Member States and the development of WISE Reference GIS datasets. Definition of terms – unique identifier, code, etc. – used in this GIS guidance can be found in Chapter 1.3 and Appendix 14.

The application of unique identifiers to spatial objects contributes to data harmonisation. Data harmonisation has two aspects – harmonisation of the content (attributes, metadata) and harmonisation of geometry (horizontal and vertical level). For further detail see Chapter 6.1). Unique identification of spatial objects is necessary to harmonise the content. Furthermore, feature coding is an important component of the linkage between GIS datasets (object referencing).

4.4.2 WISE specific aspects

There will be four main types of datasets available in WISE (see Chapter 1.3): (1) Member State submitted GIS datasets; (2) WISE Reference GIS datasets; (3) Background GIS datasets; and (4) External GIS datasets. The framework for the unique identification of spatial objects provided in this GIS guidance applies primarily to the Member State submitted GIS datasets and the WISE Reference GIS datasets. Background and External GIS datasets will have – in the framework of INSPIRE – their own specifications for identifier management.

Furthermore the spatial feature available in WISE can be classified into:

- **Hydrological features;**
    - River basins and sub basins;
    - Rivers;
    - River segments (reaching from confluence to confluence);
    - Lakes.
- **Non-hydrological features;**
    - Management units such as River Basin Districts, Sub-units, water bodies, sensitive areas, etc;
    - Monitoring stations;
    - Features indicating point source pollution, such as discharge points, waste water treatment plants, etc;

[26] INSPIRE Generic Conceptual Model. D2.5, Version 3 (2008-06-20 ; Drafting Team « Data Specifications » - deliverable D2.6 : Methodology for the development of data specifications. Version 3 (2008-06-20)

- Features indicating pressure information, such as dams, weirs, etc;
- Protected Areas, bathing waters;
- …

Hydrological features should carry a unique **hydrological feature code**. Non-hydrological reference features should be assigned with a **non-hydrological unique object identifier** but should carry the code of the hydrological feature to which they are related as a foreign key.

The **hydrological feature code** is structured in a hydrological sense and takes the drainage system of a river network into account. It follows the principles of the Pfaffstetter coding. This enables rapid manual or automated analyses without the need to refer to GIS. Hierarchical structured coding also tends to ease long-term unique code maintenance.

The **Non-hydrological unique object identifier** should consist of two parts:

- A namespace to identify the data source. This namespace can also include entity type codes;
- A local identifier, assigned by the data provider. The local identifier should be unique within the namespace. It is the responsibility of the data provider to guarantee uniqueness of the local identifier within the namespace.

Further detail about the structure of the hydrological feature code and the non-hydrological unique object identifier are provided in Chapter 5.4.

An important aspect for WISE with regard to unique identifiers will be the **object referencing**[2]. Unique identifiers will be used as primary keys or foreign keys in geographical datasets and databases to allow the linkage of different spatial objects and to reference tabular information to their respective spatial object. Object referencing in WISE will be relevant:

- Between different GIS datasets submitted by Member States, both reported under one and different water related directives (e.g. WFD monitoring stations should be linked to WFD water bodies; sensitive areas reported under the UWWTD directive should be linked to water bodies reported under the WFD);
- Between Member State submitted GIS datasets and WISE Reference GIS datasets (e.g. Member States reported GIS data under WFD should be linked to the WISE Reference GIS dataset "River Basin Districts").

Furthermore the linkage of attribute information (descriptive data) to spatial objects will be relevant for the reporting process (e.g. information related to water bodies like status information to the geographic feature water body; water quality data reported under the SoE process to monitoring stations or water bodies reported under the WFD).

It is strongly recommended that unique identifiers should be provided for spatial objects where references from other spatial objects are expected to be applicable.

Information on how datasets refer to each other will be available in WISE. As soon as a Member State updates a dataset, WISE will send an automatic note to inform the Member State which datasets are related to the one that has been updated. The Member State is responsible for maintaining referential integrity between the related datasets.

4.4.3 Non-hydrological identifier - general requirements and recommendations

According to INSPIRE[27] unique identification of spatial objects is provided by external object identifiers, i.e. identifiers published by the responsible data provider. In case of WISE, the responsible data providers will be the Member States, the EEA with regard to the WISE Reference GIS datasets, and the providers of the Background and External datasets.

The following requirements and recommendations for identifier management are given:

Requirements:

Uniqueness: No two spatial objects of spatial object types shall have the same identifier. The identifier has to be unique within all the spatial objects published in WISE. The identifier shall not be used again if an object is modified.

The same spatial object shall be reported always using the same identifier (e.g. monitoring stations reported to SoE, WFD, Nitrates Directive, etc).

Persistence: The identifier has to remain unchanged during the life-time of a spatial object. If features are re-coded, links to historical data and links to data related to these features will be lost. The specification of every spatial object type shall state which modifications (e.g. attribute changes, merging with other spatial objects) may change the identity of a spatial object, i.e. when the existing object is "retired" and a new object with a new identifier is created. Lifecycle rules for spatial object types in a spatial dataset should be documented in the metadata of the dataset (see Appendix 11 for more details on metadata). It will not be necessary to copy the lifecycle rules to the metadata, a reference to a source that provides information is sufficient.

New identifiers may be created if:

- The location of a point features changes (e.g. if a monitoring station is moved upstream or downstream); threshold 125 m in accordance to the positional accuracy recommended for GIS datasets (according to the scale 1:250,000);
- The location or length of a line feature changes (e.g. if a river water body is divided or merged with another);
- The location or size of a polygon changes (e.g. if a groundwater body is divided or merged with another).

The rules for unique identifiers of spatial objects shall apply for spatial datasets, too.

Recommendations:

The identifier should be as short as possible to avoid typing mistakes, yet as long as is required to support unique code maintenance at local operational levels. Precise structures are a matter for each Member State to decide upon.

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[27] INSPIRE Generic Conceptual Model. D2.5, Version 3 (2008-06-20)

4.4.4 WISE Reference GIS datasets

WISE Reference GIS datasets will be published by the EEA (see Chapter 3.1). One purpose of these datasets will be to provide a reference for reporting. Member State submitted GIS datasets will be referenced against European-wide harmonised GIS datasets, i.e. WISE Reference GIS datasets. This will facilitate harmonised analysis of reported data and data visualisation.

The EEA will be responsible for the unique identification of spatial objects within WISE Reference GIS datasets, guaranteeing persistence over time. For the time being, identifiers and codes will be developed and maintained at EC level for the following WISE Reference GIS datasets:

- **Hydrological features codes** of the WISE Reference GIS datasets;
    - Main rivers and main lakes (this will include also the coding of the river basins of main rivers and large rivers).
- **Non-hydrological identifiers** of the WISE Reference GIS datasets;
    - River Basin Districts;
    - Sub-units;
    - Water bodies.

The management of the identifiers and codes at European level will include:

- The publication of the identifiers/codes in WISE and the description of their development;
- The registration of the namespace used (including entity type codes if used);
- The description of life-cycle rules of the spatial objects of the WISE Reference GIS datasets;
- An explanation if identifiers/codes have been changed or new identifiers/codes have been created (e.g. change of RBDs or Sub-units) during an update. The respective WISE Reference GIS datasets will be provided to Member States via WISE in time for the next reporting period (including a documentation of new/changed objects/identifiers);
- The description how Member States should use the identifiers/code, including how the referencing of objects provided by Member States to the objects of the WISE Reference GIS datasets will be performed.

4.4.5 Member State submitted GIS data and historical data management

Member States are responsible for the unique identification of spatial objects reported to WISE and to guarantee persistence over time. This applies to the hydrological and non-hydrological features mentioned above. However two major problems arise on implementing these rules:

- Objects in the real world change over time. For example a monitoring station is removed from a network, River Basin Districts are restructured (due to changes in administrative boundaries), etc. Detailed guidelines are required on how to handle identifiers for these spatial cases.

- As the objects are changing over time this also means that foreign keys or references to other datasets may become obsolete.

Member States will be responsible for:

- Maintaining the references between national data submitted to WISE as required by the respective reporting guidelines and described in the WISE data model (e.g. sensitive areas reported under UWWTD linked to water bodies reported under WFD);
- Referencing their spatial objects to the respective objects of the WISE Reference GIS datasets and maintaining these references;
- Maintaining correct linkages between datasets where objects have changed or new objects have been created, and updating all related datasets accordingly (e.g. if a new river water body dataset is submitted, the river monitoring stations also have to be updated because the stations are linked to river water bodies).

4.4.6 Identifier management and object transaction

Depending on the data, the reporting obligations and the intended use of the data, it will be necessary to establish a system that manages temporal changes of non-hydrological features including the identification of predecessors and successors. Changes will occur from one reporting period to another (submission of datasets according to reporting deadlines) but also in between reporting periods (update/resubmission of datasets).

The following changes within GIS datasets are possible:

- Change of identifiers only (e.g. wrong identifier was provided, geometry remains unchanged);
- Change of geometry and identifiers (e.g. a water body is divided);
- Change of geometry only (e.g. wrong geometry was provided, identifiers remain unchanged).

The current situation of reporting to WISE is described in Figure 4.4.1. Sets of spatial object instances having an agreed structure are reported at fixed points in time (reporting deadlines). They describe the situation at a certain reference date. The spatial objects carry identifiers which are unique within the dataset.

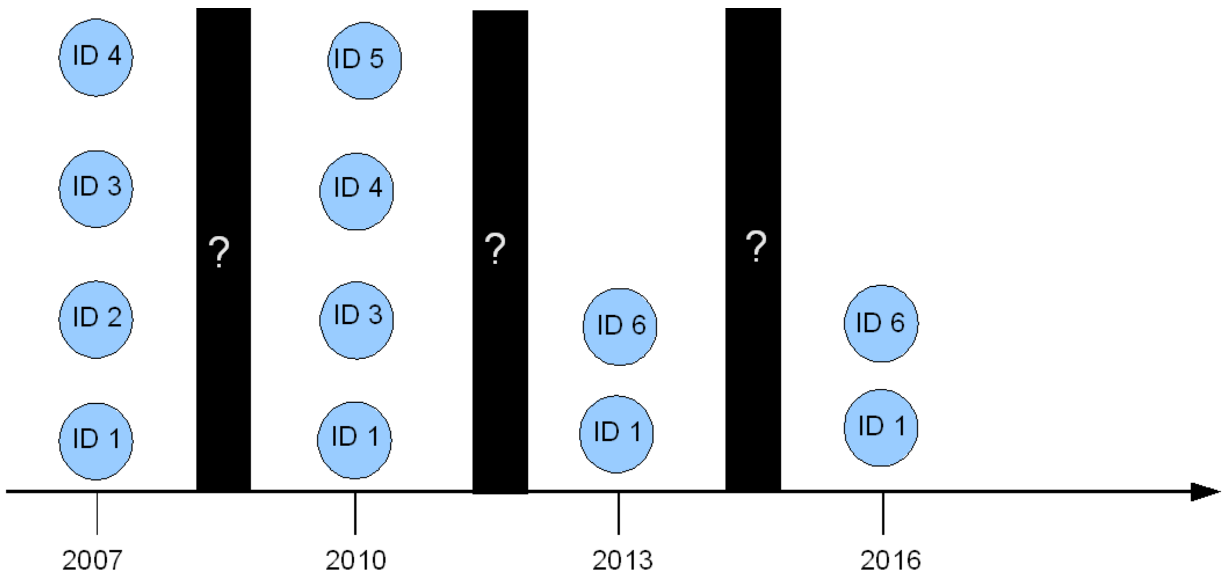


Figure 4.4.1 Time series information in existing reporting practices

Subsequent reporting cycles do not provide any explicit information on previously reported data, so the analysis of temporal development is mainly based on "best guesses", e.g. based on the invariance of names or locations. Analysis with on-going reporting exercises show that it is sometimes very difficult to link currently reported objects to objects reported in previous reporting cycles.

Information on temporal changes is needed for most of the data reported to WISE. WFD reporting demonstrates how data reported under different reporting obligations and at different dates are interlinked.

Example: WFD, water bodies – reporting of risk analysis 2005 and status 2010:

- In 2005 according to Article 5 of the WFD, water bodies at risk of failing to reach good status were reported;
- After this risk analysis, a monitoring network was put in place to obtain information on the status of the water bodies. The monitoring network was reported to WISE in 2007. At this time the first reference to historic data was made. The monitoring stations had to be linked to 2005 reported water bodies. If water bodies changed from 2005 to 2007, the water body dataset should have been updated as well;
- In 2010 the status of water bodies will be reported to WISE. According to the WFD it is necessary to analyse the status of water bodies previously reported in 2005. This can only be done if linkages can be made between the datasets and any changes made to water bodies between 2005 and 2010 are also reported.

Thus the data and update cycles needed to maintain a complete, historic view of the data are dependent on the level of the "temporal coupling" required in WISE. In future WISE should allow the tracking of changes between different data submissions, resubmissions and updates (see Figure 4.4.2 on the proposed history management in WISE).

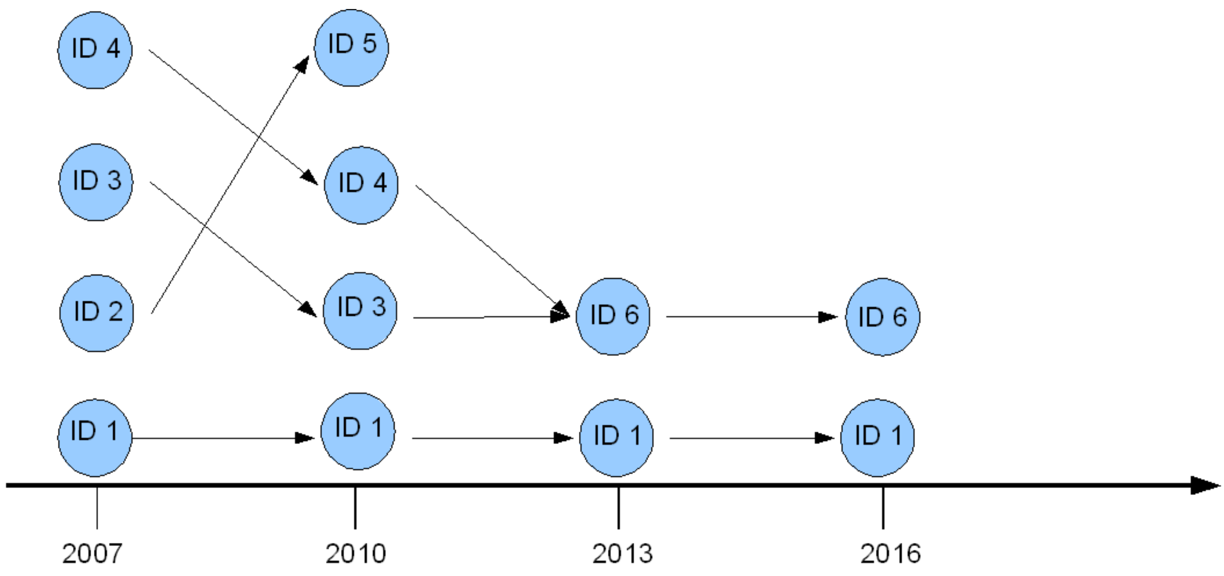


Figure 4.4.2 Proposed history management in WISE

Several concepts exist relating to historic data management and these are described in Appendix 09. In principle either predecessors or successors can be identified. Within each WISE reporting process it should be defined whether historic data management of GIS data is necessary and how this will be achieved. The data model and dataflow should be developed accordingly.

TECHNICAL CHAPTERS

5 Technical Descriptions

5.1 General approach for definition of datasets

	Look out! Guidance may change as INSPIRE and WISE develop *This Chapter has been developed in parallel with INSPIRE developments and discussions at COM and EEA on the implementation of INSPIRE recommendations in WISE. The content and advice may thus change as INSPIRE and WISE develop.*

5.1.1 How to develop the data specifications

The WISE data specifications are targeted towards meeting the needs of a wide audience and should fulfill legal requirements as well as from the GIS technical side. The specifications should be sufficiently unambiguous so when they are applied by GIS specialists throughout Europe they lead to harmonised datasets which, with minimal additional effort, can be viewed and analysed in a comparable way.

INSPIRE is targeted towards providing Europe with a spatial data infrastructure. INSPIRE is developing guidance for the data specification process. The INSPIRE drafting team "Data Specifications" has issued a document "Generic Conceptual Model"[28]. The following figure (Figure 5.1.1) from ISO 19109 ("From reality to geographic data") illustrates the modeling process.

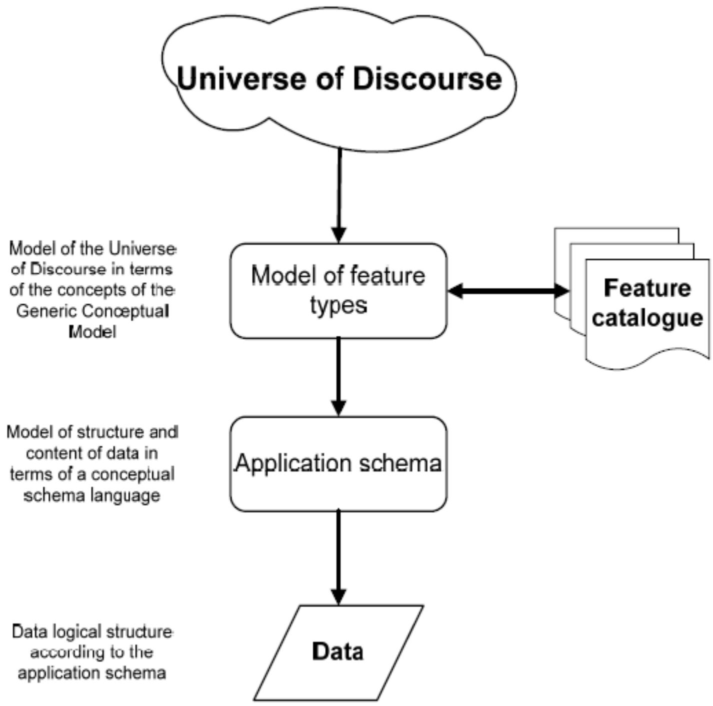


Figure 5.1.1 Data modelling process (from ISO 19109)

[28] http://www.ec-gis.org/inspire/reports/ImplementingRules/inspireDataspecD2_5v2.0.pdf

5.1.1.1 Universe of Discourse

The data modeling process originates in the concepts found in the area of interest described as the “Universe of Discourse”. The concepts are found for example by text analysis of the legislation. The target for WISE application of the developed spatial data is however wider than reporting purely for documentation of legal compliance. The wider applicability thus requires more than a simple analysis of legal texts.

5.1.1.2 Conceptual model

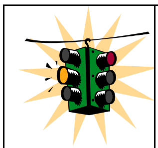
The conceptual model should include all the concepts (not only spatial objects) and their properties (attributes, operations and the relationships that exist among the objects). In this part of the modeling process, the focus is on common understanding and agreement of the concepts (features) involved including the level of details needed (resolution) and the relationships between the concepts. In this phase there are no considerations about technical detail of delivery etc. The WISE outputs from this phase are Reporting sheets (first drafts of feature catalogues) and UML overview diagrams.

5.1.1.3 Application schema

When a common understanding of the concepts involved has been agreed, the application schema may be developed. The application schema is a rigorous description of how the Universe of Discourse should be described as data. The application schema takes the form of UML static structure diagrams (class diagrams) supported by data specifications and a data dictionary. The “INSPIRE Generic Conceptual Model” recommends to express the constraints in OCL (Object Constraint Language) and include them in the UML diagrams. Although preferable for the long term implementation in WISE data flows, the UML diagrams in this guidance do not include constraints.

5.1.1.4 Reporting schemas

The application schema may also be converted and expressed in the logical form specifying the structure for (for example) reporting the data. The WISE reporting schemas have so far taken the simple approach of ESRI shape file templates. Geography Markup Language (GML) may be an alternative to express the reporting schemas in a vendor independent form. GML would be a requirement for compliance with INSPIRE.



Look out! The format of reporting GIS may change

The change to GML schemas is to be confirmed, (see Chapter 5.6)

The INSPIRE drafting team "Data specification" has issued a draft document "Methodology for the development of INSPIRE data specifications[29], which provide further details of the data specification process.

5.1.2 Principles to be applied during data specification work

Article 8 of the INSPIRE Directive provides a set of principles (see text box below) to be applied in the INSPIRE context when defining implementing rules (data specifications) of INSPIRE Annex I and Annex II data. Furthermore, the document "INSPIRE Generic Conceptual model" recommends to apply a "keep it simple" approach to the development of rules for data specifications. Simplicity should be the focus in particular for two aspects:

- The processing and use of (INSPIRE) data should be as simple as possible for users and their software applications.
- For data providers, the transforming/harmonising of their existing data sets should be as simple as possible.

INSPIRE Article 8:

1. In the case of spatial data sets corresponding to one or more of the themes listed in Annex I or II, the implementing rules provided for in Article 7(1) shall meet the conditions laid down in paragraphs 2, 3 and 4 of this Article.

2. The implementing rules shall address the following aspects of spatial data:

(a) a common framework for the unique identification of spatial objects, to which identifiers under national systems can be mapped in order to ensure interoperability between them;

(b) the relationship between spatial objects;

(c) the key attributes and the corresponding multilingual thesauri commonly required for policies which may have an impact on the environment;

(d) information on the temporal dimension of the data;

(e) updates of the data."

3. The implementing rules shall be designed to ensure consistency between items of information which refer to the same location or between items of information which refer to the same object represented at different scales."

4. The implementing rules shall be designed to ensure that information derived from different spatial data sets is comparable as regards the aspects referred to in Article 7(4) and in paragraph 2 of this Article."

[29] http://www.ec-gis.org/inspire/reports/ImplementingRules/inspireDataspecD2_6v2.0.pdf

The "INSPIRE Generic Conceptual Model" also recognises that a major part of INSPIRE data specifications will be the result of a harmonisation process based on existing data specifications. The situation regarding WISE data will, to large extent, also be based on the harmonisation of existing data.

From the first years of WFD implementation a number of useful principles can be provided which help a smoother process of data specification. The principles include:

- Use UML models for communicating the relationship between concepts. The UML modelling (graphic) language is becoming a de facto standard, which is also recommended by INSPIRE guidance documents. The graphic models present the complex relationships in a simple way to an audience with a non-technical background. The UML models help in analysing the relationships between data;
- Be clear and explicit in describing the intended content. In areas where different communities apply a similar terminology and/or set of concepts, confusion may arise from the fact that the perception and interpretation of the concept may originate in different approaches. The perspective on a particular concept will be different depending on the tradition of application. The *implicit* understanding of a concept by each party may thus be different and should be made *explicit*. If ambiguity of terms is suspected the semantics should be supported with clear rules for (for example) data capture and validation;
- Clarify expected resolution and spatial properties. As a major part of the (harmonised) data in question will originate from existing data collections, the issue of data capture is very important. If only a subset of a particular feature class is expected the selection criteria should be specified. Similarly, if the set of features is expected to have certain application properties, e.g. main rivers are expected to be connected through lakes and artificial stretches (canals) and have an outlet at the coastline;
- Be clear on how the object will be identified (primary identifier). Each object should have at least one persistent unique identifier. The identifiers should be of data type text string. Although slower in matching and indexing, the use of text string prevents problems with different numerical encoding;
- Consider the separation of the geometry and primary identifier from other attributes in reporting specifications;
- Keep the spatial feature class slim. Usually several attributes may be assigned to a specific feature class. Care should be taken that only stable attributes are included in the class. Attributes describing a state or a classification subject to a potential change should be modelled in separate tables and linked through unique identifiers. In a similar way, attributes which can be deduced from spatial relationships with other spatial objects should be avoided. During a reporting delivery cycle some redundant information may be included for verification purposes;
- Attribute names should be informative;

- Codelists for attributes should be applied to the maximum extent possible. Wherever possible attribute domains should be enumerated and explained to reduce ambiguity;
- When an attribute contains geographic names, the language as well as the character set allowed should be made clear.

5.1.3 General specifications

5.1.3.1 Spatial reference system

The use of a common geodetic datum (horizontal and vertical) is a first step towards the harmonisation of geographic information across Europe. The adoption of a common reference system makes it possible to maintain seamless distributed spatial data set, assigned to different custodians and avoiding or simplifying the work of geometric harmonisation. A common geodetic datum is particularly important for GIS users who require a seamless dataset. Furthermore, the fact that spatial data provided by Member States is often insufficiently documented (e.g., the used Datum may be unknown or only partially or ambiguously described), is a source of error when national data are converted to a European system. To avoid these problems, it will be the responsibility of Member States to provide data according to the proposed European datum.

ETRS89[30] is recognised by the scientific community as the most appropriate European geodetic datum to be adopted. It is defined to 1cm accuracy, and is consistent with the global ITRS[31]. ETRS89 is now available due to the creation of the EUREF[32] permanent GPS station network and the validated EUREF observations.

For islands not belonging to the European continental landmass the use of ETRS89 may not be applicable. For those areas the WGS84 (World Geodetic System 1984) should be used as the geodetic datum.

The IAG[33] sub-commission for Europe (EUREF) has defined a European vertical datum based on the EUVN[34] /UELN[35] initiative. The datum is named the EVRS[36] and is realised by the EVRF2000.This vertical datum should be applied for deliveries requiring absolute 3-D coordinates.

The National Mapping Agencies (NMA) (or comparable institutions and organisations) provided the information for the descriptions of the national Coordinate Reference Systems and for the transformation parameters between the national Coordinate Reference Systems and the European Coordinate Reference System ETRS89. Formulae can be requested from the NMAs or are directly accessible at http://crs.bkg.bund.de/crs-eu/.

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30 ETRS : European Terrestrial Reference System; EPGS code 3035, http://www.epsg-registry.org/
31 ITRS : IERS Terrestrial Reference System (IERS : International Earth Rotation Service)
32 EUREF : European Reference Frame
33 IAG : International Association of Geodesy
34 EUVN : European Vertical Reference Network
35 UELN : United European Levelling Network
36 EVRS : European Vertical Reference System

We make the following recommendations:

Spatial Reference System:

- To adopt ETRS89[37] as geodetic datum and to express and store positions in ellipsoidal co-ordinates (decimal degrees), with the underlying GRS80 ellipsoid [ETRS89];
- To use the official formulae provided by NMAs or comparable National Institutions for the transformation between National Co-ordinate Reference systems and the ETRS89;
- To document National Co-ordinate Reference systems according to ISO19111;
- To further adopt EVRF2000 for expressing practical heights (gravity-related).

5.1.3.2 Geometric representation

The spatial features may be represented using simple geometry types only (i.e. points, lines, polygons). Optionally, a part of the same set of real world entities could be modeled as a simple or complex network.

Linear referencing systems and topologic networks are supported in some GIS systems and have been applied in several Member States. The implementation may be performed in several ways and the exchange of data between systems is not yet adequately supported. Although the two data structures have many benefits in data management as well as spatial analysis, the application of linear referencing and topologic network is thus not recommended for the data specification work inside WISE.

Network analysis may however be supported using the hydrological feature coding approach described in Chapter 5.4, provided that the simple lines reported are geometrically connected (node to node). Needs for later network analysis should be reflected in the topology rules in the specific data specifications.

When specifying the spatial properties in the application schema it is recommended to apply only the following simple geometry types (See Table 5.1.3.2, from ISO 19107 Geographic Information –Spatial Schema").

Table 5.1.3.2 Recommended ISO Geometry types

ISO Geometry types	**Description**
GM_Point	Single point features
GM_MultiPoint	Multi-point features
GM_LineSegment	A line-segment between two vertices
GM_LineString	A line composed of simple line-segments
GM_Polygon	Polygon features

[37] Except for islands out of the European continental landmass, here WGS84 should be applied.

5.1.3.3 Scale, resolution and positional accuracy

When specifying the spatial data characteristics, the (recommended) scale of the visualisation of data can be regarded as an indicator of the resolution (which level of detail is available for map making). In the WISE context, where data mainly are based on harmonisation of existing, more accurate, national data, the traditional perspective of the scale as an indicator of positional accuracy (which is the possible difference between the true real world co-ordinates and the co-ordinates of the data) is less relevant though positional accuracy by itself is very important.

The resolution determines both the size of the smallest object in the data set and the amount of detail that might be discerned. On a large scale map (i.e. 1:250.000) a river is presented with more points than on a small scale map (i.e. 1:1.000.000), where, for example, small meanders may not be visible. While in theory a dataset at 1:1.000.000 scale might cover the same set of entities (objects) as a dataset at 1:250.000 scale, the latter can present the information in a better way (i.e. the positional accuracy is higher and the shapes of the entities are represented more accurately). Showing a dataset intended for large scale use e.g. 1:50.000 of a meandering stream together with a dataset with an intended scale of 1:250.000 without prior generalisation will emphasise the large scale data. The large scale streams give the impression of being drawn with a broader (but uneven) line symbol. The generalisation rules may be defined as "the features should be registered by as few co-ordinate pairs as possible, though the distance between a vertex and the true position of the feature should never exceed 125 metres". The value of 125 metres can be considered as the simplification tolerance.

Member States are recommended not to simplify spatial data before submitting to WISE. The accuracy of the data should however be documented in the metadata so the simplification process performed in WISE during e.g. reference data production can respect the original accuracy.

If linear or area entities are represented as points (centroids) these should be 'geometric' centroids in the sense that the point should fall inside a polygon representation or for linear features be a point on the line. It is generally recommended not to apply centroids as the representation for features. Whether a given entity is at all represented in a data set is specified by the harmonisation component "Data Capture."

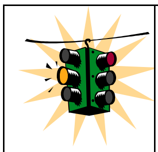
The generally agreed scale of presentation in WISE ranges from 1:250.000 to 1:10.000.000.

The following table (Table 5.1.3.3) shows the relationships between scale, resolution, simplification tolerance and spatial (positional) accuracy.

Table 5.1.3.3 The relationship between scale, resolution, simplification tolerance and spatial accuracy

Scale	Resolution	Simplification tolerance	Spatial accuracy
1:250.000	0.5 km^2	125 metres	125 metres
1:1.000.000	8 km^2	500 metres	500 metres

1:10.000.000	800 km^2	5000 metres	5000 metres



Look out! The requirement for accuracy has been modified

The previous guidance document had a spatial accuracy of 1000 metres. It has been evaluated that the accuracy of the spatial datasets have improved and an accuracy better than 500 metres may be expected.

Considering both the WISE needs and the practical constraints of data availability, the GIS Working Group recommended that the required positional accuracy for reported data should be better than 125 metres. The positional accuracy should always be kept as high as possible and ideally be similar to the national operational datasets.

5.1.4 Data layer characteristics

From the "INSPIRE Generic Conceptual Model" an overview of necessary harmonisation components can be provided, see Figure 5.1.4. Each of the harmonisation components contributes with a specific element to the data specifications. Table 5.1.4 further elaborates the scope of each of the harmonisation components.

For the development of WISE GIS data specifications, (see Chapters 5.2 and 5.3 and Appendices 05 and 06) a subset of the component are considered. For some of the component a few decisions cover all WISE layers. As an example, the previous GIS guidance (as well as the current) recommends to adopt ETRS89 as the geodetic datum and to express and store positions, as far as possible, in ellipsoidal coordinates, with the underlying GRS80 ellipsoid [ETRS89]. This is a part of the general specifications which (partly) fulfil the component "(G) Coordinate referencing and units model".

Other harmonisation components are considered in Chapters 5.4 to 5.7 and 6.1.

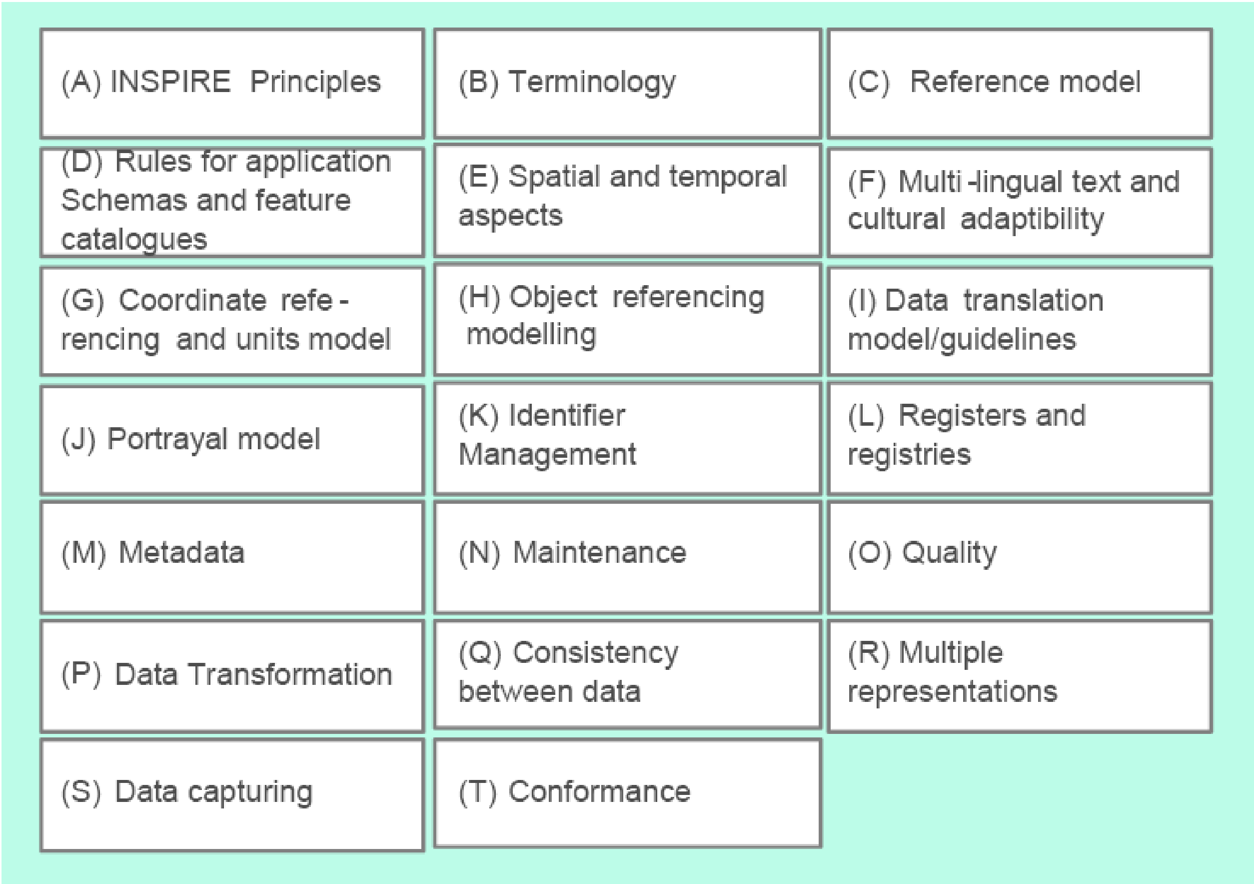


Figure 5.1.4 Data Harmonisation Components from INSPIRE D2.5 Generic Conceptual Model

Table 5.1.4 Scope of INSPIRE harmonisation components from INSPIRE D2.5 Generic Conceptual Model

Component	**Description**
(A) Principles	The principles cited in recital (6) of the Directive are considered to be a general basis for developing the data harmonisation needs. The first three of the five principles are to be considered to help define the data harmonisation process: • *That spatial data are stored, made available and maintained at the most appropriate level;* • *That it is possible to combine spatial data from different sources across the Community in a consistent way and share them between several users and applications;* • *That it is possible for spatial data collected at one level of public authority to be shared between other public authorities.*
(B) Terminology	This component will support the use of a consistent language when referring to terms via a glossary. This needs to be registered and managed through change control with multi-lingual support. The ESDI needs to select a common terminology from all of the existing terminologies and/or their translations.
(C) Reference model	This component will define the framework of the technical parts including topics like information modelling (i.e. conceptual modelling framework with rules for application schemas) and data administration (i.e. reference systems). It will provide a structure which allows the components of INSPIRE which are related to data specifications to be described in a consistent manner.
(D) Rules for application schemas and feature catalogues	The purpose of this component is to • Provide a computer-readable data description defining the data structure - enabling automated mechanisms for data management; • Achieve a common and correct understanding of the data, by documenting the data content of the particular theme, thereby making it possible to unambiguously retrieve information from the data. Feature catalogues define the types of spatial objects and their properties (attributes, association roles, operations) as well as constraints and are indispensable to turning the data into usable information. Feature catalogues promote the dissemination, sharing, and use of geographic data through providing a better understanding of the content and meaning of the data. The full description of the contents and structure of a spatial dataset is given by the application schema which is expressed in a formal conceptual schema language. The feature catalogue defines the meaning of the spatial object types and their properties specified in the application schema. Text elements in the feature catalogues should be maintained at least

	in the official European languages.
(E) Spatial and temporal aspects	Conceptual schema for describing the spatial and temporal characteristics of spatial objects: • Spatial geometry and topology; • Temporal geometry and topology; • Coverages (examples of coverages include rasters, triangulated irregular networks, point coverages, and polygon coverages); • etc. While the component "reference model" specifies an overall framework, this component deals with the spatial and temporal aspects in more detail, for example, the types of spatial or temporal geometry that may be used to describe the spatial and temporal characteristics of a spatial object.
(F) Multi-lingual text and cultural adaptability	Conceptual schema for multi-lingual character strings in spatial objects and supporting information: • To be used in all application schemas and as a result in data instances: all string valued properties that may be provided in a language shall use this type; • To be used in the dictionary model so that dictionaries may be multi-lingual, e.g. the feature catalogue, the feature concept dictionary or codelists. Since the feature catalogue and the feature concept dictionary are multilingual, the definition and names of all spatial object types, their attributes/associations and their attribute values provided by enumerations/codelists are multi-lingual. So far representation of constraints in the different languages has not been formally required, but such a requirement may be added in the future. At the moment, it is not planned to document the formal application

	schema (classes, attributes, associations, constraints) in multiple languages as the definitions are part of the feature catalogue and data dictionary. In principle, cultural differences have to be taken into account, e.g. not all terms may be translatable from one language to another. Furthermore, cultural differences between communities working in the same language can be at least as much a problem as multi-lingual issues. Ontologies may help to capture multi-cultural aspects.
(G) Coordinate referencing and units of measurement model	This component will describe methods for spatial and temporal reference systems as well as units of measurements – including the parameters of transformations and conversions. The focus is on reference systems that are valid across Europe (in case of projected systems split into zones this will be a collection of such systems covering the different zones). This component will also support European geographical grids.
(H) Object referencing modelling	This component will describe how information is referenced to existing objects, typically base topographic objects, rather than directly via coordinates. It will be specified how the spatial characteristics of a spatial object can be based on already existing spatial objects. As a result, this component will support the generation and maintenance of application-specific "user geographies" based on reference data. The aim is to promote the easy and reliable exchange of data that is associated with spatial objects (e.g. river quality sample records) across several users who use a common base (thus avoiding spatial inconsistencies and massive data transfers to support regular reporting).The approach improve data integrity across distributed systems and services as well as more reliable data sharing. Object referencing is especially relevant in referencing spatial objects of Annex III themes to those of the themes in Annex I and II.
(I) Data translation model / guidelines	This component is about translating from a national/local application schema to the INSPIRE application schema and vice versa. Translations are required for data and for queries. NOTE No well-defined set of translation capabilities has been standardised in the GI community at this time. It is not yet clear, if there will be a need to specify translations also between different European application schemas, e.g. for different representations or for creating specific information products, e.g. for reports or from base data etc. Also, further research would be required to identify how consistent adoption of ontologies could be exploited here.
(J) Portrayal model	This component will define a model for portrayal rules for data according to a data specification. It will clarify how standardised portrayal catalogues can be used to harmonise the portrayal of data.
(K) Identifier management	Spatial objects from Annexes I and II should have an external object identifier. This component will define the role and nature of unique object identifiers (or other mechanisms) to support unambiguous

	object identification. To ensure uniqueness some form of management system will be required. This does not mean that all organisations need to adopt a common form of identifier or other mechanism but the identifier management mechanisms (e.g. registers) in use at national level will need to be synchronised/mapped to ensure pan European integration. Note that the same real-world phenomenon may be represented by different spatial objects (with their own identifiers).
(L) Registers and Registries	Registers will at least be required for: • All reference systems used in spatial data sets; • All units of measurement used in spatial data sets; • All codelists / thesauri used in the application schemas (multi-lingual, at least in all official European languages); • The feature concept dictionary for elements used by application schemas (multi-lingual, at least in all official European languages); • Identifier namespaces; • All feature catalogues; • All application schemas. The registries will be available through registry services. Metadata on dataset level will be available through catalogue services.
(M) Metadata	This component will cover metadata on the following levels: • Discovery; • Evaluation; • Use. Metadata associated with individual spatial objects will in general be described as part of the application schemas.
(N) Maintenance	This component will define best practice in ensuring that application data can be managed against updates of reference information without interruption of services. This will require the definition of mechanisms by different stakeholder areas to manage where this is required and it is feasible: • Change only updates; • Versioning of objects (and their properties); • Object lifecycles. Propagation of changes across scale and between dependent objects is required in general to maintain consistency of the data (automatic or manual processes).
(O) Data & information quality	This component will advise the need to publish quality levels of each spatial dataset using the criteria defined in the ISO 19100 series of standards, including completeness, consistency, currency and

	accuracy. This will include methods of best practice in publishing: • Acceptable quality levels of each spatial dataset; • Attainment against those levels for each spatial dataset. Quality information associated with individual spatial objects is part of the metadata associated with the respective spatial object (see component "Metadata") and will in general be described as part of the application schemas.
(P) Data transfer	This component will describe methods for encoding application and reference data as well as information products. The encoding of spatial objects will in general be model-driven, i.e. fully determined by the application schema in UML. To support network services that are implemented as web services, spatial objects are expected to be primarily encoded in XML/GML for the exchange of spatial data. Coverage data is expected to use existing encodings for the range part.
(Q) Consistency between data	This component will describe guidelines how the consistency between the representation of the same entity in different spatial datasets (for example along or across borders, themes, sectors or at different resolutions) shall be maintained. The custodians of such spatial datasets will decide by mutual consent on the depiction and position of such common spatial objects or they will agree on a general method for edge-matching or other automatic means to maintain data consistency.
(R) Multiple representations	This component will describe best practices how data can be aggregated: • Across time and space; • Across different resolutions ("generalisation" of data). Such aggregation processes are used in particular to create the following results: • Multiple representations; • Derived reporting (example: typically water samples at 1 km intervals are reported to the European level).
(S) Data capturing rules	This component will describe the data specification-specific criteria regarding *which* spatial objects are to be captured and which locations/points will captured to represent the given spatial object (e.g. all lakes larger than 2 ha, all roads of the Trans European Road Network, etc.). For INSPIRE data specifications it is in general not relevant, *how* the data is captured by the data providers.
(T) Conformance	This component will describe how conformance of data to a data specification is tested, i.e. it will be necessary to apply conformance tests as specified in the individual data specification. Ideally these will be automated.

	In addition, all INSPIRE data specifications will conform to the Generic Conceptual Model as well as, since Data Specifications are specified using ISO 19131 (Data product specification), to ISO 19131.

5.2 Overview of the GIS layers and their relationships

5.2.1 Overview of GIS layers

WISE provides a repository for a wide range of GIS datasets. These datasets include those compiled by Member States for regulatory reporting and for other voluntary purposes as well as the WISE Reference GIS datasets.

Each set of data is termed a theme. The themes within WISE are:

1. **WISE Reference GIS datasets***
2. **Member State submitted GIS datasets, including data relating to:**
   - Water Framework Directive;
   - State of the Environment Reporting (WISE-SoE);
   - Urban Waste Water Treatment Directive;
   - Bathing Waters Directive;
   - Nitrates Directive*;
   - Drinking Water Directive*;
   - Floods Directive*;
   - Marine Strategy Directive*;
   - E-PRTR.*

* Data models are not yet available for these themes.

The WISE viewer also accommodates a number of background and external GIS data sets – a list of these datasets may be found in Appendix 05.

Further details of the GIS layers in each theme are provided below. The availability in WISE indicates when data have been accepted and entered into the WISE production data bases.

An updated list of publicly visible layers can be found at: http://www.eea.europa.eu/themes/water/mapviewers.

5.2.1.1 WISE Reference GIS datasets (based on WFD reporting)

Layer Code	Layer Name	Feature Type	Availability in WISE
Large Rivers and Large Lakes			
REF1a	Large Rivers	Line	2007
REF1b	Large Lakes	Polygon	2007
Main Rivers and Main Lakes			
REF2a	Main Rivers	Line	2009
REF2b	Main Lakes	Polygon	2009

Layer Code	Layer Name	Feature Type	Availability in WISE
Water Bodies			
REF3a	River Water Bodies	Line/Point	2007
REF3b	Lake Water Bodies	Polygon/Point	2007
REF3c	Transitional Water Bodies	Polygon/Point	2007
REF3d	Coastal Water Bodies	Polygon/Point	2007
REF3e	Groundwater Bodies	Polygon/Point	2007
River Basin Districts			
REF4	River Basin Districts	Polygon	2007
Sub-units			
REF5	Sub-units	Polygon	2009

5.2.1.2 Member State submitted GIS datasets

- **Water Framework Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE
Article 3			
WFD_RBD1	River Basin Districts	Polygon	2007
WFD_RB1	River Basin, Sub-basin	Polygon	Not yet available but reported
WFD_SW1a	Main River	Line	Part of REF2A
WFD_SW1b	Main Lakes	Polygon	Part of REF2B
WFD_SW1c	Transitional Waters	Polygon	Part of REF4
WFD_SW1d	Coastal Waters	Polygon	Part of REF4
WFD_GW1	Groundwaters	Polygon	Part of REF4
WFD_CA1	Competent Authorities	Point	2007
Article 5			
WFD_SW2a	River Water Bodies	Line/Point	2007
WFD_SW2b	Lake Water Bodies	Polygon/Point	2007

Layer Code	Layer Name	Feature Type	Availability in WISE
WFD_SW2c	Transitional Water Bodies	Polygon/Point	2007
WFD_SW2d	Coastal Water Bodies	Polygon/Point	2007
WFD_GW2	Groundwater Bodies	Polygon	2007
WFD_PA1	Drinking Water Protected Areas	Polygon	Not yet available but reported
WFD_PA2	Economically Significant Aquatic Species Protected Areas	Polygon	Not yet available but reported
WFD_PA3	Recreational Waters Protected Areas	Point	Not yet available but reported
WFD_PA4	Nutrient-Sensitive Protected Areas[38]	Polygon	Not yet available but reported
WFD_PA5	Habitats Protected Areas	Polygon	Not yet available but reported
WFD_PA6	Birds Protected Areas	Polygon	Not yet available but reported
Articles 7 and 8			
WFD_SW3a	Operational Monitoring Sites	Point	2008
WFD_SW3b	Surveillance Monitoring Sites	Point	2008
WFD_SW3c	Drinking Water Abstraction Points from Surface Water	Point	Not yet available
WFD_SW3d	Investigative Monitoring Sites	Point	Not yet available but reported
WFD_SW3e	Reference Monitoring Sites	Point	2008
WFD_GW3a	Groundwater Monitoring Network	Point	2008
WFD_GW3b	Operational Monitoring Network Chemical	Point	2008

[38] Nutrient sensitive protected areas means sensitive areas and their catchments falling under Urban Waste Water Treatment Directive (91/271/EEC), and Nutrient Vulnerable Zones falling under Nitrates Directive (91/676/EEC). It shall be ensured that if these are reported under UWWTD and NiD there will be no request for reporting those under WFD (2000/60/EC), as the reported geo-data/files will have the same requirements/structure for reporting and the link between UWWTD and WFD and NiD and WFD will be clearly identified by the Member States when reporting both ways (for WFD or NiD&UWWTD).

Layer Code	Layer Name	Feature Type	Availability in WISE
WFD_GW3c	Surveillance Monitoring Network Chemical	Point	2008
Other data requested by the European Commission			
WFD_SU1	Sub-units	Polygon	2009
WFD_ECO1	Ecoregions	Polygon	Not yet available but reported

- **State of the Environment Reporting (WISE-SoE)**

Layer Code	Layer Name	Feature Type	Availability in WISE
SOE1	WISE-SoE River Stations	Point	Yearly
SOE2	WISE-SoE Lake Stations	Point	Yearly
SOE3	WISE-SoE Quantity Stations	Point	Yearly
SOE4a	WISE-SoE Transitional, Coastal and Marine Water Stations	Point	Yearly
SOE4b	WISE-SoE Transitional, Coastal and Marine Water Flux Stations	Point	Not yet available
SOE5a	WISE-SoE Groundwater Bodies	Polygon	Not yet available but reported
SOE5b	WISE-SoE Groundwater Sampling Sites	Point	Not yet available
SOE5c	WISE-SoE Groundwater Saltwater Intrusion	Polygon/Point	Not yet available but reported

- **Urban Waste Water Treatment Directive**

Layer Code	Layer Name	Feature Type[39]	Availability in WISE[40]
UWWT1	Agglomerations	Point	2008
UWWT2	Urban Waste Water Treatment Plants	Point	2008

[39] Point feature types (e.g. agglomerations, treatment plants, discharge points) layer can be generated from the tabular data (coordinates) provided by the Member State when reporting under UWWTD
[40] Geo-data in sense of the Shapefiles of sensitive areas and their catchments was requested by the Commission for the first time in UWWTD questionnaire of 2007 for the reference year 2005 or 2006 (Member States could choose the reference year to report).

Layer Code	Layer Name	Feature Type[39]	Availability in WISE[40]
UWWT3	Discharge Points	Point	Not yet available but reported
UWWT4	Sensitive Area - River	Line	Not yet available but reported
UWWT5	Sensitive Area - Lake	Polygon	Not yet available but reported
UWWT6	Sensitive Area – Coastline	Line	Not yet available but reported
UWWT7	Sensitive Area – Coast Area	Polygon	Not yet available but reported
UWWT8	Sensitive Area – Transitional Water	Polygon	Not yet available but reported
UWWT9	Sensitive Area - Catchment	Polygon	Not yet available but reported
UWWT10	Less Sensitive Area – Transitional Water	Polygon	Not yet available but reported
UWWT11	Less Sensitive Area - Coastline	Polygon	Not yet available but reported

- **Bathing Waters Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE
BWD1	Bathing Waters	Polygon[41]	Not yet available
BWD2	Sampling Points	Point	Yearly

- **Drinking Water Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE
DWD1	Water Supply Zones	Polygon[42]	Not yet available

- **Nitrates Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE

[41] Currently not available yet, and not requested yet.
[42] The coordinates of WSZ or the polygons of these zones are/will not be requested until 2010.

Layer Code	Layer Name	Feature Type	Availability in WISE
NID1	Nitrate Vulnerable Zones	Polygon	Not yet available
NID2	Monitoring Zones on Surface Waters	Polygon	Not yet available

- **Floods Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE
FLD1	Flood Risk Zones	Polygon	Not yet available
FLD2	Extent of Past Flooding Events	Polygon	Not yet available
FLD3	Damage Maps	Polygon	Not yet available

- **Marine Strategy Directive**

Layer Code	Layer Name	Feature Type	Availability in WISE
MSD1a	Coastline 3 miles zone	Polygon	Not yet available
MSD1b	Coastline 6 miles zone	Polygon	Not yet available
MSD1c	Coastline 12 miles zone	Polygon	Not yet available
MSD1d	Coastline 50 miles zone	Polygon	Not yet available
MSD1e	Coastline 200 miles zone	Polygon	Not yet available
MSD2	Ports	Point	Not yet available
MSD3a	Depth Contours	Line	Not yet available
MSD3b	Temperature Regime	Line	Not yet available
MSD3c	Currents	Line	Not yet available
MSD3d	Salinity	Line	Not yet available
MSD4a	Habitats (Fish, Birds, Others)	Polygon/Point	Not yet available
MSD4b	Pressure Areas	Polygon/Point	Not yet available
MSD5a	Nutrients Input	Polygon/Point	Not yet available
MSD5b	Pollution Input	Polygon/Point	Not yet available

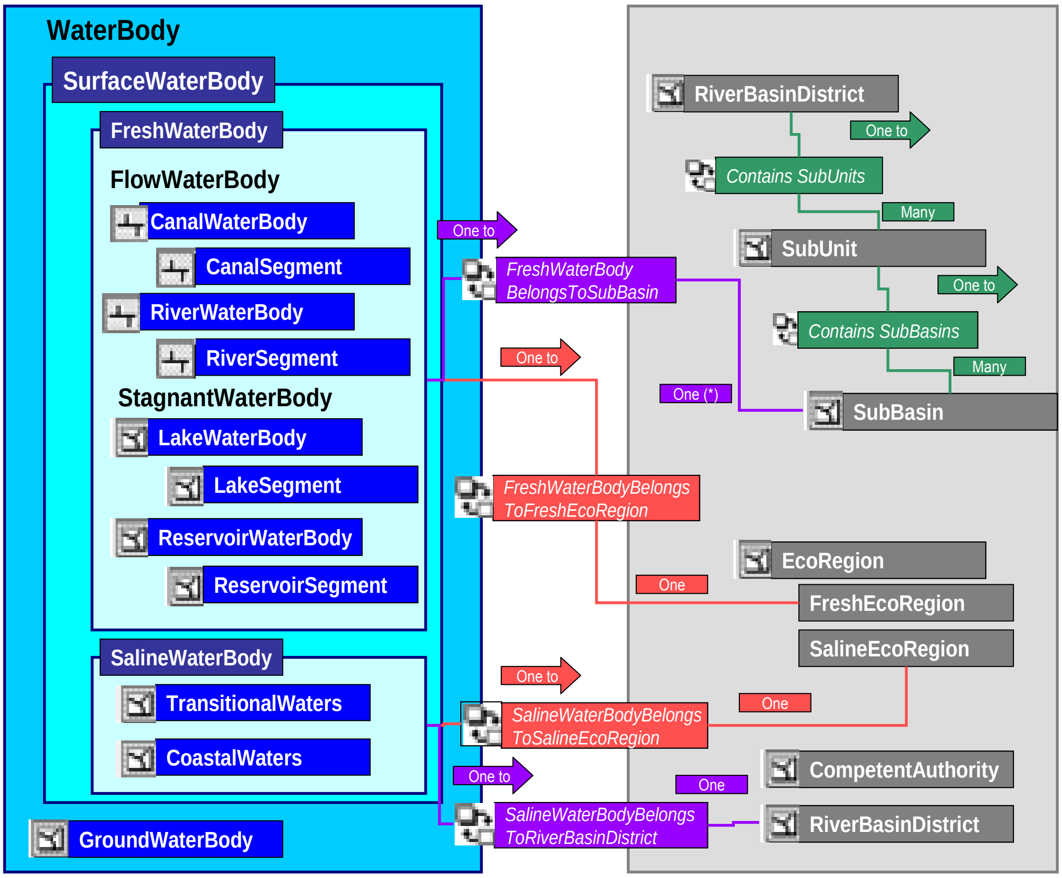
- **E-PRTR**

Layer Code	Layer Name	Feature Type	Availability in WISE

Layer Code	Layer Name	Feature Type	Availability in WISE
EPRTR1	Location of Sites	Point	EPER 2006

Detailed information on the GIS layers within each theme, including technical data specifications as defined by the INSPIRE Data Specification Methodology, is available in Appendix 05.

Under the WFD reporting requirements, several of GIS layers will have relationship to each other. Figure 5.2.1 shows the relationship between the WFD Articles 3 and 5 submitted data.



(*) A canal may belong to many subbasins, depending on how it was constructed

Figure 5.2.1 Relationship between features reported under WFD Articles 3 and 5

Further information on the data models associated with each of the themes is available in Chapter 5.3 and Appendix 06.

Data models and schemas are made available at the schema repository on the web site of the European Topic Centre on Water[43].

Short reporting guidelines are being developed for each obligation, see the template in Appendix 13.

[43] http://water.eionet.europa.eu/schemas/dir200060ec

5.3 Data Model

5.3.1 Purpose of the data model

Data models and data modeling are used in many parts of information system design and are also an important element of WISE development and documentation. Data models define the interaction between objects and their associated attribute information.

Data modeling is the first step in database and data exchange design: it is the blueprint from which the data structures and database will be built. By modeling, complexity is reduced in order to understand the essence of the data and its relationships.

Data models provide the basis of a common understanding of all of the features in a database, and how they can be used and accessed. Data models also aim to encourage consistency in data structures and so facilitate improved data sharing.

Data models describe how objects relate and link to other objects and also describe the attribute information associated with the objects. These descriptions are termed ‘data dictionaries’.

The use of the modeling language UML (Unified Modelling Language) is recommended by the INSPIRE Directive[44]. UML as well as other modeling languages, in conjunction with data dictionaries, are used to describe the data models in WISE.

There are other conventions that describe the basic building blocks required for data modeling, namely:

- Structure diagrams that describe the inter-relationships between objects;
- Entity descriptions that describe the data object types and their attributes;
- Data dictionaries that provide detail about each attribute.

The use of other modeling conventions are therefore acceptable if the data modeling work has already been completed, in particular where schemas have been defined that can be used to automatically generate data dictionary definitions.

Data models and data dictionaries describe the inter-relationships of objects in each of the WISE datasets, or themes, and their associated attribute information. The data dictionary will include the following detail: field name, text description, field type and length, flag to indicate whether the field is mandatory or optional, any restrictions and enumeration or code lists (see Appendix 06).

5.3.2 INSPIRE – WISE models

The INSPIRE Directive requires that data structures used by multiple themes are modelled against a common conceptual model for a European Spatial Data Infrastructure, taking into account the following:

- Abstract types are used to model properties shared by objects across the different themes;

[44] http://inspire.jrc.ec.europa.eu/

- The conceptual model includes generic mechanisms to support simple integration or inter-linking of objects based on a common methodology for references to other features;
- A minimal base application schema is developed and types are moved to the base schema as become of general use.

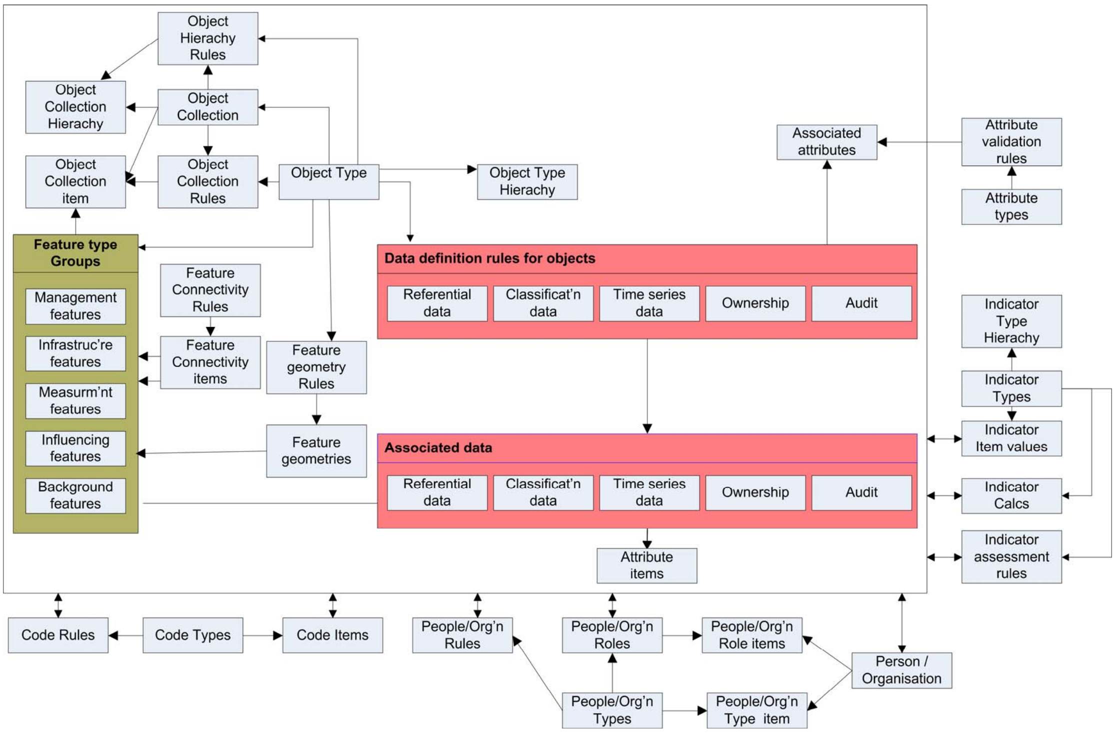


Figure 5.3.1 WISE conceptual model

The purpose of the WISE conceptual model is to identify commonality and to determine the building blocks that will enable integration and harmonisation. It is not the intention to create a single data model or database holding all data.

The WISE conceptual model is a meta-model and does not replace the data models associated with each theme within WISE, but allows the data for the themes to be put into the context of WISE, identifying inter-operability and harmonisation.

5.3.3 Description of the WISE conceptual model

Each geographic object (feature) falls into one of five group types:

- **Infrastructure features** - the basis of the water environment, e.g. rivers, lakes, groundwater, coastal waters, etc;
- **Management features** – the features used in sub-dividing the water environment into manageable units, e.g. River Basin Districts, water bodies and Sub-units;
- **Influencing features** – features that impact upon the water environment, e.g. Urban Waste Water Treatment Plants, Discharge Points, etc;
- **Measurement features** – where measurements are made on the above features, e.g. monitoring stations, gauging stations, sampling points, etc;

- **Background features** – features and objects that provide context to the above, e.g. cadastral maps, CCM, Corine Land Cover, etc.

Each feature has a specific feature type. Each feature type falls within a feature type hierarchy. For example, WaterBody can be sub-divided into SurfaceWaterBody and GroundwaterBody.

Each feature type has data associated with it. Data attributes are sub-divided into the following discrete types of data:

- **Referential data** - e.g. description, name;
- **Classification data** - e.g. typology;
- **Time series data** - e.g. value, unit of measurement, parameter, etc;
- **Ownership data** - e.g. responsible authority, External GIS dataset owner, etc;
- **Audit data** - e.g. date created, date last updated, etc.

Each of these types of data may be time-stamped as detail may change over time and the history may need to be retained.

Features can be grouped to form collections of objects, e.g. catchments, River Basin Districts, etc. Collection objects fall within a hierarchy, e.g. River Basin Districts contain Sub-units. Rules, based on feature type, determine which features can be grouped into collections of features. A collection object can also have attribute data associated with it, e.g. a River Basin District has associated referential, ownership and audit data.

Features also have a connectivity associated with them, e.g. monitoring station (measurement feature type) to river (infrastructure object), etc. Rules ensure that valid connectivity is defined. Connectivity rules will also be required for some collection features, e.g. catchment A flows into catchment B.

Calculation and assessment rules are identified to enable presentation and analysis.

Data standards are required to enable integration and ensure inter-operability. They apply to defined attributes and include the validation that should be applied, the rules needed to determine values, and the common codes that should be agreed and maintained so that common values can be shared across different datasets.

The WISE conceptual model recognises that there will be a need to maintain an agreed set of users and organisations. The data model identifies the need to determine ownership at various levels either through an organisation or a person within that organisation and to declare what role that user or organisation is undertaking.

5.3.4 Examples of the use of the WISE conceptual model

The various feature types can be grouped in accordance with their overall clasification.

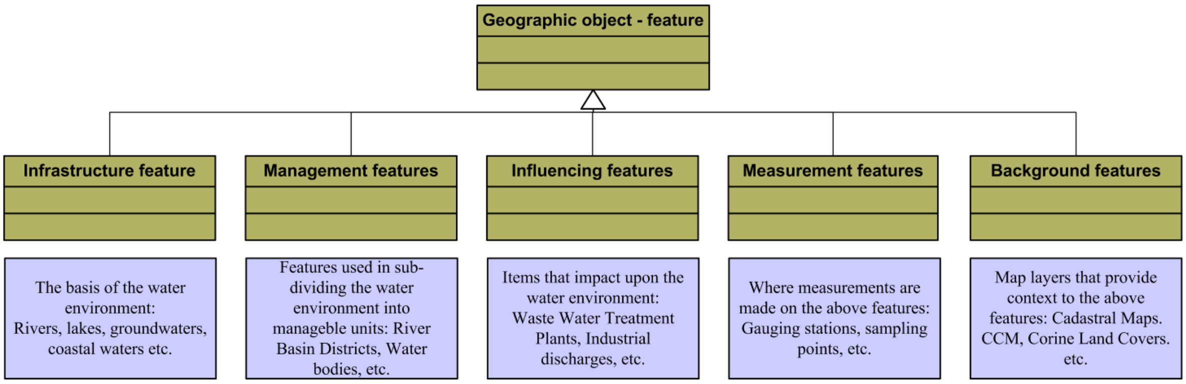


Figure 5.3.4a Groups of WISE feature types

Objects can be grouped into collections of objects, have sub-types and have attribute data. Relations between objects and feature types are also illustrated in the following diagram.

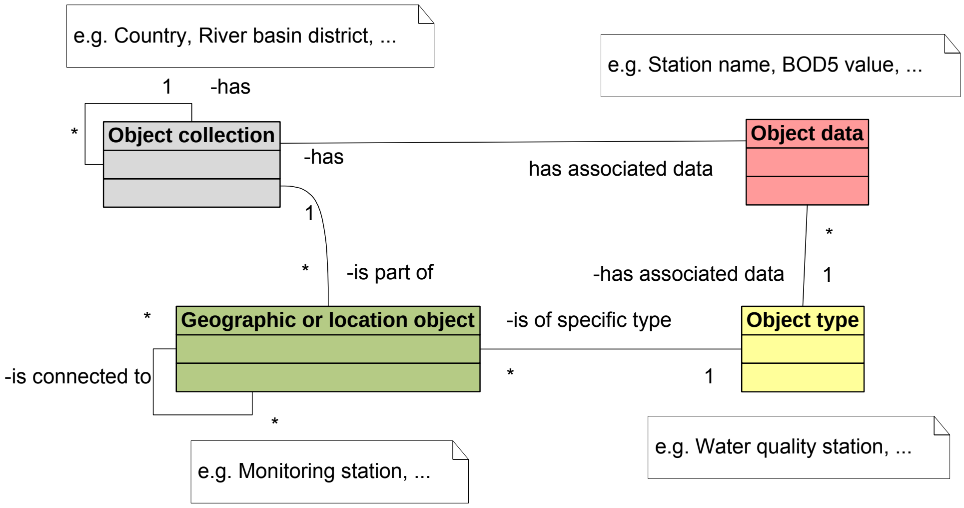


Figure 5.3.4b Example of relationships between objects and features

Objects can be part of hierarchies, as illustrated below.

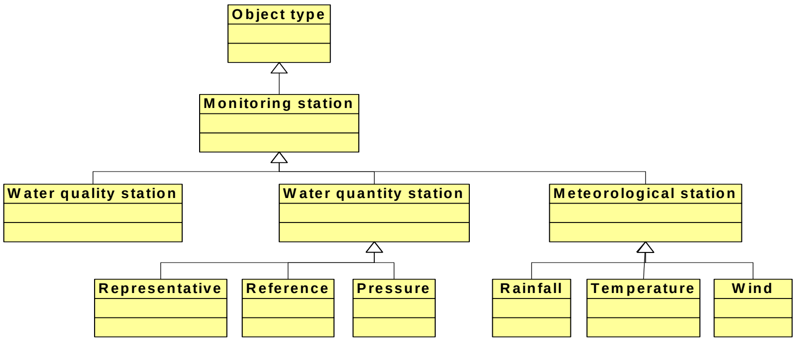


Figure 5.3.4c Object type hierarchies

Objects can have different types of data attributes associated with them.

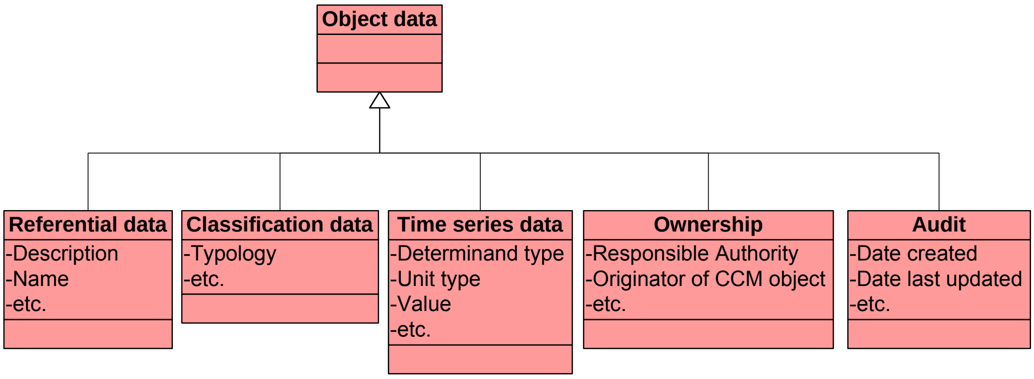


Figure 5.3.4d Types of attributes associated to objects

A transformation model can be used to describe data in terms of the WISE conceptual data model. This example refers to data relating to the Bathing Waters Directive.

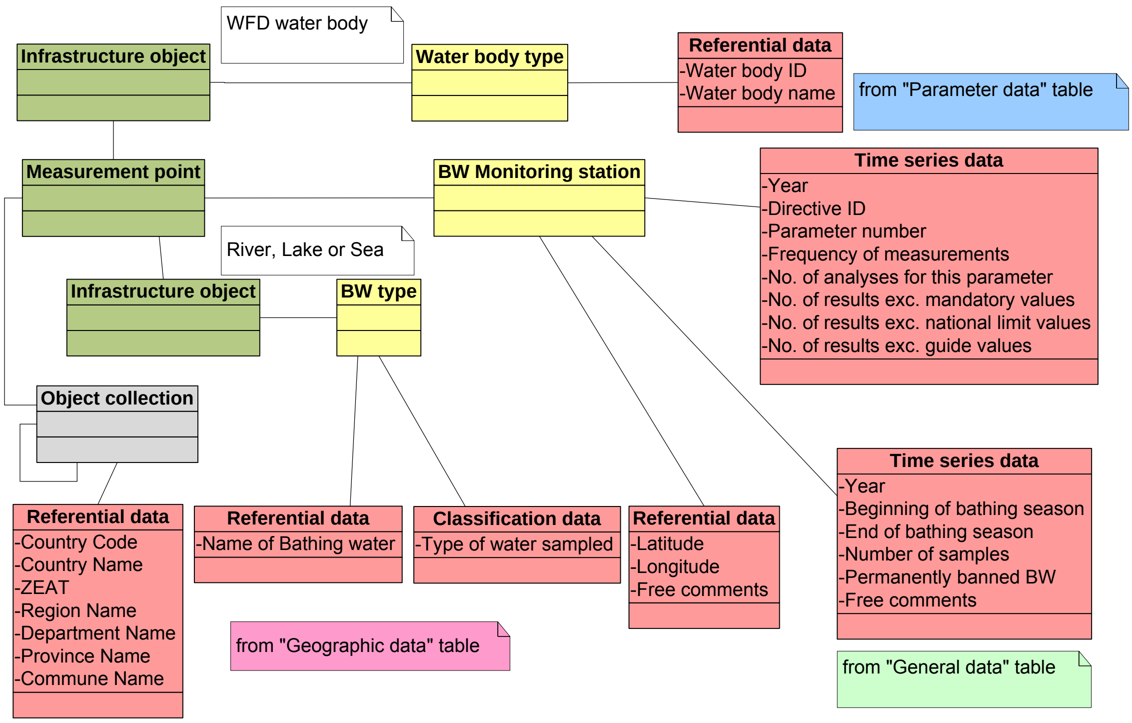


Figure 5.3.4e Transformation data model for the Bathing Water Directive theme

5.3.5 Data structure (class) diagrams

Within the WISE conceptual data model, data structure or class diagrams describe how logically related features are grouped together. For example, within the Water Framework Directive theme there are basic groups of features that have interactions: water bodies fall within River Basin Districts that in turn are managed by Competent Authorities.

These are represented by class diagrams within UML. The following data structure diagram describes conceptually a part of the Water Framework Directive data structures.

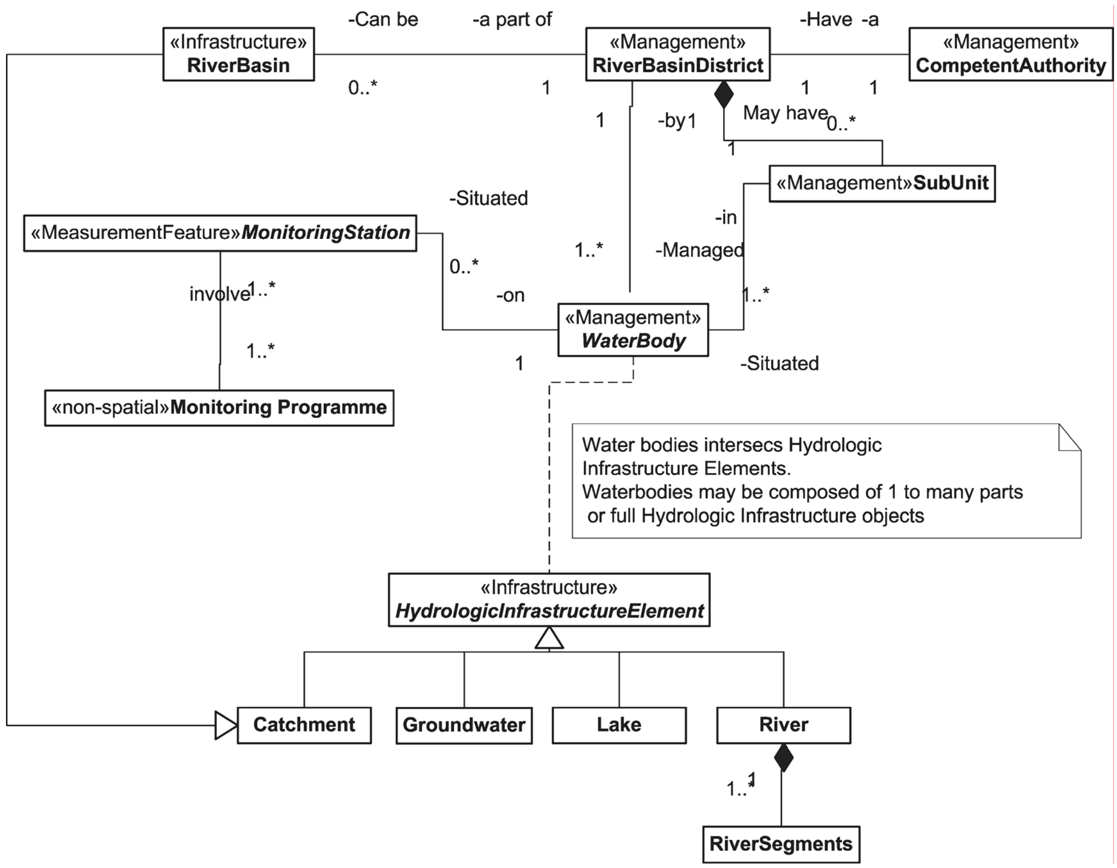


Figure 5.3.5 Part of the WISE conceptual data model relating to the Water Framework Directive

5.3.6 Feature classes

Feature classes group objects within the data model which contain explicit geometry. Feature classes are therefore either point, line or polygon features. All features in the feature class have geometry and a unique internal identifier in the database. Feature classes cannot mix geometry types: they must be exclusively points, lines or polygons.

Feature classes can be grouped and further sub-divided into nested hierarchies.

Example:

Feature

RiverBasinDistrict

Sub-unit

CompetentAuthority

RiverBasin

SubBasin

Feature *WaterBody*

- GroundwaterBody
- *SurfaceWaterBody*
  - *FreshWaterBody*
    - *Flow Water Body*
      - RiverWaterBody
        - RiverSegment
      - CanalWaterBody
        - CanalSegment
      - LakeWaterBody
        - LakeSegment
      - ReservoirWaterBody
        - ReservoirSegment
  - *SalineWaterBody*
    - TransitionalWaters
    - CoastalWaters

Feature

- EcoRegion

Feature

- *ProtectedArea*
  - HabitatsProtection
  - BirdsProtection
  - NutrientSensitiveArea
  - NitratesVulnerableArea
  - EconomicSpeciesProtection
  - Drinking water protection
  - RecreationalWater

Feature classes named in italics are abstract types never being realized. Inheritance allows classes to be related to parents through generalisation. The more specific class inherits attributes from the more general class. The Figure 5.3.6 show a small extract of the WISE logical data model, inheritance is in UML shown with a hollow triangle.

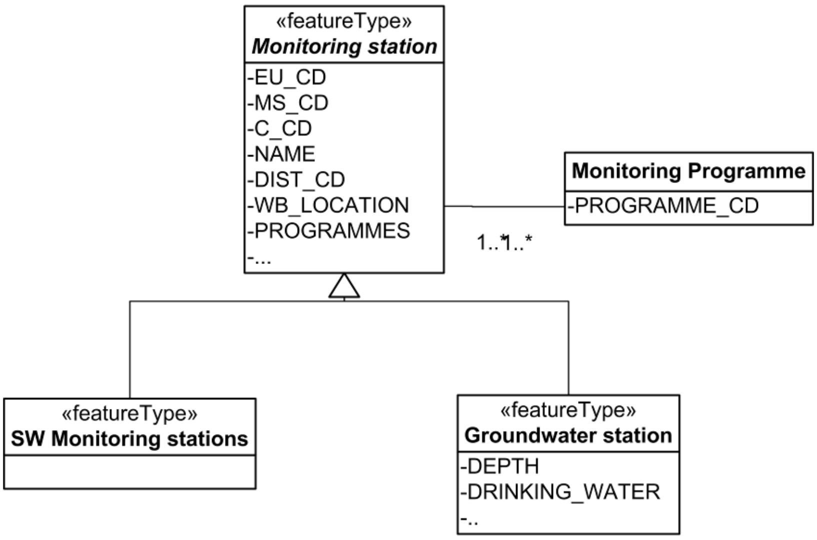


Figure 5.3.6 An extract of WISE logical data model

5.3.7 Object descriptions

In practical terms, every UML feature class becomes a table. Every UML feature class has attributes associated with it.

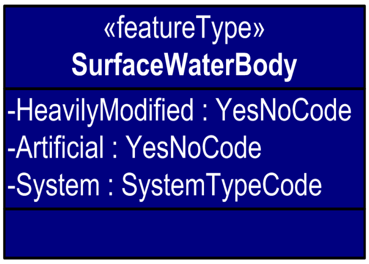
Two examples of object descriptions are shown below:

<u>WaterBody</u>

The WaterBody feature class defines the following attributes:

- **EuropeanCode** – a unique identifier at the European level (cf WG Coding Systems), including the 2 character ISO 3166 country code;
- **Name;**
- **MSCode** - the unique code for the water body defined by the Member State;
- **EcoRegionCode** - the relationship between a water body and its parent EcoRegion is via the EcoRegionCode;
- **InsertedWhen;**
- **InsertedBy;**
- **RiverBasinCode** - the relationship between a water body and its parent River Basin District is via the RiverBasinCode;
- **StatusYear.**

SurfaceWaterBody



All SurfaceWaterBody feature classes inherit from the WaterBody feature class. A SurfaceWaterBody feature class defines attributes which are associated specifically with the SurfaceWaterBody feature class:

- **HeavilyModified** - True/False;
- **Artificial** - True/False;
- **System** - whether the water body is Type A or Type B.

Each attribute in a class becomes a field in a database table. Data dictionaries contain further detail about the attributes. The domains shown refer to the common data types defined in the XML schema WFDCommon.xsd.

5.3.8 Data dictionary

All the attributes that are associated with each GIS layer and dataset, or theme, in WISE are detailed in data dictionaries. The following information is provided for each attribute:

- Its given name;
- Its data type;
- Its data length;
- Any associated codes;
- Any associated constraints.

The following is an example of a data dictionary entry:

EcoRegion

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		
Name	NAME	Locally used name	String	40	
EcoRegionCode	REGION_CD	Codes as specified by Annex XI	String	2	{1-25} {AT = Atlantic, NO = Norwegian, BR = Barents, NT = North Sea, BA = Baltic, ME = Mediterranean}

Figure 5.3.8 Example of an entry in a data dictionary

More details of a data dictionary can be found in Appendix 06.

The Eionet-Water data dictionary is an example of an on-line data dictionary: http://dd.eionet.europa.eu/. Direction to the proper part of the data dictionary may also be obtained from the relevant reporting obligation from the (on-line) Reporting Obligations Database: http://rod.eionet.europa.eu/.

5.4 European Feature Coding

5.4.1 Introduction

GIS feature coding is the assignment of unique identifiers or codes to each spatial object that will be referenced by GIS. This assignment needs to be managed to ensure uniqueness at national and international levels. Standard identifier formats will ease electronic data transfer and enhance the possibility of central querying against distributed storage.

The common framework for the unique identification of spatial objects and the concept for ID management in WISE are described in Chapter 4.4. It deals with specific aspects of identifier management as regards reporting of spatial data by Member States and the development of WISE reference GIS datasets.

The spatial feature available in WISE can be classified into **Non-hydrological features** and **Hydrological features:**

- **Non-hydrological features** should be assigned with a **non-hydrological unique object identifier** but should carry the code of the **hydrological feature** to which they are related as foreign key;
- **Hydrological features** should carry a unique **hydrological feature code**.

This Chapter provides details of the structure of the non-hydrological unique object identifier and the hydrological feature code.

5.4.2 Non-hydrological unique identifiers

The structure of the non-hydrological unique identifiers will be as follows:

- A namespace to identify the data source. The namespace is owned by the data provider;
- A local identifier, assigned by the data provider. The local identifier should be unique within the namespace.

5.4.2.1 Member States submitted GIS data

If the data provider is a Member State, the namespace shall be the two letter ISO 3166 code of the Member State. The local identifier can be 22 characters long at maximum. Thus, the unique non-hydrological identifier provided by Member States should have the following structure:

MS$\#_1\#_2\ldots\#_{22}$ where:

MS . = a 2 character Member State identifier, in accordance with ISO 3166-1-Alpha-2 country codes; and

$\#_1\#_2\ldots\#_{22}$ = an up to 22 character feature identifier that is unique within the Member State.

(symbol # = wildcard character (a wildcard character can be used to substitute for any other character or characters in a string)).

The maximum total length of the identifier therefore will be 24 characters.

Example:

a *Groundwater Body in Germany* might have the identifier DE45734

or a *Lake Monitoring Station in Spain* might have the identifier ES67003800958730

Special advice given is that:

- The local identifier shall only use the following set of characters: {“A”…”Z”, “a”…”z”, “0”…”9”, “_”, “.”, “-“, “,”}, i.e. only letters from the Latin alphabet, digits, underscore, point, comma, and dash are allowed;
- Alphabetical characters should always be in upper case;
- Special characters must be avoided, such as ‘$’, ‘!’, ‘&’, ‘ë’, ‘á’, etc;
- Digits should be used where practical to help avoid the above problems.

Entity types can be used to identify the type of a feature. The entity type code segment is fixed to two characters. An example is given below. The list can be extended as needed, but has to be managed at the European level in order to prevent creating ambiguous codes.

- Non-hydrological features (examples);

Entity type	Code
o Monitoring station	MO
o River Basin District	BD
o …	

- Specifications for reporting geographical data under UWWTD (examples)

Entity type	Code
o Sensitive Area	SA
o Sensitive Area – river	RI
o Sensitive Area – lake	LK
o …	

5.4.2.2 WISE Reference GIS datasets

So far the WISE Reference GIS datasets: **Large Rivers and Large Lakes** and **River Basin Districts** have been developed. The datasets are available in the WISE map viewer (See Chapter 3.2 for an illustration of the River Basin Districts WISE Reference GIS dataset). The identifiers of the River Basin Districts (identifying the

RBD irrespective of country borders) and the Member State parts of RBDs can be seen at:
http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=1041.

5.4.3 European coding system for hydrological features

If rivers are already substantially identified, it may be pragmatic to extend the existing approach to uniquely identify objects. However, the number of rivers to be identified may amount to many times the number already coded. Codes may also need to be reviewed to achieve harmonisation with Member States involved in shared RBDs. Coding could be as simple as sequential identifiers; however, structured hydrological codes are recommended. This enables rapid manual or automated analyses without the need to refer to GIS. This includes tracing facilities including rivers, catchments and associated objects (upstream/downstream identification). Furthermore connectivity between rivers across boundaries has to be created and thus data analysis within international RBDs will be facilitated. Hierarchical structured coding also tends to ease long-term unique code maintenance.

A modified version of the Pfafstetter system is proposed as the European coding system for hydrological features. The hydrological code is composed of different segments, which together uniquely identify a hydrological feature. The hydrological code consists of 6 hierarchical related items. The first item is a character defining the Ocean or Endorheic system. It is followed by one digit numbering of the seas into which the Ocean can be subdivided. In the case of islands subsequently a sequence number of the island order along the coast is defined. The landmasses thus defined can be subdivided at sea outlet level using the 5 digit length commencement code. Finally the river system can be coded up to the river reach level using the Pfafstetter methodology. Furthermore an entity type code segment will define the type of feature that is referenced by the code. These are e.g. river segments, lakes and basins.

Table 5.4.3a Elements of the Hydrological Coding

Abbreviation	**Logical Element**	**Relation to**	**Data type**	**Min., Max. Length**
H or HDM_ID	Coastline, Hydrological system		String	1
S or SEA_ID	Coastline, Sea	Hydrological system	Number 1-9,	1
II or Island sort	Landmass, Island sort	Sea and Hydrological system	Hexadecimal number	2
CCCCC or Commencement	Sea outlet commencement code	Sea and Hydrological system and Island	Number 11111 – 99999,	5
P or Pfafstetter	River segments, lakes, river basins Pfafstetter	Seaoutlet	Number	1-12
E or Entity type	Entity type code		Character	2

L or Lake identifier	Lake identifier		Character	0,2

In a database typically these codes are to be stored in separate files, allowing a programmer to use the various data elements in a flexible manner. For data exchange functions it is useful to concatenate the elements, thus simplifying the exchange procedures and the eventual need to type in the code by a user.

The format of the code will be as follows:

HSIICCCCCPPPPPPPPPPPPEELL

Hydrological system and Sea region code (**HS**IICCCCCPPPPPPPPPPPPEELL)

The identification of the sea region constitutes the first segment of the whole code. The hydrological coding system reveals into which sea the various European watersheds are flowing and how those seas are connected to the ocean, the ordering of data can be enhanced. A limited hierarchical model is used in order to make these connections explicit in the coding system for the oceans and seas.

The coding of the sea region would be mandatory for all hydrologic reference features. It is proposed to define a unique identifier of one letter to mark the various Hydrological Systems or oceans that can be distinguished. The seas that are part of these oceans can subsequently be marked with one number. If the number is higher (9) than the distance of the sea to the ocean it exchanges water with is longer, in accordance with the Pfafstetter coding in which digit 9 marks the longest flow path and 1 the outlet of a river system into the sea. Thus the length of the code segment would be two characters, a letter for the Hydrological System or ocean and a number for the seas.

We propose to distinguish seven Oceans: Arctic Ocean, Northern Atlantic Ocean, Southern Atlantic Ocean, the Indian Ocean, the Pacific Ocean and the Mediterranean Sea. In the coding system these oceans all receive one letter as proposed in Table 5.4.3b.

Table 5.4.3b Definition of an Ocean letter to identify into which hydrographic system water from a surface water body eventually flows into.

Code	**Oceans**
A	Northern Atlantic Ocean
M	Mediterranean Sea
N	Arctic Ocean
S	Southern Atlantic Ocean
I	Indian Ocean
P	Northern Pacific Ocean
B	Southern Pacific Ocean

For endorheic systems relevant for Europe, including Turkey and the Caucasus, the codes proposed can be found in Table 5.4.3c.

Table 5.4.3c Definition of endorheic systems with surface water flow in Europe including Turkey and the Caucasus

Code	Endorheic System
C	Caspian Sea
H	Orumiyeh Lake
V	Van Lake
Z	Tuz Saltlake

There are two more endorheic systems, Prespa Lake and Trasimeno Lake. These systems are quite small and for the purpose of the WISE, they are integrated into the surrounding drainage area.

Most of the thus defined hydrographic systems can be subdivided by subsystems such as seas, bays or straits. For the use of grouping data within European policies we only propose here a subdivision of the Northern Atlantic Ocean East coasts. In order to code the seas relevant to the European Subcontinent it is proposed to distinguish the following seas (Table 5.4.3d):

Table 5.4.3d Numeric code of the Seas around Europe

Hydrographical System	Sea number	Sea Name
North Eastern Atlantic	1	Open Ocean
	2	Norwegian Sea
	4	Celtic Sea and Channels
	5	North Sea
	6	Baltic Sea
Mediterranean Sea	2	North Western Basin
	4	North Eastern Basin
	5	Black Sea
Arctic Ocean	7	Barents Sea East
	8	White Sea
	9	Barents Sea West
Caspian Sea	1	No subdivision
Indian Ocean	1	Persian Gulf

Island coding (HS**II**CCCCCPPPPPPPPPPPPEELL)

A proposal to code islands can be found in Appendix 08. The islands can be identified by the code of the sea they lie within, followed by a sequence number. The sequence number is generated by selecting the closest continental coast line segments ordering number. It is proposed to relate the sequence number to the coastal segment at the shortest distance to the island. In some cases many islands are to be connected to the same coastal segment. In such cases the final sequence number can be generated by using the shortest distance to the coastal segment.

Pfafstetter commencement code (HSII**CCCCC**PPPPPPPPPPPPEELL)

The second code segment would identify the primary catchment or a coastal catchment within the respective sea region. The commencement code will be defined at the European level based on the basins and sub-basins of the national datasets that have been reported according to Article 3 of WFD. The determination of the code should follow the same logic as the Pfafstetter code. The four largest sea outlets (river basins) within each sea region should be assigned with the figures 2, 4, 6 and 8 in clockwise rotation. The coastal region between these sea outlets (river basins) should be assigned with odd numbers 1,3,5,7 and 9 (see Figure 5.4.1).

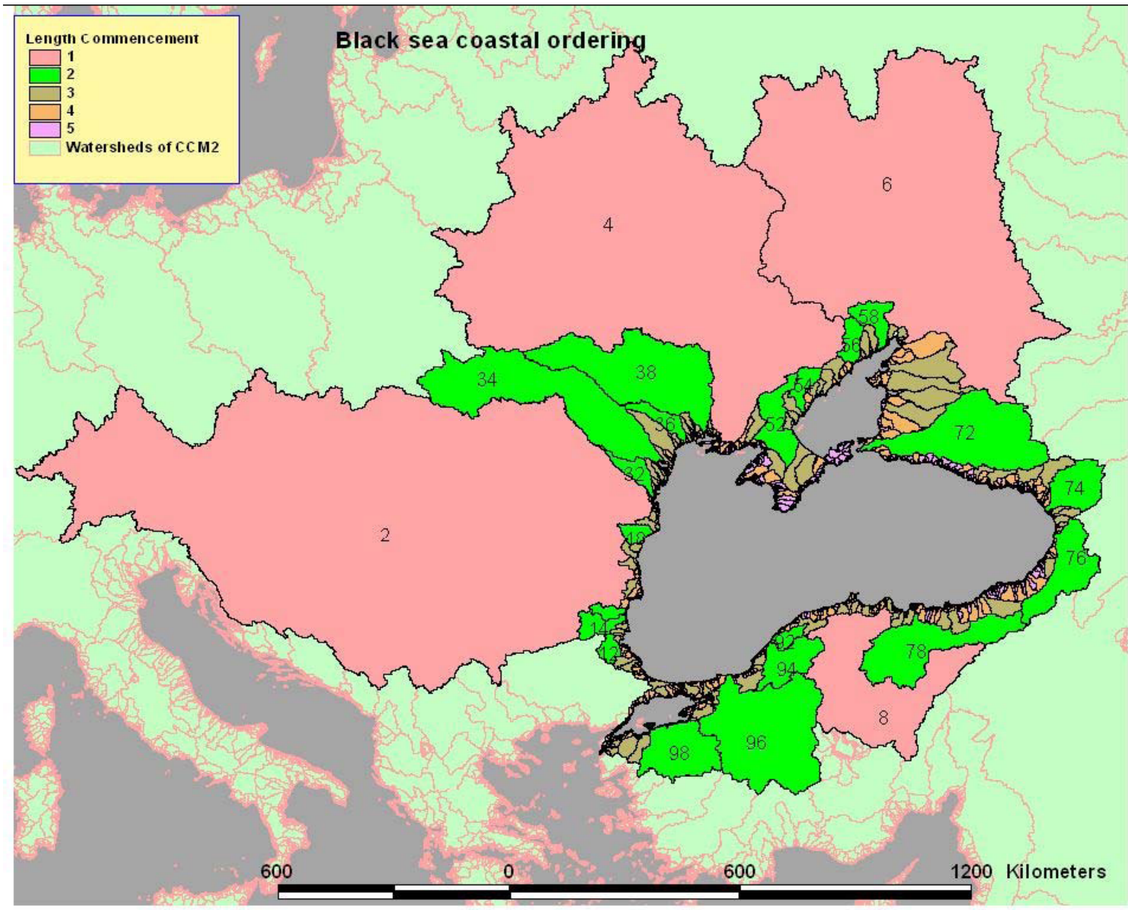


Figure 5.4.1: Commencement code for the Black Sea related Seaoutlets. The length of the code yields an indication of size

This commencement code has already been defined for CCM2 and the data can be downloaded at http://desert.jrc.ec.europa.eu/water/ccm/php/index.php.

River segments, lakes and river basins (HSIICCCCC**PPPPPPPPPPPP**EELL)

The Pfafstetter approach is recommended for providing a structured hydrological code segment, identifying river basins and river sub basins. Codes identified for river basins and sub-basins can be assigned to the associated river segments. The Pfafstetter system follows a systematic approach as it is derived from topological relationships of the underlying drainage system. The numbering schema is self-replicating from the largest to the smallest drainage system. With Pfafstetter codes it is possible to identify all nested sub-basins within the larger basin and the “parent” basin from a sub-basin. All upstream sub-basins or river segments as well as all downstream segments are identifiable at each location of the river network. More details of the creation of the code can be found in Appendices 07 and 08. (The principles of the system are explained in Appendix 07. Appendix 08 gives more details about the application of the system, taking also the island coding into consideration and the extension of the ocean and sea region coding as explained in this Chapter).

Lakes should be included in the Pfafstetter coding system. If they are connected to the river network, they should receive the Pfafstetter code of the river segment to which they drain (the outlet). If they are not connected to the river network, they should receive the code of the lowest level river (sub-) basin or interbasin in which they are located. In case that more than one isolated lake is located within one sub- or interbasin, lakes should be distinguished by a specific identifier. This specific identifier should be appended after the entity code to be able to code international lakes. A maximum of 2 characters are reserved for this segment. The code segment should only contain digits. Examples of lake coding are illustrated in Appendix 07.

For the implementation of a Pfafstetter system, the river network must be fully connected also within the lakes. These hypothetical river segments are sometimes called continua. As a consequence, water bodies within a lake can be identified according to the codes of the underlying river segments, if required.

Entity type (HSIICCCCCPPPPPPPPPPPP**EE**LL)

As described with the coding system for non-hydrological reference features, an entity type code can be used to identify types of hydrological features. A list of possible entity type codes is given in Appendix 07. Examples are given below. The list can be extended as needed, but has to be managed at the European level in order to prevent ambiguous codes being created.

- Hydrological features (examples)

Entity type	**Code**
o River basin	BA
o River segment	RS
o …	

Conditional lake identifier (HSIICCCCCPPPPPPPPPPPPEE**LL**)

An additional unique string is required for identifying lakes that are not connected to a river network. The identifier is necessary if there is more than one lake within a specific river basin. International lakes should be identified with one code (identifying the total lake and not only national parts of the lake). As a consequence, the identifier has to be managed within an international river basin on the European or international level.

It is proposed to reserve a maximum of two characters for this code segment. The code could consist of numbers and characters.

Other identifiers

The coding of special cases such as bifurcations, karst phenomena and canals is described in Appendix 07.

5.4.4 Application of the European coding system for hydrological features

The application of the code to hydrological features requires a topologically correct and connected river network including lakes and a dataset of basins with the catchment boundaries. There has to be a spatial relationship between the basins dataset and the river network as the order of Pfafstetter code assignment is determined by the size of the catchments. International basins, rivers and lakes have to be consistent across national boundaries.

The European coding system for hydrological features will be applied at EU level to the WISE Reference GIS datasets of main rivers (including river segment coding and river codes) and main lakes. The coding system is being tested in the Danube River Basin District at rivers with a catchment > 1000 km². The methodology and results will be available as Appendix 09 from March 2009.

5.4.4.1 Application of the coding system at EU level - Hydrological Reference Features

The European coding system for hydrological features will be applied at the European level to hydrological reference features used in harmonised European reference datasets (WISE Reference GIS datasets). These will be the Main Rivers and Main Lakes and, in future, the correlated river basins, sub-basins and catchments. The codes will be defined using the European dataset of catchment areas and derived rivers (CCM2). The generated codes will then be transferred from CCM2 to the submitted national datasets which form the reference datasets of Main Rivers and Main Lakes. The datasets will be created at the European level and provided to Member States.

Each river segment of the European reference dataset Main Rivers will carry the European hydrological feature code for river segments, the European river code and the RBD code. Each lake of the European main lakes dataset will carry the European hydrological feature code of the lake and the European RBD code.

5.4.4.2 Application of the coding system at Member State level (rivers, lakes)

Member States are not requested to apply the proposed European coding system for hydrological features to their national hydrological features as they probably have a national hydrological coding system already in place. However, Member States are invited to apply the European coding system for hydrological features at the national level. The Pfafstetter commencement code can be obtained from the CCM2 dataset.[45]

To allow the linkage of national hydrological features to European hydrological reference features, it is recommended that Member States add the following as attributes to their national hydrological river and lake datasets:

- European river code of the WISE Reference GIS dataset main rivers;
- European lake code of the WISE Reference GIS dataset main lakes;

[45] http://desert.jrc.ec.europa.eu/action/php/index.php?action=view&id=23

- European Pfafstetter codes of transboundary rivers segments (including border river segments) and transboundary lakes.

Of particular importance are transboundary features, border rivers and border lakes. It is proposed to harmonise these features respectively at national and international River Basin District levels (see Chapter 6.1). As long as these features are not harmonised, harmonisation will take place at EU level (see Chapter 3.1) and the dataset and the corresponding codes will be provided to Member States. As soon as national/international harmonised features are available they will substitute features harmonised at EU level.

5.5 Metadata

5.5.1 What are metadata?

Metadata are information that describe the content, quality, condition, origin and other characteristics of data or other pieces of information related to the data. Metadata are important since they make data understandable and they make it easier for data to be shared. As we are witnessing a rapid increase in the availability of digital data, the need for effective metadata increases so that users can properly discover and evaluate relevant data resources.

5.5.2 Structured and unstructured metadata

Although in many cases metadata can be inferred from data resources, a structured approach to collecting and publishing metadata is beneficial since it increases consistency. The advent of sophisticated Internet-based indexing and search engines and tools have gone a long way to help locate digital information resources, but basic problems remain in that categorisation and cataloguing of resources remains limited.

5.5.3 Metadata standardisation

5.5.3.1 International Standards Organisation (ISO)

In the domain of geographic information a number of standardisation activities have taken place which provide a formal basis for describing geographic data and services.

In 2003 the International Standards Organisation (ISO) adopted the standard ISO19115:2003 Geographic Information – Metadata.

In 2005 this was followed by the adoption of ISO19119:2005 Geographic Information – Services.

With the adoption of ISO19139:2007 Geographic Information – Metadata – XML Schema Implementation, developers now have access to a comprehensive metadata implementation specification.

The ISO standards are over-arching. ISO19115 has approximately 300 elements, an exhaustive list, but of course many of these are redundant for certain applications. As a consequence, many communities have developed profiles, an agreed sub-set of elements.

5.5.3.2 Other standardisation initiatives

The development of the US FGDC Metadata format (CSDGM) preceded ISO19115, and has been widely adopted outside the US. CSDGM is now being aligned to ISO19115. The other widely used metadata standard is the DCMI (Dublin Core Metadata Initiative).

5.5.4 INSPIRE and WISE metadata profiles

The elements required for describing geographic data and services falling under the scope of INSPIRE are detailed in the INSPIRE Directive[46].

The INSPIRE metadata elements have been selected to support the primary function of discovery. For 10 categories, there are a total of 27 metadata elements.

It is important to note that whilst in general INSPIRE advocates the use of recognised standards it is not a requirement to fulfil the obligations of the INSPIRE metadata regulation to adopt ISO19115 or related standards for implementation. However, in practical terms, many organisations will choose to adopt such an approach, and non-binding guidelines have been published, see: http://inspire.jrc.it/reports/ImplementingRules/metadata/Draft_Guidelines%20_INSPIRE_metadata_implementing_rules.pdf which "map" INSPIRE metadata elements to their corresponding ISO elements.

The WISE metadata profile should support the functions of discovery and usage. The original WFD GIS Guidance Document (Vogt 2002) defined a metadata profile based on the draft version of ISO19115 that existed at the time, and further work was undertaken with the SDIGER-project.

Since the majority of WISE datasets and services will fall under the scope of INSPIRE, this guidance recommends the adoption of a profile which extends the INSPIRE metadata to include all those additional elements already agreed by the WISE community.

This guidance recommends the use of INSPIRE terminology for element names wherever possible, thus ensuring compatibility with metadata created in other environmental policy areas.

An overview of the WISE metadata profile is provided below with a more elaborated version found in Appendix 10. Details of implementation of the metadata elements are provided in Appendix 11.

Table 5.5.4 Overview of the WISE metadata profile

Category	Element Name	Description	Condition	Value Domain	Multiplicity
IDENTIFICATION	1.1 Resource title	This is a characteristic, and often-unique, name by which the resource is known.	Mandatory	Free text	1
	1.2 Resource abstract	This is a brief narrative summary of the content of the resource	Mandatory	Free text	1
	1.3 Resource type	This is the type of	Mandatory	Part D.1. of the	1

[46] http://inspire.jrc.ec.europa.eu/

Category	Element Name	Description	Condition	Value Domain	Multiplicity
		resource described by the metadata		MD IR	
	1.4 Resource locator	The resource locator defines the link(s) to the resource and/or the link to additional information about the resource	Mandatory if a URL is available to obtain more information on the resource, and/or access related services	Character string expressed by a URL	0..*
	1.5 Unique resource identifier	A value uniquely identifying the resource	Mandatory	Character string + character string namespace	1..*
	1.6 Coupled resource	*Identification of the target spatial data set(s) of the services trough their Unique Resources Identifiers (URI)*	*Mandatory if linkage to the service is available*	*Character string code + character string namespace*	*0..**
	1.7 Resource language	The language(s) used within the resource	Mandatory if the resource includes textual information	ISO 639-2	0..*
CLASSIFICATION OF SPATIAL DATA SETS & SERVICES	2.1 Topic category	High-level classification scheme	Mandatory	Part D.2 of the MD IR	1..*
	2.2 Spatial data service type	*This is a classification to assist in the search of available spatial data services*	*Mandatory*	*Part D.3 of the MD IR*	*1*
KEYWORD	3.1 Keyword value	A commonly used word, formalized word or phrase used to describe the subject	Spatial data set or spatial data set series: at least one keyword from GEMET	Free text	1..*
			Spatial data service: at least one keyword from Part D.4 of the MD IR	*Part D.4 of the MD IR*	*1..**
	3.2 Originating controlled vocabulary	The citation of the originating controlled vocabulary shall include at least its title and a reference date (publication, last revision or creation)	Mandatory if the keyword originates from a Controlled vocabulary	Free text + date	1..*
GEOGRAPHIC LOCATION	4.1 Geographic bounding box	Extent of the resource in the geographic space	Spatial data set or spatial data set series: Mandatory	Decimal degrees with at least two decimals	1..*
			Spatial data service: Mandatory for services with an explicit geographic extent	*Decimal degrees with at least two decimals*	*0..**
TEMPORAL REFERENCE	5.1 Temporal extent	Time period covered by the resource as an individual date, an interval of dates or a mix of both	At least one of the metadata elements referred to points 5.1 to 5.4	ISO 8601	1..*
	5.2 Date of	Date of publication or	At least one of	ISO 8601	1..*

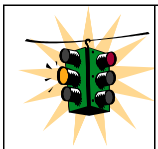
Category	Element Name	Description	Condition	Value Domain	Multiplicity
	publication	entry into force of the resource	the metadata elements referred to points 5.1 to 5.4		
	5.3 Date of last revision	Date of last revision of the resource	At least one of the metadata elements referred to points 5.1 to 5.4	ISO 8601	1
	5.4 Date of creation	Date of creation of the resource	At least one of the metadata elements referred to points 5.1 to 5.4	ISO 8601	1
QUALITY & VALIDITY	6.1 Lineage	Statement on process history and/or overall quality of the spatial data set	Mandatory	Free text	1
	6.2 Spatial resolution	Level of detail of the dataset: it shall be expressed as a set of zero to many resolution distances or equivalent scales	Mandatory	Equivalent scale expressed as an integer; resolution distance expressed as a numerical value	0..*
CONFORMITY	7.1 Specification	Citation of the implementing rules adopted under Article 7(1) of Directive 2007/2/EC or other specification to which a particular resource conforms	Mandatory	Free text + date	1..*
	7.2 Degree	Degree of conformity of the resource to the implementing rules adopted under Article 7(1) of Directive 2007/2/EC or other specification	Mandatory	Part D.5 of the MD IR	1
CONSTRAINT RELATED TO ACCESS & USE	8.1 Conditions applying to access and use	Conditions for access and use of spatial data sets and services, and where applicable, corresponding fees	Mandatory	Free text + URL if applicable for information on any fees	1..*
	8.2 Limitations on public access	Limitations on public access and the reasons for them	Mandatory	Free text	1..*
ORGANISATIONS RESPONSIBLE FOR THE ESTABLISHMENT, MANAGEMENT, MAINTENANCE AND DISTRIBUTION OF SPATIAL DATA SETS AND SERVICES	9.1 Responsible party	Description of the organisation responsible for the establishment, management, maintenance and distribution of the resource	Mandatory	Free text + e-mail address as a character string	1..*
	9.2 Responsible party role	Role of the responsible organisation	Mandatory	Part D.6 of the MD IR	
METADATA ON METADATA	10.1 Metadata point of contact	Description of the organisation responsible for the creation and maintenance of the metadata	Mandatory	Free text + e-mail address as a character string	1..*
	10.2 Metadata date	Date the metadata	Mandatory	ISO 8601	1

Category	Element Name	Description	Condition	Value Domain	Multiplicity
		record was created or updated			
	10.3 Metadata language	Language in which the metadata are expressed	Mandatory	ISO 639-2	1
WISE METADATA	11.1 Distribution format	Provides a description of the format of the data to be distributed	Mandatory	Free text	1..*
	11.2 Metadata standard name	Name of the metadata standard (including profile name) used	Mandatory	Free text	1
	11.3 Metadata standard version	Version (profile) of the metadatastandard used	Mandatory	Free text	1
	11.4 Metadata file identifier	Unique identifier for this metadata file	Optional	Free text	0..1
	11.5 Metadata character set	Full name of the character coding standard used for the dataset	Optional	MD_CharacterSet Code <<CodeList>> (B.5.10)	0..1
	11.6 Reference system	Description of the spatial and temporal reference systems used in the dataset	Optional	MD_ReferenceSys tem (B.2.7)	0..*
	11.7 Spatial representation type	Method used to spatially represent geographic information	Conditional: if the resource is a dataset or dataset series	MD_SpatialRepres entationTypeCode	0..*
	11.8 Credit	Recognition of those who contributed to the resource(s)	Optional	Free text	0..*
	11.9 Presentation form	Mode in which the resource is represented	Optional	CI_PresentationFo rmCode	0..*
	11.10 Purpose	Summary of the intentions with which the resource(s) was developed	Optional	Free text	0..*
	11.11 Specific usage	Brief description of the resource and/or resource series usage	Optional	Free text	0..*
	11.12 Vertical extent	Provides vertical component of the extent of the referring object	Optional	EX_VerticalExtent	0..*

Note: Metadata elements marked in italics are only relevant for metadata covering services.

5.5.5 Which WISE components require metadata?

Metadata should be created with all geographical information being reported to, developed in the context of, or disseminated through WISE. A sub-set of the metadata elements found in the WISE profile for spatial data would also be applicable for non-spatial data submitted by Member States.



Look out!

Mandatory delivery of metadata may develop further

The application of mandatory metadata using specific elements from the profile may be extended to reporting outside the scope of GIS data.

5.5.6 Metadata creation methods

The authoring and editing of metadata in WISE can be done in a number of ways including:

- The use of a dedicated WISE metadata web-based entry page, with basic client-side validation. At the present time this does not exist, but could be developed in the future;
- The use of a metadata editor, capable of outputting metadata according to the recognised WISE metadata XML schema. This can be direct (i.e. if the tool can be configured to export according to this schema), or indirect (i.e. using XSL transformations to map from the native XML schema of the specific tool to the WISE XML schema).

There are many tools which allow metadata editing and which are based on the ISO standards.

5.5.7 WISE XML Schema

An XML schema for the WISE metadata will be available from the WISE portal.

5.6 Standards for data exchange

5.6.1 Purpose for standards in data exchange

In addition to the optimisation of data collection and the reuse of data, one of the major goals of WISE is to streamline the data exchange between the Member States and the European Commission (EC).

The way data is collected and stored, its quality and coverage will vary from organisation to organisation responsible for the managing and reporting of data. Each organisation will have to implement procedures and modules that facilitate the data exchange processes according to formats agreed between the data provider and the data user.

The development of common standards serving the WISE community has a number of benefits:

- The users may reduce the cost for development and implementation of a specific reporting flow;
- The development of the reporting specifications will be easier and may reuse previously developed components;
- Given that GML is recommended, the developed application and data structure schemas may provide a basis for both file exchange and web service development.

In 2004, the WFD guidance document no. 9 Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive[47] identified a short term approach and a long term approach.

The short term approach pointed to the use of Geography Markup Language (GML) as best practise and the published open standard file format ESRI shape file[48] as a minimum standard. The long term approach (for 2009) recommends the use of web services, which is covered in more detail in Chapter 5.7.

The recommendation of GML has recently been supported by the INSPIRE Drafting Team on Data Specifications in the document D2.7: Guidelines for the encoding of spatial data, Version 2.0[49]. The application of GML and GML application schemas are in line with the development of web services.

The common standards for data exchange can be viewed and developed at different levels. This Chapter will not discuss the choice of GML as a common standard for the encoding of spatial data to be exchanged, but rather bring recommendations on how the GML standard should be exploited in the context of WISE.

5.6.2 GML – a natural choice with decisions to take

The OpenGIS® Geography Markup Language Encoding Standard (GML) is an ISO standard (ISO 19136:2007) that defines data encoding in XML for geographic data and a grammar to express models of such data using XML Schema. GML provides a means of encoding geographic information for both data transport and data storage, especially in a web context. It is extensible, supporting a wide variety of spatial tasks, from portrayal to analysis. It separates content from presentation (graphic or otherwise) and permits easy integration of spatial and non-spatial data. Clients and servers with interfaces that implement the OpenGIS® Web Feature Service Interface Standard read and write GML data.

The following diagram shows how GML would integrate with the reporting process:

[47] Document is available on CIRCA at:
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/gds09sgisspolicysummary/_EN_1.0_&a=d (policy summary), and on
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidancesnos9sgisswgs31p/_EN_1.0_&a=d (complete guidance no.9)
[48] http://www.esri.com/library/index.html
[49] http://www.ec-gis.org/inspire/reports/ImplementingRules/DataSpecifications/inspire_dataspec_D2.7_v2.0.pdf

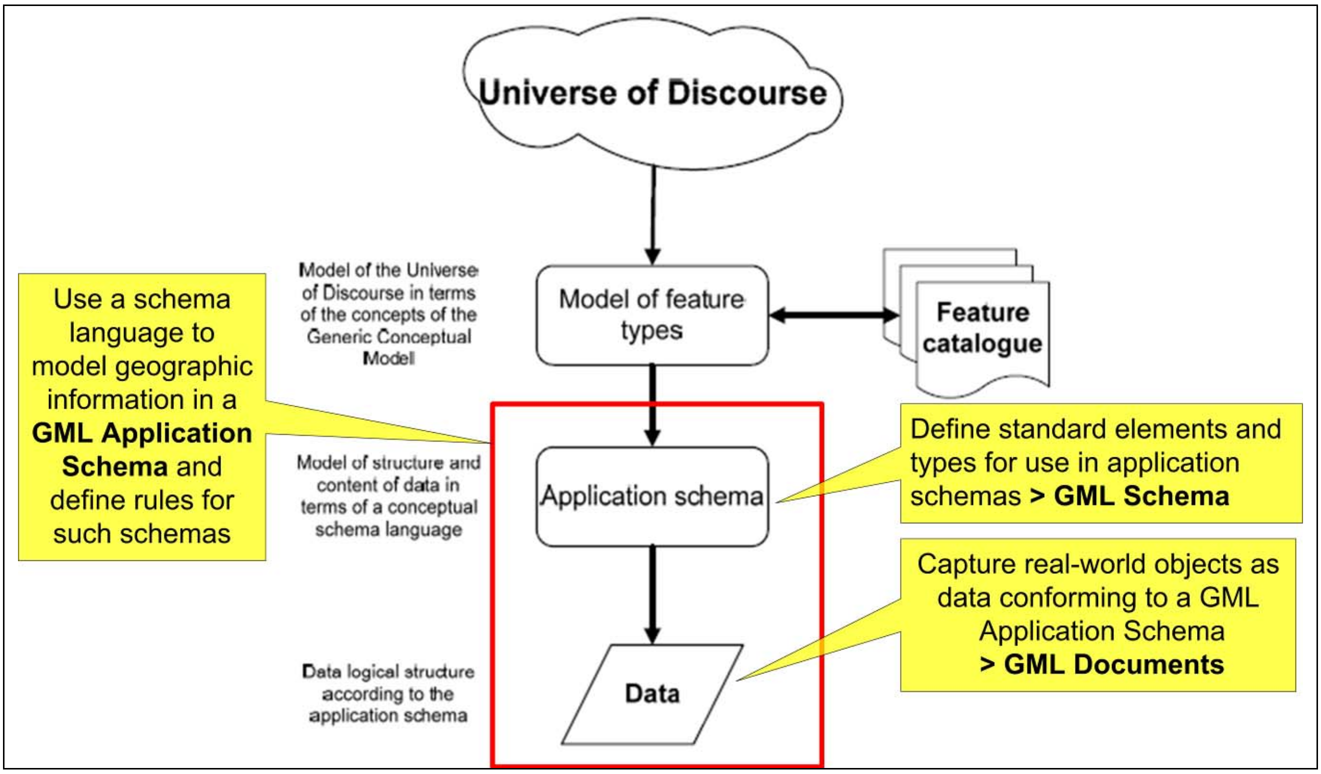


Figure 5.6.2 Development of data exchange specifications in the reporting process

The GML standard (currently version 3.2.1) is an exhaustive and flexible standard covering a wide set of possible spatial data structures and service types. It is thus beneficial both to restrict the application of GML to a common sub-set of the standards and to define a set of encoding rules to be applied to the standard. The INSPIRE Drafting Team on Data Specifications already specify, in the document D2.7, a number of recommendations on such encoding rules.

5.6.2.1 GML in a nutshell

Version

GML is jointly developed by ISO/TC 211 and OGC and published as ISO 19136:2007. The current version is GML version 3.2.1 (available from http://www.opengeospatial.org/standards/gml). GML version 3.x.x provides the option of encoding several elements: geometry properties, topology properties and time properties. A major benefit of using GML is that all necessary information can be encoded in a single GML document and be validated according to the GML application schema. No specific recommendations are provided regarding use of version. It is anticipated that the data receiver will have to implement the capability of translating more than one version.

At the time of writing GML version 3.1.1 has some advantages:

- This version is stronger than the previous version 2. by supporting e.g. topology and time;
- GML version 2 is more open and leaves several implementation choices for the same aspect;

- The software support is wider for this version than the latest version 3.2.1.

Profiles

One way of restricting the application of GML is through the application of profiles. Profiles are distinct from application schemas. Profiles are part of GML namespaces (Open GIS GML) and define restricted sub-sets of GML. Profiles are often created in support for GML derived languages (see application schemas) created in support of particular application domains such as commercial aviation, nautical charting or resource exploitation. OGC has defined a few data type specific profiles of which the Simple Features Profile[50] is recommended for WISE. The GML-Simple Feature Profile has three compliance levels: level 0, 1 and 2 (SF-0, SF-1, SF-2).

Example:

An example of the structure of GML application schemas and the encoding of elements can be found in Appendix 12.

Software support

GML is to a varying degree supported by commercial as well as Open Source GIS packages. As software is constantly developing this guidance will not provide specific software recommendations, but rather point to the OpenGeospatial[51] website for the updated information.

As GML is based on XML many of the existing XML tools may also be applied to read, write, manipulate, and validate GML documents.

5.6.3 GML and data modelling

Application schemas are XML vocabularies defined using GML and which live in an application-defined target namespace. Application schemas can be built on specific GML profiles or use the full set of GML schemas. In order to expose an application's geographic data with GML, a community or organisation creates an XML schema specific to the application domain of interest, i.e. the application schema. This application schema describes the object types whose data the community is interested in and which community applications must expose. For example, WISE may define object types of coastal water bodies, transitional water bodies etc in its application schema. Those object types in turn reference the primitive object types defined in the GML standard.

Based on the application schema, a data structure schema will be developed to facilitate the specific data exchange. Typically a GML data structure schema should include:

- Metadata section;
- Extent element;
- Features;
- Feature attributes.

[50] http://www.opengeospatial.org/standards/gml
[51] http://www.opengeospatial.org/resource/products

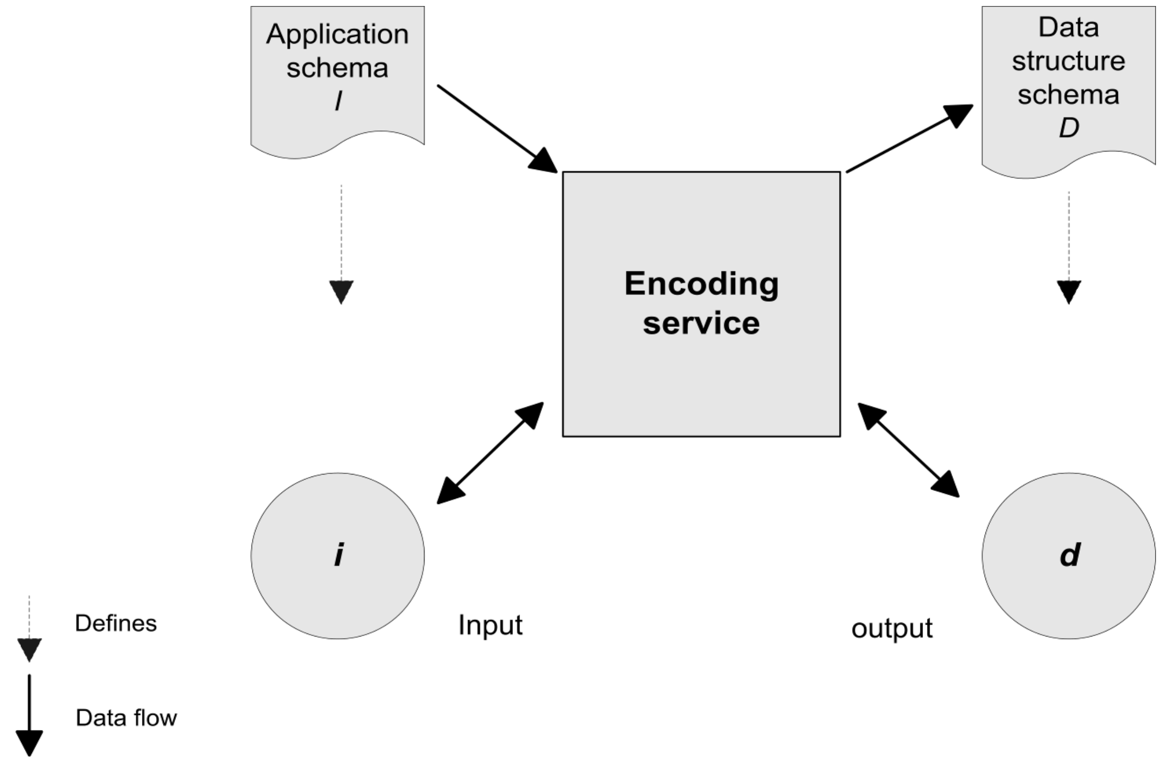


Figure 5.6.3a Overview of encoding process (ISO 19118)

Schema coding patterns for compliance level SF-0:

The schema fragments in a GML application schema that complies to GML-Simple Feature Profile level 0 are:

- Root element encoding;
- Identifying the compliance level;
- Importing and including schemas (among them the GML schema);
- Defining a feature collection (only one per application schema);
- Defining features types;
- Defining properties encoding within the feature types (including geometry properties).

The structure of each of these fragments is presented in Appendix 12.

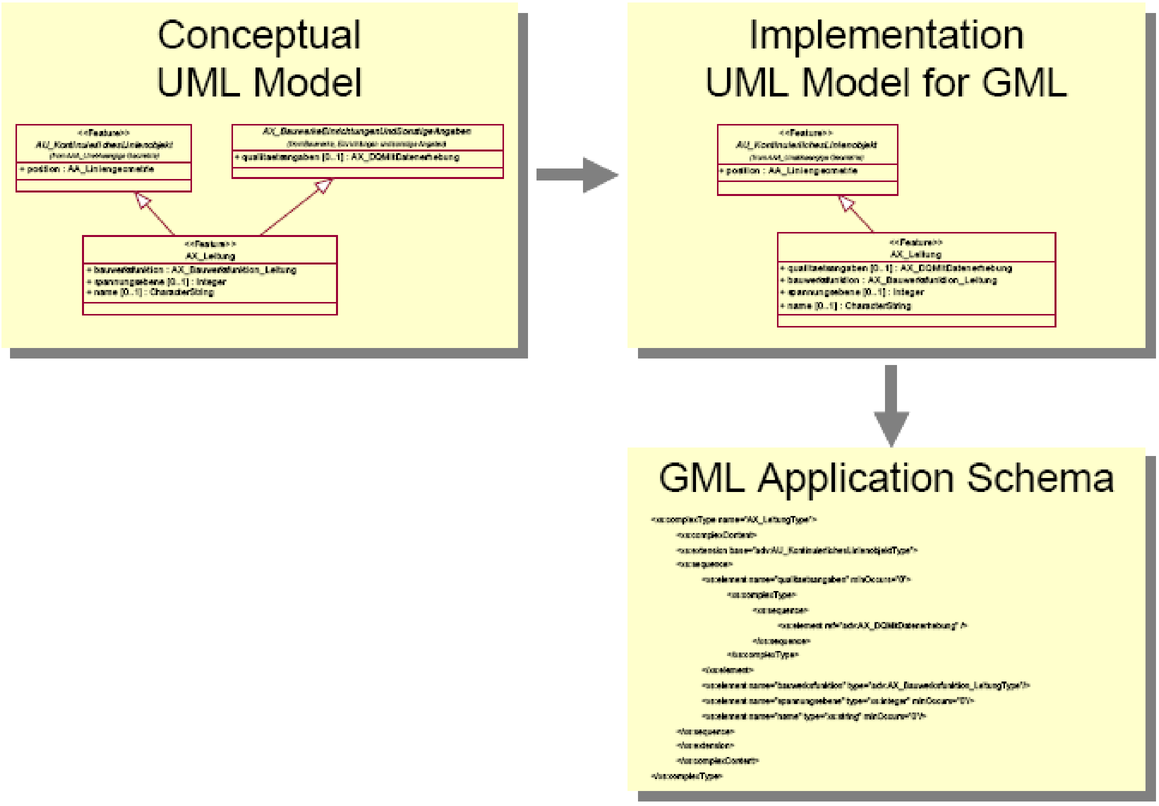


Figure 5.6.3b Process of creating the GML application schema (from INSPIRE D2.7)

5.6.4 GML in WISE

The use of GML will gradually be extended in WISE with the development of WISE GML application schemas and translation of previous Shapefile based reporting templates and schemas into data structure schemas. GML will have a role both in the further development of file based data exchange and in the development of web service specifications to be applied by the WISE and SEIS community. Figure 5.6.4 shows the relation between GML and the web services.

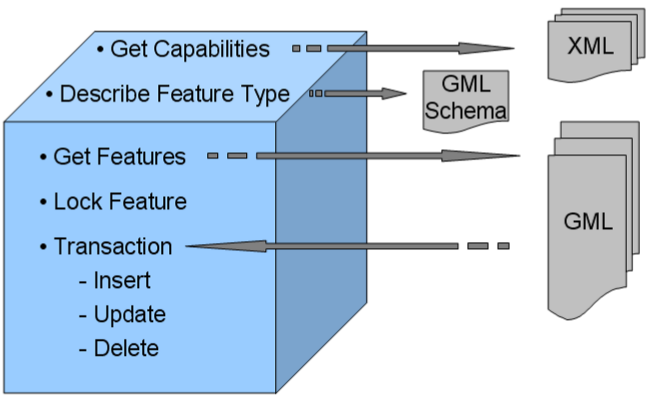
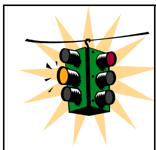


Figure 5.6.4 Relation between GML and OGC WFS web service

5.6.5 Encoding rules for WISE

During the development of GML in WISE a number of rules should be followed. The INSPIRE Drafting Team on Data Specifications has developed a set of recommendations for encoding rules in INSPIRE, a number these are adopted by WISE either directly or in a slightly modified way. The full set of recommendations (there are currently fifteen) and their details can be found in INSPIRE D2.7 Guidelines for the encoding of spatial data.



Look out!

The URN NID may change

INSPIRE work on the assumption that the URN NID “inspire” will be registered and applied. INSPIRE use ”x-inspire” as the placeholder.

In the context of WISE it still remains to be decided whether a specific namespace will be registered and which acronym it will take.

Extract of rules recommended by INSPIRE Drafting Team on Data Specifications:

- Encoding rules should be based on open standards (INSPIRE Recommendation 2);
- Additional encoding rules should only be added, if the new encoding rule has unique characteristics required by the encoded data that are not fulfilled by an encoding rule that has already been endorsed (INSPIRE Recommendation 3).

Recommendations for GML application schemas:

- The encoding rule specified in ISO 19136 Annex E should be applied. For types within the scope of the ISO/TS 19139 encoding rule, the encoding rule of ISO/TS 19139 should be applied. To identify the applicable encoding rule, a tagged value “xsdEncodingRule” should be provided for packages and classifiers. A value “iso19136_2007” (the default, if no value is provided) indicates the GML encoding rule, “iso19139_2007” indicates the ISO/TS 19139 encoding rule (INSPIRE Recommendation 5);
- The transformation from the application schema on the conceptual level to the UML implementation profile from which the GML application schema is automatically derived should follow a common set of rules across all themes (INSPIRE Recommendation 6);
- All navigable feature association roles should be assigned a tagged value "inlineOrByReference" with the value "byReference" (INSPIRE Recommendation 7).

Recommendations for XML documents:

- XML documents should be encoded using UTF-8 or UTF-16 as character encodings (INSPIRE 9).

Recommendations for the use of URNs:

- The target namespace of the GML application schema should be a URN of the form:

  urn:x-inspire:specification:<name>:<version>

  where

  <name> is a name of the GML application schema

  <version> identifies the particular version (INSPIRE Recommendation 10).

Encoding of an external identifier:

- URNs should be used to encode unique identifiers including the namespace and the local identifier part. The URNs should use the following structure:

  urn:x-inspire:object:id:<namespace>:<local identifier>[:<version>]

  where

  <namespace> is the namespace of the object identifier;

  <local identifier> is the local identifier part of the object identifier;

  <version> is an optional version qualifier to be added only if a specific version of the object shall be identified. (INSPIRE Recommendation 11)

Encoding of a reference to a spatial object:

- To reference a spatial object or a specific version of a spatial object the URNs specified in Recommendation 11 should be used (INSPIRE Recommendation 12).

Encoding of a reference to a registered item:

- URNs should be used to encode item identifiers of items in registers and to reference such items.

  The URNs should use the following structure:

  urn:x-inspire:def:<item class>:<register>:<item identifier>

  where

  <item class> is the name of the item class (ISO 19135: RE_ItemClass) of the registered item;

  <register> is the name of the register (ISO 19135: RE_Register);

  <item identifier> is the item identifier of the registered item (ISO 19135: RE_RegisterItem).

  Other URIs may be used, too. It is recommended to register them as an alias of the item in the INSPIRE register (INSPIRE Recommendation 13).

Modified INSPIRE rules:

- To support interoperability and enhance coherence across communities, the encoding rules and output data structure schemas in WISE should be as consistent across the various themes as possible (INSPIRE Recommendation 1);
- For every WISE application schema, a GML application schema should be specified (INSPIRE Recommendation 4);

- All code lists should be assigned a tagged value "asDictionary" with the value "true". Instance should reference the WISE register that is used to manage this code list (INSPIRE Recommendation 8).

Rules for exchange of metadata:

- For data transfer, using the transfer model (download of a complete spatial dataset), the dataset should include the dataset metadata for evaluation (MD_Metadata as specified in the WISE data specification) and use (INSPIRE Recommendation 14);
- For data transfer, using the interoperability model (download of a spatial objects based on a query), the response of the download service should not include any dataset metadata but should provide a reference to the dataset or dataset series metadata in a discovery or registry service (INSPIRE Recommendation 15).

WISE-specific rules:

- Although GML allows more than one geometry to represent a feature which could lead to, for example, water bodies that are presented as point features and as Linestring or Polygon feature, WISE recommends separating each geometry type in different GML documents which will keep it simple to manage the upload and metadata of exchanged data

5.6.6 Role of Shapefiles in WISE

The available reporting interfaces developed between 2004 and 2007 were based on Shapefile formats and XML schemas as a bundle completing the electronic reporting content on Articles 3, 5 and 8 of the Water Framework Directive. These reporting interfaces will remain for updating the information on the mentioned Articles under the first River Basin Management Plan and following reporting phases. Alternatively GML schemas (covering the content of the Shapefile formats and XML schemas) can be used to substitute the former reporting formats. The GML schemas will be made available by the EEA as they are developed.

The use of GML in WISE will gradually be extended and further use of Shapefiles will not be stimulated. Although quite widespread the Shapefile format has some major disadvantages:

- No validation rules can be applied directly to the set of files;
- The format does not fit into the service oriented architecture;
- Problems with controlling and determining the character set applied in attribute tables;
- Multiple files needed for transmitting a single theme;
- Vendor-specific origin (though openly documented).

5.7 Web services

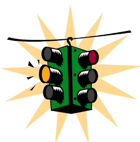
5.7.1 What are spatial data web services

5.7.1.1 Service definitions

Network services are designed to perform machine-to-machine communication which may be embedded in end user applications. The primary purpose of the network services is to provide information in a standardised way independent of the underlying application software, platform or framework.

Spatial data may be disseminated and shared in real-time through the use of these web-based network services. Open Geospatial Consortium, Inc (OGC) has drafted a number of OpenGIS® Web Service (OWS) interface specifications. These service specifications have been widely adopted by the user community, ISO, CEN and INSPIRE.

Each of the network services is implemented using a specific interface specification. Examples of such interfaces are OGC-WMS (Web Map Services), OGC-WFS (Web Feature Services) etc. described further in Chapter 5.7.2. From a user perspective the various network services together should be able to support a workflow following a "publish – find – bind" design pattern. However, users do not necessarily have to follow this pattern; they can also invoke services directly.



Look out!

Definition OGC Web Services (One Geology)

An OGC Web Service (OWS), or open web service, is a 'self-contained, self-describing, modular application that can be published, located, and invoked across the web. Web services perform functions that can be anything from simple requests to complicated business processes. Once a web service is deployed, other applications (and other web services) can discover and invoke the deployed service.' (Ref: OGC).

Typically a web server is a computer placed on the Internet that offers an OGC Web Mapping Service or WMS (responds to requests from a computer client to send a map in the form of a raster or image over the Internet) and/or an OGC Web Feature Service or WFS (responds to queries from a computer client to send an application of GML representation of some data often with a geographic part in an XML document based on a schema such as GeoSciML).

A web server can publish more services than WMS and WFS and there are other OGC web servers that publish mapping services.

The OGC WMS specification standardises the way in which web clients request maps. Clients request maps from a WMS instance in terms of named layers and provide parameters such as the size of the returned map as well as the spatial reference system to be used in drawing the map.

	The OGC WFS specification supports INSERT, UPDATE, DELETE, QUERY and DISCOVERY of geographic features. WFS delivers GML representations of simple geospatial features and other feature attributes in response to queries from HTTP clients. Clients access geographic feature data through WFS by submitting a request for just those features that are needed for an application.

5.7.1.2 Services within Spatial Data Infrastructures

Thanks to new legislation such as INSPIRE and several initiatives to (re)use geographical data more efficiently, the concept of Spatial Data Infrastructures (SDI) has gained more attention. Network services are seen as one of the core elements of SDIs and are paramount in fulfilling the target of interoperability and data distribution.

The conceptual organisation (i.e. the logical architecture) of the services within an SDI is still subject of discussion. Two major examples of possible architectures are the INSPIRE Network Services Architecture[52] drafted by The INSPIRE Network Services Drafting Team and the Web Service Architecture (WSA)[53] which is a standardised architecture for services on the Internet and is drafted by the W3C. Figure 5.7.1.2 provides an overview of the INSPIRE Network Services Architecture.

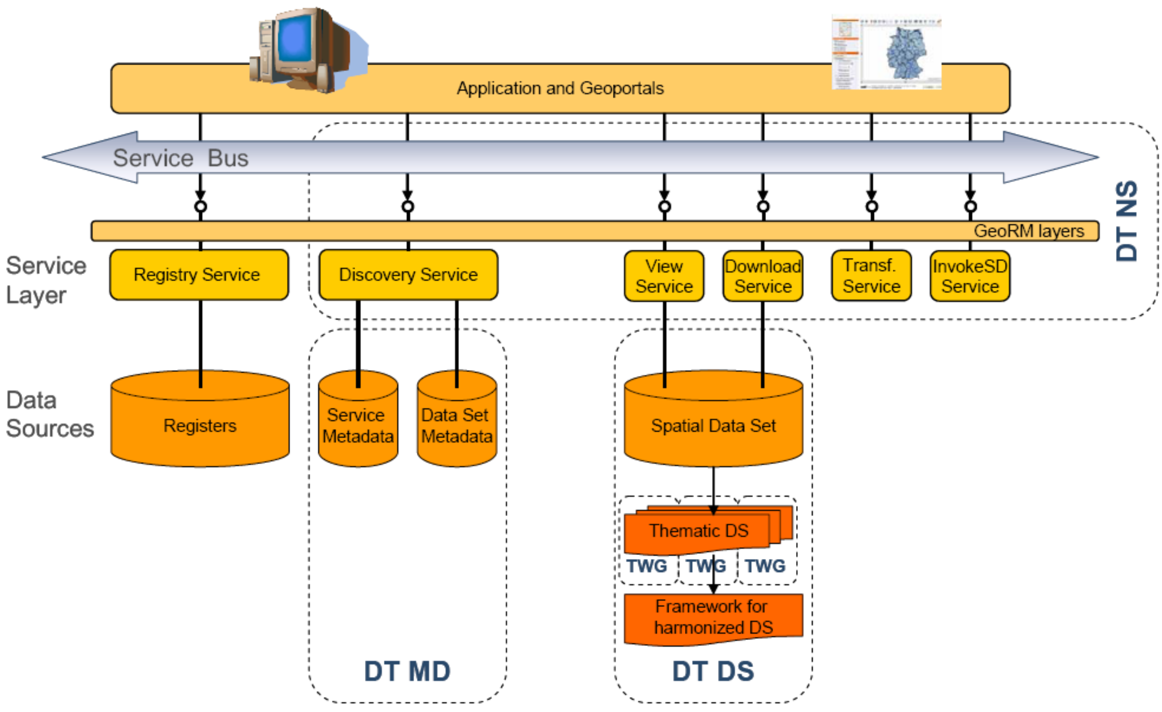


Figure 5.7.1.2 Overview of the INSPIRE Network Services Architecture

The INSPIRE Network Services Architecture aims at providing guidelines towards all initiatives in Europe that implement SDIs under the umbrella of the INSPIRE

[52] http://www.ec-gis.org/inspire/reports/ImplementingRules/network/D3%205_INSPIRE_NS_Architecture_v2.0.pdf
[53] http://www.w3.org/TR/2004/NOTE-ws-arch-20040211/

legislation and the related implementation of this European initiative by Member States.

The control of access from applications and GeoPortals to view and exploit spatial data services is, under the INSPIRE Network Services Architecture, performed through the Geo Rights Management layer (GeoRM), see Figure 5.7.1.2. The GeoRM should allow public authorities to electronically specify licence terms and conditions in such a way which supports the automated transfer of legal rights to use the spatial data or service, provide services to enable e-government integration of network services, manage authentication, authorisation, pricing, billing, logging, etc.

5.7.1.3 Software

OGC Web Services are to a varying degree supported by commercial as well as Open Source GIS packages. As software is constantly developing this guidance will not provide specific software recommendations, but rather point to the OpenGeospatial[54] website for the updated information.

5.7.2 Types of web services

Architecture of services ISO 19119 classifies the services as follows:

- Human interaction services (GIS clients, Geo Portals, catalogue clients, etc, also WS-BPEL viewers for workflow definition);
- Model/Information management services (management and access to data, WMS, WFS, CSW, etc);
- Workflow services (chain definition and enactment such as the WS-BPEL standard);
- Geo-processing services (spatial, thematic, temporal and metadata);
- Communication services (encoding and infrastructure, application servers and Enterprise Service Bus ESB).

The INSPIRE Network Services Architecture classifies the network services slightly differently and uses more a usage perspective.

The following services are defined in INSPIRE: (text taken from D3.5_INSPIRE_NS_Architecture_v2.0.pdf):

- **Discovery services:**

  Discovery services make it possible to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata. Within the geographic community various names have been assigned to instruments for discovering spatial data and services through the metadata properties; examples are Catalogue Services, Spatial Data Directory, Clearinghouse, Geographic Catalogue and Geodata Discovery Service. In INSPIRE these services are referred to as Discovery Services. The goal of discovery is to support discovery, evaluation and use of spatial data and services through their metadata properties. Metadata is the information

[54] http://www.opengeospatial.org/resource/products

and documentation, which makes these resources understandable and sharable for users over time. Indexed and searchable metadata provide a controlled vocabulary against which discovery can be performed. INSPIRE Discovery Services shall provide the functionality for users both to manage and search catalogues or the purpose of discovery and evaluation within the context of the INSPIRE Directive. The network of services should also include the technical possibility to enable public authorities to make their spatial datasets and services available. The INSPIRE Directive specifies that Member States shall ensure that public authorities are given the technical possibility to link their spatial datasets and services to the network. This 'linking' service is also offered in the context of a discovery service as a capability of the discovery service.

- **View services:**

  View services make it possible, as a minimum, to display, navigate, zoom in and out, pan or overlay viewable spatial data sets and to display legend information and any relevant content of metadata". Member States shall ensure that e-commerce and GeoRM services are available for view services if required.

- **Download services:**

  Download services will enable copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly. In addition, where public authorities levy charges for the download services, Member States shall ensure that e-commerce and GeoRM services are available.

  A download service supports:

  - Download of a complete dataset or datasets; or
  - A part of a dataset or datasets; and
  - Where, practicable, provide direct access to complete datasets or parts of datasets;
  - Gazetteer-like services are also covered by a type of download service.

- **Transformation services:**

  Transformation services, enable spatial datasets to be transformed with a view to achieving interoperability.

- **Invoke spatial data services:**

  The Invoke Spatial Data Service allows the definition of both the data inputs and data outputs expected by the spatial service and define a workflow or service chain combining multiple services. It also allows for the definition of the external web service interface of the workflow or service chain.

Guidance from INSPIRE

The INSPIRE roadmap[55] foresees the development and implementation of INSPIRE Implementing Rules (IR) for each of the service types. The timeline for services is

[55] http://www.ec-gis.org/inspire/inspire_roadmap.cfm

outlined in Table 5.7.2. Based on the roadmap it is anticipated that more specific guidelines in relation to WISE nodes will be provided in later amendments to this guidance document. It should be noted that the INSPIRE IR will not prescribe a specific service implementation (e.g. WFS) but rather specify the interfaces requested from the various types of INSPIRE services.

Table 5.7.2 INSPIRE Implementing Rules (IR)

Milestone date	Description
IR adoption	
2008-11-15	Submission for opinion of the INSPIRE committee of IR for discovery and view services
2009-05-15	Submission for opinion of the INSPIRE committee of IR for download services
2009-05-15	Submission for opinion of the INSPIRE committee of IR for coordinates transformation service
2010-05-15	Submission for opinion of the INSPIRE committee of IR for schema transformation and "invoke spatial data service" services
IR implementation	
2010-11-15	Discovery and view services operational
2011-05-15	Download and Coordinates transformation services operational
2012-11-15	Schema transformation and "invoke spatial data service" services operational

5.7.3 How web services will expand the WISE coverage

5.7.3.1 WISE distributed system

Since January 2008 discussions have started to establish an architecture for the WISE distributed system (WISEds). The WISEds is based on GIS web services and will allow the WISE community to work according the INSPIRE regulations.

To understand the use of web services in WISE one has to differentiate between a REPORTING and a DISSEMINATION flow;

- REPORTING will be defined as the data flow from Member States to the European commission;

- DISSEMINATION will be defined as the data flow out from the WISE database.

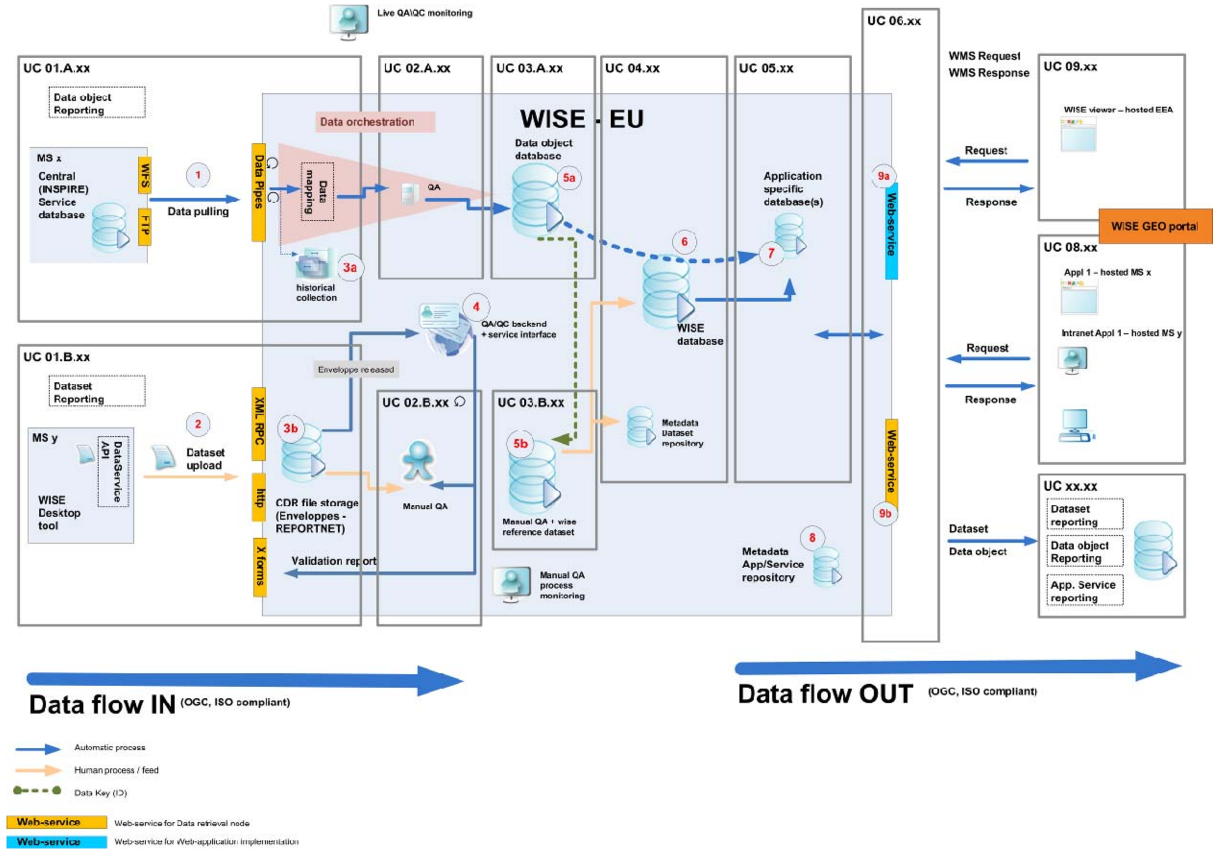


Figure 5.7.3.1 Overview of WISE distributed system

5.7.3.2 REPORTING data flow

Figure 5.7.3.2 illustrates how four types of REPORTING data flow can be distinguished based on the amount of data and the transaction frequency.

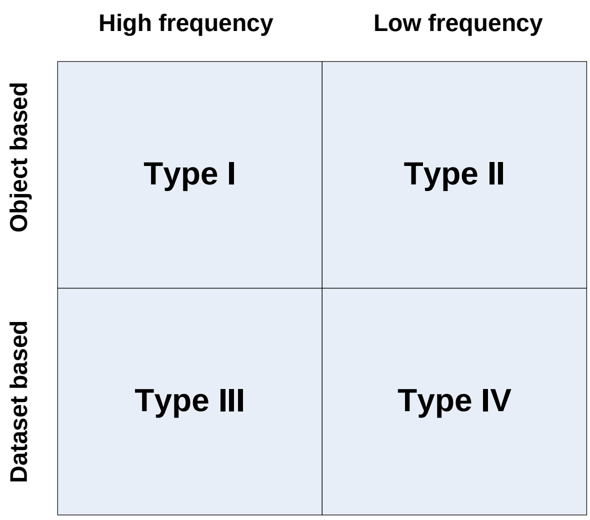


Figure 5.7.3.2 Data reporting types

At present WISE is almost only using Type IV data flows organised through a file based exchange mechanism (Reportnet). This type of communication will continue to exist in the future. However the introduction of GIS web services into WISE aims at opening the REPORTING data flow towards all other types and to introduce new possibilities for Type IV. Typical usage of each type are:

- Type I: This type of communication could occur when a Member State reports any change they make in their database related to WISE data. It means that every transaction in the central database of the Member States is directly pushed to the WISE distributed system. Each transaction might have a single object (record) or a limited list of objects. It also should be related to datasets that are changing frequently, such as weekly bathing water quality measurements;
- Type II: A typical data flow could be the update of a River Basin District. A single object is reported but most likely a Member State is not updating its River Basin Districts every month;
- Type III: This is a less common type but could be used to exchange, for example, aggregated datasets;
- Type IV: Some Member States might have revised the complete dataset of their rivers (new surveys). In this case the Member State reports a complete dataset on a certain topic. Based on WFS and GML based SOAP services upload mechanisms could be foreseen to handle this type of input data.

How these new types of data flow will be implemented is still subject of discussion as it relies on the implementation rules of INSPIRE, which are still being drafted, and several stakeholders are involved with the set-up of the infrastructure which requires strong coordination and consultancy.

5.7.3.3 DISSEMINATE data flow

The DISSEMINATE data flow will be used to disseminate the data that has been collected and processed under the reporting obligations covered by WISE. The flow is the machine-to-machine complement to the human interfaces of the WISE map viewer and will distribute all WISE data with a public access license.

The Member States can expect download, view, discovery etc services from the WISE output service node. The detailed specifications of each service will be defined based on:

- Current services provided by the WISE website;
- New user requirements;
- SEIS implementing rules (when available).

Member States that have the interest or capability may integrate the WISE web services directly into their own applications.

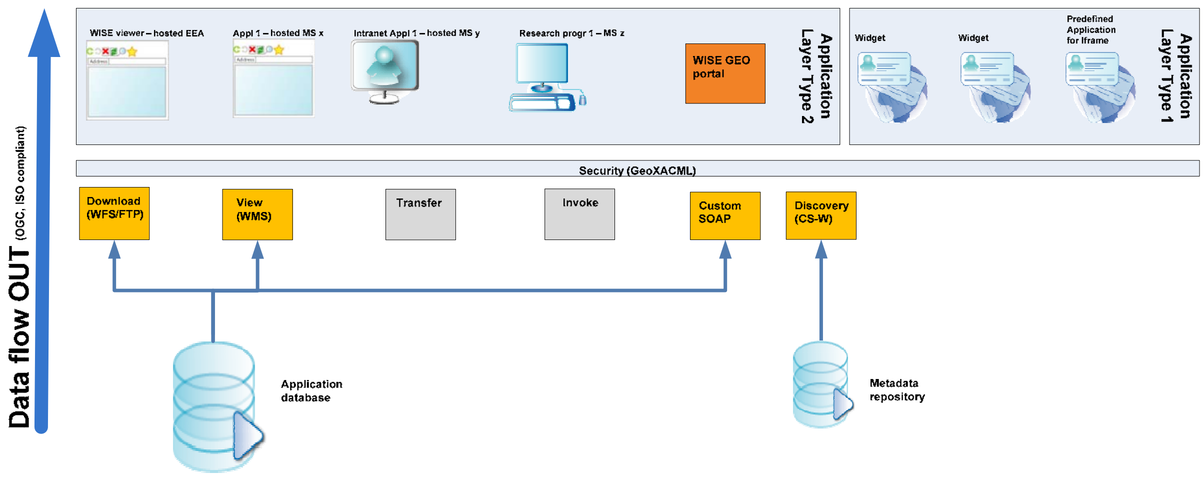


Figure 5.7.3.3 DISSEMINATE Data Flow

5.7.3.4 Role of MS provided web services

WISE compliant web services provided by the Member States will complement the WISE map viewer in several ways:

- Web services with data according to common WISE specifications will provide access to up-to-date information operationally in use in the Member States;
- National web services with data outside the scope of WISE specifications can extend the information available to the European users in two dimensions:
    - The granularity of information may be expanded, so the full set of information available at the Member State level may be exploited rather than a potentially sub-selected and aggregated set reported. The WISE map viewer currently operates with a threshold of scale 1:250,000 when providing web map services. Data with a better resolution should be provided and visualised by connection to national SDI nodes;
    - Feature types and parameters outside the WISE data specifications may be made available outside the Member State. These parameters and features could, for example, relate to the locally relevant pressures, monitoring data, potential measures or socio-economic conditions.

5.7.4 Recommendations for the set up of WISE compliant nodes

Member States that wish to extend the WISE coverage with national web services are encouraged to do so. While INSPIRE IR are not yet in place some recommendations can be given for implementation in the short term, as follows:

Software:

- WMS services should be implemented using SLD compliant software to allow a common (client specified) symbology to be applied.

Services to be provided:

- It is recommended that the data provision services as WFS, WMS and download services are established (see also data policy below);
- The services should be provided using the application schemas developed in WISE;
- Services outside the scope of WISE should be documented in English;
- Metadata services should be available from WISE and from the Member States;
- Service registry will be available from WISE.

Data policy:

- Provision of a spatial dataset specified as Member State submissions under European legislation should always be provided as free and open WFS and be downloadable;
- National spatial data established in relation to the implementation of water environmental policies should, as much as possible, be provided as free and open WFS and download services alternatively as WMS services.

A manual on the set-up of a WISE service node will be drafted once the architecture of the WISE distributed system is defined in detail and has been tested for robustness, scalability and performance.

6 Harmonisation

6.1 Validation and harmonisation of geometry, data definitions, data models, naming

Given that WISE is aimed at multiple use of the information reported from MS, the importance of harmonising has increased. The target of having comparable quality in data submissions from MS for assessment of compliance as well as the basis for developing reference datasets at the European level requires a common understanding of the harmonisation and validation procedures required.

Harmonisation of the national submissions has so far been one of the most resource consuming tasks at European level.

6.1.1 The purpose of harmonisation and validation of MS data

There are several reasons for harmonising MS data into common European data specifications:

- By conforming to European specifications the MS ensure that the provided data comply with the requirements given by the directives and other requests calling for the data;
- The Commission can streamline their evaluation of MS compliance with a directive when the input data conform to a common set of specifications;
- The Commission can streamline the process of producing and updating the pan-European WISE Reference GIS datasets from the MS submitted data;
- A streamlined process is particularly important when datasets are being updated or resubmitted;
- Harmonised data is a requirement for comparable analysis, reporting and visualisation of the European state of implementation of directives and state of the environment reporting;
- Working with harmonised datasets reduces the risk of misinterpretation as the harmonisation process ideally eliminates the national differences in data structures, encoding data schemas and level of detail.

Harmonisation starts at the MS/RBD level, where the primary information is available. A part of the harmonisation may take place at either MS level or EC level. The validation of data submitted by the Member States is the first step of the verification that the MS are fulfilling the requirements of reporting specified in the directives in question. Secondly, a data quality assessment to ensure that the data are of sufficient quality for further application has to be made. Finally, a single harmonised feature dataset can only be produced at the European level. Figure 6.1.2 depicts where the various processes takes place.

6.1.2 Harmonising MS data for submission to WISE

Harmonisation of data in the Member States prior to submission into WISE is the most crucial part of the harmonisation process. As the data specifications from the implementing rules of the INSPIRE Directive have not yet been implemented, the data collections at MS level will be of varying structure, thematic content and quality.

The starting point is the selection of a spatial dataset covering the proper spatial object type (monitoring stations, river segments etc.) and having a resolution complying with the data specification.

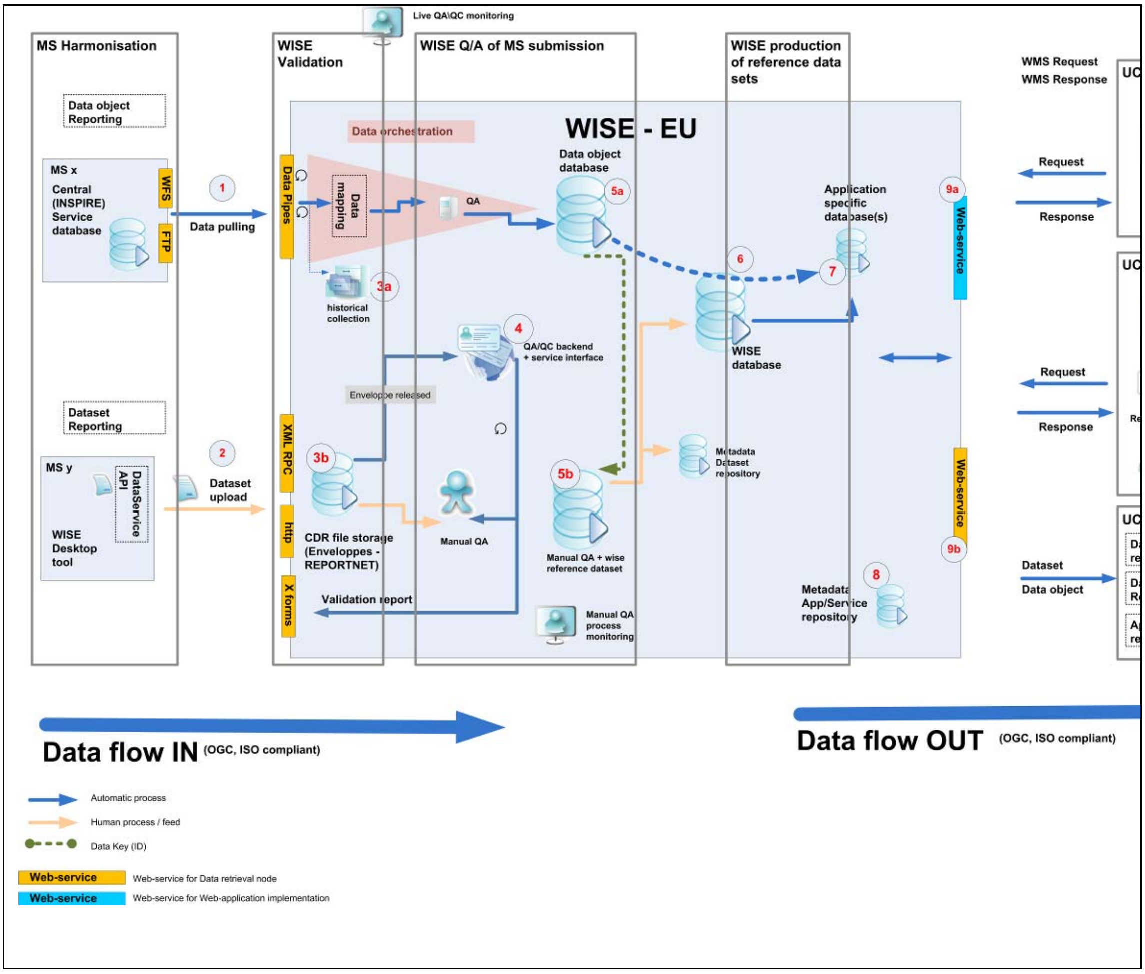


Figure 6.1.2 Harmonisation and validation processes in the WISE architecture. (Detailed explanation in the WISE architecture document available from https://svn.eionet.europa.eu/projects/Reportnet/wiki/WiseDS)

Member States have, in many cases, several spatial datasets with the proper object type. The dataset to be used will be selected on criteria such as:

- Having a level of detail and resolution similar to or better than requested;
- Being up-to-date;
- Having an operational use in the relevant national implementing authorities;
- Having features attributes that either contain similar feature attributes as specified or can, through feature identifiers, be linked to such information.

Spatial reference system transformation:

MS should deliver the spatial dataset in the agreed coordinate reference system (see Chapter 5.1.3) using ETRS89 as the geodetic datum and using ellipsoidal coordinates (decimal degrees).

As experience has shown that the transformation formulae from the national coordinate reference system to the ETRS89 system in some areas are less accurate, it is recommended to validate the transformation using e.g. boundary data from the EuroRegionalMap. The feature harmonisation with neighbouring regions/countries may also be used as a part of this validation.

Feature harmonisation:

Harmonisation of features to the data specifications has two main elements:

Harmonisation of features with neighbouring regions and countries:

The RBDs and MS are expected to deliver data that has been harmonised with the neighbouring countries/RBDs. Experience still has to be gained to identify the usage of River Convention data. Appendix B of the INSPIRE document D2.6 Methodology for the development of Data specifications, provides recommendations regarding harmonisation of continuity of linear and polygon features across borders.

Member States will report spatial datasets to EU bodies under various articles of the WFD. These datasets come from national repositories which are not necessarily geometrically aligned across national borders or to a pan-European coastline. To connect borders of River Basin Districts or rivers across national borders, one option for Member States will be to align their data with a selection of EuroRegionalMap at scale 1:250 000. This data selection essentially comprises the national borders, the coastline and hydrological features that cut across national borders. Member States will be able to download these data sets free of charge from a dedicated section of WISE provided they do not use these data for any other purpose. Download will be restricted to authorised persons in the water authorities.

As recommended in Chapter 5.1.3.3. Member States need not to simplify their datasets before submitting to WISE. Thus, if agreed within the respective RBD, also larger scale data can be used for the geometrically alignment across national borders. EU bodies will align these submissions to EuroRegionalMap.

Feature attribute harmonisation (schema transformation)

The feature attribute names and associated code lists in the national databases will rarely be the same as specified in the WISE application schema. The harmonisation will require a transformation of the national database schema into the application schema and similarly a transformation of the feature attribute values to fit into the code lists of both the data model and the data dictionary. The XML schemas and end-user tools support the correct feature attribute transformation by applying code lists and schemas.

Format transformation:

The GIS data and the associated feature attributes should be converted to either shape files or GML according to the Data Structure schema specified for the specific reporting obligation. More details on GML may be found in Chapter 5.6.

File naming:

Applying common file naming conventions helps streamlining the validation process when data is received into the WISE system. The file naming include the following elements:

- Country ID;
- River Basin District ID;
- Feature set name;
- Date.

Specific guidelines for the naming of files will be included in short GIS reporting guidelines for each reporting obligation.

6.1.3 WISE validation of MS submissions

The validation of a MS submission ideally takes place immediately after the upload of data. The validation process is a set of technical tests to check whether or not data conform to the data specifications.

Validation steps:

- Does submission include the expected files?
    - Is the naming of files in line with the specifications?
    - If the submission is split into more than one region – are all regions provided?
    - If the submission is split into several themes – are all themes provided?
- Is each set of files complete and in conformance with the specifications?
- Within each set of files:
    - Is the type and format of files correct?
    - If the delivery is in XML:
        - Can the file be validated against the defined application schema?
- Metadata:
    - Do the referenced data sets exist in WISE?
- Spatial coverage:
    - Is the spatial reference system documented and in conformance with the data product specifications?
    - Does the provided spatial data set have the expected coverage (MS, River Basin District, Sub-unit etc.)?
    - EuroRegionalMap should be applied to verify that:
        - all features fall inside the proper territory (evaluated within the tolerance of the spatial accuracy)

        - that features with continuity into neighbouring countries have an end-point on the border (evaluated within the tolerance of the spatial accuracy).

- Feature attributes (If the delivery is in non-XML format):
    - Have the right feature attribute names been defined?
    - Are mandatory feature attributes given valid information?
    - Are attribute values, including size, within the specified domain?
- Feature associations:
    - Do features that are referenced to through matching feature IDs exist (previous deliveries or other feature data set in same submission)?
    - Is there consistency between the feature extent and the position/extent of the referenced features (e.g. is a monitoring station situated inside the RBD it belongs to)?
- Topological relations:
    - Does the coverage fulfil the topological rules defined for the feature data set – e.g. no gaps and no overlaps between features, connected features etc?

Determining data quality:

The spatial data submitted by the MS should in general comply with:

- Fitness for use. The data submitted by the MS should fit the requirements expressed in the Reporting sheets (to be replaced by the Consolidated Guidance on Reporting) and data specifications;
- Customer satisfaction (in close relationship with the previous point). The final layer should satisfy the expectations of the MS with regards to the WISE reference layers;
- Conformance to requirements, standards and expectations.

After the MS submission, it is a requirement to have a clear assessment of:

- Completeness (contains no missing features or values);
- Consistency;
- Accuracy (closeness to reality);
- Resolution.

Discovering errors:

Two forms of analysis should be undertaken:

- Exploratory – look for the unusual;
    - Visual checks: completeness, positional accuracy, etc.;
        - Verify: spatial reference, scale, resolution, positional accuracy, existence of metadata (following standards), completeness of the metadata, etc.

- Confirmatory – verify rules and criteria have been met;
    - o Automated checks: To discover geometry/topology/attribute errors, supported by the use of GIS tools.

6.1.4 Harmonisation at European level:

Harmonisation at the European level has the purpose of producing a single feature dataset of homogenous quality according to an application schema. If the European dataset is to be produced with the same specifications as MS deliveries, the process is ideally a simple merge of national submissions that only should consider duplicated features forming the borders between MS.

A few manual checks may however be applied, if they are not already integrated as a part of the validation process:

- Does the variation in the density of features across each Sub-unit, RBD, MS and Europe as a whole reflect the expected variation or have e.g. the data-capturing rules been applied differently?
- Is there continuity of matching features of same object meeting at the border (rivers or lake borders)?
- Where the border is formed by a feature (river or lake) there is a risk of duplication:
    - o Do they share same geometry, can one geometry be substituted by the other or should they be dissolved into a single geometry?
    - o Transmission of feature attribute values from both countries to a harmonised feature.

6.2 Production of the WISE Reference GIS datasets

The WISE Reference GIS datasets are managed and maintained by the EEA and have been compiled from data provided by Member States under WFD Articles 3 and 5, or, in the case of Sub-units, at the request of the European Commission.

Some additional processing is applied to the data provided by the Member States, where necessary, in order to produce the WISE Reference GIS datasets, including:

- The harmonisation of ‘duplicate’ features and geometrical inconsistencies at national borders using EGM (up to 20% of the features[56]) or ERM (up to 10% of the features;
- Complementation of geometries using ERM data where data provided by MS do not fulfil the WISE Reference GIS dataset specification;
- The selection of rivers with specific catchment areas from submitted data using CCM2.1 or the EEA’s European River Catchments (external GIS datasets);

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[56] Due to copyright restrictions, Eurogeographics allows for public distribution of parts of EGM and ERM (20% and 10% of features, respectively). If a larger share of the features in a feature class is used the resulting dataset cannot be publicly distributed.

- The application of consistent and stable hydrological codes to features in order to successfully manage the linkages between WISE Reference GIS datasets.

Many Member States are already involved in bilateral co-operation agreements with, for example, International River Commissions, in an effort to harmonise their data and resolve geometrical inconsistencies at national borders. Data resulting from these important agreements will be beneficial for the production of WISE Reference GIS datasets and MS are encouraged to document/identify when the submitted data are outcomes of such agreements.

The European Commission is in the process of reviewing the WFD Articles 3, 5 and 13 Reporting sheets with the aim of producing a consolidated Guidance on Reporting in time for the reporting of RBMPs under Article 13. This may require Article 3 and 5 data resubmissions from MS where there were gaps in the original submissions or where details have changed. The aim is to produce a more efficient and streamlined reporting system through WISE in the future.

In the following Chapters, the processing of WISE Main Rivers and Main Lakes are provided as examples.

6.2.1 Approach for the processing of the WISE Main Lakes and Main Rivers layers

6.2.1.1 Main Lakes:

The development of the Main Lakes layer for WISE is based on the objects reported by the Member States under WFD Articles 3 and 5 complemented with data from ERM (EuroRegionalMap v2.0).

Two main issues are related to the processing of WFD Articles 3 and 5 data into the WISE Main Lakes dataset:

- The size criterion for WFD Article 3 Main Lakes is different from the WISE Main Lake specification (lake surface area of 100 km^2 versus 10 km^2).
- Lake Water Bodies reported in WFD Article 5 may be reported as centroids instead of polygons. Furthermore, does the definition of a Lake Water Body allow for the option that a) a lake may be divided into more than one Lake Water Body and b) a Lake Water Body may consist of more than one lake.

Since the WFD Articles 3 and 5 data are not in all cases sufficient to build the polygon layer of WISE Main Lakes, an additional layer has been taken into account. The ERM (EuroRegionalMap[57] v2.0 - feature class LakesresA) was selected as that additional layer.

The main objective for the production of the WISE Main Lakes layer is a good set of geometries representing the lakes submitted by Member States under Articles 3 and 5. As the same lake might be represented differently in the input layers a list of priorities has been established:

- First priority - WFD Article 3 Main lakes;
- Second priority – WFD Article 5 Lake Water Bodies;

[57] http://www.eurogeographics.org/eng/04_products_regionalmap.asp

- Third priority – ERM, feature class LakesresA.

The main principle has been that if a lake with a surface area above 10 km^2 has not been delivered as a polygon feature under either WFD Articles 3 or 5 then the proper geometry has been selected from ERM using WFD Article 5 centroids. The workflow of the processing the geometries of the features is summarised in Figure 6.2.1.1.

The results of processing the WISE Main Lakes layer were:

- Total number of lakes based on Articles 3 and 5 submissions: 9822 lakes;
- Main Lakes (Area ≥ 10km2): 856 lakes, where:
    - o 576 geometries (67.3%) originate from Articles 3 and 5;
    - o 280 geometries (32.7%) originate from ERM.

More information about the input layers, GIS processes applied and the methodology will be made available from the WISE web site.

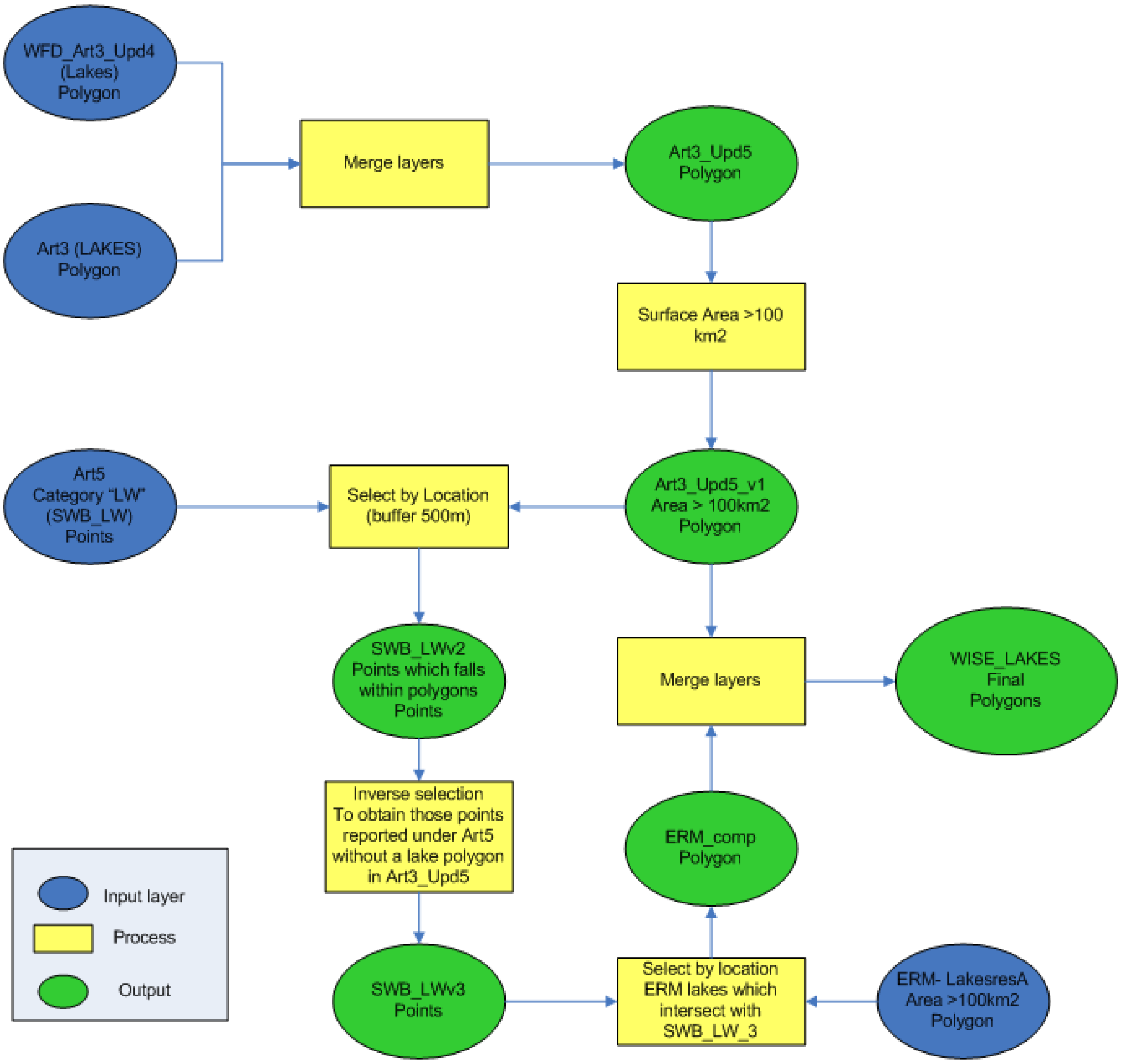

Figure 6.2.1.1 GIS workflow for the construction of the Main Lakes layer based on Articles 3 and 5 submissions and ERM v2.0. Lakes with an area equal or larger than 10 km2 are considered to be Main Lakes.

6.2.1.2 Main Rivers

As for lakes, the development of the Main Rivers layer for WISE is based on the objects reported by the Member States under WFD Articles 3 and 5, complemented with data from ERM (EuroRegionalMap v2.0). Catchments from CCM2.1 are used to ensure a consistent data capture criteria throughout Europe.

A number of issues are related to the processing of WFD Art. 3 and Art 5 data into the WISE Main Rivers dataset:

- Although the WFD Article 3 Main Rivers and the WISE Main Rivers have the same catchment size criterion (catchments > 500 km^2) an overview of the submitted data show differences;
- River Water Bodies reported in WFD Article 5 may be reported as centroids instead of polylines. Furthermore does the definition of a River Water Body allow for the option that:
  - a river/ river segment is divided into more than one River Water Body and;
  - a River Water Body may consist of set of rivers/river segments.
- As WFD Article 5 data consists of water bodies for evaluation of ecological status, continuity through lakes and heavily modified stretches is not ensured.

Analysis of the data submitted by the Member States revealed several problems, basically due to quality aspects, completeness, geometry consistency, connectivity, attributes, etc. More information about the input layers, error analysis, GIS processes applied and the methodology will be made available from the WISE web site.

Since the WFD Articles 3 and 5 data are not in all cases sufficient to build the WISE Main Rivers layer with a connected set of rivers for all rivers with a catchment area above 500 km^2, a complementary layer, ERM (EuroRegionalMap v2.0 (feature class WaterCourses) has been selected.

The input GIS layers used for the analysis and for the development of the methodology are:

- Article 3 submissions (and its update) line feature classes;
- Article 5 submission (point and line type geometries);
- ERM v2.0 (WaterCourses) as complementary source of features.

The main objective for the production of the WISE Main Rivers layer is a good set of geometries representing the rivers submitted by Member States under Article 3 and Article 5. As the same river might be represented differently in the input layers a list of priorities has been established:

- First priority - WFD Article 3 Main Rivers;
- Second priority – WFD Article 5 River Water Bodies;
- Third priority – ERM, feature class WaterCourses.

The main principle has been if the Main River in a catchment with an area greater than 500 km^2 has not been delivered as a polyline feature under WFD Articles 3 or 5 then the proper geometry has been selected from ERM using WFD Article 5 centroids. In the future, Member States may provide features that may supersede the ERM features.

If the aggregation of the geometries of the selected Articles 3 or 5 data do not result in a continuous geometry, complementary data are obtained from the ERM data. If neither river segments nor water body centroids are present for a CCM2.1 catchment with an area greater than 500 km^2, ERM data are also used.

6.3 WISE reference features for visualisation

6.3.1 Purpose of WISE reference features for visualisation

WISE reference features for visualisation are features such as River Basin Districts or water bodies available in a European wide topological harmonised dataset (WISE Reference GIS dataset). They will be used to:

- Visualise data reported by Member States in a harmonised way;
- Provide comparable units for data analysis and the development of indicators.

WISE reference features can also be used to link tabular reported data and information to GIS data that is already available in WISE. The reference established between WISE reference features and Member State reported data will be either:

- The reference between different features based on a specified relationship (e.g. Member States reported river monitoring stations to WISE reference river water bodies); or
- The reference between the same entities:
    - o Either between Member States reported not harmonised GIS data and harmonised WISE GIS datasets (Member States River Basin Districts to WISE River Basin Districts); or
    - o Between Member States reported tabular information and harmonised WISE features (e.g. status information on Groundwater bodies to WISE Reference Groundwater bodies; data reported for WISE-SoE monitoring stations to already reported WFD (Article 8) monitoring stations).

The reference will be done by means of a database. Spatial overlay of geographical datasets to link and analyse data will not always give the required results because of different data quality, level of detail and positional accuracy. Furthermore, problems might occur in handling of coordinates, reference systems and projections as well as during transformation of data. The exercise to locate WISE-SoE river monitoring stations to a European wide river dataset proved to be very troublesome. River monitoring stations are quite often located near the mouth of a river. To receive the correct location at the river overlaying point information (which is most of the time quite accurate) with a river dataset in the scale of 1:250.000 or even smaller will fail in many cases. Thus it will be necessary to refer monitoring stations to rivers in the dataset itself (attribute).

Relationships as regards case (a) mentioned above need to be defined in the data model. As regards case (b); Member States reported data should also include the identifier of the WISE objects as attribute (foreign key) either in the GIS dataset or in the table (e.g. Member States River Basin District (RBD) code and WISE RBD code).

Visualisation:

Data reported by Member States to WISE can be visualised either by:

- Displaying the Member States data regardless of whether data have been harmonized with neighboring countries or not, and regardless of whether or not data specifications developed for specific reporting have been taken into consideration (in this case Member States data will be marked accordingly);or

- Displaying the reference features and the harmonised data linked to them.

Example: Visualisation of river water bodies

In WFD Article 5 reporting, Member States were requested to provide information on the centroids of all water bodies. During this exercise, some Member States also provided information on river stretches. This has resulted in a variety of non-homogeneous information being provided (see Figure 6.3.1a): centroids-only, centroids & river network, and centroids and river stretches.

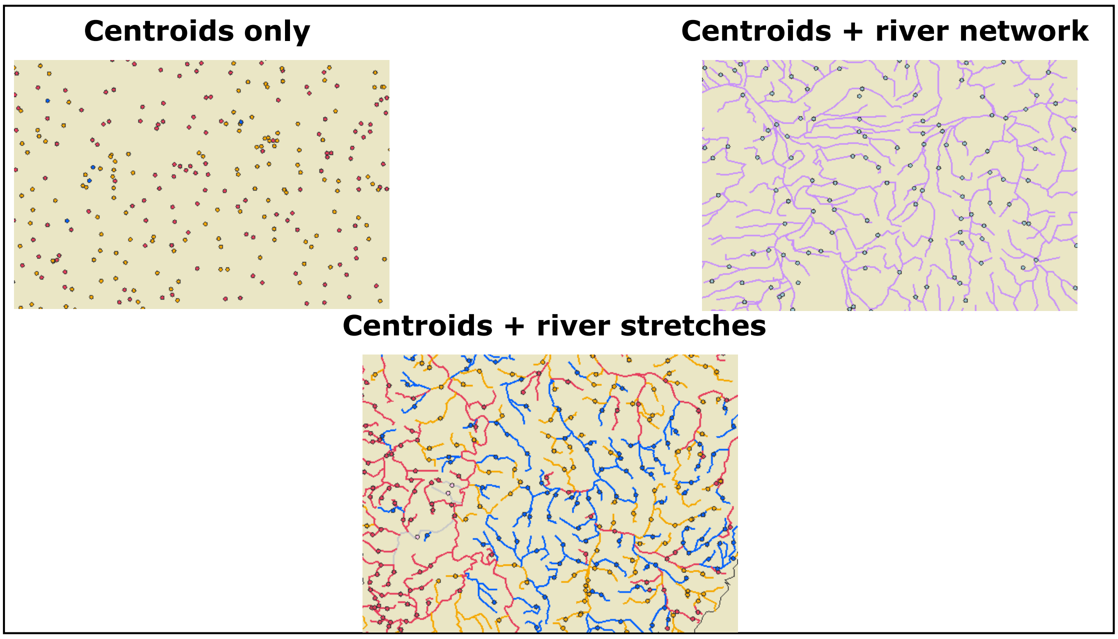

Figure 6.3.1a Information provided by Member States for visualisation of water bodies (WFD Art. 5 2005 submission)

Furthermore, Member States have used different methods to calculate the centroids of water bodies (see Figure 6.3.1b).

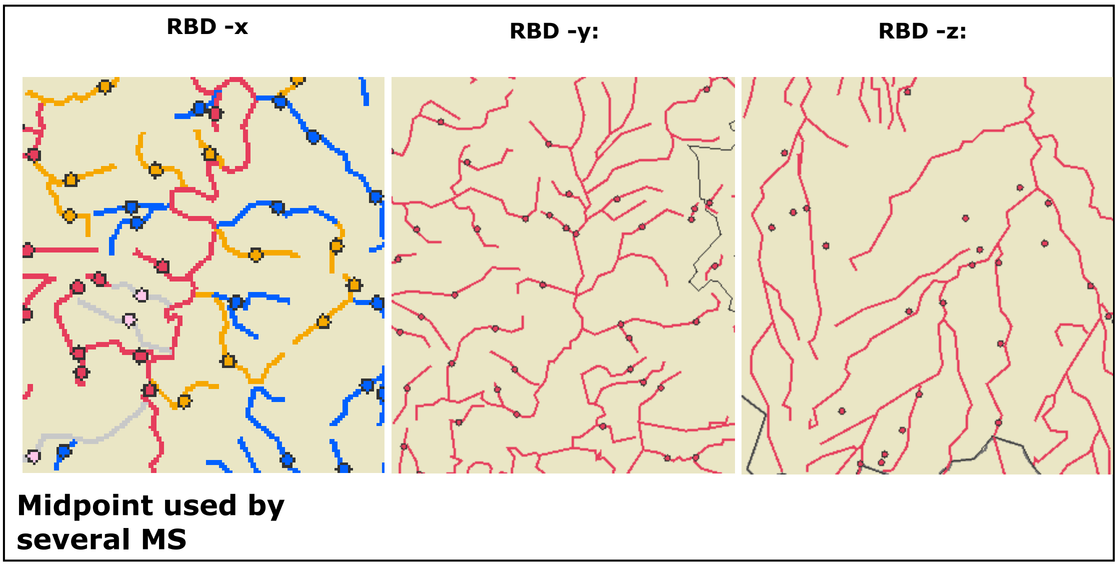

Figure 6.3.1b Representation of water body centroids provided by MS (WFD Art. 5 2005 submission)

This has resulted in an heterogeneous EU-wide dataset on 'water bodies'. To solve these problems it has been proposed to visualise river water bodies based on the WISE Reference GIS dataset Main Rivers. River water bodies located on Main Rivers should now be reported as hydrologically connected and harmonised river stretches (line features).[58] Thus a harmonised visualisation of reported data on river water bodies will be achieved in future.

Analysis:

Data and information reported to WISE will be used to present an EU-wide picture of water- related issues. The detailed information provided by Member States will be aggregated and visualised using meaningful spatial units at a European scale. To meet these demands, WISE reference features allowing comparable statistics and the development of indicators, have been defined (see Chapter 5.2).

As regards statistics, WISE reference features will be:

- Meaningful units to present information at a European scale (in relation to the aspired visualisation scale);
- Comparable depending on the specified statistical analysis and assessments.

Thus the definition of WISE reference features will also accommodate the purpose of use (e.g. compliance check; indicator development) and the required statistical analysis into consideration.

Example: River Basin Districts – Sub-units

Reporting under WFD is related to River Basin Districts. There was a general agreement that the portrayal of information at RBD scale is of value given the breadth of information associated with it. However, it was concluded that the use of the RBD scale alone could distort the comparison of data between Member States, due to the existence of a few RBD’s that are much larger than the rest (see Figure 6.3.1c).

There was agreement between the EC and Member States of the need to subdivide the larger RBDs to provide Sub-units of more similar size for better comparable analysis. A WISE reference GIS dataset of Sub-units will be developed (see Chapter 3.1) and in future, in addition to RBDs, data reported under the WFD should also be linked to Sub-units.

[58] Presentation at WISE conference on 22-23 March 2007: http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/european_conference/presentations_speeches/part_4_23_march/deugenio-pdfpdf/_EN_1.0_&a=d

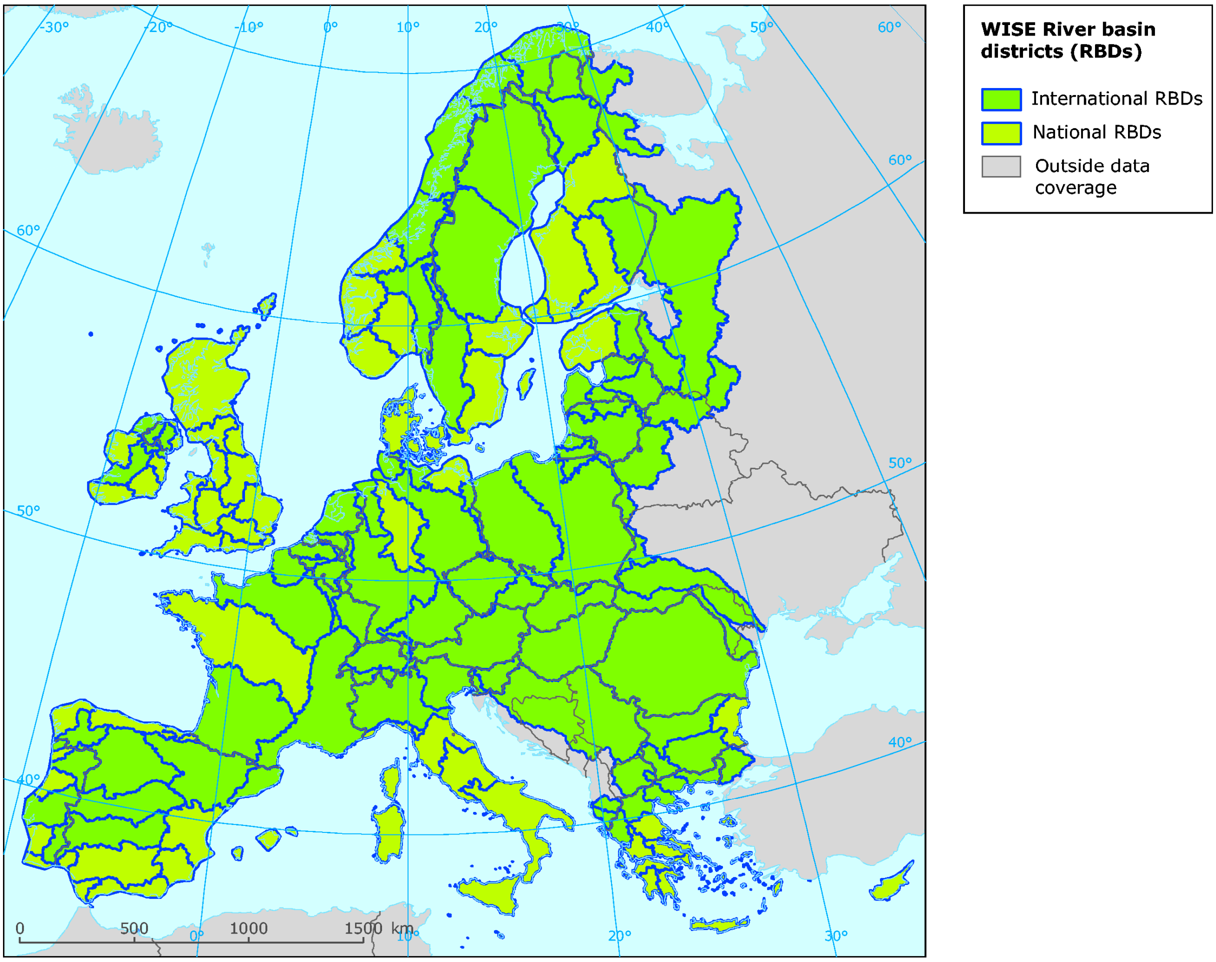

Figure 6.3.1c River Basin Districts[59] of the EU

6.3.2 Issues associated with WISE reference features

The main criterion for the use of reference features will be that they **should be built from Member States submitted data** to be able to visualise reported data correctly. Furthermore the positional accuracy and level of detail of the reference dataset should be in line with the required visualisation scale (for more details see Chapter 5.1.3).

If data provided by Member States are generalised to build reference features, the outcome of the generalisation must be validated by the data provider. This needs to be done to ensure the correct linkage between Member States data and reference features.

The guidelines for the development and use of reference features for visualisation are:

- **Definition of data use;**
  - Specification of the required visualisation of the data;
  - Specification of the required data analysis and/or indicator development.
- Specification of the **relationships between reference features and Member States reported datasets and objects**, needed to fulfill the intended use of data.

[59] http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3687

To define correct relationships, data specifications, especially data capturing rules (see Chapter 5.1), of provided data must be analysed. Relationships defined will also depend on the intended use of data (data analysis, indicator development).

For Example:

- All WFD reported information or datasets are linked to River Basin Districts/Sub-units;
- River monitoring stations are linked to river water bodies;
- River water bodies are linked to rivers.

  The above given relationship must be specified further before it can be transferred to a data model. In most cases, the relationship will be n:m (a river water body can be located at several rivers; a river will be composed of several water bodies). But this will only be true if river water bodies have been defined as river stretches (reaching from river km A to river km B). If they have been defined as polygons (catchments) the relationship could be different.

  Thus data capturing rules of river water bodies within Member States need to be analysed to be able to define the correct relationship between rivers and river water bodies.

- Development of **data models** supporting the specified relationships:
  - WFD objects reported should carry the WISE RBD code as foreign key;
  - River monitoring stations should carry the WISE river water body code as foreign key;
  - River monitoring stations located at Main Rivers should carry the hydrological code of the main river and the hydrological code of the river segment as foreign key;
  - **Unique identifier must be available for all relevant objects** (Member States data and reference features) and requirements given in Chapter 4.4 for identifier management must be taken into account (uniqueness, persistence). Furthermore to allow a persistent reference over time, rules for historic data management should be specified.

A description of the relevant WISE reference features and reference datasets (data specification, metadata) including the necessary details as mentioned above will be available in WISE.

6.3.3 Examples of WISE reference features for visualisation

Proposed WISE reference GIS datasets related to WFD reporting are described in Chapter 3.1 and an overview of the GIS layers in WISE is given in Chapter 5.2. In the following, text, some examples of reference features and their use will be provided. In future, further WISE Reference GIS datasets and reference features might be identified.

Main Rivers & Main Lakes:

The WISE Reference GIS dataset Main Rivers and Main Lakes contains rivers that have a catchment area > 500 km^2 and lakes that have a surface area ≥ 10 km^2. They are based on WFD Article 3, Article 5 submissions and when needed ERM (EuroRegionalMap) will been used to complement the layer. For more details about the datasets see Chapter 6.2. ERM data will be replaced by Member State data as soon as they become available.

Main Rivers and Main Lakes will be reference features for objects related to surface waters such as monitoring stations, bathing waters, waste water treatment plants. If desired, statistical analysis such as "number of river monitoring stations on a certain river" can be carried out.

The datasets will be related to the reference datasets on Surface Water Bodies on Main Rivers and Main Lakes (see below). Only surface water bodies located on Main Rivers will be visualised as river network in WISE.

Surface Water Bodies on Main Rivers & Main Lakes:

Surface water bodies on Main Rivers and Main Lakes will be the reference features to visualise surface water bodies reported by Member States as a connected river network (line feature) and lakes (polygon feature). They will be based on WFD Article 5 submissions of surface water bodies. A precondition to build this dataset will be that Member States report surface water bodies in future as line and polygon features and not as centroids (points) for this reference dataset. Furthermore the selection of the surface water bodies should be based on the rivers and lakes available in the WISE Reference GIS dataset "Main Rivers & Main Lakes".

The reference features will be used to visualise information related to water bodies that are located at Main Rivers and Main Lakes like status information or heavily modified and artificial water bodies.

Furthermore, objects related to surface water bodies on Main Rivers and Main Lakes such as monitoring stations, bathing waters, waste water treatment plants can be visualised and analysed.

Groundwater Bodies:

The reference features Groundwater bodies will be based on WFD Article 5 submissions of Groundwater bodies. Groundwater bodies are transnational features and can also cross borders of River Basin Districts. Thus a harmonised European dataset will be developed including a unique European identifier.

River Basin Districts:

The reference feature River Basin Districts is based on the Member State submission under WFD Article 3. The data have been merged and harmonised to a European wide dataset. RBDs can be transnational features (international RBDs), thus a European unique identifier will be developed (see Chapter 5.4).

All data and information reported under the WFD is related to RBD. Thus RBD will be the main unit to analyse and visualise WFD data at the European scale. However, the issue of Sub-units needs to be considered.

Sub-units:

River Basin Districts are quite different in size. A few RBDs are much larger than the rest. Therefore it was agreed between EC and Member States to subdivide the larger RBDs to provide Europe-wide Sub-units of more comparable size which would be better suited for comparative analysis. It was agreed that the Sub-units should fall within national boundaries and be of a size between 5,000 and 50,000 km^2. This lower size limit does not mean that declared RBDs that are of a size less than 5,000 km^2 need to be redefined. Where RBDs exceed the threshold, the sub-basins or other suitable hydrological areas within the RBD could be defined as Sub-units.

In future, all data and information reported under the WFD should be related to Sub-units and/or RBDs . Thus in addition to RBDs, Sub-units will be the main units for analysis and visualisation of WFD data at the European scale.

Monitoring stations:

Monitoring stations will not be a WISE Reference GIS dataset as defined in Chapter 3.1. However, the monitoring stations of the WISE Reference GIS dataset reported under WFD Article 8 will be the reference feature to visualise various data related to monitoring stations. This should comprise all water-related monitoring stations (e.g. WISE-SoE monitoring stations or monitoring stations relevant for Nitrates Directive reporting should be subsets of the WISE Reference GIS dataset Monitoring stations). Thus data linked to monitoring stations can be reported in tabular form and linked to the information already available in WISE.

A precondition will be that monitoring stations must carry unique identifiers and, irrespective of the use of the station (SoE, WFD, BWD, NID, …), they will always be reported with the same unique identifier.

Note: *Monitoring stations or any other point information, for example agglomerations, urban waste water treatment plants, discharge points from urban waste water treatment, bathing water monitoring stations, etc. are the thematic layers that can be interlinked with the WISE Reference GIS datasets.*

Other WISE Reference GIS layers for other EU water policies, e.g. Sensitive Areas and their catchments for UWWTD, Nitrate Vulnerable Zones for NiD, etc. may be developed in the near future.

7 Coordination

7.1 Development phases of reporting cycle

The process on *what* to report is based on the legal requirements of EU water policy areas, and on the information needs of the European Parliament, other EU services and the European Commission's obligation to provide information for European Citizens.

The development of specific guidelines for the content and transmission of information of a particular reporting obligation follows a defined process under the Common Implementation Strategy (CIS) as seen in Figure 7.1.

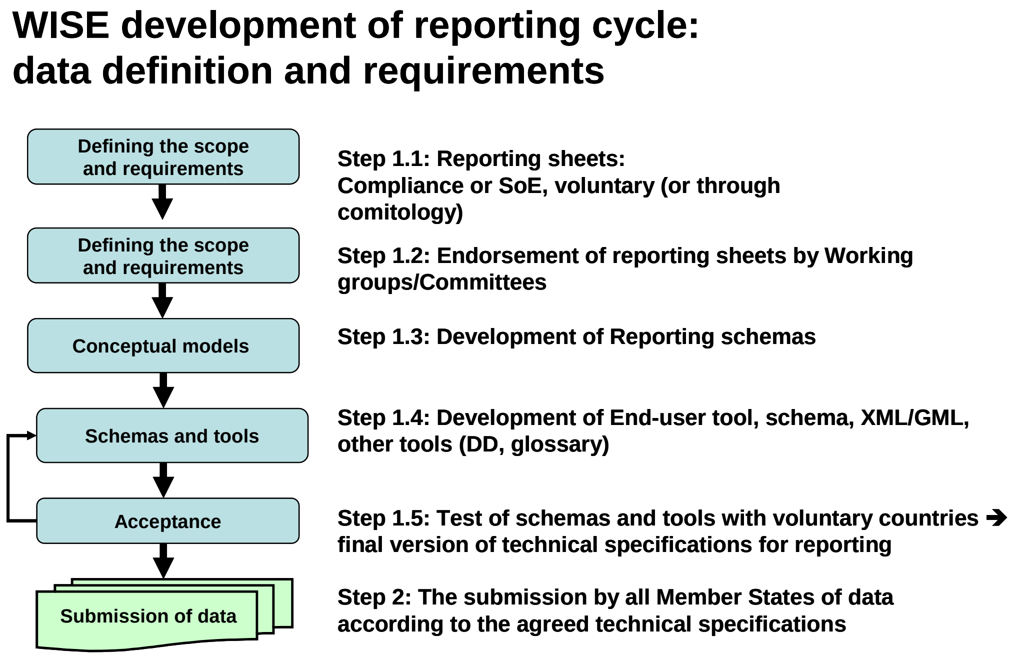

Figure 7.1 The development of specifications for a specific reporting obligation

In some cases, a Concept Paper on Reporting for a particular directive or an Article of a directive may be produced as a precursor to the Reporting sheets to allow the stakeholders to see and discuss the broader, strategic context of reporting before focussing on the more specific aspects of the Reporting Sheets.

Having the agreement on the contents and the form of reporting under each reporting exercise, technical implementation of reporting takes part.

Further steps of work flow and data flow via WISE is already presented in Chapter 1.2. The development cycle ideally starts 2-3 years in advance of the reporting deadline to allow Member States a timely implementation followed by the reporting.

7.2 Main coordinating groups

The central role of WISE development belongs to the WISE Steering group (WISE SG).

7.2.1 WISE Steering group

The WISE Steering group (WISE SG) is the main coordination body established at the EU level. It consists of representatives of four EU services (Group of 4: DG ENV, JRC, ESTAT and EEA) who guide the development of WISE. It ensures proper linkages with European Commission processes such as INSPIRE, SEIS and GMES. DG Environment chairs the WISE SG, holding meetings 2-3 times per year and external experts are invited as needed. The WISE SG reviews progress and plans upcoming work. It is also the forum to make connections to new and related work areas of WISE. WISE SG work is based on the WISE Implementation Plan agreed among the Group of 4 partners. On technical/IT matters, the WISE SG is supported by the WISE Technical group.

WISE Technical group

The WISE Technical group (WISE TG) assists on the development of the WISE system. It is chaired by EEA with representatives from DGs Environment , Eurostat and JRC, ETC-Water and a number of invited experts from Member States and external experts under support contracts. The WISE TG holds meetings 2-3 times per year and reports to and advises the WISE SG.

7.2.2 Water Directors, Committees, Strategic Coordination group and associated Working groups

Water Directors, Committees, Strategic Coordination Group (SCG) and associated working groups of relevant EU water policy areas[60] and other reporting activities at EU level[61] are the main consultation bodies involving Member States for issues related to the status of implementation of each water directive and other reporting exercises at EU level.

The Water Directors

Water Directors and the European Commission are steering the processes of the Common Implementation Strategy for the WFD which started in 2001. The group of Water Directors is an informal forum meeting twice a year under the auspices of the rotating EU Presidency. The main aim of the group is to ensure a coherent and harmonious implementation of EU water policy based on common understandings of the technical and scientific implications.

From the beginning it was realised that "*Most of the challenges and difficulties arising will inevitably be common to all Member States and many of the European river basins are shared, crossing administrative and territorial borders, where a* ***common understanding and approach*** *is crucial to successful and effective implementation. A Common Strategy could limit the risks of bad application of the Directive and subsequent dispute*".

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[60] WG D on reporting and GIS for WFD, working groups on reporting for BWD, DWD, NiD, UWWTD, etc.
[61] Groups of national contact points for Eionet and water statistics under OECD/Eurostat Joint Questionnaire on Inland Waters.

The current progress and work programme[62], the 4th since the start of the CIS process, bears the main title "Improving the comparability and quality of the Water Framework Directive implementation."

Public documents on the implementation of WFD can be found at the EC document server[63].

The CIS model has recently been used when implementing the WISE Implementation Plan via streamlining reporting exercises and integrating all EU water policies and other reporting activities (such as SoE reporting, reporting on water statistics under the OECD/ESTAT joint questionnaire) into WISE.

Committees

The formal side of WISE development, as for example, endorsement of WISE reporting arrangements, reporting sheets/guidance documents, technical formats on reporting by each thematic area of water may be dealt with via Committees created for relevant EU water directives[64]. The Committees, based on the requirements of each water directive, are chaired by the Commission and have delegates from each Member State. The task of the Committee is to assist the Commission in guiding the implementation of water directives, primarily in an informal way, by endorsing documents produced jointly with Member States and relevant working groups through a common understanding.

Strategic Coordination group and Working group on Reporting

The Strategic Coordination Group (SCG) is an informal group mandated by the Water Directors. The SCG is chaired by the Commission and consists of delegates from Member State representatives and also includes NGO participation to ensure transparency and involvement of relevant stakeholders. The Working group on Reporting (WG D – Reporting) includes consideration of WISE and GIS and is one of 7 Working groups which function in the frame of the SCG and the Common Implementation Strategy.

As a basic principle of the CIS is to reach common understanding on reporting requirements, the relevant Working groups/expert forums on reporting for all water directives are actively involved in the WISE development process in the sense of discussing Reporting sheets and endorsing the process as such. The Working Groups are chaired by representatives from the Commission. The mandate and/or work programme is established and agreed by SCG (and endorsed by the Water Directors) for each Working group.

WISE GIS expert network

This network consists of experts in Information Systems and GIS nominated by the Member States. The network was formerly known as the "WFD GIS expert group" under the auspices of WG D. The network is invited, on an ad-hoc basis, to discuss

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[62] "Improving the comparability and quality of the Water Framework Directive implementation *Progress and work programme for 2007-2009"* available from http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_documents/strategy4pdf/_EN_1.0_&a=d

[63] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive

[64] Art.21 Committee for WFD, art. 18 Committee of UWWTD, art.16 Committee for BWD, art.12 Committee for DWD, etc.

technical elements, in particular GIS and electronic reporting issues, regarding the development of WISE. In recent years in the frame of this initiative at least one workshop/seminar on WISE development has been held involving the water community concerned with reporting at EU level.

7.3 Involved organisations

7.3.1 Directorate-General Environment (DG ENV)

The main role of the European Commission's Environment Directorate-General (DG ENV) is to initiate and define new environmental legislation and to ensure that agreed measures are put into practice in the EU Member States. Its mission is protecting, preserving and improving the environment for present and future generations, and promoting sustainable development. DG ENV has overall responsibility for the WFD including the evaluation of Member State compliance with the directive. The responsibilities also include a number of proposals for specific measures and standards in various areas. DG ENV is responsible (under Article 18 of the WFD) for reporting the progress of implementation to the European Parliament and Council. DG ENV steers the process of integrating other EU water directives into WISE.

7.3.2 European Environment Agency (EEA)

The European Environment Agency (EEA) is an agency of the European Union. Its task is to provide sound, independent information on the environment and is a major information source for those involved in developing, adopting, implementing and evaluating environmental policy, and also the general public. Currently, the EEA has 32 member countries. The EEA's mandate is to help the Community and member countries make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability, and to coordinate the European Environment Information and Observation Network (Eionet).

As a part of the “Technical Arrangement between DGs Environment, ESTAT and JRC and EEA on Environmental Data Centres” EEA has the role of the Data Centre for Water. EEA is responsible for the development of the WISE system and processing of data reported under WISE. EEA’s own thematic State of the Environment (SoE) reporting is incorporated into WISE.

7.3.3 DG Eurostat (ESTAT)

DG Eurostat is the Statistical Office of the European Communities. Its mission is to gather and analyse figures from the different European statistics offices in order to provide comparable and harmonised data to the European Institutions so they can define, implement and analyse Community policies. With regard to WISE, ESTAT is mainly involved regarding two roles. With the Eurostat/OECD joint questionnaire, ESTAT is taking an active part in European water data reporting which is intending to be streamlined with WISE. This also strengthens the cooperation on water quantity and emissions. GISCO, the Geographic Information System of the European Commission, is a service of Eurostat which promotes and stimulates the use of GIS within the European Statistical System and the Commission. It manages and disseminates the Geographical reference database of the Commission, acts as a reference centre concerning GIS, promotes geo-referencing of statistics and collaboration between national statistical institutes and mapping agencies, pursues and ensures standardisation and harmonisation in the exchange of Geographic Information, and co-leads the INSPIRE initiative on the introduction of a European Spatial Data Infrastructure.

7.3.4 DG Joint Research Centre (JRC)

The European Commission's Joint Research Centre (JRC) is a department (Directorate-General, DG) of the European Commission providing independent scientific and technological support for EU policy-making. It works closely on the development of EU legislation with the relevant Commission services. The Joint Research Centre has many roles related to WISE. JRC developed the WISE reporting prototype during the initial years of the WFD reporting and is now a user of the system in the frame of its environmental assessment and scenario modelling work. JRC also chaired the first WFD GIS Working Group and played a leading role in the preparation of the first WFD GIS Guidance document and contributes to the ongoing activities with expertise in the INSPIRE process. JRC is also active in several areas (e.g., flooding and drought) which could provide specific information to WISE. With the OECD/Eurostat Joint Questionnaire on Inland Waters, ESTAT is taking an active part in European water data reporting which will be streamlined with WISE. This also strengthens the cooperation on water quantity and emissions. GISCO as part of ESTAT is contributing with its experiences and services around GIS metadata and data.

Appendices

Appendices to the guidance are available on EEA CIRCA at: http://eea.eionet.europa.eu/Public/irc/eionet-circle/eionet-telematics/library?l=/technical_developments/wise_technical_group/updated_2nd-edition/appendices_updated&vm=detailed&sb=Title

Appendix 01: Elements of the WFD relevant to GIS

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 23

GUIDANCE DOCUMENT ON EUTROPHICATION ASSESSMENT IN THE CONTEXT OF EUROPEAN WATER POLICIES

EUROPEAN COMMISSION

environment

Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://ec.europa.eu).

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FOREWORD

Eutrophication is one of the most important and long lasting water quality problems in the EU. Since at least two decades, several policies have been adopted to tackle nutrient pollution and its consequences. The Water Directors, conscious of the challenge and the complexity of the subject, agreed in 2004 to start an activity to develop guidance on harmonisation of eutrophication assessment. The guidance should cover all water categories (inland waters, coastal and marine) and all existing European policies, and should be firmly based on the methodological concepts of the Water Framework Directive.

The activity delivered a first Interim Guidance Document in November 2005 that was endorsed by Water Directors at their meeting in London. Although the document provided useful guidance both on technical and on policy relevant concepts, it was recognised that any attempt to harmonise eutrophication classification criteria should be informed by a number of important projects on-going at the time, notably intercalibration exercise and some of the projects lead by the Marine Conventions.

The Water Directors agreed at their meeting in Dresden in June 2007 to revise and update the Interim Guidance Document on Eutrophication. The present Guidance reflects the outcome of this process, led by a Steering Group chaired by the European Commission and with participation of experts from Finland, Germany, the Netherlands, Spain and the UK. Consultations were held with the CIS Working Group on Ecological Status and with the Strategic Co-ordination Group.

The main issues addressed in the guidance document are a unified conceptual framework to understand eutrophication in all water categories, a conceptual read across EU directives (mainly Water Framework, Urban Wastewater and Nitrates Directives) and international policies (e.g. OSPAR and HELCOM) addressing eutrophication and an in-depth understanding of eutrophication in the context of WFD ecological status assessment. The guidance also includes an overview of current assessment methods and recommendations for harmonisation of classification criteria.

This document is the result of several years of work by many experts across Europe and it will contribute to a better understanding of the policies involved in tackling eutrophication and their interactions, improving harmonisation of assessment methods. In the coming years the guidance should be used and tested and those experiences should be considered in future developments.

The Water Directors recognise that eutrophication is a complex phenomenon and it may be necessary to work further on its assessment in the future. However, the publication of the WFD river basin management plans in 2009 and recent policy developments like the Marine Strategy Framework Directive (2008) and the Baltic Sea Action Plan (2007) will inevitably move the focus of the attention in the coming years towards measures to combat eutrophication and its effectiveness. The Water Directors, in close collaboration with the Marine Directors, stay committed to continue to lead on tackling this important environmental problem.

May 2009

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1. INTRODUCTION

1.1. Scope of the activity

1. European policy has consistently identified eutrophication as a priority issue for water protection. Substantial progress has been made in combating eutrophication but there remain several areas where co-ordination is necessary to achieve a harmonised result for different policy areas, in particular:

- the harmonisation of assessment methodologies and criteria for agreed eutrophication elements/ parameters/ indicators for rivers, lakes, transitional, coastal and marine waters;
- the use of water type-specific objectives for biological and general physico-chemical elements;
- the co-ordination of monitoring and reporting;
- the harmonisation of models for assessing or predicting anthropogenic or natural nutrient loading into inland and marine waters based on nutrient sources information or nutrient sources scenarios (e.g. EUROHARP models);
- the systematic identification of sources of nutrients and possible restoration measures for water bodies.

2. Thus an activity was initiated under the Common Implementation Strategy of the Water Framework Directive and the European Marine Strategy to provide guidance on the first three points. Therefore it serves as a guidance document for the common assessment and monitoring of eutrophication across different European policies.

3. On the other issues, work may be started subsequently following the finalisation of this guidance. This may also include work related to:

- developing and harmonising cause-effect models linking nutrient loading to ecological impact in different water body types and categories.
- identifying the most cost-effective measures to tackle problems induced by nutrient enrichment.

4. There is a general agreement that this activity has to be firmly based on the methodological concept of the WFD and to explore thereafter to what extent this methodology can be used in the context of other directives and policies. The final outcome of this activity should be guidance for the purpose of the implementation of the above-mentioned policies. It should also be useful for the preparation of the River Basin Management Plans at the national and international level.

1.2. Understanding eutrophication in its policy context

5. Nutrients in the appropriate amounts (i.e. background levels) are essential to maintain an adequate primary production, which in turn is essential to support all the other trophic levels in the ecosystem, i.e. to maintain a healthy structure and functioning. In general, excessive nutrients of anthropogenic origin cause an increase in plant growth, which in still waters causes increased phytoplankton biomass, which can be dominated by harmful or toxic species. In rivers, eutrophication may be seen as increased algal growth or even excessive growth of higher plants, resulting in an imbalance between the processes of plant/algal production and consumption. The decay of organic matter will lead to a stimulation of microbial decomposition and oxygen consumption depleting bottom-water oxygen concentrations particularly in stratified water bodies[1]. Eutrophication can cause severe increases in plant and algal growth but can also have adverse effects on species diversity and lead to reduced suitability of the water for human use, e.g. consumption, recreation and industrial needs.

6. In 1995, the report of the European Environment Agency (EEA) "*Europe's Environment: The Dobris Assessment*", identified eutrophication of inland and marine waters as a European wide problem of major concern. The EEA report (2003) "*Europe's water: An indicator-based assessment*" reported that progress was achieved in improving water quality and quantity particularly in the European Union but that many of Europe's rivers, lakes, estuaries and coastal waters were still impacted by human activities leading to eutrophication. The "*Fourth Assessment of Europe's Environment*"[2] (2007) by EEA indicates that concentrations of phosphorus have generally decreased in rivers and to a lesser extent in lakes in Western and Central Europe since the 1990s, reflecting the general improvement in wastewater treatment. Eutrophication remains a problem in all enclosed seas and sheltered marine waters across the pan-European region. There have been some improvements in the West-European seas, as well as in the North-Western shelf of the Black Sea, as a result of large cuts in point sources of nutrient pollution from industry and wastewater by EU15 Member States. However, diffuse nutrient sources, particularly from agriculture, remain a major obstacle for recovery and need increased control throughout Europe. Eastern European countries need to both reduce point sources and prevent the export of nutrients to marine waters from further agricultural expansion and intensification. Furthermore, the recent eutrophication assessment undertaken by OSPAR has identified eutrophication related problems in certain areas mainly covering estuaries, fjords, coastal and some offshore areas. The current HELCOM eutrophication assessment comes to comparable results.

7. It should be emphasised that aquatic systems can show different natural background concentrations of nutrients, depending on the geology and other characteristics of the catchment, giving rise to different natural trophic conditions described as oligotrophic (low), mesotrophic (medium) to eutrophic (significant primary

[1] Deep water anoxia/hypoxia can also be a purely natural phenomenon in permanently stratified water bodies.

[2] http://www.eea.europa.eu/publications/state_of_environment_report_2007_1/

production). However, in the policy context, eutrophication is widely used to refer to the undesirable effects of anthropogenic increases in nutrient loads to aquatic ecosystems. The guidance only considers anthropogenic eutrophication, i.e., resulting from nutrient enrichment caused by human activities. Further details on concept and definitions are provided in Chapter 3.

8. In case of dealing with artificial or heavily modified water bodies, all references made in the document to ecological status should be construed as references to ecological potential.

1.3. Structure of the document

9. This document compares how eutrophication is understood, defined and assessed in different EC directives and other international policies. It develops a generic conceptual framework for the assessment of eutrophication which includes existing cause-effect relationships in both marine and freshwater ecosystems.

10. The document is structured in two parts (Chapters 2-4 and Chapters 5-8). The first part deals with the development of a common understanding of the processes involved in eutrophication a) from a technical and scientific point of view (Chapter 2), b) in the context of different policies (Chapter 3), and c) in the WFD concept of ecological status with respect to impacts caused by nutrient enrichment (Chapter 4).

11. The second part of the guidance gives an overview of current assessment methods and criteria for assessing eutrophication in different kinds of waters (Chapter 5), gives guidance on the harmonisation of classification criteria (Chapter 6), addresses the co-ordination of monitoring requirements stemming from different policies and obligations (Chapter 7) and discusses the links of eutrophication assessment with the pressure and impact analysis and the programme of measures (Chapter 8).

2. OVERALL CONCEPTUAL FRAMEWORK FOR THE ASSESSMENT OF EUTROPHICATION

2.1. The need, requirements and principles of a common conceptual framework

12. A fundamental aspect of defining a common monitoring and assessment guideline for the eutrophication process is identifying a common conceptual framework that can be adapted for specific water categories. Such a common starting point should capture the commonalities in the process and manifestations of eutrophication in different water categories, and should also provide the means of linking the "process" of eutrophication (i.e. a rate process) to the requirements of the WFD for assessing the ecological status of all surface water bodies.

13. In addition, a common generic conceptual framework valid across all surface water categories would provide a suitable means for developing category-specific checklists as a basis for the classification assessment and for specifying monitoring requirements (see Figure 1).

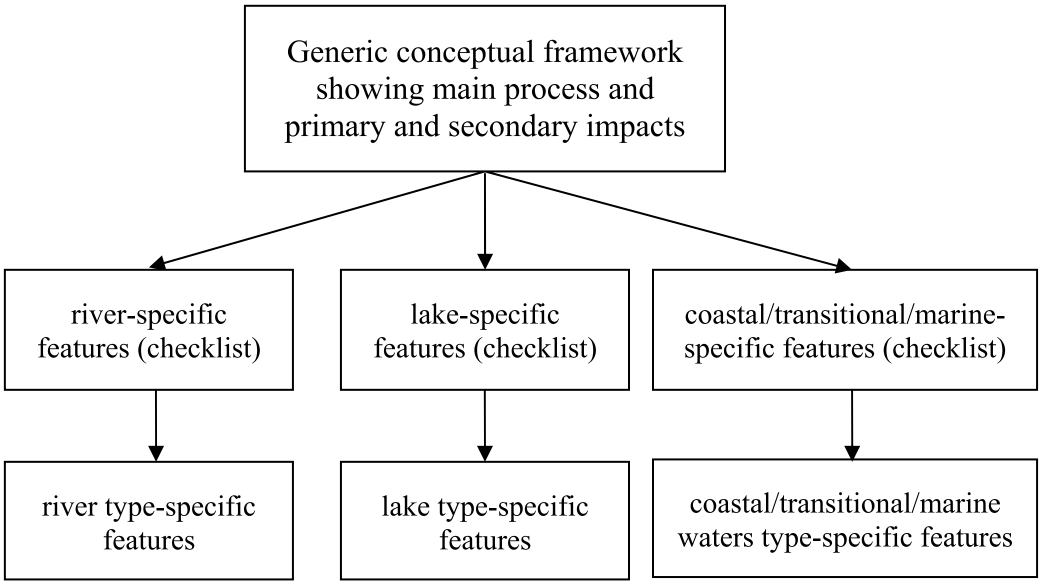

Figure 1. Schematic diagram for using a conceptual framework to assess eutrophication across different aquatic environments.

14. Assessing eutrophication in specific water categories and types will require water category-specific and perhaps type-specific monitoring. Several CIS Guidance documents have already addressed some of the specific monitoring needs (e.g. Monitoring guidance[3], COAST guidance document[4]); however the spatial and temporal monitoring requirements strongly depend on the seasonality of nutrients, chlorophyll and oxygen concentrations in different water categories. Specific monitoring requirements to assess eutrophication are addressed in Chapter 7.

15. A common "all encompassing" conceptual framework should be able to represent generic aspects of eutrophication which are common in different aquatic environments, but also be detailed enough to be useful for deriving the aspects which are specific to individual water categories and regions. Aspects of the process that may be common to all aquatic environments include:

- Nutrient enrichment;
- Enhanced primary production/biomass;
- Algal blooms;
- Changes to taxonomic composition of algae/ plants;
- Effects on light climate and hence on biota;
- Increased fixation of carbon;
- Decreased/increased oxygen levels, possible anoxia and consequent effects on biota;
- Reduced diversity of benthic fauna.

[3] Guidance Document No. 7: Monitoring under the Water Framework Directive

[4] Guidance Document No. 5: Transitional and Coastal waters – Typology, Reference Conditions and Classification Systems

2.2. Description of the conceptual eutrophication framework

16. There are numerous models of the eutrophication process: both in the scientific literature and in policy implementation documentation. All the different models link the cause (i.e. nutrients) and effect (e.g. excessive algal growth) of the eutrophication process. This overarching link has been long implemented in classification activities using regression models based on water body mass balance and algae element ratios, particularly in freshwaters (e.g. OECD, 1982; Vollenweider, 1976)[5]. However, it is now well known that manifestations of eutrophication may be much more subtle and non-linear in their occurrence (for a review see Cloern, 2001). Regression between nutrients and biomass for example may not be applicable in all aquatic environments. Regression models therefore may not always be expected to be used for classification of water bodies showing non-linear response patterns along the eutrophication gradient. In this perspective a more comprehensive approach to classification is required, that accounts for the different non-linear relationships and the different intrinsic manifestations of eutrophication.

17. An example of such an approach is the OSPAR Common Procedure[6], described in Annex 1, section 2.1.2. This procedure was developed based on a common conceptual framework of eutrophication.

18. Based upon the OSPAR conceptual framework, and taking into account discussions at the

- Joint Workshop on Marine Assessment and Monitoring with emphasis on eutrophication. JRC, Black Sea Commission and Helsinki Commission (Istanbul, Turkey, 21-22 April 2004); and the
- Eutrophication Workshop on a Common Assessment Methodology. JRC (Ispra, 14-15 September 2004)

the common conceptual framework of eutrophication presented in **Figure 2** was developed. This diagram describes the eutrophication process, the different elements and partial processes involved, and the ecological impacts which may arise. The effects of hydrological and morphological changes and their potential influence on eutrophication which play an important role in WFD ecological status assessment and can be an important factor for eutrophication are not detailed in the diagram, but summarised under "environmental factors". It is important to understand the complexity of the eutrophication process, not only for the assessment of ecological status of a water body, but also for planning appropriate mitigation measures; e.g. it is well known that top-down effects on eutrophication, e.g. through predatory fish, can be quite significant. This known from freshwater systems, but has recently also been shown for coastal and marine waters.

19. The figure does not cover (use-related) impacts on man, either directly or indirectly, which is part of what constitutes an undesirable disturbance.

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5 The statistical variability in such models may be too large to obtain a precise classification of single water bodies, because they are not sufficiently type-specific. The REBECCA-project has investigated the potential for improving such models by restricting the datasets used for a regression to data from single water body types. For more information see: http://www.rbm-toolbox.net/rebecca/index.php .

6 Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area

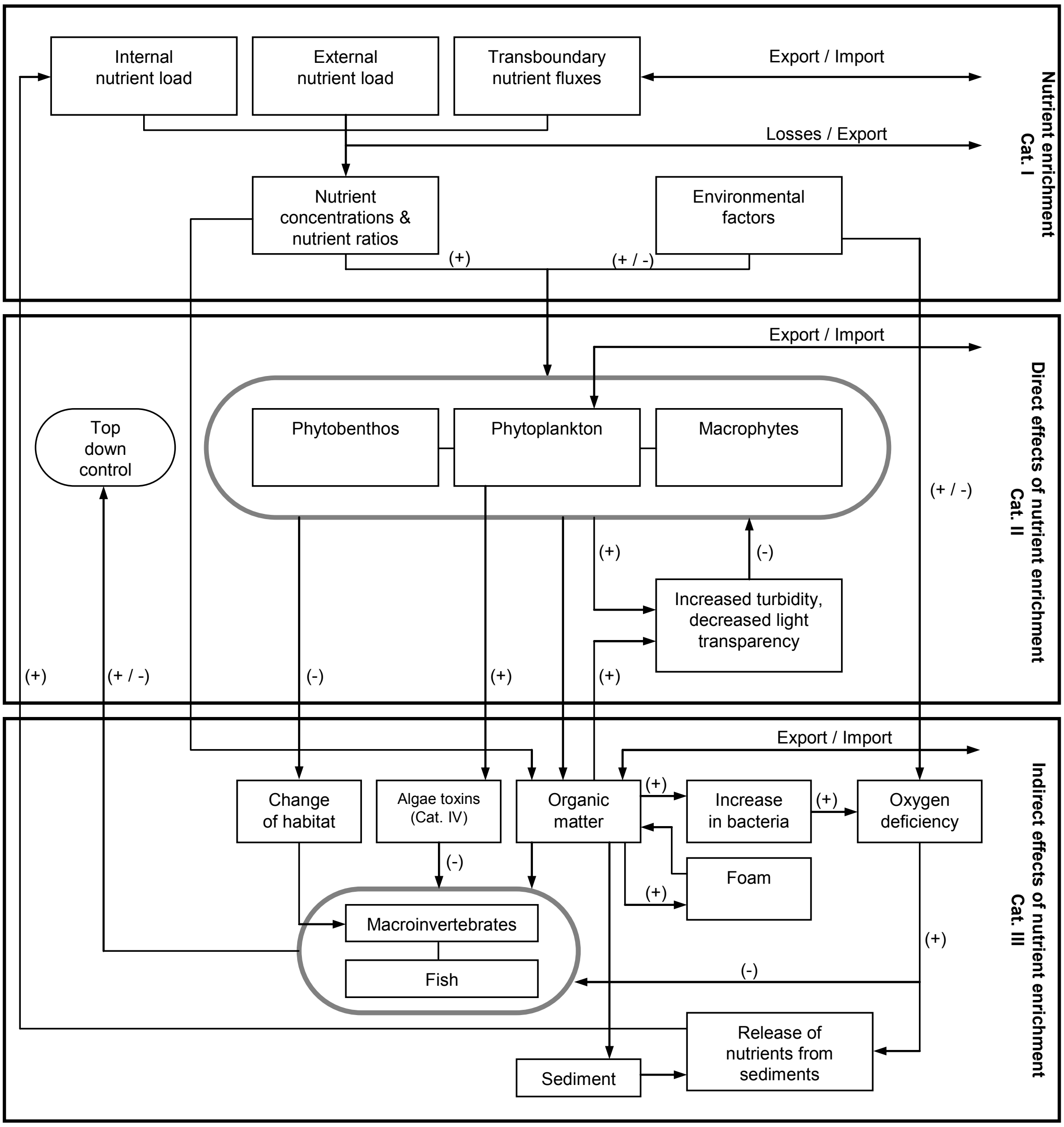

Figure 2. General conceptual framework to assess eutrophication in all categories of surface waters. (+) indicates increase; (-) indicates decrease; round boxes indicate biological quality elements of WFD.

20. To understand environmental policy and related evaluation and assessment, a framework has been developed in the past which distinguishes driving forces (D), pressures (P), state (S), impact (I) and responses (R) – this became known as the DPSIR framework. In the WFD context, P is addressed in the Article 5 reports when assessing pressures and presenting typology/characteristics of a water body. S and I are addressed by the work on classification, intercalibration and monitoring. R is addressed in the WFD programmes and measures. The conceptual framework for eutrophication assessment can be linked to the general DPSIR assessment framework as follows (Figure 3). Category I in the conceptual framework corresponds to pressures and state whereas Categories II and III refer to impacts. The focus of this guidance document is on state and impact assessment. Responses are not covered by the mandate to develop this guidance document although Chapter 8 outlines possible future work in this area.

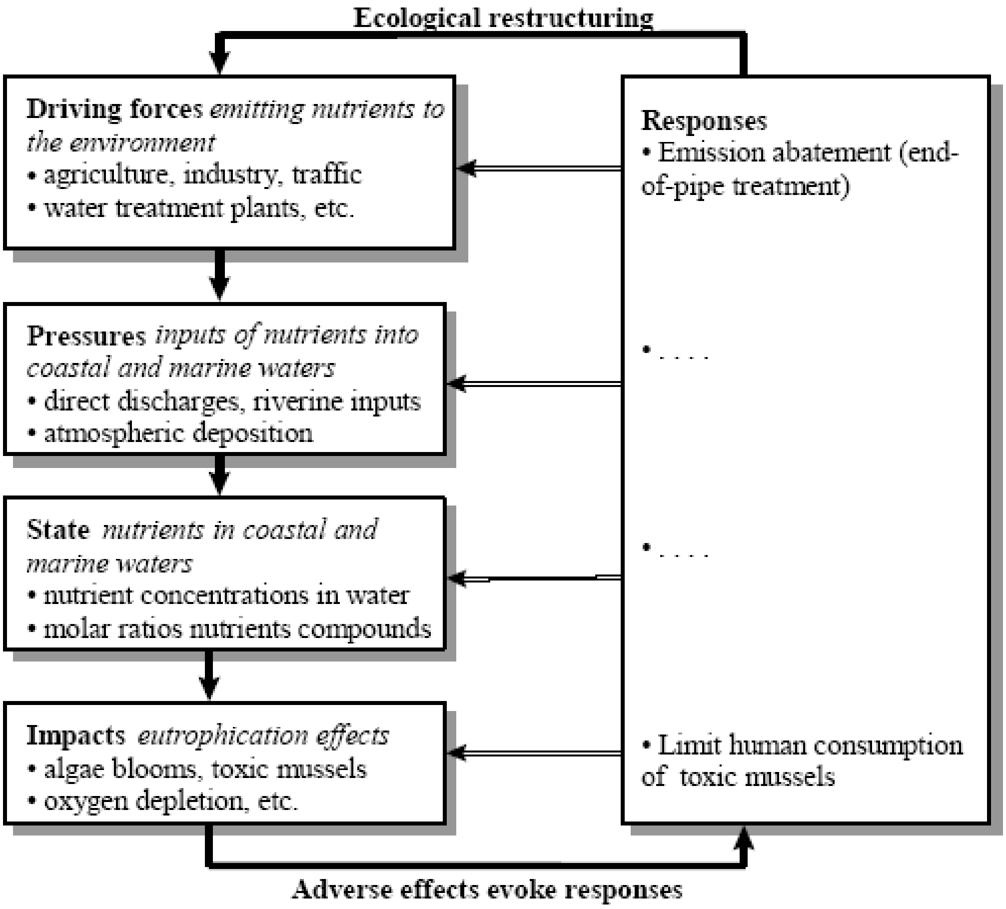

Figure 3. DPSIR assessment framework in the context of eutrophication (EEA, 2001).

21. The eutrophication conceptual framework provides an effective means of identifying the critical processes that can be adapted to processes specific to different water body categories. However, in order to provide a link to the subsequent steps of the assessment process (i.e. establishing reference conditions and classification), holistic checklists have been derived for the different water categories highlighting the critical processes and variables under the headings of: causative factors, primary or direct effects and secondary or indirect effects. The level of detail included in the checklist (presented in Table 1) reflects the specificity of the eutrophication process in rivers, lakes, transitional, coastal and marine waters. The complete checklists for each water category can be found in Annex 2.

Table 1. Indicative checklist for general and category-specific features of the impact of eutrophication in rivers, lakes, transitional, coastal and marine waters.

General assessment factors for all water categories	Additional river-specific factors	Additional lake-specific factors	Additional transitional/coastal [and marine] waters-specific factors
a. Causative factors:			
The degree of nutrient enrichment: With regard to inorganic/organic nitrogen With regard to inorganic/organic phosphorus With regard to silicon Taking account of: Sources (differentiating between anthropogenic and natural sources) Increased/upward trends in concentration Elevated concentrations Changed N/P, N/Si, P/Si ratios Changes in nutrient fluxes and nutrient cycles		Riverine, direct and atmospheric inputs internal nutrient loading	Across boundary fluxes, recycling within environmental compartments, riverine, direct and atmospheric inputs and internal loading
b. Supporting environmental factors:			
Light availability (irradiance, turbidity, suspended load) Hydrodynamic conditions () Climatic/weather conditions (wind, temperature) Typology factors Other pressures (toxic substances, hydromorphological pressures)	Hydromorphological conditions (current velocity, water flow, substrate type and mobility, water depth, flood frequency,) Typology factors: alkalinity, colour, size of catchment	Stratification, flushing, retention time, Zooplankton grazing (top-down control) (which may be influenced by other anthropogenic activities) Typology factors: alkalinity, colour, size, depth, share of area shallower than the stratification layer	Upwelling, salinity gradients, Typology factors: e.g. salinity, wave exposure

General assessment factors for all water categories	Additional river-specific factors	Additional lake-specific factors	Additional transitional/coastal [and marine] waters-specific factors
c. Direct effects of nutrient enrichment:			
i. Phytoplankton; Increased biomass (e.g. chlorophyll a, organic carbon and cell numbers) Increased frequency and duration of blooms Increased annual primary production Shifts in species composition to higher proportion of potentially harmful or toxic species ii. Macrophytes including macroalgae (such as Characeans); Increased biomass Shifts in species composition Reduced depth distribution until disappearance of macrophytes iii. Phytobenthos	i. Phytoplankton in parts of rivers with low flow or lake-like structure due to damming iii. Microphytobenthos; Increased biomass and primary production, increased areal cover on substrate Shifts in species composition from diatoms to chlorophytes and cyanobacteria	i. Phytoplankton; from chrysophytes and diatoms to cyanobacteria and chlorophytes ii. Macrophytes In very shallow lakes switches occur from macrophytes dominance and phytoplankton dominance Reduction in depth distribution, consequent shift in balance of species	i. Phytoplankton indicator species cells/L (blooms and duration) Shift from diatoms to flagellates ii. Macrophytes including macroalgae: shift from long-lived species to short-lived species, some of which are nuisance species (Ulva, Enteromorpha) Coverage of areas
d. Indirect effects of nutrient enrichment			
i. Organic carbon/organic matter; Increased organic carbon concentrations in water and sediment ii. Oxygen; Decreased concentrations and saturation percentage Increased frequency of low oxygen concentrations Increased consumption rate iii. Fish; Changes in abundance	ii. Oxygen; More extreme diurnal variation iii. Fish; Disruption of migration or movement iv. Benthic heterotrophic organisms: Increased biomass and areal cover of fungi and bacteria	ii. Oxygen More extreme diurnal variation in surface waters (oversaturation at day and undersaturation at night) Reduction in hypolimnion during stratification periods Occurrence of anoxic zones at the sediment surface ("black spots") iii. Fish Mortalities resulting from low oxygen concentrations	i. Organic carbon/organic matter; Occurrence of foam and/or slime ii. Oxygen; Occurrence of anoxic zones at the sediment surface ("black spots") iii. Fish Mortalities resulting from low oxygen concentrations iv. Macrozoobenthos Mortalities resulting from low oxygen concentrations

General assessment factors for all water categories	Additional river-specific factors	Additional lake-specific factors	Additional transitional/coastal [and marine] waters-specific factors
Changes in species composition iv. Benthic invertebrates; Changes in abundance and biomass Changes in species composition v. pH vi. Nutrients		iv. Macrozoobenthos Mortalities resulting from low oxygen concentrations v. pH increase in surface waters vi. Internal loading of phosphorus vii. Increased ammonia concentration in bottom waters viii. Often changed top-down control due to changed predation on zooplankton Often reduced top-down control due to loss of habitat structure provided by macrophytes leading to heavy fish Release of soluble Fe, Mn from sediments	vi. Release of nutrients and sulphide from sediment Occurrence of algal toxins
e. Other possible effects of nutrient enrichment			
• Amenity values compromised: • Bad smell, turbid waters,	Clogging of pipes and filters, build up of iron deposits due to low DO	Incidence of toxic algal blooms increases Loss visual amenity due to colour in water	

3. Overview and common understanding of eutrophication in EC and international policies

3.1. Introduction

22. Eutrophication is addressed in several EU policies. Nutrient levels to describe the water quality were introduced in several early pieces of EU water legislation (e.g. Freshwater Fish Directive 78/659/EEC). The main anthropogenic sources of nutrient loadings were addressed in two directives in 1991: 1) The Urban Wastewater Treatment Directive (91/271/EEC) addresses the major point sources, in particular the municipal waste water discharges. 2) The Nitrates Directive (91/676/EEC) deals with diffuse pollution of nitrogen from agriculture. Both directives define the term "eutrophication". In addition, through the identification of sensitive areas and compliance with treatment requirements (UWWTD) as well as designation of nitrate vulnerable zones and application of action programmes (Nitrates Directive), both Directives, respectively, provide for measures to combat eutrophication. Starting from the 1980s and 1990s, a number of international conventions addressed eutrophication in marine waters including OSPAR (for the North-East Atlantic), HELCOM (for the Baltic Sea), the Barcelona Convention (for the Mediterranean Sea) and the Bucharest Convention (for the Black Sea).

23. In 2000 the Water Framework Directive (2000/60/EC) introduced – amongst other requirements – a comprehensive ecological status assessment of all surface waters, based on a number of biological, hydromorphological, chemical and physico-chemical quality elements (cf. Annex V 1.1 and V 1.2). The WFD provides a basis for a clear and detailed assessment of eutrophication, and provides the potential for a more consistent and integrated approach to managing nutrient inputs to water taking fully into account the requirements of previous EU legislation.

24. In addition to these directives, the EU Marine Strategy Framework Directive (2008/56/EC) aims at achieving or maintaining 'good environmental status' including the minimisation of eutrophication in Member States' marine waters. Member States are required to develop their marine strategies and identify measures based upon the initial assessment and their determination of 'good environmental status' for their water within a harmonised methodological framework.

25. A workshop on eutrophication criteria was hosted by DG Environment, in, Brussels in May 2002. This considered eutrophication in the context of the WFD, UWWT Directive, the Nitrates Directive and the future Marine Strategy of the Commission. It launched a process to harmonise existing definitions and criteria for the assessment of eutrophication. One conclusion of this workshop was a recognised need to move from definitions to a common understanding of eutrophication, acceptable levels of deviation from reference conditions and the extent of adverse indirect effects on ecosystems and water use (European Commission 2002b). Since then, the intercalibration has addressed the harmonisation of ecological classification, also

related to eutrophication. Further workshops have dealt with harmonisation of assessment methods and the use of nutrient standards in assessing eutrophication:

1) 1st Workshop on Eutrophication, held in Ispra in September 2004,

2) 2nd Workshop on Eutrophication, held in Brussels in September 2005,

3) Nutrient Standards Workshop, held in Zandvoort in October 2007,

4) ECOSTAT Classification Workshop, held in Brussels in March 2008.

26. This chapter considers and compares how eutrophication is understood, defined and assessed in European Community directives, policies and guidance documents. In addition, the understanding and the assessment of eutrophication in other regional bodies are presented, in particular in the international marine conventions OSPAR and HELCOM.

27. An overview of the understanding of eutrophication in EU legislation and policies as well as in a number of international organisations is provided in Annex 1. This annex was the basis for the following overview of approaches.

3.2. Overview of policy instruments

28. A number of EC Directives require Member States to monitor parameters relevant to eutrophication and set ecologically relevant guideline values, however only the UWWT Directive and the Nitrates Directive have an explicit requirement to assess eutrophication (the former through the exercise to identify "sensitive areas", i.e. sensitive water bodies, and the latter through identification of "polluted waters" [7] and subsequent designation of nitrate vulnerable zones). The Water Framework Directive supports both these Directives in its provisions for protected areas, and, in addition, has an implicit requirement to assess eutrophication when classifying the Ecological Status of surface water bodies. Unlike the UWWT Directive and the Nitrates Directive, the WFD stipulates a specific framework for assessing water quality. Eutrophication assessment criteria and methods have also been developed by several European conventions, including OSPAR and HELCOM and recently by UNEP/MAP.

29. The requirements of EC directives and other relevant international policies to assess or monitor eutrophication are summarised in general in Table 2.

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[7] For the purposes of this guidance the term “polluted waters” is taken, for the sake of brevity, to mean “waters affected by pollution and waters which could be affected by pollution if action is not taken” in line with Article 3 of the Nitrates Directive. Specifically, it refers to waters that are eutrophic or in the near future may become eutrophic if action is not taken, as per the criteria in Annex IA3 of the Directive.

Table 2. General overview of requirements of EC directives and regional conventions regarding eutrophication

Directive /Policy	Requirement to assess eutrophication	Minimum monitoring requirements relevant to eutrophication
WFD	Included in classification of Ecological Status where nutrient enrichment affects biological and physico-chemical quality elements Protected Area's support and upholds requirements of UWWTD and Nitrates Directive	Phytoplankton (6 months), aquatic flora (3 yrs), macroinvertebrates (3 yrs), fish (3 yrs) Hydromorphological quality elements (Hydrology continuous - 1 month; others 6 years) Physicochemical quality elements (3 months)
UWWT Directive	In order to identify sensitive areas under Annex IIA(a) criteria (i.e. water bodies that are eutrophic or may become eutrophic in the near future if protective action is not taken)	Review of the existing sensitive areas and designation of new ones at least every 4 years (Article 5(6))
Nitrates Directive	In order to identify "polluted waters" [7] and to designate their catchment area as nitrate vulnerable zones.	For the purpose of designating the nitrate concentrations in freshwaters (surface water and groundwater) should initially be monitored over a period of one year. This monitoring programme should be repeated at least every four years. A review of the eutrophic state of their fresh surface waters, estuaries and coastal waters should be made every four years.
Freshwater Fish Directive	No specific requirements to assess eutrophication, but guideline values for phosphorus are explicitly to reduce the effects of eutrophication	Ammonia, pH and dissolved oxygen (monthly)
Shellfish Water Directive	No specific requirement to assess eutrophication	Dissolved oxygen (monthly) & algal toxins
Dangerous Substance Directive	No specific requirement to assess eutrophication, but requirement on setting quality objectives for phosphorus and for substances which have an adverse effect on the oxygen balance, particularly ammonia and nitrates	No specific requirements
Groundwater Directive	No explicit mention of eutrophication but quality standards are established for nitrates and pesticides and in some cases more stringent threshold values have to be set. A minimum list of pollutants is set up for which MS have to consider establishing threshold values including e.g. ammonium and conductivity	Details of groundwater chemical monitoring are included in WFD Annex V point 2.4, core parameters are: oxygen content, pH value, conductivity, nitrate, ammonium
Bathing Water Directive	As a part of the obligations of the new Bathing Water Directive bathing water profiles have to be established. When the bathing water profile indicates a tendency for proliferation of macro-algae and/or marine phytoplankton, investigations shall be undertaken to determine their acceptability and health risks and adequate management measures shall be taken, including information to the public.	Old Directive: Transparency (fortnightly), pH, dissolved oxygen (when water quality has deteriorated). Nitrates and phosphates, ammonia and nitrogen (Kjeldahl) when there is a tendency towards eutrophication. New Directive: When establishing, reviewing and updating bathing water profiles, adequate use shall be made of data obtained from monitoring and assessments carried out pursuant to Directive 2000/60/EC.

Directive /Policy	Requirement to assess eutrophication	Minimum monitoring requirements relevant to eutrophication
Marine Strategy Framework Directive	Included in assessment of environmental status based on 'good' environmental status concept Complementarity with WFD in 'coastal waters' (following definition of 'marine waters' in MSFD Art. 3(1)), hence no MSFD specific issues in those waters as regards assessment of eutrophication	A monitoring programme will be established by each Member State under Art. 11 by July 2014, taking account of the information needs derived from their development of the earlier elements of their marine strategies (initial assessment, determination of good environmental status, identification of environmental targets and indicators, in 2012).
Habitat Directive	If threatening protected habitats or species	None
Emission Ceilings, LRTAP	No requirement to assess eutrophication but specific national emission ceilings for ammonia and NOx emissions to reduce nitrogen atmospheric deposition and ecosystem eutrophication	No requirement to monitor water quality under the Directive, but monitoring of nitrogen deposition and critical loads for ecosystems eutrophication under the Convention
OSPAR Eutrophication Strategy	Explicit requirements for assessing the eutrophication status of waters in OSPAR maritime area using the OSPAR Common Procedure (in particular its Comprehensive procedure)	Monitoring of selected parameters for nutrient enrichment, direct effects, indirect effects and other possible effects according to the mandatory Eutrophication Monitoring Programme (OSPAR 2005-4)
HELCOM	Explicit in quantifying and assessing emissions/discharges/losses and inputs to as well as concentrations and effects in the Baltic Sea [HELCOM Periodic Assessments of the Status of the Baltic Sea and PLCs (Air and Water)]	MONAS: Pollution Load Compilation (PLC Air and Water) Monitoring Programme (total nitrogen, nitrates, ammonia, orthophosphate and total phosphorus) and COMBINE (including total nitrogen, total phosphorus, DIN, DIP, Si, phytoplankton and zoobenthos species composition, abundance and biomass, Chl a, dissolved oxygen and Secchi depth)
Barcelona Convention - Strategic Action Programme (SAP) to address LBS	The SAP states eutrophication as the result of input of nutrients from rivers and sewage into inshore waters such as lagoons, harbours, estuaries and coastal area which are adjacent to river mouths, so actions should be taken to reduce inputs of nutrients from Land Based Sources (LBS).	MED POL: Eutrophication monitoring strategy (2003) – DIN, DIP, TP, Si, Chl a, phytoplankton (total abundance, abundance of major groups, bloom dominance), transparency, dissolved oxygen, T, S, pH
Black Sea Strategic Action Plan (SAP)	Eutrophication is still a challenge at regional and national levels even though there are substantial improvements in the North Western shelf of the Black Sea. For these reason the SAP has provisions to monitor and reduce the inputs of nutrients.	Black Sea Integrated Monitoring and Assessment Programme: nutrients are monitored in water, sediment and biota

3.3. Concepts and definitions of eutrophication

30. It is recognised that different geochemical and hydromorphological conditions are reflected in different characteristics of water bodies such as different trophic and biological conditions. Thus, the assessment of eutrophication should consider these issues and assess the deviation from the type-specific condition. This concept is directly or indirectly addressed in all the relevant policies that aim at controlling the pressures stemming from human activities with an impact on the natural condition of the ecosystem. For the purpose of this guidance, the term "eutrophic" is used to refer to this situation, when the natural trophic status (including the biology) is out of balance because of anthropogenic pressures.

31. This understanding of "anthropogenic" eutrophication corresponds with how the WFD classifies surface water ecological status in relation to type-specific reference conditions. A pressure (in this case nutrient inputs) causes an adverse change in biological quality elements (e.g. 'composition, abundance and biomass of phytoplankton'). This in turn might cause indirect effects on physicochemical quality elements (e.g. transparency, oxygenation conditions), and other biota (e.g. macroinvertebrates). Water bodies that fail to achieve Good Ecological Status due to the effects of human induced nutrient enrichment can be considered to be adversely affected by eutrophication.

32. In the context of this guidance, eutrophication involves adverse ecological changes (an "undesirable disturbance") and it can apply to waters from anywhere within the trophic spectrum. It should not be confused with the same term when used in relation to limnological trophic classification, where its meaning is more limited and not necessarily linked to assessing the extent of ecological change. In that sense, an oligotrophic water body (e.g. a lake) which deteriorates to mesotrophic would require UWWTD/ND/WFD designation/action despite the fact that it would not have become "eutrophic" in terms of OECD trophic status. In contrast a naturally "eutrophic" water body, as measured through OECD classification, would require no designation or action under the UWWTD/Nitrates Directive/WFD unless its ecological status had deteriorated, or was at risk of doing so due to nutrient enrichment.

33. These deliberations concur with conclusions from the May 2002 Eutrophication Workshop (European Commission 2002b) that the definition of eutrophication in the UWWT Directive is adequate as a starting point for further development of a guidance on the issue of eutrophication assessment, which is as follows:

Definition of eutrophication (cf. Art. 2(11) of the UWWT Directive 91/271/EEC):

Eutrophication is "the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned".

3.4. Key terms used in different European policies

34. Table 3 compares different terms used in the WFD, UWWT and Nitrates Directives, as well as the OSPAR and HELCOM Conventions.

Table 3: Comparison of key terms used in relevant European policies in relation to eutrophication

	Water Framework Directive	UWWT Directive	Nitrates Directive	OSPAR	HELCOM
Assessment result (not fulfilling the objective and requiring measures)	Water body at less than good status based on eutrophication-related biological quality elements or judged at risk of deterioration	Sensitive area (=sensitive water body) due to eutrophication	"Polluted waters" [7]	Problem area and potential problem area	Areas affected by eutrophication
Location of pressures (other than those directly on the water body)	River basin or sub-basin	Catchment area of sensitive area	Nitrate vulnerable zone (areas which drain into identified waters and which contribute to pollution)	Any location that is relevant, directly or indirectly influenced by nutrient pressures	Coastal waters relevant to WFD and open sea

35. Although different terms are used the underlying concepts are similar, e.g. there is a quality problem in a (part of a) particular river, lake or coastal area (called water body, sensitive area, polluted water or problem area) that is caused by an activity or pressure located at the water body having less than good status, or upstream of this water body in the catchment area, river basin, sub-basin or vulnerable zone.

36. In OSPAR there is no explicit reference to river basins, because in the marine area the pressures causing eutrophication may be located somewhere else. However, one of the main pillars of the OSPAR approach to combat eutrophication is the source-oriented action which should be taken in "areas from which nutrient inputs are likely, directly or indirectly, to contribute to inputs into problem areas with regard to eutrophication"[8]. This definition is broader and includes anthropogenic nutrient inputs into the river basins of transitional, coastal and marine areas affected by eutrophication. In addition, OSPAR is also considering transboundary nutrient transport of anthropogenic origin from other parts of the maritime area.

3.5. Overview of classification of water bodies with regard to eutrophication

37. The way in which different EC Directives and OSPAR classify eutrophic water bodies with regard to human induced eutrophication is summarised in Table 4. The comments in the table describe the focus and extent of each classification.

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8 The same wording is used in several OSPAR normative and technical documents, for instance in OSPAR Eutrophication Strategy.

Table 4. The classification of water bodies not achieving the objective with regard to eutrophication under different directives and policies (overview).

Directive/ Policy	Classification	Comments
WFD	Worse than good Ecological Status (deterioration in Ecological Status)	Good ecological status for the algal and plant quality elements includes an absence of undesirable disturbances due to accelerated growth. Nutrient conditions must support the biology. Being worse than good ecological status for these quality elements due to nutrient enrichment implies a eutrophication issue. Covers all freshwaters and transitional waters, and all coastal water that is on the landward side of a line that is 1 nautical mile seaward of the baseline from which the breadth of territorial waters is measured.
UWWT Directive	Sensitive area	Sensitive areas include water bodies (including freshwater bodies, estuaries and coastal waters) that are eutrophic or in the near future may become eutrophic if protective actions are not taken. Designation of sensitive areas results in action regarding waste water treatment independent of the origin of the pollution (i.e. independent whether pollution comes from urban waste water discharges or originates from agricultural-based sources, since both of them contribute to eutrophication)[9].
Nitrates Directive	"Polluted waters" [7] whose catchments require designation as nitrate vulnerable zones.	Nitrate vulnerable zones must be established over the catchment of "polluted waters" [7] which include water bodies that are eutrophic or in the near future may become eutrophic if protective action is not taken. Only applies to pollution by nitrogen from agricultural sources.
Habitats Directive	Non-favourable condition	If affecting protected habitats or species.
Shellfish Water Directive	No direct link	Might result in a shellfish water site failing water quality criteria.
Marine Strategy Framework Directive	Worse than good environ-mental status	Areas where human induced eutrophication is not minimised; in particular where it entails adverse effects.
OSPAR Common Procedure	Problem area	Applies to the OSPAR Convention Waters (estuaries and marine waters). All anthropogenic nutrient sources and inputs are taken into account in assessing the eutrophication status.
HELCOM	Areas affected by eutrophication	Applies to the Helsinki Convention (HELCOM) area (coastal and open waters). All anthropogenic nutrient sources and inputs are taken into account in assessing the eutrophication status.

38. For the purpose of this guidance, it is assumed that the process of eutrophication may occur in water bodies regardless of their natural status (in line with the concept of anthropogenic eutrophication referred to in the previous section). However, water bodies are not considered to be "eutrophic" or to fall in the "may become eutrophic" category unless the nutrient enrichment causes (or could cause in the near future) the ecological status to be (or to become) moderate or worse. This ensures the same level of protection in all EC directives as far as nutrient enrichment is concerned.

[9] According to the Judgement of the Court in the case C-280/02 (for more details, see Annex 1, Section 1.2.4)

39. From the legal point of view the terms "eutrophic" and "may become eutrophic in the near future" as used in Nitrates and UWWT directives are similar and require similar consequence, i.e. the designation of those areas as nitrate vulnerable zones (Nitrates Directive) or identification as "sensitive areas" (UWWT Directive). However, technically speaking, they reflect different situations. These concepts will be further addressed in the following sections.

3.6. Assessment results under various policies

40. The analysis and comparison of assessment results is an important starting point for the development of a harmonised assessment framework. Ultimately, the assessment should lead to a comparable and consistent conclusion under different policies. In general, the outcome of the assessment is used to determine whether or not certain measures need to be taken under different policies. At this stage, it is important to recall two basic principles when interpreting the content of this document:

a. in case that the assessment under different policies leads to a different level of protection the most stringent requirement shall apply.

b. it is ultimately up to the European Court of Justice (ECJ) to interpret legal requirements of EC Directives. Recently, the ECJ has interpreted the designation of sensitive areas under the UWWT Directive in a broad sense (see EJC judgement C-280/02 in section 1.2.4 of Annex 1). In consequence, the application of this guidance must lead, at least, to the same level of protection provided by this ruling independent of which EC Directive is applied insofar as the judgement is relevant to other policies.

41. In Table 5 the WFD ecological status classes are compared with (i) sensitive areas and not sensitive areas (so called 'normal' areas) (cf. the UWWT Directive), (ii) "polluted waters" [7] requiring designation of nitrate vulnerable zones (cf. Nitrates Directive), (iii) problem and non-problem areas or potential problem areas (cf. OSPAR Comprehensive Procedure), and (iv) the terms used in HELCOM. The comparison considers when action is required to address eutrophication under each directive/policy. As regards the obligation to identify sensitive areas under UWWT Directive or designate nitrate vulnerable zones under the Nitrates Directive Table 5 is not applicable to Member States that have chosen to implement the "whole territory approach" (see paragraphs 52-54 for more information on the whole territory approach).

WFD moderate, poor and bad status, compared with the eutrophication categories

42. As stated in the previous section, the use of the terms "eutrophic" and "in the near future may become eutrophic" in the Nitrates and UWWT Directives are interchangeable from the legal point of view and both have similar consequences (identification/designation of nitrate vulnerable zones or of sensitive areas). However, in order to establish a consistent link with the WFD status classes, they can be interpreted as the result of different degrees of ecological deviation from reference conditions. The term "eutrophic" can be identified with a situation where undesirable disturbances are common, whereas the term "in the near future

may become eutrophic" corresponds with a situation where undesirable disturbances[10] are not necessarily present, but the degree of ecological change is such that they are likely. Therefore, based on the text of normative definitions for the algal/plant quality elements, moderate status under the WFD corresponds broadly with the "in the near future may become eutrophic" situation, particularly if there is increasing nutrient pressure.

43. As the degradation of water quality increases, so does the likelihood of undesirable disturbances, and from a certain point in the moderate class and beyond into poor and bad, the conditions would correspond with "eutrophic". The moderate class is interpreted as a transition class between good status, where no undesirable disturbances are present, and poor or bad, where they are increasingly common and severe. See Chapter 4.4 (including paragraph 73 and Table 8 on undesirable disturbances) for a more detailed interpretation of eutrophication in the context of WFD ecological status assessment.

44. In deciding on whether and with what certainty to report a water body as being at less than Good Ecological Status (in terms of eutrophication) and in determining the appropriate follow-up actions, the issues covered and guidance given in Chapter 6.2, on (a) dealing with mismatches between nutrients and biology (paragraphs 188-190) and (b) accounting for uncertainty in eutrophication assessment (paragraphs 198-200), should be considered. These issues are important not only in relation to classification but also in a policy context in terms of decisions on priorities for control measures (under the WFD and, where relevant, via identification of waters as sensitive/polluted under UWWT and/or Nitrates Directives) and further monitoring or other investigations.

WFD good and high status compared with the eutrophication categories

45. Table 5 and paragraphs 41-43 above address the assessment of current status. However, the WFD also requires Member States to assess the risk of future deterioration of status, linked to the WFD objective of preventing such deterioration. This means water bodies that are currently in good or even high status and that may deteriorate in the future due to increasing pressures will need to be part of the Programme of Measures under the WFD. This forecasting of future breaching of the prevent deterioration principle equates well with the forecast/estimation of "may become eutrophic in the near future" of the UWWT and Nitrates Directives, at least if the deterioration may result in a moderate or worse status due to eutrophication. However, at least until the first WFD River Basin Management Plans are in place in 2009, the time scales of the WFD objectives and 'the near future' estimation may not necessarily coincide. In order to assess whether undesirable disturbances are likely to occur, nutrient pressures/concentrations, data on the effects of eutrophication (e.g. large phytoplankton blooms, mats of green algae, oxygen deficiency) and other environmental factors that influence eutrophication should be taken into account, for example light

[10] On the definition of undesirable disturbances see Annex 1, section 1.2.4 Relevant Case Law. Some examples of significant undesirable disturbances can be found in Chapter 4, Table 8.

availability/turbidity, hydrodynamic conditions, temperature, etc. (see category-specific checklist in Annex 2). The following WFD activities should be considered:

i. ecological status assessment – whether there is a trend/development in the recent past from high to good status or in values for individual quality elements that determine eutrophication, indicating movement towards moderate/poor/bad and thus "eutrophic";

ii. risk assessment to estimate future status and prevent deterioration – using information on expected change in pressures that are likely to result in a water body becoming eutrophic in the near future (predictive analysis).

46. The initial results of the Article 5 analysis under WFD will be further refined with the information from the monitoring networks, and by further characterisation and classification. The status assessment of water bodies is part of the River Basin Management Plans (RBMP) which are due by December 2009. Along this process from the Article 5 analysis to the RBMP, increasing certainty will be attained on the evaluation of future status of water bodies. At any point, designation under UWWT and/or Nitrates Directives must take place if sufficient certainty is attained that a water body may become eutrophic in the near future.

Summary of links between WFD status and eutrophication categories

47. In summary, it is proposed that in terms of WFD status classification and environmental objectives, the term "eutrophic" relates to situations where undesirable disturbances are common or severe and equates primarily to poor or bad status, whereas "in the near future may become eutrophic" of the UWWT and Nitrates Directives can be interpreted in two complementary ways:

- in the context of **current status** assessment, as corresponding to moderate status (undesirable disturbances are not necessarily present, but the degree of ecological change is such that they are likely, particularly if there is increasing nutrient pressure) or,
- in the context of **future status** evaluation especially for waters of high or good status as corresponding to a risk of breaching the Water Framework Directive prevent-deterioration principle.

48. It is noted that moderate is a transition class between good and poor and that where there is a read across to UWWT or Nitrates Directives, water bodies can be either in the "may become eutrophic" or "eutrophic" categories depending on the extent of ecological impacts.

49. As discussed in Chapter 3.6 (paragraph 44) and Chapter 6.2, information on confidence/uncertainty in classification is important for informing decisions on the appropriate follow-up actions.

50. The interpretation set out in the preceding paragraphs ensures a coherent action against eutrophication across the various policies. Action requirements under the various Directives should be considered together in order to produce the final outcome of the RBMP in December 2009. Therefore, whenever pressures

addressed by UWWT and Nitrates Directives are present, the list of water bodies subject to WFD Programme of Measures should be coherent with the designation of sensitive areas and polluted waters under UWWT and Nitrates Directives. It should be recalled that measures under these Directives are part of the Programme of Measures foreseen in Article 11.3 and Annex VI part A of the WFD.

51. It is worth noting that both sensitive areas under the Urban Waste Water Treatment Directive 91/271/EEC and nitrate vulnerable zones under Directive 91/676/EEC become Protected Areas under Article 6 and Annex IV of the WFD.

52. As regards concrete measures foreseen in the various Directives to combat eutrophication, according to Art. 5(2) of Directive 91/271/EEC, Member States shall ensure that urban waste water entering collecting systems shall before discharge into sensitive areas be subject to a more stringent treatment to reduce the nutrient load, for agglomerations of more than 10,000 p.e.. In addition, in accordance with Art. 5(5), discharges which are located in the relevant catchment areas of sensitive areas and which contribute to the pollution of these areas shall also be subject to a more stringent treatment[11]. Similarly, Art. 5(1) of Directive 91/676/EEC requires Member States to establish action programmes consisting of mandatory measures in respect to designated nitrate vulnerable zones (Art. 5(4)), as well as additional measures or reinforced actions if necessary to achieve the objectives (Art. 5(5)).

53. Nevertheless, following Article 5.8 of Directive 91/271/EEC, Member States do not have an obligation to identify sensitive areas (i.e. sensitive water bodies) if they implement, on their whole territory, more stringent treatment (Art. 5.2 and 5.3) or apply 75 % reduction of the overall load of total nitrogen and of total phosphorus entering all urban waste water treatment plants (Art. 5.4).

54. In the same way, following Article 3.5 of Directive 91/676/EEC, Member States shall be exempt from the obligation to designate specific vulnerable zones, if they establish and apply action programmes referred to in Article 5 throughout their national territory.

55. Member States may decide to apply the whole territory approach without taking into consideration the status of water bodies. Therefore, the fact that Member States have chosen to apply in their whole territory the control measures mentioned in the previous two paragraphs does not prejudge the result of the status assessment under WFD.

[11] See ECJ judgement in §§18 to §§ 20 of the case C-396/00, of 25 April 2002 (Milano case)

Table 5. Comparison of assessment results under various policies for waters responding to nutrient enrichment (based on the assumption that the WFD classification is the starting point and that the different sources of pollution are relevant).

ASSESSMENT OF CURRENT STATUS						
Ecological status	**WFD normative definition**	**UWWT Directive[12]**	**Nitrates Directive[12]**	**OSPAR**	**HELCOM**	**MSF Directive**
High	Nearly undisturbed conditions	Non-eutrophic, designation of sensitive area is **not required[13]**	Non-eutrophic, not a polluted water [7], designation of nitrate vulnerable zone is **not required**	Non-problem area	Area not affected by eutrophication	-
Good	Slight change in composition, biomass	Non-eutrophic, designation of sensitive area is **not required**	Non-eutrophic, not a polluted water [7], designation of nitrate vulnerable zone is **not required**	Non-problem area[14]	Area not affected by eutrophication	Human induced eutrophication is minimised[15]
Moderate	Moderate change in composition, biomass	Eutrophic or may become eutrophic in the near future, designation of sensitive area is **required**	Eutrophic or may become eutrophic in the near future, polluted water [7], designation of nitrate vulnerable zone is **required**	Problem area[14]	Area affected by eutrophication	Human induced eutrophication is not minimised[16]
Poor[17]	Major change in biological communities	Eutrophic, designation of sensitive area is **required**	Eutrophic, polluted water [7], designation of nitrate vulnerable zone is **required**	Problem area	Area affected by eutrophication	Human induced eutrophication is not minimised[16]
Bad	Severe change in biological communities	Eutrophic, designation of sensitive area is **required**	Eutrophic, polluted water [7], designation of nitrate vulnerable zone is **required**	Problem area	Area affected by eutrophication	Human induced eutrophication is not minimised[16]

12 If Member States have chosen to apply the whole territory approach, there is no obligation to designate sensitive areas under the UWWT Directive or nitrate vulnerable zones under the Nitrates Directive.

13 In coastal zones, with good water exchange and other conditions described in the Directive 91/271/EEC, Annex II.B, even less sensitive areas can be designated.

14 If insufficient data is available, ‘good’ or ‘moderate’ Ecological Status could correspond to a potential problem area. Nevertheless, in the case of potential problem areas with regard to eutrophication, preventive measures should be taken in accordance with the Precautionary Principle. Furthermore, there should be urgent implementation of monitoring and research in order to enable a full assessment of the eutrophication status of each area concerned within five years of its being characterised as a potential problem area (see OSPAR Strategy to Combat Eutrophication § 3.2b.).

15 Human induced eutrophication is minimised, especially effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters (MFSD Annex 1 (5))

16 Work on the development of the respective descriptor is under way.

17 Indirect effects of eutrophication (e.g. decline in dissolved oxygen) will be evident at poor Ecological Status.

56. Table 5 provides a general comparison but has to be interpreted with care. The following aspects should be considered in more detail, in particular:

a. In general, the designation of many sensitive areas (under the UWWTD), the identification of "polluted waters"[7] requiring designation of nitrate vulnerable zones (under the Nitrates Directive), and the first designation of "problem areas" (2003) under the OSPAR Common Procedure has taken place before the WFD entered into force. All existing designations will be unchanged by the WFD independent of the ecological status of the water bodies concerned, although that status will be important in determining what nutrient control measures will be required. Sensitive areas and nitrate vulnerable zones will become protected areas under Article 6 and Annex IV of the WFD. After 2006, any classification of the status of these water bodies under the WFD will not change this designation, but will affect decisions on the range and extent of control measures required to achieve WFD objectives[18].

b. After 2006, however, when the monitoring programmes under the WFD will have become operational, the results of the ecological status assessment should be considered in reviews of the identification of "sensitive areas" and the designation of nitrate vulnerable zones in accordance with the UWWT and Nitrates Directives, respectively. Where these directives apply, a complementary approach to eutrophication assessment under the WFD is desirable as these two directives are basic measures under the WFD. In considering any read across from WFD classes to identification of waters as "sensitive" or "polluted" under the UWWT or Nitrates Directives, the advice on checking procedures (paragraph 43 and Chapter 6.2) and accounting for uncertainty in eutrophication assessment (paragraphs 44 and 46 and Chapter 6.2), should be taken into account.

c. Designation of sensitive areas or nitrate vulnerable zones is only necessary when pressures covered by the UWWT or Nitrates Directives are significant (regarding the latter see paragraph 35 of Judgement Case C-293/97). Recent ruling by the Court of Justice helps to interpret this concept of significant contribution (see paragraphs 40, 52, 77 and 87 of Judgement Case C-280/02 and paragraphs 81 to 88 of the Case C-221/03).

d. Water bodies may still be in moderate-bad status for a long time after pressures have been reduced, due to delayed soil leaching/run-off response, internal loading and/or time-lagged response in the biological quality elements. In such cases, the clause on "natural processes" in the exemption of the WFD (Article 4.4 WFD) may be checked to see whether it is applicable. Alternatively, other internal restoration measures (e.g. bio-manipulation or sediment dredging) may be required to speed up the recovery back to good status.

e. Finally, also other criteria (independent from eutrophication of surface water) may lead to designation of nitrate vulnerable zones and identification of sensitive areas (for example high nitrate concentrations in surface and groundwater)[19]. However, these are not part of the deliberations in this guidance.

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18 The requirements on review of sensitive areas and designation of vulnerable zones every four years remains unchanged according to Art. 5(6) of 91/271/EEC and Art. 3(4) of 91/676/EEC.

19 See section A of Annex II of Urban Waste Water Treatment Directive 91/271/EEC, and Section A of Annex I of Nitrate Directive 91/676/EEC.

57. The pressures causing eutrophication may originate a long way from the water body being affected. In accordance to UWWT and Nitrates Directives, measures have to be taken in the relevant catchment areas of sensitive areas and which contribute to the pollution of these areas (Art. 5(5) of Directive 91/271/EEC), or in all known areas of land which drain into "polluted waters" [7] and which contribute to pollution (Art. 3(1), 3(2) and 5(1) of Directive 91/676/EEC). However, from the WFD perspective, this does not mean that all the water bodies upstream will need to be classified as less than good status.

58. Moreover, there may be situations where the nutrient pressures on affected water bodies may be located in another river basin (district) or adjacent areas of the marine waters (e.g. different parts of the Baltic Sea). This situation mainly occurs in transitional and coastal waters, where nutrient loads and/or eutrophication effects may be transported from one coast to another (e.g. North Adriatic Sea or German Bight, parts of the Baltic Sea, etc.) or from estuaries to coastal waters[20]. The assessments needed in this type of situation can be complex.

59. In comparing class boundaries used by the WFD and OSPAR it is helpful to describe the criteria for assessing Ecological Status in terms of primary and secondary impacts of eutrophication; this is done in Table 6. Environmentally significant undesirable impacts are expected to start at moderate Ecological Status (see Chapter 4 for more detail). It is proposed that the probability and severity of adverse effects increases from moderate to bad status.

Table 6. Examples of qualitative criteria for assessing WFD Ecological Status in terms of primary and secondary eutrophication impacts

Ecological Status	**WFD normative definition**	**Primary impacts (e.g. phytoplankton biomass)**	**Secondary impacts (e.g. O_2 deficiency)**
High	Nearly undisturbed conditions	None	None
Good	Slight change in abundance, composition or biomass for relevant biological quality elements	Slight	None or only slight
Moderate	Moderate change in composition or biomass for relevant biological quality elements	Change in biomass, abundance and composition begins to be environmentally significant, i.e. pollution tolerant species more common.	Occasional impacts from increased biomass
Poor	Major change in biological communities	Pollution sensitive species no longer common. Persistent blooms of pollution tolerant species	Secondary impacts common and occasionally severe
Bad	Severe change in biological comm.	Totally dominated by pollution tolerant species	Severe impacts common

20 Recent European Court of Justice ruling is relevant to interpret this concept. See Annex I, Section 1.2.4.

3.7. Examples of class comparisons

60. In this section some examples are given to clarify the relationships between different policies and, in particular, the differentiation between current status and the evaluation of status in the future, as set out in the preceding section. Table 7 summarises those examples. In all cases, it is assumed that pollution from urban waste water and agriculture sources are significant.

Table 7: Examples illustrating the relationship between WFD assessment classes, the result of the assessment of status in the future and the need for action under UWWT Directive, Nitrates Directive (ND) and WFD Programme of Measures

	Example A		Example B		Example C		Example D		Example E	
	Today	Future	Today	Future	Today	Future	Today	Future	Today	Future
High	●				●	►		►		
Good	●				●	►		►		
Moderate		►	●	► (1)			●		●	►►
Poor		►	●	►			●		●	►
Bad		►	●	►			●		●	
Action under UWWTD or Nitrates Directive needed?	Yes, in this case status may become eutrophic in the near future, action is needed		Yes, current status is eutrophic or may become eutrophic in the near future (case 1), action is needed		No		No. This can reflect the case in which measures under UWWTD or ND have already been taken and it is predicted that they will be effective to achieve the WFD objectives		Yes. This can reflect the case in which measures under UWWTD or ND have already been taken but it is predicted that they will NOT be effective to achieve the WFD objectives	
Action under WFD Programme of Measures needed?	Yes, status is predicted to deteriorate if no action is taken, therefore this case is at risk of not achieving WFD objectives		Yes, status less than good, this case does not achieve the WFD objectives		No		No additional measures than that already taken are necessary		Yes, additional measures under WFD Programme of measures are needed	

61. Some comments on the examples:

EXAMPLE A: In this case it is predicted that the status of the water body will deteriorate in the future. Action is needed under UWWT and Nitrates Directive because the water body "may become eutrophic in the near future". This water body would also be included in the WFD Programme of Measures because it is at risk of breaching the prevent deterioration principle.

EXAMPLE B: The water body is eutrophic or it may become eutrophic in the near future (case 1 corresponding to current moderate status). Therefore action is needed under UWWT and Nitrates Directives and it will also be included in the WFD Programme of Measures as this water body will not achieve the WFD objective of good status unless action is taken.

EXAMPLE C: This is the case where no eutrophication problem exists today and none is envisaged for the future. It should be noted that if it is predicted that the water body will deteriorate from high to good status, action should be taken under WFD Programme of Measures as this water body would be at risk of breaching the prevent deterioration principle.

EXAMPLE D: In this case it is predicted that the status of the water body will improve and it will reach good or high status. This can reflect the case in which measures under UWWT and Nitrates Directives have already been taken and are predicted to be sufficient to achieve WFD objectives. No further action under WFD is thus necessary.

EXAMPLE E: The last case has also the same starting point as D, but it is not expected that the measures taken according to the requirement of the Nitrates and UWWT Directives will give sufficient improvement in order to achieve a non-eutrophic status. This means that this water body has been identified as a polluted water and/or a sensitive area. WFD assessment would not change this designation. The WFD assessment results in a "less than good" status in the future as concerns nutrient enrichment. Additional measures to achieve WFD objectives are necessary under WFD Programme of Measures.

62. Linked with Example E, it is important to recall that under Article 5.5 of the Nitrates Directive "Member States shall take, in the framework of the action programmes, such additional measures or reinforced actions as they consider necessary if, […] it becomes apparent that the measures referred to in paragraph 4 will not be sufficient for achieving the objectives specified in Article 1". Therefore, in case of pollution from agricultural sources, the obligation to take additional measures and to review their effectiveness every four years (Art 5(7)), is already in force. In case of UWWT Directive, according to the Annex IB.4, more stringent measures must be applied where required to ensure that the receiving waters satisfy any other relevant Directives, for example the WFD.

63. It is important to note also that measures under UWWT and Nitrates Directives are considered basic measures in the WFD Programme of Measures, and therefore are minimum requirements to be complied with (Article 11.3 and Annex VI, Part A of the WFD).

64. The comparison of assessment results under various policies introduced in the preceding section and illustrated with the examples in Table 7 ensure a coherent and reinforced action against eutrophication across different policies.

65. In the examples, a generic "future" scenario is used, deliberately omitting any deadline for implementation of different directives. Measures under Nitrates and UWWT directives should have already been taken to combat eutrophication as appropriate. Nevertheless, as stated previously, from 2006 onwards and for new developments and newly identified problems, the WFD assessment framework may help in the implementation of these other directives.

4. THE WFD CONCEPT OF ECOLOGICAL STATUS IN THE CONTEXT OF EUTROPHICATION

66. This section summarises the main outcomes of a paper drafted by the Working Group on Ecological Status (ECOSTAT) under the WFD Common Implementation Strategy, on the interpretation of the WFD concept of ecological status in the context of eutrophication (the full paper is available as a background document)[21]. This paper is based on and further develops the Classification Guidance Document which was adopted by the Water Directors in November 2003 (see Annex 1, section 1.1.6 for a summary of this document).

67. The objective of this chapter is to set out a proposed common understanding of the Water Framework Directive's normative definitions in the context of nutrient enrichment and eutrophication. Such an understanding is necessary to underpin the ecological status classification in the context of eutrophication and thus the intercalibration exercise and the design of monitoring programmes. The proposed understanding focuses on those key principles of the normative definitions that are relevant across the water categories.

4.1. Most sensitive biological quality elements

68. As a general rule, the aquatic flora will have an earlier response to changes in nutrient conditions than benthic invertebrates or fish. The relative 'sensitivity' of different quality elements of the aquatic flora (e.g. macrophytes, phytobenthos or phytoplankton) to nutrient enrichment may vary, depending on the water category, surface water body type, the quality, amount and transport of nutrient loading as well as the specific environmental conditions such as flow conditions, salinity or turbidity. Furthermore, the most sensitive quality element or parameter to changes in eutrophication status, be it either in a deterioration or a recovery situation, will depend on the state of the water body's biological community's development towards 'equilibrium' with the altered pressure status.

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21 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm=detailed&sb=Title

69. For instance phytoplankton, phytobenthos and macroalgae derive their nutrients from the water column and, under the right conditions, can colonise, grow and reproduce quickly. As a consequence, they tend to respond rapidly to changes in nutrient concentrations. However, these quality elements can also be characteristically highly variable. This may make reliable assessments of their condition difficult.

70. Rooted macrophytes and angiosperms derive their nutrients from sediments or from a combination of sediments and the water column. Their response to nutrient enrichment tends to be slower than that of phytoplankton, phytobenthos and macroalgae, and therefore may enable reliable assessments to be achieved more easily. On the other hand, this relative ‘stability’ means that assessments based solely on macrophytes and angiosperms may in some situations fail to detect the early onset of eutrophication or the effects of restoration measures.

4.2. Role of the normative definitions in the development of ecological assessment methods

71. The normative definitions are the basis for identifying suitable boundary values for each of the indicator parameters. After selecting the metric or metrics to be used to assess the condition of the quality element, the common interpretation of the normative definition will drive the setting of the boundaries for each metric. Once a boundary has been set up, the monitoring results can be used to classify the condition of the quality element.

4.3. Shared principles in the normative definitions for the different water categories

72. The type-specific conditions defined for good and for moderate ecological status in rivers, lakes, transitional and coastal waters represent equivalent stages in the process of eutrophication in the different water categories, even if the conditions are sometimes expressed in the Annex V normative definitions using different wording.

4.4. Description given for abundance and taxonomic composition of aquatic flora

73. The condition of phytoplankton, phytobenthos, and macroalgae would not be consistent with good status unless there was a negligible probability (i.e. risk) that accelerated algal growth would result in a significant undesirable disturbance to the aquatic ecosystem (see Figure 4). The condition of macrophytes and angiosperms would not be consistent with good status unless there was a negligible probability that accelerated growth of higher forms of plant life would result in a significant undesirable disturbance to the aquatic ecosystem.

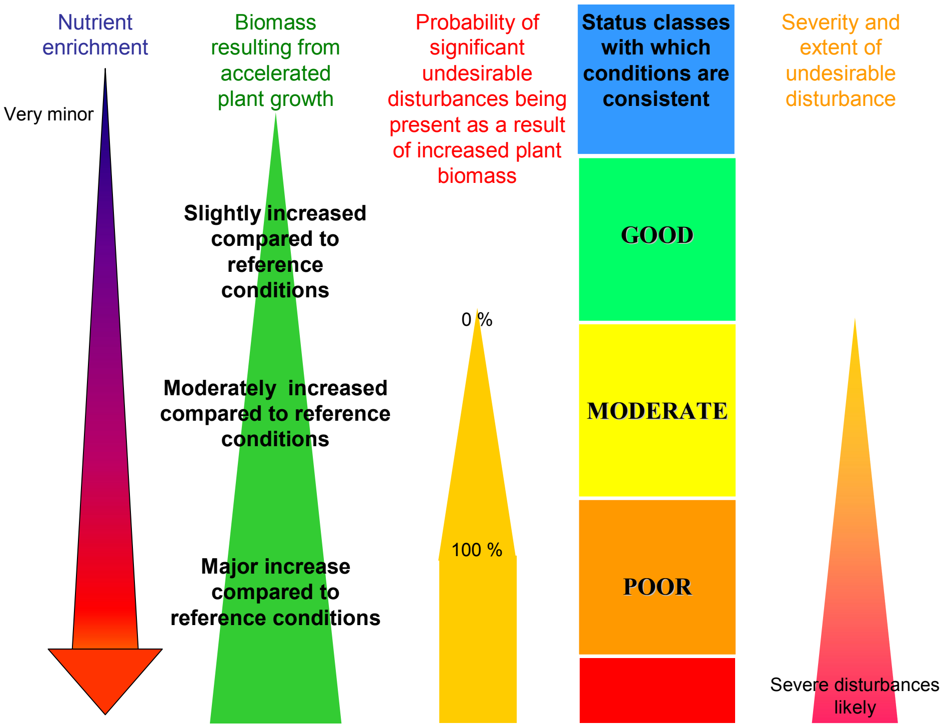

Figure 4. The condition of the water body would not be consistent with good status, once phytoplankton biomass, macroalgal cover, average phytobenthic abundance, average macrophytic abundance or angiosperm abundance has reached levels at which the probability of a significant undesirable disturbance to the aquatic ecosystem is no longer negligible.

74. A significant undesirable disturbance is a direct or indirect anthropogenic impact on an aquatic ecosystem that appreciably degrades the health or threatens the sustainable human use of that ecosystem (see Table 8). For a water body to be at good status there must be a negligible probability of such disturbances being present as a result of human activity.

75. Nutrients can sometimes cause changes in the taxonomic composition of plants or algae, without causing the biomass to increase to a level where it shows secondary impacts on flora, fauna or water quality in general. These rather subtle effects of eutrophication may occur in oligotrophic lakes in particular (see Figure 5).

76. The condition of phytoplankton, phytobenthos, macrophytes, macroalgae or angiosperms would not be consistent with good ecological status where, as a result of anthropogenic nutrient enrichment, changes in the balance of taxa are likely to adversely affect the functioning or structure of the ecosystem (see Table 9). For a water body to be at good status there must be a negligible probability of such disturbances to the balance of organisms being present.

Table 8. Significant undesirable disturbances that may result from accelerated growth of phytoplankton, macroalgae, phytobenthos, macrophytes or angiosperms (Source: ECOSTAT Paper on classification related to eutrophication[22])[23]

a.	Causes the condition of other elements of aquatic flora in the ecosystem to be moderate or worse (e.g. as a result of decreased light availability due to increased turbidity and shading caused by increased phytoplankton growth)
b.	Causes the condition of benthic invertebrate fauna to be moderate or worse (e.g. as a result of increased sedimentation of organic matter; oxygen deficiency; release of hydrogen sulphide; changes in habitat availability)
c.	Causes the condition of fish fauna to be moderate or worse (e.g. as a result of oxygen deficiency; release of hydrogen sulphide; changes in habitat availability)
d.	Compromises the achievement of the objectives of a Protected Area for economically significant species (e.g. as a result of accumulation of toxins in shellfish)
e.	Compromises the achievement of objectives for a Natura 2000 Protected Area
f.	Compromises the achievement of objectives for a Drinking Water Protected Area (e.g. as a result of disturbances to the quality of water)
g.	Compromises the achievement of objectives for other protected areas, e.g. bathing water.
h.	Causes a change that is harmful to human health (e.g. shellfish poisoning; toxins from algal blooms in water bodies used for recreation or drinking water)
i.	Causes a significant impairment of, or interference with, amenities and other legitimate uses of the environment (e.g. impairment of fisheries)
j.	Causes significant damage to material property

77. It is relevant here to introduce the interpretation of the European Court of Justice of the concept of "undesirable disturbances of the balance of organisms present". A recent Court ruling states that this concept means species changes involving loss of ecosystem biodiversity, nuisances due to proliferation of opportunistic macroalgae and severe outbreaks of toxic and harmful phytoplankton (see Annex 1, section 1.2.4).

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22 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm=detailed&sb=Title

23 See also §§18 and 22 of the ECJ judgement for the case C-280/02.

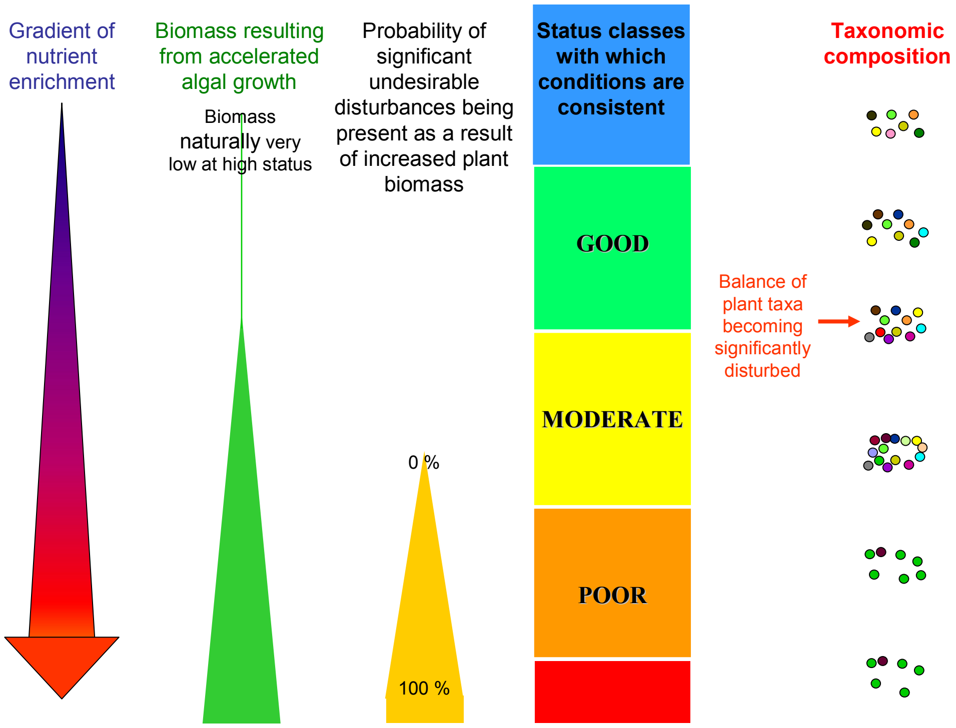

Figure 5. Ecologically undesirable changes in the composition of aquatic flora taxa may occur earlier along an increasing nutrient enrichment gradient than ecologically undesirable disturbances resulting from changes in the biomass of that flora (e.g. in some lakes that at reference conditions are low in nutrients and plant biomass)

Table 9. Examples of ecologically significant, undesirable changes to the composition of taxa.

Moderate conditions	**Poor or bad conditions**
The composition of taxa differs moderately from type-specific reference conditions such that:	
• nutrient-tolerant taxa or a functional group[24] of taxa that are absent or rare at reference conditions is no longer rare	• communities are dominated by nutrient-tolerant functional groups normally absent or rare under reference conditions
• moderate number of taxa are absent or rare compared to reference conditions such that a functional group of taxa is in significant decline; or • The condition of the functional group of taxa is exhibiting clear signs of stress such that there is a significant risk of localised extinctions at the limits of its normal distributional range	• one or more functional groups of taxa normally present at reference conditions has become rare or absent • the distribution of a functional group of plant taxa is so restricted compared to reference conditions that a significant loss of function has occurred (e.g. invertebrates or fish are in significant decline because of the loss of habitats normally provided by functional groups of macrophyte; macroalgal or angiosperm taxa)
• a group of taxa normally present at reference conditions is in significant decline	• a group of taxa normally present at reference conditions has become rare or absent

[24] Functional groups of taxa are different groups of taxa within a biological quality element that serve particular ecological roles

4.5. The role of general physico-chemical quality elements

78. The relative significance of the two most critical eutrophying nutrients, nitrogen and phosphorus, will vary in different surface water categories and types of surface waters. In transitional and coastal waters anthropogenic nitrogen enrichment is generally the most important cause of eutrophication, although there are cases where both nutrients may be limiting, but during different seasons. In freshwaters, generally phosphorus enrichment is the main cause of eutrophication.

79. If the monitoring results for (a) the biological quality element or elements most sensitive to nutrient enrichment and (b) the nutrient or nutrients being discharged in significant quantities meet the relevant type-specific conditions required for good ecological status, the level of nutrient enrichment in the water body will be consistent with good ecological status.

80. However, if either (a) one of the most sensitive biological quality elements to nutrient enrichment; or (b) one of the nutrients being discharged in significant quantities do not meet the conditions required for good ecological status, the ecological status of the water body will be moderate or worse.

81. Further guidance on classification and, in particular, on the role of general physico-chemical quality elements is provided in CIS Guidance on the Classification of Ecological Status. The guidance describes a checking procedure aimed at helping to ensure that the good status type-specific levels for nutrient concentrations are neither more stringent nor less stringent than required to support the achievement of good status for the type-specific conditions for the biological quality elements and the functioning of the ecosystem (see also Chapter 6.2 and Annex 1, section 1.1.6).

5. Overview of current eutrophication assessment methodologies and criteria in European countries

5.1. Introduction

82. Eutrophication assessment methodologies and criteria for classification of water quality status have been used by Member States in particular in the implementation of the Urban Waste Water Treatment and Nitrates Directives, and in relation to the commitments taken within the marine conventions OSPAR and HELCOM. Member States have completed the WFD Article 5 risk assessments for which existing eutrophication assessment criteria were used or newly derived criteria to determine whether surface water bodies are at risk of failing their environmental objectives in 2015 from eutrophication related pressures. Since then, new eutrophication-related assessment methodologies and criteria, or some degree of modification of already existing methods, were developed in the Member States in relation to the implementation of the requirements of the WFD for the classification of ecological status in lakes, rivers, coastal and to a lesser extent in transitional waters. These requirements included the choice of the appropriate indicators, typology of water bodies, reference conditions, and agreement on common principles for setting

quality class boundaries (see Heiskanen et al., 2004). In addition, some of the methods developed were subjected to an intercalibration process during the years 2004 to 2007. This process, to a large extent focused on methods sensitive to eutrophication, has established the value for the boundary between the quality classes of high and good status, and the value for the boundary between good and moderate status for the Member State's biological classification systems ensuring their consistency with the normative definitions (WFD annex V, section 1.2) and the comparability between Member States.

83. The results of the intercalibration exercise were adopted in Commission Decision 2008/915/EC on 30 October 2008[25]. Technical reports on the Water Framework Directive intercalibration exercise (Carletti and Heiskanen, *in press*; Poikane, *in press*; Van de Bund, *in press*), one for each water category (i.e. lakes, rivers and coastal and transitional waters), describe in detail how the intercalibration exercise has been carried out in each Geographical Intercalibration Group (GIG), including the procedures and criteria that were agreed for setting reference conditions, to ensure consistency with the normative definitions, and to ensure comparability of class boundaries between Member States.

84. In several cases, the results of European collaborative research projects were used in the development of new indicators and/or classification schemes (e.g. Charm, AQEM, STAR, REBECCA, FAME; see Heiskanen et al., 2005; Hering et al., 2006; Solimini et al., 2006; Pont et al., 2006). In this sense, one of most supportive projects was REBECCA (2003-2007) which has contributed to development of methodologies and criteria with a timetable for the project deliverables synchronised to some extent with the timetable for the intercalibration process.

85. This overview of current eutrophication assessment methodologies and criteria gathers information provided by Member States during the development of this guidance document and new methodologies and criteria from the intercalibration exercise and REBECCA project.

86. Sections 5.2 to 5.4 summarise the information available from these sources for lakes, rivers, transitional, coastal and marine waters, respectively.

5.2. Lakes

5.2.1. Assessment methodologies and criteria used for water quality status classification

87. Many Member States had water quality assessment systems prior to the adoption of the WFD which already included assessment methods and criteria for eutrophication related parameters. Information collated in previous syntheses (i.e. Cardoso *et al*., 2001) and as part of this activity[26] indicates that the assessment of the degree of eutrophication in lakes has been, until the adoption of the WFD, primarily determined through

[25] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008D0915:EN:NOT

[26] see Eutrophication Workshop held in Brussels on the 7-9 September 2005

the application of nutrient (phosphorus and nitrogen) concentration criteria supplemented with the use of criteria for indicators of eutrophication direct effects. The most commonly included were the criteria for chlorophyll a and Secchi depth but occasionally other indicators, such as changes to phytoplankton composition were also used. A number of other parameters (indicators) were used in some Member States, although indicators of indirect eutrophication effects (dissolved oxygen concentrations and responses in benthic invertebrate and fish communities) were not generally used.

88. Some of these water quality assessment schemes recognised the existence of different lake types in broad terms but many schemes were applied indiscriminately to all lakes in a Member State. However, for management purposes the assessment was done in relation to a rough estimation of the lake's natural trophic status. Thus, with few exceptions these assessment systems are not type-specific in terms of WFD typology and do not relate to reference conditions.

89. Information of the assessment systems for which information has been shared at the Eutrophication Workshop (Brussels, 2005) for Norway, Sweden, Finland, Austria, Italy and Hungary showed that the most commonly used assessment parameters, i.e. chlorophyll a, total phosphorus (TP) and Secchi depth, of most of these countries' systems (with exception of the Hungarian) showed relatively good agreement in the criteria for the best quality classes. For chlorophyll a (summer mean values) the best quality class varies from < 2 μgl^{-1} in Norway and Sweden to < 4 μgl^{-1} in Finland and Austria. For total phosphorus (summer mean values) the best quality class varied from < 7 μgl^{-1} in Norway to < 13 μgl^{-1} in several other countries. For Secchi depth the best quality class varies from > 6 m to > 3 m between countries. For all these three basic eutrophication assessment parameters, the between country variation for the best class is roughly a factor of 2. For the other classes the differences between countries are larger, probably due to both different class definitions, as well as to real regional differences.

90. The Hungarian system has considerably higher boundary criteria between the quality classes for total phosphorus and chlorophyll a, which is probably mainly explained by different lake types in Hungary (very shallow, calcareous) compared to the Northern and Alpine countries (deeper, more siliceous geology). The Hungarian class I includes values comparable to class III (moderate) of the other countries compiled, whereas the Hungarian class II compares to class IV or V (poor or bad) in the other countries.

91. For the indirect effect criterion oxygen saturation, the two systems compiled (Hungary and Finland) show relatively good agreement, with class I having 80-110 % O_2 saturation, whereas class V has < 20 % or < 40 % O_2 saturation for the Hungarian and Finnish systems respectively.

92. The two countries, Sweden and Austria that have developed classification systems for phytoplankton biomass (mgl^{-1}) show remarkably good agreement: Class 2 is <1 mgl^{-1} and class 5 is > 5 mgl^{-1}.

93. For other assessment criteria the data provided is not sufficient to enable comparisons between countries.

94. For additional information on national criteria for eutrophication assessment in the context of the UWWT and Nitrates Directives see Cardoso *et al*. (2001).

5.2.2. Impact and pressure criteria used in WFD Article 5 risk assessment

95. In completing the WFD Article 5 risk assessments for eutrophication related pressures, some Member States have derived pressure and impact criteria to determine whether a lake water body was at risk of not achieving its environmental objective in 2015. Where used, the pressure criteria have been based on the presence of point sources of nutrients and/or a proportion of a particular land use (most commonly agricultural and urban land uses) in the catchment of the lake. One country (Spain) assesses a water body to be probably at risk if the application of fertilizer is > 25 kg N ha^{-1} year or if major point sources are present, such as urban waste water > 2000 PE, unless no impact is documented.

96. For the most part, the impacts were measured based on nutrient concentrations (phosphorus and nitrogen) with occasional examples of the use of direct effects (chlorophyll a) to supplement them. For the latter the existing classification systems are used in a way in which lakes in the high or good classes are assessed as being not at risk, whereas lakes in the poor or bad classes are assessed as being at risk of failing the WFD objective. One Member State (UK) use the EQR< 0.5 for current phosphorus concentrations relative to type or site-specific background concentrations to assess water bodies at risk, whereas other (NL) use, among others, the existing management target value to assess water bodies at risk. The actual cut-off for TP between at risk and not at risk is comprised within a wide band of concentrations from < 10 µg l^{-1} to > 100 µg l^{-1} for the different countries, which is probably related to type differences. For chlorophyll a the only two Member States who have reported cut-off values (Norway and Spain) both use 8 µg l^{-1} to say that a water body is clearly at risk (Norway) or probably at risk (Spain)[27]. Other impact parameters are too scarcely used to allow comparisons between countries. Many Member States also evaluate future trends in nutrient pressures from the catchment as part of their risk assessment. Further details on the parameters used are provided in the reports provided by the Member States under Article 5 WFD.

5.2.3. New WFD-compliant assessment systems

97. Many Members States have been engaged in the development of new, or refinement of existing, assessment methods for the eutrophication related biological quality elements required for the assessment of ecological status under the WFD. The work under the Intercalibration process for lakes has focussed on the calibration and harmonisation of the national assessments based on phytoplankton and macrophyte responses to nutrients. Intercalibration metrics (Poikane, *in press*) used for lakes are: phytoplankton parameters indicative of biomass - chlorophyll a and total biovolume; phytoplankton parameters indicative of taxonomic

[27]http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm=detailed&sb=Title

composition and abundance - Brettum Index, PTSI - Phytoplankton Taxa Lake Index, PTI_{ot} - Phytoplankton Taxa Index, $PTI_{species}$ - Phytoplankton Taxa Index, Catalan Index, Med PTI Index, % bluegreens, % chrysophytes, % diatoms; macrophyte composition (% isoetids, % characeans) and reduction in depth distribution of macrophytes (Austrian Index Macrophytes for lakes, German Macrophytes Assessment System, Free Macrophyte Index, Swedish Macrophyte Trophic Index (Ecke), Norwegian Macrophyte Trophic Index (Mjelde), UK Macrophyte Assessment System: LEAFPACS).

98. The development of these methods and their intercalibration (included the definition and agreement on reference conditions and collation of data illustrating the metric (=indicator) response to a pressure gradient) also supported the development of criteria for the eutrophication related supporting physico-chemical elements such as Secchi depth and nutrients, primarily total phosphorus concentrations.

99. The intercalibration process partially included methods sensitive to the indirect effects of eutrophication, such as oxygen depletion in bottom waters and fish kills. In several GIGs secondary effects were used for setting chlorophyll a boundaries, such as oxygen depletion and fish kills.

100. The REBECCA project Work Package 3 (WP3 Lakes) has supported the intercalibration process by establishing the relationships between nutrient concentrations or an indicator of the trophic condition (e.g. trophic score) and response variables (= effects indicators, metrics) relating to phytoplankton, macrophytes, macroinvertebrates and fish (see report on dose-response relationships between biological and chemical elements in different lake types; Lyche-Solheim, 2007). These results have already, because of the close collaboration between the REBECCA project and the intercalibration expert groups, where appropriated, been considered in the intercalibration process. Further details of the REBECCA results can be found in a review of the literature on these relationships in European lakes based on the knowledge until 2005 (Solimini *et al.* 2006), as well as a report on Reference conditions of European Lakes (Lyche-Solheim *et al.* 2005).

101. The work carried out in recent years within Member States and at the EU level, in research projects and as part of the intercalibration process, has provided scientifically based and intercalibrated assessment systems and further understanding of the relationships between biological and supporting physico-chemical elements of lakes. The results of the intercalibration process, the Ecological Quality Ratios for the high/good and good/moderate class boundaries (for phytoplankton also the absolute metric values, i.e. chlorophyll a concentration and biovolume), per Geographic Intercalibration Group (GIG) and lake type, for the phytoplankton and macrophyte metrics listed above, have now been agreed and included in Annex to the Commission Decision (Commission Decision 2008/915/EC). The Member States will now need to translate the values published in the Decision into their national systems with the help of guidelines prepared for this purpose and available online at:

http://circa.europa.eu/Members/irc/jrc/jrc_eewai/library?l=/intercalibration&vm=compact&sb=Title.

102. The application of these assessment systems as part of the WFD implementation, including the collation and analysis of data from WFD monitoring and from research projects, may lead to a review of the intercalibration results and thus also to changes to the national assessment systems.

103. Another important issue that may lead to a need for revision of the intercalibration results is related to lack of standardisation of methods for collection of the data used in this first round of the process. Thus, with maybe the exception of the Northern GIG, where there was already some degree of harmonisation of the methods, the noise in the data associated to the method is probably an important component of all variance in the data.

104. Through the intercalibration, all GIGs have now agreed on the good/moderate quality class boundary for the metrics list above (see paragraph 87), and all but the Mediterranean GIG have agreed on the high/good quality class boundary for chlorophyll a for a small number of broadly defined lake types, which are applicable in all the countries sharing the type.

105. The national lake phytoplankton metrics can be roughly divided into taxonomic based and non-taxonomic based metrics. The use of phytoplankton taxonomic metrics for water quality assessment has a long tradition, with the first indicators developed in the 40's and since then numerous indicators were developed, some of which have been included in the WFD assessment schemes. Yet, a number of new indicators were developed tailored to address the WFD requirements. Three new phytoplankton trophic indices (PTI-s) where elaborated for deep subalpine lakes (Salmaso et al., 2006). Another development is the method adopted in the WFD monitoring scheme in Hungary based on functional groups, i.e. groups with species frequently found to co-exist and to increase or decrease in number simultaneously are thus given association identities. The method was first developed by Reynolds et al. (2002) and further developed Padisák et al. (2003, 2006).

106. Phytoplankton abundance and occurrence of blooms are the parameters for which a taxonomic determination is not necessarily required. The abundance is measured as the total count of cells and/or colonies in a unit volume of water or recalculated further into biovolume or biomass. The WFD allows using chlorophyll a as a surrogate for phytoplankton biomass, and in fact chlorophyll a is still the most frequently measured phytoplankton metric in lakes. Not all countries have included the bloom occurrence in routine monitoring as in some areas (e.g. countries belonging to the Alpine GIG) they occur too rarely and irregularly (if at all). Other non-taxonomy based metrics, like size composition and primary production, are not considered in lake monitoring schemes.

107. Classification schemes for macrophytes were developed by many Member States. One approach being followed in Germany (Schaumburg et al., 2004) and England (Willby et al., 2006) is to designate macrophytes as reference, impacted, or indifferent for specific lake types. The classification of a lake is then based on the proportions of macrophytes that are indicative of reference and impacted conditions. The method used in Northern Belgium also incorporates aspects of this approach together with metrics describing

the diversity of growth forms and changes in abundance (Leyssen et al., 2005). The Dutch method incorporates information on the percentage cover of submerged macrophytes (for a depth range of 0-3 m), shoreline emergent vegetation cover and species composition (divided into three indicative groups weighted by their abundance) (Van der Molen, 2004; Coops et al., 2007). In Sweden assessment is based on taxa richness and the assignment of a trophic ranking score for different lake types (Swedish EPA, 2007). In Ireland a multimetric approach is followed incorporating several of the aforementioned parameters as well as the depth of colonization of macrophytes (Free et al., 2007).

108. Although there appears to be some concordance of assessment approaches across Europe, the methods used to collect such data are diverse and may in some cases not be fully representative of the pressure impact (e.g. strong biased towards sampling the shallower areas and not the full representative of macrophyte depth distribution). Future work needed includes the gathering of an extensive standardized dataset matched with important environmental parameters, including sediment characteristics, and to further understand the role of macrophytes in lake ecosystem functioning.

109. Several GIGs have attempted to relate environmental factors like TP and Secchi depth with chlorophyll a. Such relationships may be used for setting criteria of quality classes for those environmental factors which is of fundamental importance in lake management. The main approaches followed, with the support of data and their analysis from the REBECCA project (Table 10), were either based on a percentile of the reference lakes data set (mostly the 75 %ile for reference sites) or based on regressions between chlorophyll a and TP compiled for a large number of lakes, or based on both methods. The use of this type of relationships can be, however, limited. For shallow lakes discontinuous relationships may be present e.g. between TP and chlorophyll a, and therefore linear regression is not very appropriate. In addition, the TP is providing generally the best prediction for the maximum chlorophyll a values, because there can be many biological reasons why not all TP is transferred into phytoplankton biomass.

Table 10. **Regression equations for relationships between mean growing season chlorophyll a and TP for lakes categorised by grouped typology factors (Phillips et al, 2008).**

Type group	Equation	R^2	p
Low and moderate alkalinity shallow and very shallow lakes	Log10 Chl = -0.528(±0.03) + 1.108(±0.02)Log10 TP	**0.81**	<0.001
High alkalinity shallow and very shallow lakes	Log10 Chl = -0.306(±0.10) + 0.868(±0.07) Log10 TP	**0.52**	<0.001
All deep lakes	Log10 Chl = -0.286(±0.04) + 0.776(±0.041) Log TP	**0.65**	<0.001

5.3. Rivers

5.3.1. Assessment methodologies and criteria used for water quality status classification

110. As for lakes, in most cases Member States water quality assessment systems for rivers, prior to the adoption of the WFD, included assessment methods and criteria for eutrophication related parameters. Information collated in previous syntheses (i.e. Cardoso *et al*., 2001) and as part of this activity (see Eutrophication Workshop, Brussels 2005) indicates that the assessment of the degree of eutrophication in rivers to date has been primarily determined through the application of nutrient (phosphorus and nitrogen) concentration criteria with the occasional supplementary use of metrics indicative of direct effects (chlorophyll a and changes to phytobenthos and macrophyte communities) and metrics indicative of indirect effects (e.g. dissolved oxygen concentration and changes to benthic invertebrate communities) criteria. The most commonly used parameter for rivers is TP concentration and the criteria for excellent water quality are broadly comparable (0.01 to 0.07 mgl^{-1} TP; though these include summer mean, annual mean and 90 and 75 %ile values). Criteria for orthophosphate are used in one Member State. Criteria for total nitrogen (TN) and nitrate are used in 2 Member States and also show good agreement. In all cases existing classification schemes are river type-specific but were applied to all types of river.

111. For additional information on national criteria for eutrophication assessment in the context of the UWWT and Nitrates Directives see Cardoso *et al*. (2001). The most commonly used criterion for designation of nitrate vulnerable zones is the 50 mgl^{-1} NO_3 value. However, for UWWT sensitive area designation, phosphorus criteria are used along with further information from metrics indicative of direct effects (chlorophyll a concentration and phytobenthos and macrophytes community metrics) and from metrics indicative of indirect effect (changes to the dissolved oxygen regime) in a weight of evidence approach to determine the case for designation.

5.3.2. Impact and pressure criteria used in WFD Article 5 risk assessment

112. In completing the WFD Article 5 risk assessments for eutrophication related pressures, some Member States have derived pressure and impact criteria to determine whether a river water body was at risk of not achieving its environmental objective in 2015. Where used, the pressure criteria have been based on the presence of point sources of nutrients and/or a proportion of a particular land use (most commonly agriculture, forestry and untreated wastewater from settlements) in the upstream catchment of the river water body. For the most part, the impact criteria were based on nutrient concentrations (phosphorus and nitrogen). The most commonly used impact criteria were TP and orthophosphate. Values for the estimated good/moderate class boundary used in the Article 5 risk assessments were comparable for similar river types (i.e. lowland rivers) (0.15 mgl^{-1} TP and 0.1mgl^{-1} orthophosphate-P). Criteria for TN and for nitrate were used in some Member States supplemented with criteria for metrics indicative of indirect effects (dissolved

oxygen concentrations, benthic invertebrate and phytobenthos metrics). Further details on the criteria used are provided in the reports provided by the Member States under Article 5 WFD.

5.3.3. New WFD-compliant assessment systems

113. Many Member States have been engaged in the development of new, or refinement of existing, assessment methods for the eutrophication related biological quality elements required for the assessment of ecological status under the WFD. For rivers, the eutrophication related biological quality elements are principally phytobenthos, macrophytes and, where appropriate, phytoplankton and macrozoobenthos. The development of assessment methods for these elements will necessarily result in the definition of type-specific reference conditions and class boundary criteria for the classification of ecological status with respect to these biological quality elements. Also, the development of assessment methods for these biological quality elements and their intercalibration (as explained above this process included the definition and agreement on reference conditions and collation of data illustrating the metric response to a pressure gradient) have resulted, in some cases, in the development of criteria for the eutrophication related supporting physico-chemical determinands such as nutrients and dissolved oxygen concentrations. Information collated under this activity on the development of new methods (compare overview of nutrient standards)[28] indicates that preliminary criteria for nutrients (TP, orthophosphate, TN and nitrate) have been proposed for reference conditions and the good/moderate boundary in a number of Member States. Additional criteria for chlorophyll a and dissolved oxygen have also been suggested.

114. The REBECCA project Work Package 4 (WP4 Rivers) has supported the intercalibration process by exploring new tools for assessing eutrophication through the response of phytobenthos metrics to nutrients, i.e. diatom based techniques, making use of diatoms morphological-functional attributes and biotypes, but also revaluating existing indexes in a WFD perspective (see report on suitable single and integrated biological indicators for different pressures in rivers; Friberg, 2007). Further details of the REBECCA WP4 results can be found in a review of the literature on these relationships in European rivers based on the knowledge until 2004 (Andersen *et al.* 2004), as well as a report on relations linking pressures, chemistry and biology in rivers and tools for assessing these linkages (Friberg, 2007).These results have already, because of a close collaboration between REBECCA researchers and the intercalibration expert groups, where appropriated, been considered in the intercalibration process.

115. The work under the Intercalibration process has for rivers focussed on benthic invertebrates as indicators of organic contamination or general degradation. However, four of the five river GIGs, the Alpine, Central/Baltic, Mediterranean and Northern GIG have successfully intercalibrated phytobenthos metrics which are primarily eutrophication indicators, thus have also provided criteria for eutrophication related

[28] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm=detailed&sb=Title

supporting physico-chemical elements. The results of the intercalibration process, the Ecological Quality Ratios for the high/good and good/moderate quality class boundaries, and for the phytobenthos national classification systems, per GIG and river type have now been agreed and included in Annex to the Commission Decision (Commission Decision 2008/915/EC). The Member States will now have to translate the values published in the Decision into their national systems with the help of guidelines prepared for the purpose.

116. The application of these assessment systems to data to be collected as part of the WFD monitoring requirements, the analysis of this data and other data collected through research projects may eventually lead to a review of the intercalibration results in order to improve their quality. Unlike the problems found with phytoplankton metrics in lakes related to the noise (i.e. highly variable due to different national sampling procedures) in the data available, the existence and common use of standard methods for sampling of phytobenthos was responsible for the good quality of the data available which greatly facilitated the intercalibration exercise.

117. All but the Eastern Continental GIG have agreed on the high/good and good/moderate quality class boundary for phytobenthos national assessment metrics for a small number of broad river types.

The biological monitoring of water quality in rivers has a long tradition in Europe (see Ziglio et al., 2006 for a recent review). However, the fulfilment of the WFD's requirements imposed a revision of many old assessment methods which were either adapted to meet WFD specifications or resulted in the setup of new classification systems.

118. Annex V of the WFD refers to ‘macrophytes and phytobenthos’ as a single biological element and identifies four characteristics (taxonomic composition, abundance, likelihood of undesirable disturbances and presence of bacterial tufts) that need to be considered for the purpose of ecological status assessment. Most countries decided to develop separate methods for macrophytes and phytobenthos. Some MS included larger algae such as Cladophora in their macrophyte methods while others included the latter as part of the phytobenthos. However, most of the countries decided to use diatoms as a representative group for the whole phytobenthos.

119. The term “phytobenthos” refers to a highly diverse group of organisms (diatoms, filamentous algae, blue-green, etc.) with heterogeneous growth forms on many different river substrates. For the assessment of ecological status, diatoms are the most frequently used indicators included in monitoring programs. Almost all metrics rely on the taxonomic composition of the assemblages, often relating the metric value to the pressure gradient with weighted averaging like in the Trophic Diatom Index (TDI; Kelly, 2001) or in the Indice de Polluosensibilité (IPS; Coste in Cemagref, 1981). For example, the TDI relies on the fact that (in theory) at least the diatom assemblages characteristic of low, moderate and high phosphorus concentrations can be defined (Kelly, 2001). In practice, there are many other factors that can also influence the composition of the diatom assemblage, making assessment difficult. The phytobenthos abundance is also

highly temporally and spatially variable and its assessment, also in relative terms, is problematic. Few Member States have developed new methods based on the relative abundance of positive and negative indicator species.

120. Phytoplankton is an important component of riverine food webs in large rivers (Prygiel and Haury, 2006). The short generation time makes this group of organisms highly reactive to changes in flow conditions, light and nutrients. However, phytoplanktonic biomass is strongly linked to the water residence time and significant amount of biomass may be reached only in low gradient tracts of large rivers and canals when the residence time is long enough for algal development (e.g. more than 6 days). Routine monitoring using phytoplankton is foreseen by those countries where such river types are present in a relevant number but may be often limited to the measure of chlorophyll a as an indicator of phytoplanktonic biomass.

5.4. Transitional waters

5.4.1. Assessment methodologies and criteria used for water quality status classification

121. Eutrophication is a recognised threat to the ecological status of transitional water bodies as these accumulate nutrients transported from river systems, from direct inputs from their surrounding catchments and, in some cases, from coastal waters. The expression of the direct and indirect effects of eutrophication in response to increasing nutrient inputs is more complicated in many transitional water types due to the confounding influences of other natural and anthropogenically induced processes. Transitional waters can support a high degree of anthropogenic activity. Zaldívar et al. (2008) identified this phenomenon and termed it the 'transitional water quality paradox', based on the 'estuarine water quality paradox' suggested by Elliott and Quintino (2007 in Zaldívar et al. 2008) for estuaries, to describe the difficulties in identifying a pressure-specific signal (such as eutrophication) against a highly variable natural background compounded by the competing effects of the impacts arising from other pressures.

122. Nevertheless, approaches to eutrophication assessment have been developed for transitional water bodies. Zaldívar et al. (2008) reviewed these approaches and categorised them into screening methods, model-based assessments and mixed approaches.

123. Screening methods typically include the consideration of a number of diagnostic physico-chemical and biological determinands to assign an eutrophication status class. Methods specific to transitional water body types include those for estuaries, fjords and coastal lagoons. The OSPAR Common Procedure (see Section 2.1.2) is the screening type method most commonly used for transitional waters within the OSPAR Convention area. The NOAA ASSETS (Assessment of Estuarine Trophic Status) method (see Zaldívar et al. 2008) has been modified for use in Portugal. This method combines measures of pressure (an estimate of net nutrient load to the water body), state (an assessment of eutrophication status based on indicators of direct and indirect effects) and response (an assessment of the susceptibility of the estuary to eutrophication) into an integrated assessment of trophic status. The measure of state comprises metrics for physico-chemical

(dissolved oxygen) and direct biological response determinands. Methods appropriate for coastal lagoons are less well developed. The Trophic Index (TRIX) (Vollenweider et al. 1998 in Zaldívar et al. 2008) integrates measures of chlorophyll a, oxygen saturation, total nitrogen and total phosphorus to provide a value indicative of trophic status. Zaldívar et al. (2008) indicate that this method is commonly used for coastal lagoons but is poorly suited to shallow water systems where phytoplankton are not the only component of the primary producer community responding to increasing nutrient concentrations. The importance of sedimentary processes in shallow water systems is important with respect both to the mobilisation of nutrient deposits and the detection of secondary effects of eutrophication. Two indices that exploit sedimentary responses to oxygen production and respiration include the Benthic Trophic Status Index (BSTI) (Rizzo et al. 1996 in Zaldívar et al. 2008) and the Trophic Oxygen Status Index (TOSI) (Viaroli and Christian 2003 in Zaldívar et al. 2008). Coastal lagoons dominated by macroalgae as a response to eutrophication demonstrate different responses to those unimpacted lagoons dominated by seagrasses on the basis of these indices. Both sediment and water quality variables have been integrated into the lagoon water quality index (LWQI) (Giordani et al. 2008 in Zaldívar et al. 2008). This index includes metrics for macroalgal and seagrass cover along with water column metrics for nutrients (DIP, DIN), oxygen saturation and phytoplankton chlorophyll a.

124. Model-based assessments identified by Zaldívar et al. (2008) tended to be restricted to site-specific applications that sought to link inputs of nutrients with hydrodynamic and biogeochemical models to provide predictions of nutrient regimes for transitional water bodies from which the likelihood of eutrophication effects could be estimated.

125. Mixed or hybrid approaches that combine the use of screening methods with simplified model-based approaches have the potential to deliver the advantages of a wider degree of applicability and predictive power (Zaldívar et al. 2008). Two examples of this include the use of the ASSETS tool with an ecological model in water body definition in estuaries (Ferreira et al., 2008 in Zaldívar et al. 2008) and the combination of the LWQI with a biogeochemical model and interfaced with a Decision Support System (Mocenni et al. 2008 in Zaldívar et al. 2008).

5.4.2. Impact and pressure criteria used in WFD Article 5 risk assessment

126. The available information for Article 5 related criteria indicates that whenever pressure criteria were reported these were based mainly on the presence of surface point sources (sewage) of nutrients loads and surface water run-off. The impact criteria were based mainly on nutrient concentrations and chlorophyll a (direct effect) and occasionally on dissolved oxygen, macrovegetation, etc (indirect effects).

5.4.3. Examples of development of new WFD-compliant assessment systems

127. The implementation of the Water Framework Directive has stimulated the development of assessment methodologies addressing the appropriate eutrophication-related, direct and indirect physico-chemical and biological determinands.

128. A workshop on Classification of Ecological Status[29] held under the auspices of ECOSTAT included a questionnaire on the quality elements most likely to be used in the classification of status for the common pressures. For transitional and coastal waters, Member States indicated the phytoplankton, macroalgae and angiosperm biological quality elements were most likely to be used for the assessment of ecological status in relation to nutrient pressure and that macroinvertebrates and fish (in transitional waters only) were most likely to be used in relation to oxygen depletion.

129. Zaldívar et al. 2008 reviewed the methodologies under development for the purposes of WFD status assessment and intercalibration for each of the biological and supporting physico-chemical quality elements.

130. The assessment of the phytoplankton quality element requires tools to address all aspects of the normative condition, namely: phytoplankton biomass, composition and bloom frequency. Estimation of phytoplankton biomass is most commonly undertaken using chlorophyll a concentration as a surrogate. Methods and class boundary values have been intercalibrated for chlorophyll a for most coastal water body types but have yet to be developed for transitional water types. Similarly, some work has been undertaken to develop tools for phytoplankton composition and bloom (*Phaeocystis*) frequency for coastal water body types but these have yet to be intercalibrated. These tools are likely to be adapted for use in some transitional water types in the second phase of intercalibration due for completion in 2011.

131. The assessment of the macroalgae quality elements requires consideration of the composition of macroalgal communities and the extent of macroalgal cover.

132. A proposed classification tool for macroalgal cover has been developed by Scanlan et al. (2007 in Zaldívar et al. 2008) based on the relationship between percentage cover and biomass of opportunistic species of macroalgae such as *Ulva* and *Entermorpha*.

133. The angiosperm quality element comprises a requirement for the assessment of taxonomic composition and abundance. A classification tool called the Ecological Evaluation Index (EEI) based on the abundance of macroalgae and angiosperms has been proposed by Orfanidis et al. (2001, 2003 in Zaldívar et al. 2008). This utilises the known shift in community status from one dominated by angiosperms to one dominated by macroalgae in response to increasing nutrients as a measure of ecological quality.

134. The benthic macroinvertebrate quality element can be useful in the assessment of the indirect effects of eutrophication. The normative definition requires the assessment of the diversity and abundance of benthic

[29] Report on Workshop Setting Nutrient Standards (2007).

invertebrates and the presence of disturbance sensitive taxa. Zaldívar et al. (2008) identify three indices that are under consideration for use in the assessment of transitional water benthic invertebrate status.

135. The AMBI index (Borja et al. 2000 in Zaldívar et al. 2008) utilises the known response of benthic invertebrates inhabiting soft sediments to pollution gradients and the classification of polluted conditions has been adapted to reflect the status classification of the Water Framework Directive. The BENTIX index (Simboura and Zenetos 2002 in Zaldívar et al. 2008) has been developed specifically to meet the requirements of the Water Framework Directive in the Eastern Mediterranean. The approach is similar to that used for the AMBI index. These tools have been developed for use in coastal water body types but have the potential to be adapted and used in transitional water body types. The Benthic Ecosystem Quality Index (BEQI) (Hoey et al. 2007) has been developed and applied in both coastal and transitional water body types in the Netherlands and Belgium. This index uses the relationship between the density of the number of species or individuals and increasing sampling area to determine impacts on soft sediment benthic communities. The ISD index (Reizopoulou and Nicolaidou 2007 in Zaldívar et al. 2008) is a taxonomy free approach developed specifically for use in coastal lagoons based on the distribution of individual benthic invertebrate species among biomass classes.

136. The fish quality element can also be useful in the assessment of the indirect effects of eutrophication. Preliminary work has been undertaken in the North-East Atlantic GIG to develop a tool for fish in transitional waters and this is due for completion in 2011.

137. The key supporting physico-chemical determinands in relation to eutrophication assessment are those related to nutrients and to dissolved oxygen.

138. The approach to the development and use of nutrient standards in ecological status classification was addressed in a workshop organised by the Netherlands in 2007[30], in a workshop on ecological status classification in 2008[31] and through the responses to a questionnaire issued to Member States by the Eutrophication Steering Group in November 2007.

139. While the workshops did not deal specifically with the issues of setting nutrient standards in transitional waters, it is clear that all Member States are deriving type-specific nutrient standards for use in ecological status classification in all water categories. In setting the value of the standard, Member States are faced with a choice of selecting values anywhere on the spectrum between close to the Good/Moderate boundary for either most sensitive or the least sensitive water body in the type. The former more precautionary option has an associated low confidence in the status classification with a high risk of misclassification. However, the use of such values in practice will allow water managers to control the risk

[30] Report on Workshop Setting Nutrient Standards (2007)

[31] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/ecological_classificatio/classification_2008-05pd/_EN_1.0_&a=d

of deterioration and deliver restoration of the water body. The latter less precautionary option, while providing a status classification with higher associated confidence, is less useful in the control of the risk of deterioration. Exceedances of nutrient standards will not in themselves determine the ecological status of the water body. The role of the supporting physico-chemical determinands and the approach to combining these results with those from the biological quality elements is addressed in the checking procedure detailed in the CIS Guidance on classification.

140. Based on the responses to the questionnaire on nutrient standards, Member States are in the process of setting values for forms of nitrogen (DIN and Total-N) and for phosphorus (DIP and Total-P) for transitional water types as seasonal averages (see compilation of existing nutrient standards, March 2009[32]). The degree of precaution in the derivation of these standards is not yet clear.

141. While some Member States reported values for dissolved oxygen standards in relation to nutrient standards in the response to the nutrient standards questionnaire, none were reported for transitional waters.

5.5. Coastal waters

5.5.1. Assessment methodologies and criteria used for water quality status classification

142. Coastal ecosystems receive nutrients either directly from the sources on the coastal line or from rivers that bring nutrients from their catchments, via sea current transport from distant coastal and marine waters, and from the atmosphere. The increased nutrient loading from anthropogenic sources has caused eutrophication of coastal ecosystems, the symptoms of which are excessive accumulation of phytoplankton biomass, depletion of oxygen in bottom waters, increased frequency of noxious algal blooms, increased turbidity, deterioration of coastal food webs and reduction of biodiversity.

143. Where coastal eutrophication is an international problem it needs to be tackled by co-ordinated national and international efforts. This reality is at the origin of the Regional Seas Conventions, which have started strategies to combat eutrophication already in the late eighties recognising the need for a harmonised way of assessing the eutrophication status of the nations ‘common’ waters. For more detailed information on the work on eutrophication by the regional sea conventions see Annex I Section 2 of this guidance.

144. Yet, procedures for assessing eutrophication are different in the different Conventions but in the last years, in specific after the adoption of the WFD, there has been an effort by all of them to converge their assessments into WFD compatible assessment systems.

145. Differences in the eutrophication assessment are at least partially explained by the characteristics of the coastal ecosystems. The extent to which nutrient loads have an affect on coastal ecosystems depend largely on their physical characteristics: regions of vertical stratification, restricted water exchange and long

[32] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm

residence time, with low tide and low mixing accumulate more nutrients and thus have a higher risk to eutrophication, while nutrients received in upwelling areas, open coastal areas with high tide or currents are rapidly diluted and transported to the open sea.

146. The Regional Seas Conventions procedures for the assessment of eutrophication typically include the measurement of nutrient enrichment, some measurement of direct effects of nutrient enrichment (phytoplankton chlorophyll a, macrophyte vegetation, and other biological elements) and indirect effects of nutrient enrichment (dissolved oxygen, algal toxins, macrozoobenthos kills, etc.).

147. Phytoplankton growth is generally considered to be limited by light or one of the major nutrients, (N or P), in addition to diatoms which are dependent of silica (Si). The optimal DIN:DIP ratio (N/P-ratio) for phytoplankton growth is 16:1 (based on molar concentrations) and is called the Redfield ratio. Significant deviations from 16 indicate potential nitrogen or phosphorus limitations to phytoplankton primary production, which might affect the biological state of the ecosystem, in particular the phytoplankton biomass, species composition and eventually food web dynamics.

148. While phosphorus is regarded as the main limiting nutrient in freshwaters, marine open waters are primarily nitrogen-limited. However, as nutrients concentrations increase due to anthropogenic loading, on average higher N:P ratios, but also lower Si:N ratios are observed in coastal areas which are likely to have either or both P and Si limitation (e.g. Black Sea (Shtereva et al. 1999); Northern Europe (Jickells 1998, Turner et al. 2003); some Danish coastal areas (Jørgensen 1996), and Dutch coastal waters (de Jonge et al. 2002)). Thus, the eutrophication phenomena in coastal areas are not only determined by the single nutrients concentrations but also and even more relevant are the nutrient ratios. The ratio of dissolved inorganic nitrogen and phosphorus, DIN:DIP is thus a an indicative number for potential nutrient limitations.

149. In coastal waters with many fjords and inlets the level of nutrient concentrations shows the same pattern as in some transitional waters with reference and actual status concentrations increasing going from the open coastal part towards the closed bays. National methods for assessing eutrophication in such sheltered parts of coastal water bodies have been developed based on the assessment of both biological and physico-chemical quality elements.

150. Transparency of the water column in coastal waters can indirectly reflect the nutrient loading/ nutrient status. Transparency can be easily measured, directly by measuring the light attenuation through the water column using light meters or alternatively using a Secchi Disc. Most often Secchi depth is measured as a proxy of transparency. Increased nutrient loading often lead to increases in phytoplankton biomass in the water column, which in turn decreases the transparency. In its turn, changes in transparency will affect the depth of the euphotic zone and thus the depth limits of macrophytes, e.g. sea grasses and macroalgae. Also,

=detailed&sb=Title

because different species have different light requirements changed transparency therefore also affects dominance patterns of the vegetation.

151. Phytoplanktonic primary producers are the first organisms to respond to elevated nutrient concentrations in their environment. Most phytoplankton species respond positively and predictably to nutrient enrichment in all European coastal areas (Olsen et al. 2001). High phytoplankton biomass results in increased amount of organic matter to be degraded after sedimentation by bacteria, meso- and macrofauna, which may lead to hypoxia or anoxia of bottom waters. Long-lasting eutrophication causes recurrent or even permanent oxygen deficit on bottom layers, leading to self-fertilization in coastal areas that may delay recovery of the ecological status when external nutrient inputs are reduced. High biomass of phytoplankton also increases the turbidity.

152. Also, it is generally believed that the frequencies of harmful algal blooms have increased worldwide due to the increased nutrient input and algal toxins are included in some cases in the eutrophication assessments. Although a strong causal relationship has not been established, there are indications that excessive blooms of nuisance algae, such as Phaeocystis spp in at least the southern North Sea, are related to nutrient loads.

153. Planktonic and opportunistic algae (mostly filamentous species) are generally favoured by high nutrient concentrations and tend to cast out seagrasses and perennial algae in eutrophic areas. Their increased biomass shades the perennial vegetation and limits its depth distribution, thereby further accelerating the decline of the perennial vegetation.

154. Changed dominance patterns of the coastal primary producers from benthic macrophytes to planktonic algae or from long-lived seagrasses and macroalgae towards opportunistic algae, as a consequence of increased nutrient concentrations and reduced water transparency, may affect the macrophyte community functional attributes. Moreover, opportunistic algae grow and decompose faster than perennial species and may thereby generate a temporal imbalance between oxygen production and consumption increasing the likelihood of anoxia having negative effects on the ecosystem (benthic invertebrates and fish kills).

155. Marine benthic macrofaunal communities often respond to decreasing oxygen concentrations and different species show different tolerance against hypoxic conditions. Adverse effects of oxygen deficiency may occur through different mechanisms. One is direct suffocation of aerobic organisms. Another mechanism is because oxygen deficiency may alter sediment chemistry, the poisonous element H2S may be released from the sediments and kill the organisms. From this it is to be expected a progressive change in diversity and structure of the benthic community in response to decreasing oxygen levels in the critical range.

5.5.2. Assessment methodologies and criteria used for UWWT and Nitrates Directive designations

156. There is limited information available from Member States regarding the criteria used for the UWWT and Nitrates Directive designations. The information available regarding designating sensitive areas under the UWWTD shows that the designation was based principally on nutrient (DIN and orthophosphate) concentrations and chlorophyll a concentrations.

5.5.3. Impact and pressure criteria used in WFD Article 5 risk assessment

157. The available information for Article 5 related criteria indicates that whenever pressure criteria were reported these were based mainly on the presence of surface point sources (sewage) of nutrients loads and surface water run-off. The impact criteria were based mainly on nutrient concentrations and chlorophyll a (direct effect) and occasionally on dissolved oxygen, macrovegetation, etc (indirect effects).

5.5.4. Examples of development of new WFD-compliant assessment systems

158. New eutrophication assessment methodologies and criteria have been developed in relation to the implementation of the WFD and the intercalibration exercise. The boundaries are set based on definitions of reference criteria and the application of the Boundary Setting Protocol (BSP) to set the high-good and good-moderate boundaries in line with the normative definitions for status class boundaries for each quality specified in the WFD.

159. The Coastal intercalibration exercise was carried out within four Geographical Intercalibration Groups (GIGs): the Baltic Sea, the Black Sea, the Mediterranean Sea and the North-East Atlantic. Common intercalibration types shared by Member States within each GIG were defined for the intercalibration exercise. The eutrophication related biological metrics that were subject to intercalibration in at least some MS coastal types are: benthic invertebrate fauna quality element (all GIGs), metrics and boundaries representing the phytoplankton quality element (chlorophyll a in all GIGs), metrics representing the macroalgae and angiosperms quality elements (Baltic, Mediterranean and NE Atlantic GIGs). There is also work on eutrophication related to supporting physico-chemical determinands including nutrient concentrations, transparency and dissolved oxygen concentrations.

5.6. Marine waters

5.6.1. Existing assessment methodologies and criteria used for water quality status classification

160. Regarding marine waters, several Member States use water quality assessment methodologies and criteria related to eutrophication that have been established in the frame of the Marine Conventions. The existing information on eutrophication assessment (Conventions and national methodologies) shows that, as in the case of rivers and lakes, eutrophication is determined according to criteria including nutrient concentration together with direct effects (chlorophyll and other biological parameters) and indirect effects (dissolved oxygen, organic matter, algal toxins, etc).

161. The Marine Strategy Framework Directive 2008/56/EC[33] is in force since 15 July 2008 and will now require monitoring and assessment tools in relation to the eutrophication-related components of 'good environmental status' (which is defined in Art. 3 (4) and (5) of the Directive, and for which further qualitative descriptors are in Annex I of the Directive) (see below Chapter 5.6.5).

5.6.2. Assessment methodologies and criteria used for UWWT and Nitrates Directive designations

162. There is limited information available from Member States regarding the criteria used for the UWWT and Nitrates Directive designations. The information available regarding designating sensitive areas under the UWWTD shows that the designation was based principally on nutrient (DIN and orthophosphate) concentrations and chlorophyll concentrations.

5.6.3. Impact and pressure criteria used in WFD Article 5 risk assessment

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5.6.4. Examples of development of new WFD-compliant assessment systems

164. Eutrophication related assessment methodologies and criteria are subject to intercalibration for marine waters. The eutrophication related biological metrics that are subject to intercalibration in at least some marine water GIGs are: chlorophyll a, phytoplankton, macroalgae, angiosperms and benthic invertebrates. There is also related work on eutrophication related supporting physico-chemical determinands including nutrient concentrations, transparency and dissolved oxygen concentrations.

165. At present there is limited information available on progress with these developments.

5.6.5. Criteria and standards under the Marine Strategy Framework Directive

166. Criteria and methodological standards are now (in 2009) under development in fulfilment of MSFD Art. 9(3) with a view to achieving a common methodological framework for the determination of 'good environmental status'. This work takes into account the existing methodologies. It starts, as regards eutrophication, with an examination by the JRC of the applicability of environmental quality elements used in the assessment of the quality status of coastal waters under the Water Framework Directive to waters on the seaward side of the limit of those coastal waters, and where applicability might extend, the formulation of the precise boundary conditions for that applicability (e.g. water depth, light conditions, habitat types). The eutrophication-related quality elements of the MSFD are mainly Annex I descriptor (5): "*Human-induced*

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[33] OJ L 164 of 25 June 2008, p. 19

eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters", but as work on the criteria and methodological standards develops for all descriptors, the lateral relations with those other descriptors (e.g. "*all elements of marine food webs, (...) occur at normal abundance and diversity (...)*") will have to be evaluated as some of them may also include elements that are strongly influenced by eutrophication.

6. HARMONISATION OF CLASSIFICATION CRITERIA

6.1. Use of nutrient standards and best practice in deriving them

167. Nutrients are supporting physico-chemical quality elements in the assessment of ecological status. According to the normative definitions in Annex V WFD "nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified […] for the biological quality elements". Figure 6 (as well as the explanations in Annex 1.1.6) provides an interpretation of how to apply supporting physico-chemical quality elements in ecological status assessment. Nutrient standards – as will be explained later – play an important role in the assessment.

168. In the context of preparing this guidance document a questionnaire had been sent to the Member States to collect information on the definition of nutrient standards, the methodologies used to derive them, as well as information on the legal status of these standards. At the time of compilation some of the standards were still under development and did not have a formal status yet. The compilation provides an overview on nutrient standards in the Member States in March 2009[34].

169. In the assessment of eutrophication, nutrients particularly support the biological quality assessments of phytoplankton, macrophytes, macroalgae and phytobenthos. At the boundary between good and moderate status and below nutrients will provide important information on the status of eutrophication, which is one of the pieces of basic information needed for setting up the programme of measures.

170. Different water categories have different sensitivities to nutrients: the same nutrient concentration does not necessarily have the same effect e.g. in small rivers versus lakes, or in freshwaters versus coastal and/or marine waters. Therefore, when setting nutrient standards it is important to consider the water category and where necessary the surface water type.

171. In setting nutrient standards one should always consider the objectives and keep in mind that the nutrient parameters are part of a supporting quality element and consequently that standards for this parameter are targets to strive for. In general, the primary objective of the WFD is good ecological status and

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

[34] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/thematic_documents/13_eutrophication&vm=detailed&sb=Title

thus can not do without an assessment of the biological quality elements. The process of deriving appropriate nutrient standards should ideally involve:

(a) having a clear view of what good status for biology/ecology looks like;
(b) having an understanding of the relationship between nutrients and the biology/ecology (and the variability in this);
(c) deciding on the best available techniques for deriving the standards and on the appropriate level of precaution and summary statistic to be used in defining the standard;
(d) having sufficient and reliable monitoring data for deriving and determining compliance with the standards.

Methodologies for setting nutrient standards

172. Discussions at a 2007 workshop on nutrient standards in Zandvoort (NL)[35] indicated that many differences exist in the standards derived and the methodologies/assumptions to derive those standards. As many countries share river basins districts and marine areas, there is a need for harmonisation of methods and assumptions at the European level, possibly in the same way as is done for ecological standards within the context of the WFD. Standards will not necessarily be the same in the different Member States, because they depend on the functioning of the ecosystems and differences across ecoregions and types.

173. In any case, setting of nutrient standards has to be linked with setting of biological boundaries for ecological status assessment. This can be an iterative process (see also Figure 8 in Annex 1.1.6). It should be kept in mind that a clear relation between biology and nutrients is less obvious when the status becomes less than good.

Toolbox to derive nutrient standards

174. **Use of empirical data:** If monitoring data from the past are available for both biological quality and nutrient concentrations, standards for nutrients can be set using these data. The most straight forward way is using a certain percentile of a distribution of nutrient concentrations of sites classified as Good Status for one or more biological quality element or parameters. This method is very simple and defendable if a sufficient low percentile is selected in order to ensure the achievement of the biological values. Exclusion of sites where other environmental factors than nutrients may hamper the biological quality is recommended. A disadvantage is that the relationship between biology and nutrient concentrations is not tested. Such a test can show the reliability and the type of the relationship.

[35] Final report available at:
http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/standards_zandvoort&vm=detailed&sb=Title

175. A more complex method is the **application of regression analysis**. In its most simple form, a linear and one factor relationship between biology and nutrients is assumed. By proper regression analysis and by plotting, the assumptions on the relationship between nutrients and biology, and the goodness of fit can be investigated. An appropriate statistical value derived from the regression analysis can be used for setting the nutrient standards. When the predicted nutrient concentration at G/M boundary value derived from a best fit relationship, the G/M nutrients concentration will result in about 50 % achievement of the biological value. By using the percentile distribution of the errors of the linear regression, the level of confidence of achievement of the biological value can be enhanced to another desired level (reference).

176. The most advanced method is **using statistical techniques** which relate nutrient concentrations to more than one environmental factor or may allow different types of relationships, e.g. non-linear. This method can be recommended in cases where it is clear that nutrients are not the only factor determining the biological quality, or where relationships are clearly non-linear. The disadvantage is that the development of standards is more difficult to understand.

177. The **level of misclassification** between biological quality elements and nutrients can also be used for setting the G/M boundary for nutrients. This method is more or less iterative and gives direct insight in the consequences of the defined nutrient standard for classification of sites. The procedure starts with making a set of potential nutrient standards in small discrete steps, which can be used for making a set of classifications for each potential nutrient standard for both biological quality elements and nutrients. For each site the classification results have four possible combinations:

1) biological quality elements are good and nutrients are not good,
2) biological quality elements are good and nutrients are good,
3) biological quality elements are not good and nutrients are good, and
4) biological quality elements are not good and nutrients are not good.

178. If nutrients are related with the biological quality elements, then the fraction of these four classification combinations are shifting over the potential nutrient standard gradient. If the discrete steps are small enough, the potential standard can be plotted against the distribution of the four types of classification results. The standard can now be defined as a contribution of one of these four types of classification combinations. For example, the nutrient concentration where e.g. 10 % of the classification results of the biological quality elements are not good and nutrients are not good may be defined as the standard. By using this definition the tested biological good status value is in about 90 % of the cases ensured by achievement of the nutrient standard.

179. The methods based on empirical data will not always be applicable for the River Basin Management Plan 2009 for all types of water, because monitoring data are not available or knowledge about ecological

relationships is not sufficient or reliable. This can be a reason to use other means of setting nutrient standards, e.g. using historical data or non-empirical models in combination with expert judgement**.**

Expert judgement methods:

180. **Hindcasting** is one means of estimating background levels. Natural background values for rivers can be deduced from models, assuming pristine conditions (e.g. forested catchments) and not a certain time period, because the latter reflects different status of eutrophication processes in different areas. Model data should be validated by comparison with values from remote areas and historical (palaeo-ecological) findings. Hindcast values are not standards but can be used with expert judgement to decide on standards.

181. Natural background concentrations in the different coastal areas have to be estimated from **modelling** or scientifically based assumptions because of the lack of pristine coastal areas. Also, in some areas there is a large exchange between coastal water and the open sea while in others it is very restricted. This has to be reflected in the decision on background levels. In setting nutrient standards (good/moderate) the natural variability should be considered and deviation from background can be used as a method of deriving standards; e.g. for coastal waters OSPAR, HELCOM and the Baltic GIG chose an acceptable deviation of 50 % above natural background, because this range reflects moderate deviation and variability (also recommended by CIS guidance documents). The deduction of natural background concentrations should be based on reproducible scientific methods allowing a harmonisation for larger areas.

Issues to consider in deriving and applying nutrient standards

182. Nutrient standards are in principle type-specific, and within the type waters will slightly differ in their sensitivity for eutrophication. These sensitivity differences are one of the sources of **potential misclassification**. The standards can be chosen to be protective for the eutrophication sensitive bodies or on the other hand for the more tolerant bodies. This delicate choice is largely an interpretation of the WFD, Annex V, where good status of nutrients is defined. In principle, the nutrient standards developed for the type should protect most water bodies from being or becoming eutrophied. However, if the standard is set to protect the most sensitive water body this will lead to most other water bodies in that type failing the standard. Furthermore, in some cases ecological knowledge or data is not sufficient to separate the effect of nutrient concentration on biological quality from those that are not related to nutrient concentration. If other factors are negatively affecting the quality of the sites involved in the analysis, automatically the standards are getting more precautionary than necessary. In addition, there may be delayed recovery effects from measures taken, because the trajectory of recovery may be different than that of deterioration – a so called hysteresis effect (Scheffer et al. 2001). Long-term trends in the maximum depth of eelgrass in Danish waters have shown an almost continuous decline, also in recent years despite strong efforts to reduce nutrient inputs from land. Examining the trajectory of eelgrass depth distribution versus the main pressure, nitrogen inputs, clearly indicates a lack of recovery. The causal explanation for this is still unclear, but the mechanisms could

be a combination of lag time in the response, a shifting baseline and a hysteresis effect where recovery can be anticipated only once the nitrogen input falls below an unknown threshold value.

183. Therefore, for an individual water body, a nutrient standard set to prevent deterioration may be ineffective at securing restoration. Consequently, choices about the purpose of the standard and the degree of precaution in setting a nutrient value will affect the likelihood of mismatches in compliance for nutrients and relevant biological elements (see chapter 6.2 and section 1.1.6 of Annex 1 on checking procedures for guidance on dealing with mismatches).

184. In conclusion, defining standards for nutrients is a real challenge where legal wordings are translated into numbers and, even more challenging, with uncertainties about dose-response relationships between biological and nutrient quality. As a minimum requirement for the first River Basin Management Plan, a transparent description of the method for deriving the standards is recommended.

185. To account for **spatial variation** within types, within water bodies or within grouped water bodies the use of water body-specific versus type-specific standards could be recommendable. This could be particularly relevant in lakes and transitional waters. In rivers, nutrient standards may be developed for different sections of the stream due to the different characteristics. Nutrient standards developed for upstream sections will not necessarily ensure that good ecological status is also achieved in the downstream section, but the measures taken in the River Basin Management Plan may need to consider reducing nutrient inputs from upstream sources. Lack of knowledge exists especially on background levels in large rivers, as there are not many good reference sites.

186. In addition, it is important to take drifting baselines into account that can be an effect of **climate change**. A Guidance Document is currently being developed under the Common Implementation Strategy on how to include effects of climate change in river basin management plans[36].

6.2. Combining information from different quality elements in the assessment of ecological status

Use of nutrient standards in classification and how to deal with mismatches between nutrients and biological quality elements

187. According to the CIS Classification Guidance, a water body may be classified as less than good ecological status under the WFD, because values for physico-chemical quality elements (in the context of eutrophication, notably nutrients) exceed levels established so as to ensure the functioning of the ecosystem and the achievement of the biological quality required for good status (compare Figure 6 and further explanations given in section 1.1.6 in Annex 1). Scientific understanding of the causal link between the levels of physico-chemical quality elements in a water body and the condition of the biological quality

elements is incomplete. Chapter 4 of the CIS Classification Guidance proposes a checking procedure designed to ensure that the type-specific values established for the general physico-chemical quality elements are no more or no less stringent than required by the WFD. The checking procedures apply only in relation to values for the good-moderate status/potential boundaries and where Member States are confident that the mismatch between the monitoring results for the biological and general physico-chemical quality elements does not occur as a result of uncertain monitoring. This will usually require evidence that there is a consistent mismatch from a significant number of water bodies in the type.[37] Accordingly it may be appropriate for Member States to relax the nutrient standards established for a type, subject to specific provisions (see Figure 8 of Annex 1.1.6), if there is evidence from a significant number of water bodies that the nutrient status is less than good but the biological status is good. The opposite situation, where the biology is not good and the supporting elements are good, may follow a similar procedure to determine whether the type-specific nutrient standard is sufficiently tight. It should be noted that adjustments to type-specific nutrient levels will reduce the extent of mismatches but will not eliminate them. This is because the characteristics of water bodies within a type are never identical.

188. In some cases it may be more appropriate to revise the status of an individual water body to good if (a) the nutrients are less than good, (b) the biology complies and the biological assessment is confident and precise, and (c) delayed impacts are unlikely, rather than revising the type-specific nutrient level.

189. Before revising the status of a water body and/or the nutrient standards, it is considered important to undertake checks to confirm the absence of biological impacts (including delayed impacts) and of upward trends in nutrient concentrations. As regards the absence of biological impacts, such checks should be done using biological assessment methods that are fully WFD-compliant[38].

Selection of biological quality elements

190. Chapter 4.1 to 4.3 explain the general concept of using the "most sensitive quality element(s)". For assessing eutrophication, quite often several biological quality elements may be suitable for this assessment. Whilst it is inappropriate to take into account elements that are not sensitive to nutrients, there may be a number of quality elements which are and there is value in a rounded assessment of ecological data. The indicative checklists in Annex 2 suggest that more than a minimalist approach is needed, and as recognised in Chapter 4.1, it is not easy to interpret the meaning of “most sensitive” as there are pros and cons of different plant/algal indicators.

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[36] Interim title: How to adapt to climate change with regard to water issues and EU water legislation

[37] CIS Guidance Doc. No. 13 Overall approach to the classification of ecological status and ecological potential, p. 14

[38] The ECOSTAT Classification Workshop (March 2008) recommended to understand the Checking Procedure in this way.

191. The relevant sub-sections of Chapter 5 on the development of WFD-compliant assessment systems provide further information on available classification methods. Further information is also provided in the report of the ECOSTAT Classification Workshop[39].

Effects of variability in space and in time relevant to classification

192. According to the CIS Guidance Document[40] on delineation of water bodies "a discrete element of surface water should not contain significant elements of different status. A water body must be capable of being assigned to a single ecological status class with sufficient confidence and precision through the Directive's monitoring programmes."

193. Nonetheless, spatial variability can be found within types, within water bodies and within grouped water bodies. A range of different approaches is currently being considered by Member States on how to deal with such variability. These include taking the average status or the worst status, considering the extension of the variability, e.g. as a percentage of the water body that is affected. Spatial criteria need to be developed for classification. A combination of criteria based on lateral extension, water depth and residence time of a water body and an even distribution of sampling sites have been suggested as a useful approach, reflecting the fact that water body sizes are variable depending on the way water bodies have been delineated. Sampling in the surrounding of specified types is often recommended for detection of exchanges with adjacent areas by currents. Sampling sites should be adequately distributed over the water body if no steep gradients are observed. In such areas, a certain percentage (e.g. 10 % of the maximum length of the water body) could be used as the distance between stations. Water bodies should be delineated such that they are more or less homogeneous, thereby reducing variability within the water body as much as possible. If it is not possible to further downsize a water body, e.g. in marine areas where there are steep gradients at frontal systems[63], a higher resolution of sampling sites is required. These must be appropriately placed considerating the relevant physical parameters, such as salinity, temperature and current speed.

194. Grouping of water bodies is important to make best use of available monitoring data and consider exchange of water masses between adjacent areas. The majority of Member States are using grouping of water bodies for classification purposes. The same principles mentioned above apply for grouped water bodies. Grouping may increase variability. This needs to be balanced with the confidence in the monitoring results. Grouping of water bodies of the same type and the same pressure does not automatically mean that all water bodies have the same ecological status. Grouping of water bodies is generally quite useful for assessing ecological status due to diffuse pressures.

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[39] http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/ecological_classificatio/classification_2008-05pd/_EN_1.0_&a=d

[40] CIS Guidance Document No. 2: Identification of Water Bodies, p. 9

195. In coastal waters, spatial gradients of standards, recent concentrations and their difference may also be related to salinity gradients or upwelling, reflecting dominant mixing and by this distance from main river sources, river plume extensions and dilution by open sea water. Furthermore, mixing diagrams can be used for comparisons/assessments, smoothing regional variability caused by hydrodynamics and identifying outliers for re-investigations. Nutrient gradients from shore to offshore areas are often combined with salinity gradients if dominant nutrient sources are river freshwater discharges. If such gradients occur, they should also be reflected by respective gradients of nutrient standards, reflecting mixing (of end-members).

Accounting for uncertainty in eutrophication assessment

196. Uncertainty in classification, particularly for water bodies close to the good-moderate boundary, is an important issue for river basin management planning. Information on confidence and precision of classifications is important for informing decisions about the appropriate follow up action. To start with the acceptable level of confidence and precision should be decided beforehand, and the sampling/monitoring should be appropriately designed (sampling sites, frequency, sampling and analysis methods, etc.) to be able to reliably classify the water bodies. Depending on the level of confidence, this information can inform, as appropriate, decisions on exemptions[41], prioritising water bodies for improvement, and/or prioritising further monitoring and investigation to improve confidence. Being clear on the level of confidence achieved and on the follow up action where confidence is insufficient to justify expensive measures is considered important: Appropriate follow-up action in such cases includes (a) further targeted monitoring and assessment to try to improve confidence and to assess the risk of deterioration, and (b) action to assess the risk of, and prevent deterioration.

197. A lack of monitoring should not be an excuse for inaction although it is recognised that in the first cycle of river basin planning, when the new classification tools and monitoring plans have not been in place for long, uncertainties will be greater than in subsequent cycles. Investigative monitoring should be introduced as a priority, where needed, to improve the evidence base and inform decisions on programmes of measures.

198. In water bodies where there is insufficient confidence in the assessment of eutrophication, the appropriate action will generally be to undertake further monitoring and investigation to improve confidence, rather than to move to immediate control measures under the WFD or through "read across" to UWWT or

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[41] See also Section 6 of the Policy Paper "Exemptions to the environmental objectives under the Water Framework Directive; Article 4.4 (extension of deadlines), 4.5 (less stringent objectives) and 4.6 (temporary deterioration)"

http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/thematic_documents/environmental_objectives/final_policy_44-45-46/_EN_1.0_&a=d

Nitrates Directive designations. This may apply when, for example, the nutrients appear less than good but we are not confident that the relevant biological quality elements are less than good. Confidence should then be improved in the biological assessments and, where necessary, the nutrient thresholds should be reviewed. In any case, Member States can not wait until all symptoms of eutrophication are present before taking action. As set out in paragraph 46 in Chapter 3.6, if sufficient certainty is attained that the water body is likely to become eutrophic in the near future, then protective measures need to be undertaken (application of the precautionary principle).

6.3. The river basin perspective: linking results of inland waters with transitional and coastal waters

199. The assessment of ecological status in upstream and downstream water bodies is independent from another, but in terms of management, good ecological status in upstream water bodies does not guarantee also reaching the environmental objectives downstream. It may be necessary to undertake measures in upstream areas to reduce nutrient inputs and transport downstream.

200. The management of nutrients in upstream areas should therefore take into account problems with nutrients downstream, for example in lakes/reservoirs connected to a river, rivers flowing into coastal or marine waters. Nutrients may also be transported between different coastal waters or marine areas due to currents or upwelling, and this needs to be taken into account when developing appropriate measures to mitigate eutrophication. These measures need to be coordinated at the river basin scale as well as between coastal and marine areas if necessary.

201. The following example from the Rhine River Basin District illustrates how river basin management can appropriately address measures to mitigate eutrophication at the basin scale. Similar examples are also available from other river basins, e.g. the Elbe River.

6.4. WFD and marine conventions: coherence of current eutrophication assessment schemes

202. Marine eutrophication has been addressed by marine conventions in Europe since many years. A considerable body of expertise has been generated for the Baltic Sea (HELCOM) and the North-East Atlantic (OSPAR), but also in the Mediterranean Sea (MED POL) and the Black Sea (Bucharest Convention) activities to address eutrophication in a common way have started. The Conventions' eutrophication combating policies (OSPAR: Eutrophication Strategy, 1998, revised 2003; HELCOM: Ministerial Declaration 1988, and recently the Baltic Sea Action Plan 2007) have required them to undertake periodic assessments. In this process, the participating countries have considered a need to ensure an approach that would be consistent with their obligations under EU instruments, most notably the WFD, but also the Marine Strategy Framework Directive.

Reduction of nitrogen discharges: The Example of the Rhine River Basin District

In the process of the production of the first river basin management plan, the Co-ordinating Committee Rhine agreed on a discharge reduction target via the river Rhine into the marine environment for nitrogen of approximately 15-20 % (reference years: 2004/2005/2006). The reduction is considered to be necessary in order to achieve a good ecological status in the coastal waters and the Wadden Sea of the international river basin district of the Rhine.

Within the Co-ordinating Committee Rhine representatives of the Rhine riparian states (Austria, Liechtenstein, Germany, France, Luxembourg, Belgium and the Netherlands), the European Community, for Germany also representatives of the federal states and for Belgium representatives of the Walloon region, are responsible for the international co-ordination of the implementation of the WFD in the international river basin district Rhine. Switzerland declared to support the EC-Member States in the co-ordination of the work. Italy, that covers only a very little part of the Rhine district, agrees with the approach.

Considering the fact that the coastal waters and the Wadden Sea are part of the international Rhine district, an integrated approach respecting upstream-downstream relations is needed. Because the coastal waters (including the Wadden Sea) as part of the international river basin district Rhine are situated in the Dutch territory only, the Co-ordinating Committee Rhine asked the Netherlands to take the initiative for estimating the potential riverine discharge reduction of nitrogen in the fresh water part of the Rhine district in order to achieve the good ecological status in its coastal waters by 2015.

Building on the intercalibrated parameter bloom frequency of Phaeocystis and the partly intercalibrated parameter chlorophyll a, it became clear that especially in the Wadden Sea the good ecological status is not achieved in the present situation. For the coastal and transitional waters the Netherlands have developed objectives for nitrogen concentrations (averaged values of Dissolved Inorganic Nitrogen) that ensures the achievement of the quality element phytoplankton. This objective depends on salinity, and is calculated to a standard at a salinity of 30. Subsequently, this objective is calculated to a concentration in large fresh water rivers. Based on this objective the maximum allowed discharge of nitrogen to the coastal waters and the Wadden Sea is calculated and compared with the current riverine discharge of nitrogen.

The Co-ordinating Committee Rhine did not directly use the Dutch objectives for Nitrogen in terms of concentrations, but accepted it as an indicator of the direction for the restoration measures and as a tool for evaluation of the measures taken. The parties involved will continue to implement their programme of measures in order to reduce the nitrogen load. The ‘polluter pays principle’ and the present EC-policies are put into practice. In addition to this, it has to be kept in mind that other sources than the River Rhine contribute significantly to the nitrogen concentrations in coastal waters as well, e.g. other river basins and atmospheric deposition. It is assumed that the other North Sea riparian states also achieve a reduction of nitrogen discharges.

For the sake of completeness, it is stressed that in line with the WFD the assessment of biological status is limited to the 1 mile zone. Therefore there can be some differences with the assessments made under OSPAR, because OSPAR takes into account the whole North Sea and its delineation of "non-problem areas" and "problem areas" with regard to eutrophication is not fixed to the WFD subdivision of coastal water bodies. In the near future, the Marine Strategy Framework Directive 2008/56/EC may play a role for eutrophication sensitive parameters of coastal states' marine waters (territorial waters and exclusive economic zones, the part of the sea between the territorial water (up to 12 nautical miles) and a max. of 200 nm).

203. In the North-East Atlantic, a first application of the OSPAR eutrophication assessment procedure was undertaken by the OSPAR countries of their waters in 2003 and, with a procedure slightly revised in 2005, repeated in 2008[42]. The background levels used in 2003 had mainly been based on expert judgement. In the 2008 assessment process, a number of OSPAR countries reviewed background levels based on more recent knowledge. One important driver for the review has been the need to harmonise the assessment methods with the Water Framework Directive in transitional and coastal waters. The review of background levels has led in some cases to the update and change of assessment levels used earlier. The 2008 OSPAR assessment report demonstrates that, although the OSPAR procedure aims to result in a comparable assessment throughout the Convention area, there are significant differences in the national application of the OSPAR procedure by the OSPAR countries, in particular in the choice of assessment parameters and assessment criteria (see report Table 3.2 of the 2008 report[42]). These differences in the choice of parameters and assessment methods imply that the OSPAR and WFD assessment outcomes for coastal and transitional waters are at present not fully interchangeable, and that there is scope for further work to make them fit together better[43].

204. HELCOM has developed a common, harmonised Eutrophication Assessment Tool, called HEAT. This assessment tool is in full accordance with the requirements for ecological status assessment of WFD and the relevant guidelines under the CIS process. It is targeted to the assessment of eutrophication in transitional, coastal and open marine areas.

205. HEAT is a multi-metric indicator based assessment method which is based on the use of reference conditions and defining an acceptable deviation from them for defining the boundary between good and moderate status. The assessment results are calculated as Ecological Quality Ratio and presented as one of five classes (high, good, moderate, bad, and poor). HEAT comprises two assessment steps. The first step is an interim assessment for specific selected indicators and/or biological quality elements (such as phytoplankton, submerged aquatic flora, benthic fauna). By a second step, these individual assessment results are merged into an overall classification using the "one out, all out" principle as laid out in the WFD. HEAT will be further improved in order to meet the requirements of the Baltic Sea Action Plan and eutrophication relevant EC directives such as the WFD, Habitats Directive and the MSFD.

206. HEAT has successfully been tested for coastal and marine waters along the Baltic Sea.

[42] http://www.ospar.org/documents/dbase/publications/p00372_Second%20integrated%20report.pdf

[43] This issue is still on the agenda of the OSPAR Eutrophication Committee.

7. MONITORING – GUIDANCE AND INTEGRATION OF REQUIREMENTS STEMMING FROM VARIOUS OBLIGATIONS

7.1. Introduction

207. The aim of this chapter is to:

- specify further which aspects in the existing Guidance on Monitoring are relevant for eutrophication assessment;
- provide guidance on how to harmonise the monitoring in a way to satisfy the requirements in the different directives and regional conventions dealing with eutrophication.

208. As Section 1.1 of this document indicates, this guidance on monitoring has to be firmly based on the methodological concept of the Water Framework Directive and to explore thereafter to what extent this methodology can be used in the context of other directives and policies. For the Water Framework Directive monitoring networks have to be designed "so as to provide a coherent and comprehensive overview of ecological and chemical status within each river basin and shall permit classification of water bodies into five classes consistent with the normative definitions in section 1.2"[44]. Table 2 (section 3.2) gives a general overview of the requirements of EC Directives and regional conventions regarding the assessment and monitoring of eutrophication.

209. Assessing eutrophication in specific water body types may change specific monitoring requirements. The implementation activities of the Water Framework Directive have already addressed monitoring needs to a certain degree (e.g. Monitoring guidance document[45]); however the spatial and temporal monitoring requirements may differ for critical variables when eutrophication issues are specifically focused on, and the requirements of specific water types (e.g. to capture the necessary seasonality and flow dependency in nutrients and of nutrient loads, chlorophyll and oxygen) are considered.

210. Member States had to establish their monitoring programmes for the Water Framework Directive by 22 December 2006. Member States will have integrated monitoring programmes that provide the data and information which will meet the needs of all the relevant policies, in this case, all those that deal with eutrophication. For example, where possible, the same monitoring stations, quality elements and sampling frequencies should be used for Water Framework Directive assessments and also for any assessment required for other policies e.g. OSPAR.

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[44] Article 8 WFD

[45] Guidance Document No. 7: Monitoring under the Water Framework Directive

7.2. Guidance documents

211. Monitoring guidance documents or guidelines have been developed for most of the policy drivers dealing with eutrophication. These have been used in this document and include:

- Common Implementation Strategy Guidance Document No. 7: Monitoring under the Water Framework Directive, 2003.
- Common Implementation Strategy Guidance Document No. 13: Overall approach to the classification of ecological status and ecological potential, 2003.
- Urban Waste Water Treatment Directive (91/271/EEC). There is no EU guidance on how the monitoring of water status/quality[46] should be undertaken. There may be national examples available.
- European Commission. Draft guidelines for the monitoring required under the Nitrates Directive (91/676/EEC), March 2003[47].
- HELCOM: Monitoring and Assessment Strategy[48] and Manual for Marine Monitoring in the COMBINE Programme of HELCOM[49]
- OSPAR (2005): Eutrophication Monitoring Programme, OSPAR Agreement 2005-04.
- UNEP-MAP (2003): Eutrophication monitoring strategy of MEDPOL. UNEP(DEC)/MED WG.231/14, 30 April 2003.

212. The European Marine Monitoring and Assessment (EMMA) group formed under the European Commission's *"Thematic Strategy for the Protection and Conservation of the European Marine Environment"* has worked on improving indicators related to eutrophication. The implications of the Marine Strategy Framework Directive 2008/56/EC[50] (MSFD; the Directive that is the legal instrument under this Strategy) for marine eutrophication assessment are being elaborated in the context of the preparation of 'criteria and methodological standards' that relate to the MSFD Annex I descriptor (5) that "human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters." A clear synergy with the existing eutrophication assessment framework is necessary.

213. Also the revision of HELCOM monitoring programmes is underway (MONPRO project). The aim of the revision is to have a monitoring and assessment framework, which is in line with obligations stemming

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46 The Directive gives guidance on the monitoring of the effluents before discharge from the treatment works (Annex 1D of Directive 91/271/EEC).

47 Non statutory guidelines, informally discussed by Member States in the Nitrates Directive Committee, however the text has never been submitted to a formal vote

48 http://www.helcom.fi/groups/monas/en_GB/monitoring_strategy/

49 http://sea.helcom.fi/Monas/CombineManual2/CombineHome.htm

50 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

from various regulations (e.g. WFD, UWWTD, Nitrates Directive) and which foresees the demands from the Thematic Strategy for the Protection and Conservation of the European Marine Environment

7.3. Water categories and geographic coverage

214. The Water Framework Directive covers all waters, including inland waters (surface water and groundwater) and transitional and coastal waters up to one sea mile (in terms of monitoring ecological status and hence eutrophication – and for the chemical status also territorial waters which may extend up to 12 sea miles) from the territorial baseline of a Member State, independent of the size and the characteristics[51.] These waters (water bodies) will need to be included in surveillance, operational or investigative monitoring programmes. Monitoring of surface freshwaters, estuarine, coastal and marine waters is also required for the Nitrates Directive. The geographic extent of marine waters included in the requirements of the Urban Waste Water Treatment Directive is not clear: Annex II (criteria for the identification of sensitive and less sensitive areas) includes estuaries and coastal waters in terms of sensitive areas, whereas marine water bodies are included in the criteria for less sensitive areas. Coastal waters are defined as "waters outside the low-water line or the outer limit of an estuary"[52].

215. Monitoring required for Marine Conventions is generally for assessing the state[53] of transitional, coastal and open marine waters.

216. Operational monitoring for the Water Framework Directive will be carried out for all those water bodies identified as being at risk of failing their environmental objectives (for example, achievement of good ecological status or good ecological potential, or no deterioration of status). Where this risk is due to nutrient enrichment and water bodies have been assessed as eutrophic under other policies, these water bodies will be, or be part of, a sensitive area/water body, or a polluted water or a problem area, respectively, under the Urban Waste Water Treatment Directive, Nitrates Directive and OSPAR Strategy to Combat Eutrophication (in waters of overlapping jurisdiction) (see section 3.6). For these water bodies, operational monitoring will potentially help assess the effectiveness of the measures introduced under those other polices, and help to decide what further measures may be needed. In waters/water bodies not previously identified as eutrophic under the other policies but have been identified by the Annex II risk assessments as being at risk due to nutrient enrichment, operational monitoring could be the basis for deciding a water body is "eutrophic", as part of its status assessment. Where there is a risk of future deterioration of status (due to increasing nutrient pressures), operational monitoring could also contribute to the assessments needed as to whether waters "may become eutrophic" under the other policies. In short, it is anticipated that, depending on the

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51 Articles 2 (1), (2) and (3)

52 Article 2.13

53 Some Marine Conventions also require the monitoring of rivers for the estimation of loads entering the marine environment.

commonalities between other aspects of monitoring e.g. geographic jurisdiction, quality elements and frequency, integrated monitoring programmes could be established that will provide the data and information required for all of the relevant policies dealing with eutrophication.

217. Surveillance monitoring for the Water Framework Directive must be carried out on a sufficient number of surface water bodies to provide an assessment of the overall surface water status within each catchment or sub-catchment within the river basin district[54]. This implies that water bodies across a range of statuses will be included and in particular those identified as not being at risk of failing their environmental objectives (good and high status water bodies, no risk of deterioration of status). Where Member States have identified sensitive and less sensitive areas for the Urban Waste Water Treatment Directive and designated vulnerable zones for the Nitrates Directive, there is a requirement for Member States to review the identification of sensitive areas[55] and nitrate vulnerable zone(s)[56] of their surface waters respectively, at least every four years. Assuming that this would involve some monitoring[57] then it is likely that this would include those water bodies not previously identified as being sensitive/vulnerable or polluted. Where relevant, in terms of overlapping geographic jurisdiction of the different policies, it would be expected that the results from surveillance monitoring (which will include parameters indicative of the quality elements relevant to eutrophication) could contribute to the review and assessment of non-eutrophic, non-polluted waters and non-problem areas (the latter as identified in the OSPAR Comprehensive Procedure) (see Table 5, section 3.6). Results from surveillance monitoring might also contribute to the establishment of the extent of nitrate pollution from agricultural sources in those countries that have established and applied action programmes throughout their national territory for the Nitrates Directive[58]. In addition, investigative monitoring might need to be carried out to get a fuller picture of existing nutrient sources and their impacts on the water bodies.

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54 Annex V.1.3.1

55 For the UWWTD, Member States do not have to identify sensitive areas if they have applied Article 5.8 of Directive 91/271/EEC.

56 For the Nitrates Directive, monitoring requirements depend on whether Member States establish and apply action programmes throughout their national territory (Article 3.5) or identify and designate specific vulnerable zones (Article 3.1 and 3.2). Monitoring for the purpose of designating and revising the designation of vulnerable zones (Article 6) does not apply to Member States who establish and apply action programmes throughout their national territory. In the latter case, Member States must monitor their surface waters and groundwater at selected monitoring points to establish the extent of nitrate pollution in their waters from agricultural sources (Article 5.6 first sentence). Those Member States who have designated vulnerable zones must monitor to assess the effectiveness of action programmes (Article 5.6 first sentence), and monitor the nitrate concentration in freshwaters over a period of a year (every 4 years or, under defined circumstances, every 8 years) and to review (every 4 years) the eutrophic state of their fresh surface waters, estuarial and coastal waters (Article 6).

57 Non statutory draft guidelines for the monitoring required under the Nitrates Directive (91/676/EEC), 2003

58 Article 3.5

7.4. Selection of monitoring sites

218. CIS Guidance No. 7 gives guidance on the selection of monitoring sites for inclusion in surveillance and operational monitoring for the Water Framework Directive. There is no EU guidance on the number of monitoring stations that might be appropriate for monitoring the quality of receiving waters under the Urban Waste Water Treatment Directive. The informal guidance for monitoring under the Nitrates Directive suggests different station densities for rivers and standing waters, with an increased density inside and at the borders of polluted waters, and waters deemed to be at risk of eutrophication, and less in areas with low nutrient pressures.

219. For the OSPAR Eutrophication Monitoring Programme, the spatial coverage of stations should be greatest in problem and potential problem areas, and least in non-problem areas. In all cases the optimum station locations are to be determined by each Contracting Party. The HELCOM Combine Manual (for monitoring) indicates that mapping stations and high-frequency stations are required. Mapping stations are used to map the winter pool of nutrients, oxygen/hydrogen sulphide in bottom waters and zoobenthos. High frequency stations are used for pelagic variables and for monitoring water exchange between the various basins in the Baltic Sea, and between the Baltic Sea and the North Sea. MEDPOL's eutrophication monitoring strategy[59] requires Contracting Parties to select representative water bodies in marine waters in order to detect changes over a selected period (e.g. 10 years), and in relation to off-shore fish farms and coastal lagoons.

7.5. Selection of quality elements/parameters to be measured

220. Annex V, Table 1.1 in the Water Framework Directive, explicitly defines the quality elements that must be used for the assessment of ecological status (e.g. composition and abundance of phytoplankton). Quality elements include biological elements and elements supporting the biological elements. These supporting elements are in two categories: 'hydromorphological' and 'chemical and physicochemical'. CIS Guidance No. 7 gives as to which quality elements and parameters indicative of the quality elements should be selected for each type of monitoring[60]. In addition the key features of each element are described with an indication of which pressures the elements respond to e.g. nutrient enrichment[61]. Further guidance on the meaning of parameters, quality elements and groups of quality elements is given in the guidance on the overall approach to the classification of ecological status and ecological potential[62]. The relevant sections in Chapter 5 give examples of the most widely used indicators.

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59 UNEP(DEC)/MED WG.231/14 30 April 2003

60 Guidance document No. 7, Monitoring under the Water Framework Directive, pages 21 and 24

61 Guidance document No. 7, Monitoring under the Water Framework Directive, pages 35 to 73

62 Guidance document No. 13, Overall approach to the Classification of Ecological Status and Ecological Potential, Paragraph 3.3

221. Guidance on the selection of quality elements/parameters to be measured for the purpose of the OSPAR, HELCOM and MEDPOL is also given.

222. At the quality element level there are many similarities between the different policies, particularly for the biological and physicochemical quality elements that are considered to be indicative of eutrophication. However, there are some differences in terms of the recommended measured parameters indicative of the quality elements. More significantly, surveillance and operational monitoring for the Water Framework Directive requires the monitoring for hydromorphological quality elements: there is no such explicit requirement in the other relevant policy drivers even though some of these elements are included as supporting environmental factors in the conceptual framework for eutrophication (see Figure 2 in section 2.2). Hydromorphological quality elements can be relevant in assessing eutrophication, e.g. in impounded rivers or in lakes with large water level fluctuations.

Use of nutrient monitoring

223. Nutrients are a key factor in eutrophication and, therefore, should be included in monitoring programmes for the assessment of eutrophication, besides other key parameters such as temperature or salinity in coastal waters. Basically, two different monitoring concepts can be applied: 1) monitoring of biological quality element(s) including supporting quality elements, or 2) monitoring of nutrients (and possibly other physico-chemical quality elements) as a screening tool. Generally, monitoring of nutrients will be at a higher frequency than for biological quality elements.

224. For screening procedures it has to be considered that nutrients may be transported over long distances, disconnected to local sources and diluted but steadily enhancing local production. It can also be useful to monitor organic matter (included partly in total nitrogen and total phosphorus; but also particulate and dissolved organic carbon may cause eutrophication), because organic matter contains nutrients and is a direct cause for secondary eutrophication effects (e.g. oxygen deficiency) and may not have been produced locally, but transported from elsewhere.

225. For a detailed analysis of eutrophication processes all fractions of nutrients (dissolved and particulate, organic and inorganic forms of nitrogen and phosphorus) should be monitored to allow a better understanding of the status and the factors explaining the status. Such a detailed analysis can be part of an investigative monitoring programme. The analysis of total nitrogen and total phosphorus is the basis for budget calculations and overall assessments. However, for detailed analyses of eutrophication processes individual parameters are needed.

226. For both types of analyses the often inhomogeneous vertical distribution of particulate organic matter in the water column has to be considered during monitoring. In stratified water bodies (lakes, transitional and

coastal waters) and in frontal areas[63] (mainly in transitional and coastal waters) nutrients have to be monitored with a sufficient vertical resolution. Therefore, it is important to adapt the monitoring strategy to different hydrodynamic regimes.

7.6. Frequency of monitoring

227. Annex V of the Water Framework Directive provides tabulated guidelines in terms of the minimum monitoring frequencies for all the quality elements. The suggested minimum frequencies are applicable to both surveillance and operational monitoring and are generally lower than those currently applied in some countries. More frequent monitoring will most likely be necessary in many cases to achieve a reliable assessment of the status of the relevant quality element, but also less frequent monitoring is justified when based on technical knowledge and expert judgment[64]. Member States are also able to target their monitoring to particular times of the year to take into account variability due to seasonal factors.

228. The frequency of sampling and the distribution of sampling sites for nutrient monitoring should be set up in a way that it is possible to detect trends. For high-frequency monitoring the use of automatic measuring devices and remote sensing tools can be very useful.

229. Monitoring is required over one year, at least once every 4 years for the Nitrates Directive[65], and the sensitivity of waters in general needs to be reviewed every 4 years for the Urban Waste Water Treatment Directive. The review does not explicitly require monitoring though undoubtedly information from monitoring would be invaluable in the assessment. For the Nitrates Directive, a minimum of monthly samples for nitrates analysis is required[66]; this compares with once every 3 months (for nutrient status) for the Water Framework Directive.

230. The OSPAR Eutrophication Monitoring Programme defines the minimum requirements for monitoring and reporting. For areas, including local areas located in wider non-problem areas, identified as problem or potential problem areas, a sufficient frequency and spatial coverage of all the parameters in the programme should be monitored and reported each year. For the areas identified as non-problem areas, results relating to the monitoring of the nutrient assessment parameters (nutrient inputs, winter DIN and DIP

[63] Frontal areas are characterised by the occurrence of steep gradients of water density, mostly including salinity gradients. They are formed at the borders of river plumes, coastal water plumes or upwelling water masses with adjacent homogenous mixed water masses.

[64] Guidance document No. 7, Monitoring under the Water Framework Directive, section 2.10.2

[65] For the purpose of designating and revising the designation of vulnerable zones

[66] At stations laid down in the Surface Water for Drinking Directive (75/440/EEC) and/or other sampling stations representative of surface waters of Member States (Article 6.1.a.i). These stations are used to identify polluted waters based on exceedance or potential exceedance of 50 mg/l nitrate (Annex I.A.1). Annex 1.A.3 also gives "eutrophic" or "may become eutrophic" as other criteria for identifying polluted waters. Though not strictly relevant to the eutrophication criteria (phosphorus is often the limiting nutrient for algal growth in freshwaters), monthly sampling of nitrate at those stations described in Article 6.1.a.i would in practice be useful in the assessment of eutrophication.

and winter N/P ratio) should be reported once in 3 years. For HELCOM, there are two main monitoring frequencies recommended: frequent and highly frequent. Frequent sampling ranges from once or twice per year to 6 to 12 times per year depending on purpose and parameter. Some high frequency stations are sampled up to 26 times per year or even more often. For the MEDPOL eutrophication monitoring strategy, the optimal sampling frequency should be chosen by each country according to the parameter variability in the affected area, and with the objective of detecting a change in concentration over a selected period (e.g. 10 years).

231. A common theme between policies is the acknowledgement that monitoring/sampling may need to be targeted to particular seasons (e.g. for seas: nutrients in winter, algae in summer) and particular water bodies/areas (e.g. problem areas, water bodies at risk) and higher sampling frequencies may be needed in more variable water bodies/areas or during periods of high variability than the minimum frequencies recommended[67].

7.7. Monitoring of protected areas

232. As already described in Section 3.6 of this guidance both sensitive areas under the Urban Waste Water Treatment Directive and nitrate vulnerable zones under the Nitrates Directive are Protected Areas under Annex IV of the Water Framework Directive. This means that monitoring programmes established under the Water Framework Directive will have to take into account any monitoring requirements in the respective Directives such as the monitoring of nitrate concentrations in freshwaters over a period of a year at least every 4 years for the Nitrates Directive[68].

7.8. Harmonisation of monitoring programmes

233. Member States will wish, where possible, to have integrated and harmonised monitoring programmes that provide the data and information which will meet the needs of all the relevant policies, in this case, all those that deal with eutrophication. This section attempts to demonstrate where this should be possible based on the commonalities of policies in terms of, for example, geographic coverage of waters and the monitoring requirements as given in Directives/Conventions and any associated guidance/guidelines.

7.8.1. Rivers and lakes

234. For fresh surface water bodies there is potentially a good deal of synergy between policies in terms of the identification and inclusion of the same water bodies impacted by nutrients, and the quality elements indicative of eutrophication that are recommended to be monitored. There is also a joint need to review periodically the status of those water bodies identified as not being impacted by nutrients or at risk of

67 See, for example, for further guidance section 2.10 in CIS Guidance Document No. 7, Monitoring under the Water Framework Directive

becoming impacted by nutrients: these (or groups of these) may be included in surveillance monitoring for the Water Framework Directive and be part of the periodic review of waters for the Nitrates Directive and Urban Waste Water Treatment Directive. Eutrophication assessment is an integral part of the ecological status assessments under the Water Framework Directive. So the assessments and monitoring to be carried out for ecological status (and for the objective of preventing deterioration in status) should be a good step forward towards integration across these three policies with the Water Framework Directive monitoring (and assessment) schemes meeting the needs for future reviews of sensitive areas and polluted waters (eutrophic).

235. Water bodies impacted by, or at risk from, nutrients will be included in operational monitoring for the Water Framework Directive (though not all will necessarily be monitored as the representative monitoring of groups of water bodies is allowed), and they will also be required to be monitored for the Urban Waste Water Treatment Directive (waters subject to discharges from urban waste water treatment works and direct discharges from some industries) and for the Nitrates Directive (diffuse sources from agriculture, assessment of effectiveness of action programmes). Surveillance monitoring for the Water Framework Directive may include water bodies across the range of statuses from high to bad (where all statuses exist), and therefore some of the impacted or at risk water bodies (from nutrient enrichment) might also be included: the results from this monitoring might also contribute to the periodic reviews required for the Urban Waste Water Treatment and Nitrates Directives.

236. There are synergies between the monitoring required in all water categories for the different policies in terms of quality elements required for assessing eutrophication particularly in terms of biological quality and physicochemical quality elements but less so for the hydromorphological quality elements required for the Water Framework Directive. There are also some differences in terms of the recommended measured parameters indicative of the quality elements, e.g. HELCOM requires the monitoring of zooplankton in coastal and marine waters, an element not required by the WFD or other policies. However these difference may not be significant as long as some common disaggregated parameters such as composition and abundance of the biological element are measured (at an appropriate taxonomic level) then other related parameters could be easily derived.

237. There are potential differences in the frequency that monitoring might be undertaken in fresh surface waters. The review of sensitive areas (including eutrophic state) and less sensitive areas under the Urban Waste Water Treatment Directive is required at intervals of no more than four years. For the purpose of designating and revising the designation of vulnerable zones under the Nitrates Directive, monitoring for nitrate is required at least every four years over one year. It is not yet clear, how Member States will implement surveillance and operational monitoring programmes for the WFD. A minimum of one year in six years (or one year in 18 years in exceptional circumstances) is given in the Directive for surveillance

[68] Article 6 (a)

monitoring, with a minimum of one sample per 3 months for nutrient status[69] in the years that monitoring is undertaken for surveillance and operational monitoring. However, an additional requirement of monitoring for the WFD is the choice of frequencies that will "achieve an acceptable level of confidence and precision"[70] in the monitoring results and subsequent assessments. Monthly sampling for nutrients is currently common practice in many Member States. Therefore, Member States might in practice wish to critically assess their sampling frequencies for surveillance and operational monitoring in terms of the confidence in the estimates of status they will provide[71], and in terms of the costs of monitoring. In conclusion, it is likely that an integrated monitoring programme based on the requirements of the Water Framework Directive would be at a frequency that meets the needs of the other policies dealing with eutrophication.

7.8.2. Transitional, coastal and marine waters

238. Monitoring undertaken for the assessment of eutrophication for Marine Conventions and the Marine Strategy Framework Directive includes offshore marine waters not required under the Water Framework Directive. Additional monitoring of coastal and marine waters will, therefore, be required beyond the WFD in order to assess eutrophication for the other relevant policies. Some policies also require the designation of specific areas in relation to eutrophication (e.g. polluted water and problem areas). These areas may not always be the same geographically or in spatial extent and this will have to be borne in mind when developing a harmonised integrated monitoring programme for eutrophication.

239. HELCOM defines frequent and highly frequent monitoring stations that have recommended sampling frequencies higher than other geographically relevant policies (i.e. WFD and Nitrates Directive). A common theme that could be incorporated into a harmonised monitoring programme for transitional, coastal and marine waters is the recognition that sampling should be targeted to specific times of the year for some of the elements (e.g. nutrients and chlorophyll). There is also a common theme of ensuring that monitoring results are fit for purpose and this implies that different frequencies would be required for different elements, different water categories and different water bodies. As examples: Member States have to achieve acceptable levels of precision and confidence in the monitoring results and subsequent assessments (Water Framework Directive); Contracting Parties have to determine optimum sampling frequencies, for example, to confirm maximum winter nutrient concentrations have been determined (OSPAR) or to detect changes in concentrations over 10 years (MEDPOL).

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69 Minimum monitoring frequencies are also given for the other quality elements in all water categories

70 Annex V.1.3.4, sentence 3.

71 CIS Guidance document No. 7, Monitoring under the Water Framework Directive, section 2.10.4

8. NEXT STEPS – LINKS OF EUTROPHICATION ASSESSMENT WITH PRESSURE AND IMPACT ANALYSIS AND PROGRAMME OF MEASURES

8.1. Use of the DPSIR framework

240. The DPSIR framework (Figure 3 in Chapter 2) is seen as giving a structure in which the indicators are presented that are needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made or to be made in the future.

241. Within the DPSIR framework, eutrophication assessment as described in the previous chapters belongs to the part of "state" and "impact". The outcome of the assessment might result in responses and measures. In order to be able to formulate the response, there is a need to understand the links between drivers/pressures, state/impact and the response.

242. The need for a response becomes evident if the result of eutrophication assessment is that a water body (or part of marine area) is eutrophic or may become eutrophic in the near future. In that case it has to be clear how the appropriate response/measures will be developed and decided upon to reduce/eliminate eutrophication in that water body. The objective of the measures should be to move to a situation where a water body (or part of marine area) is not eutrophic, in order to assist the achievement of the environmental objectives for a water body. The steps that are necessary to set objectives and to develop measures have been described in general in the WFD CIS Guidance document "Environmental objectives under the WFD"[72]. Below, more specific details are given for the steps to develop measures to combat eutrophication.

8.2. Steps in the development of measures for a water body (or part of marine area) that is eutrophic or may become eutrophic in the near future

Step 1

243. A first step in the development of measures to abate eutrophication in a water body is the assessment of all the sources that (may) contribute to the nutrient load to a water body. Such an assessment should not be limited to the sources near the water body itself, as sources upstream may contribute to eutrophication in downstream water bodies/marine areas (cf. paragraphs 51 and 52 in section 3.6). Also retention processes (denitrification and sedimentation), atmospheric deposition and re-suspension from sediments can be taken into account.

Step 2a

244. A further step is to consider the possible (combination of) reduction measures for these sources, including the effect of those reduction measures on the eutrophication status (= effectiveness of a measure) and the costs associated to the implementation of those measures (= selecting the most effective measure for

[72] http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/documentn20_mars09p

the least costs = cost-efficiency). An important question to be answered in this step is the scale at which measures need to be considered – in other words: what is the expected extent in a catchment of the impact/effect of the various measures at source.

245. The implementation of existing measures needs to be considered as well in this context – relevant existing measures in EU context are the Nitrates Directive, the Urban Waste Water Treatment Directive, the IPPC Directive, the Groundwater Directive, the National Emission Ceilings Directive and the Thematic Strategy on Air Pollution. Furthermore, the Marine Strategy Framework Directive needs to be considered.

Step 2b

246. Besides measures at source, also measures in (or nearby) the affected water body should be considered that can result in a reduction of eutrophication. Examples of such measures are alterations of the morphological characteristics of the water body, e.g. restoration of banks or floodplains, changes to the flow conditions, other changes to the infrastructure. Also for these types of measures, the extent of achievable reduction and related costs should be considered and assessed.

Step 3

247. Finally, it has to be decided which (combination of) measures at source and in the water body is most appropriate and cost-effective to reduce and eliminate eutrophication in a water body or part of marine area. At this stage, a balanced division of costs between upstream and downstream areas and between the various sectors has to be decided upon, taken into account the principles of polluter-pays and proportionality. The quality of the information gathered on the various measures will be crucial in acceptance of the justification of measures in upstream water bodies/countries where no eutrophication exists but where nutrient loads contribute to eutrophication in downstream water bodies/marine areas. The mechanism for the decision making is laid down in the WFD by preparing river basin management plans and agreement on this at the (international) catchment area level.

8.3. Identification of gaps that need to be addressed

248. A lot of the tools, guidance and mechanisms that are necessary to carry out the steps outlined in the preceding section are already available.

249. For *step 1*, the pressures and impact analysis according to Article 5 of the WFD and the drawing up of a river basin management plan has ideally resulted in an overview and assessment of all the sources.

250. For *step 2a*, on the establishment of effectiveness and cost-effectiveness of measures and the scale at which measures need to be considered is subject of the policy summary and background document on cost-

effectiveness[73]. The WFD Article 5 analysis already gives indications on the scale by identifying issues/risks that need to be considered at the international catchment level. Considerations to measures with regard to agricultural losses of nutrients have been produced by the CIS activity on "Links between WFD and agriculture"[74].

251. Several tools and examples exist or are in development to establish in a quantitative way the link between measures at sources of nutrients and the expected reduction of eutrophication effects in the fresh water and marine environment. It concerns flow studies (e.g. in Rhine and Danube catchment, COST initiative on evaluation of mitigation options for reducing nutrient losses to surface water), retention models and models for quantification of losses from diffuse sources and discharges from point sources (e.g. OSPAR HARPNUT guidelines, EUROHARP, COST action 626 European aquatic modelling network), HARMONICA. The challenge is to embed these tools in a sustainable way and to have the budgets/means to maintain the systems in the future.

252. In the area of measures in the water body itself (*step 2b*), available information and experience should be shared at European level.– a list of examples of such measures might be helpful.

253. For *step 3*, the results of the CIS Activity on cost-effectiveness deliver a useful framework to assist in the decision making.

8.4. Conclusion

254. In general, all the necessary tools, guidance and mechanisms are available to develop and decide upon the measures aiming at elimination of eutrophication in water bodies/catchments/marine areas. The challenge will be to apply all these tools in practice and to balance these with the implementation of measures in other policy areas such as agriculture or land-use.

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73 http://circa.europa.eu/public/irc/env/wfd/library?l=/framework_directive/thematic_documents/economic_issues/cost_effectiveness&vm=detailed&sb=Title

74 Catalogue of measures for tackling agricultural pollution under the WFD, see http://circa.europa.eu/public/irc/env/wfd/library?l=/framework_directive/thematic_documents/wfd_agriculture&vm=detailed&sb=Title

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ANNEX 1: THE UNDERSTANDING OF EUTROPHICATION

1. EU LEGISLATION AND POLICIES

1.1. Water Framework Directive (2000/60/EC)

1.1.1. Overview of the Water Framework Directive

255. The Water Framework Directive (WFD) establishes an integrated and co-ordinated framework for the sustainable management of water. Its purposes include preventing deterioration of water bodies, promoting sustainable water use, and ensuring "enhanced protection and improvement of the aquatic environment". This last point requires that rivers, lakes, estuaries, coastal waters and groundwater achieve and /or maintain at least ‘good status’ by 2015. For surface waters this requires both Ecological Status and Chemical Status to be at least ‘good’. Good status will be achieved by implementing a programme of measures as reported in River Basin Management Plans (Articles 11 and 13), and based on the results of river basin characterisation. The WFD stipulates detailed procedures for its implementation including the classification and monitoring of water bodies (see WFD Annex V).

256. Ecological status is derived from Ecological Quality Ratios (EQRs), which reflect the deviation of observed values from type-specific reference conditions. ‘High’, ‘good’, ‘moderate’, ‘poor’ and ‘bad’ Ecological Status have normative definitions (see Annex V of the WFD) based on the deviation, as a result of human activity, of quality elements from corresponding type-specific reference conditions. At good ecological status, the values of biological quality elements (communities of phytoplankton, plants, fish, macroinvertebrates etc.) should ‘deviate only slightly from those normally associated with the surface water body type under undisturbed conditions’ (Annex V 1.2). The boundary between good and moderate ecological status is crucial because it determines when restoration measures need to be taken.

257. The values for the biological quality elements set by Member States for the ‘high’-‘good’ class boundary and the ‘good’-‘moderate’ class boundary will be compared as part of the intercalibration exercise, which is further described below.

258. Several directives will coexist with the WFD, including: the UWWT Directive (91/271/EEC), Nitrates Directive (91/676/EEC), Bathing Water Directive (76/160/EEC), Habitats Directive (Directives 92/43/EEC) and the Birds Directive (Directive 79/409/EEC). Areas designated under these directives will have the status of Protected Areas under the WFD (Annex IV), for the protection of their surface water, groundwater or for the conservation of habitats or species directly depending on water. Several of these directives address eutrophication, increasing the need for a common framework for eutrophication assessments.

259. Sections of the WFD particularly relevant to assessing eutrophication are: Article 1 a (purpose); Article 4.1.a.i and ii (Environmental objectives and programmes of measures for surface waters); Article 5

(Characterisation); Article 6 (Register of Protected areas); Article 7.3 (Drinking Water); Article 8 (Monitoring); Article 10 (The combined approach for point and diffuse sources); Article 11 (Programme of measures); Annex II (1) (Characterisation), Annex IV.1.iv, (Protected Areas, nutrient-sensitive areas); Annex V (1) (Assessment of Surface Water Status) and Annex VIII (indicative list of main pollutants).

1.1.2. Summary of the Water Framework Directive's requirements

260. The term eutrophication is not explicitly defined in the Water Framework Directive. It is defined in two of the Directives that are to be integrated into the river basin planning process[75], Directive 91/271/EEC and Directive 91/676/EEC.

261. According to Directive 91/271/EEC concerning urban waste water treatment (the UWWT Directive), eutrophication means "the enrichment of water by nutrients especially compounds of nitrogen or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned". Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (the Nitrates Directive) has an identical definition of eutrophication. However, for the purposes of the Nitrates Directive, these effects must be caused by the enrichment of water by nitrogen compounds rather than by nutrients in general.

262. The Water Framework Directive requires Member States to classify the ecological status of surface water bodies[76] into one of five ecological status classes; high, good, moderate, poor or bad ecological status. The ecological status of a water body is an expression of the quality of the structure and functioning of its aquatic ecosystem.

263. The Directive provides general qualitative definitions for each ecological status class, and more detailed qualitative definitions for high, good and moderate ecological status for each surface water category.

264. Among other things, the definitions of each ecological status class describe the extent to which biological components of the aquatic ecosystem, called biological quality elements, may differ in that class compared to their reference, or high status, conditions as a result of the effects of human activity.

265. The reference conditions relevant to a particular water body depend on the type of water body. They are type-specific. This enables the classification system to take account of the natural variety of aquatic ecosystems across the Community's different water types.

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75 See Article 10; Article 11.3.a; and Article 4.1.c and Annex IV of the Water Framework Directive

76 The status of heavily modified water bodies and artificial water bodies is defined by their ecological potential rather than their ecological status. When considering such bodies, references to ecological status should be read as meaning ecological potential.

266. The Directive requires the Commission to facilitate an intercalibration exercise. This exercise is designed to ensure that the numeric class boundaries for good ecological status, which have to be set by each Member State to make the classification scheme operational, are consistent with the Directive's 'normative' definitions and comparable between Member States.

267. The environmental objectives of the Directive require Member States to prevent deterioration of the status of water bodies. They also require Member States to aim to restore all surface water bodies to good ecological status, except where doing so would be unfeasible or disproportionately expensive. The Directive's ecological status classification scheme is therefore central to water management across the Community.

268. Nutrient enrichment is one of the many different anthropogenic pressures on water bodies that may affect their ecological status. As such, management measures may be required to control nutrient enrichment in order to achieve the objectives of the Directive.

269. The sensitivity of water bodies to nutrient enrichment may vary depending on their physical characteristics and on the extent of other anthropogenic alterations to them. For example, modifications to hydrology or morphology may significantly influence whether or not a given concentration of nutrients causes accelerated growth of algae or higher forms of plant life to produce undesirable disturbances. Changes to hydromorphology (e.g. residence time of water in lakes) could enable accelerated growth of algae or higher forms of plant life and thus impact on the ecological status of a water body even in the absence of further anthropogenic inputs of nutrients.

270. Operational monitoring must be undertaken for water bodies, or groups of water bodies, that are at risk of failing to achieve the Directive's objectives. The monitoring data obtained through operational monitoring must be used to establish the status of those bodies and to assess changes to their status resulting from management measures.

271. Monitoring must be designed to ensure that an adequate level of confidence and precision in the classification of ecological status can be achieved. Guideline minimum monitoring frequencies are set out in the Directive. However, the actual frequencies selected must provide sufficient data for a reliable assessment of the status of the relevant quality elements.

272. For the purposes of monitoring water bodies at risk because of nutrient enrichment, Member States must monitor parameters indicative of the biological quality element, or elements, most sensitive to the effects of nutrient enrichment as well as the nutrients that are being discharged into the water body in significant quantities[77].

[77] See Annex V 1.3.2. The term 'discharge' in this context is clearly intended to include the direct or indirect introduction into water as a result of human activity of nutrients from point or diffuse sources

273. Where appropriate, Member States may group water bodies and use representative monitoring to assess the status of the water bodies in the group[78].

1.1.3. Conceptual understanding of eutrophication in the WFD

274. The WFD classifies water bodies in relation to type-specific reference conditions. This enforces the view of eutrophication as a process, where nutrient enrichment through human activities causes adverse changes in the aquatic environment, rather than as a particular level of primary production or trophic state.

275. The assessment of eutrophication is strongly implied in the classification of surface water bodies. The definition of good ecological status for the quality elements 'Phytoplankton' and 'Macrophytes and Phytobenthos' uses very similar wording as the definition of eutrophication used in the UWWT and Nitrates Directives and by OSPAR. For example, good ecological status of lake macrophytes and phytobenthos requires that '…changes do not indicate any accelerated growth of phytobenthos or higher forms of plant life resulting in undesirable disturbances to the water balance of organisms present in the water or to the physico-chemical quality of the water.' (Annex V1.2.2.).[79] In other words good status includes an absence of eutrophication problems.

276. Nutrients, as part of the physicochemical quality element, must be at a level to ensure the functioning of the ecosystem and the values specified for biological quality elements (i.e. to ensure that the above definition is met). Specific mention of eutrophication is made in the requirement to estimate the magnitude of all significant point and non-point source pollution, including 'substances that contribute to eutrophication (in particular nitrates and phosphates)' (Annex II 1.4, Annex VIII).

1.1.4. Methods specified for assessing eutrophication

277. Under the WFD Ecological Status is assessed by using quality elements. Many of these quality elements are traditionally used for assessing eutrophication, in particular 'nutrient conditions' as well as the 'composition, abundance and biomass of phytoplankton and macrophytes'. At good Ecological Status biological quality elements should have only slight deviation from type-specific reference conditions. Corresponding values for nutrients necessary to support the achievement of good ecological status may be estimated from response curves based on knowledge of the relationships between nutrient concentrations and the biological quality elements.

278. High nutrient concentrations without any corresponding biological impacts may not necessarily result in down grading Ecological Status. Thus assessments of eutrophication consistent with the WFD should

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[78] Guidance on grouping water bodies is provided in the CIS IMPRESS Guidance and the CIS Monitoring Guidance

[79] Compared to the UWWT Directive definition:*' The enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the water balance of organisms present in the water and to the quality of the water*

primarily focus on the biological effects resulting from elevated nutrient levels, taking also into account possible effect of transboundary transport of nutrients. Measures to reduce nutrient loading may still be needed (see section 1.1.6 on CIS Classification Guidance for more details) to reduce the impact of the discharge of nutrients in the area of discharge or elsewhere.

279. The main challenge for Member States is to find quantitative expressions (criteria or metrics) for the response in abundance and taxonomic composition for the different biological quality elements along the nutrient gradient, to quantify the impact of increased algal/plant biomass on other organisms and water quality and to quantify slight, moderate and large deviations from reference conditions, corresponding to 'good', 'moderate' and 'poor' Ecological Status. One challenge will be to obtain monitoring data for the required parameters from a sufficient number of sites and with a sufficient measurement frequency to ensure that assessments have sufficient accuracy and precision to differentiate between natural variation and human impact and to estimate the extent of anthropogenic pollution.

280. The CIS Monitoring Guidance recommends measurement frequencies for each parameter used in the assessments of Ecological Status. These frequencies are higher than the minimum frequencies specified in Annex V of the WFD, for many of the parameters relevant to eutrophication, such as phytoplankton and nutrient parameters (monthly or bi-weekly during growth season in the guidance as opposed to once every 3-6 months in Annex V).

281. The WFD furthermore focuses on managing whole river basins on a European scale, thus a down-stream water body failing the WFD objective of good status e.g. being eutrophic, may require measures to be taken, in the entire upstream catchment or even in other river basins including coastal water bodies or exporting coastal water bodies, even if upstream water bodies meet the objectives (transboundary transport of nutrients).

282. Further elaboration on the interpretation of ecological status and how to understand the different status classes is given in Chapter 3.

1.1.5. WFD Guidance documents

283. The following guidance documents for the implementation of the WFD with reference to eutrophication assessment have been prepared within WFD Common Implementation Strategy (CIS) working group:

- COAST: WFD CIS Guidance Document No. 5, 2003,
- Intercalibration: WFD CIS Guidance Document No. 6, 2003,
- Monitoring: WFD CIS Guidance Document No. 7, 2003,
- REFCOND: WFD CIS Guidance Document No.10, 2003,
- Classification WFD CIS Guidance Document No. 13, 2003.

concerned'.

284. These guidance documents contain helpful information assisting guidance on eutrophication assessment. Key issues mentioned in these documents for ecological classification of eutrophication are presented in the following section.

1.1.6. Common understanding of Ecological Classification from CIS guidance documents

Introduction

285. The WFD requires the establishment of classification schemes to reflect the Ecological Status or potential of surface water bodies as measured by the condition of specific biological, hydromorphological and physico-chemical quality elements. The relevant elements, and the specific conditions required for these elements in each of the classes of the classification schemes, depend on the surface water category and type to which the water body belongs, the pressures acting on the water body, and on whether the body is artificial or heavily modified. In addition the WFD requires Member States to achieve adequate confidence and precision in classification, and to give estimates of the level of confidence and precision achieved in the River Basin Management Plans.

286. The purpose of the overall ecological classification guidance is to provide general guidance on the assessment of Ecological Status and Potential leading to the overall ecological classification of water bodies for the purposes of the EC Water Framework Directive. The document also provides specific guidance on the role of the general physico-chemical quality elements in ecological classification. The guidance document draws on the existing guidance documents REFCOND, COAST, Monitoring, and HMWB&AWB.

Relationship between biological, hydromorphological and physico-chemical quality elements

287. As a basic step the values of the biological quality elements must be taken into account when assigning water bodies to any of the Ecological Status and Ecological Potential classes. In order to ensure comparability the results of the biological monitoring systems shall be expressed as ecological quality ratios for the purposes of ecological classification. The ratio shall be expressed as a numerical value between zero (worse class) and one (best class).

288. The values of the hydromorphological quality elements must be taken into account when assigning water bodies to the high Ecological Status class and the maximum Ecological Potential class (i.e. when downgrading from high Ecological Status or maximum Ecological Potential to good Ecological Status/Potential). For the other status/potential classes, the hydromorphological elements are required to have "conditions consistent with the achievement of the values specified for the biological quality elements." Therefore, the assignment of water bodies to the good, moderate, poor or bad Ecological Status/Ecological Potential classes may be made on the basis of the monitoring results for the biological quality elements and also, in the case of the good Ecological Status/Potential the physico-chemical quality elements. This is

because if the biological Quality Element values relevant to good, moderate, poor or bad status/potential are achieved, then by definition the condition of the hydromorphological quality elements must be consistent with that achievement and would not affect the classification of Ecological Status/Potential.

289. The values of the physico-chemical quality elements must be taken into account when assigning water bodies to the high and good Ecological Status classes and to the maximum and good Ecological Potential classes (i.e. when downgrading from high status/maximum Ecological Potential to good Ecological Status/Potential as well as from good to moderate Ecological Status/Potential). For the other status/potential classes the physico-chemical elements are required to have "conditions consistent with the achievement of the values specified for the biological quality elements." Therefore, the assignment of water bodies to moderate, poor or bad Ecological Status/Ecological Potential may be made on the basis of the monitoring results for the biological quality elements. This is because if the biological Quality Element values relevant to moderate, poor or bad status/potential are achieved, then by definition the condition of the physico-chemical quality elements must be consistent with that achievement and would not affect the classification of Ecological Status/Potential. The "physico-chemical quality elements" mean the physico-chemical elements supporting the biological elements listed in Section 1.1 of Annex V for each surface water category, except those for which an EQS has been set at EU-level.

290. The relationships between the biological, hydromorphological and physico-chemical quality elements in status classification are presented in Figure 6 for all natural water categories and types. The classification of heavily modified and artificial water bodies (see HMWB&AWB Guidance Document) is done in a comparable way to identify high, good, moderate, poor and bad Ecological Potential.

291. The Directive requires that Member States achieve an adequate level of confidence that water bodies are assigned to their true status classes. The level of confidence achieved must be reported in the river basin management plans. Further guidance is given in the technical Annex I to the ecological classification guidance document and may also be found in REFCOND Guidance and specifically in the Monitoring Guidance.

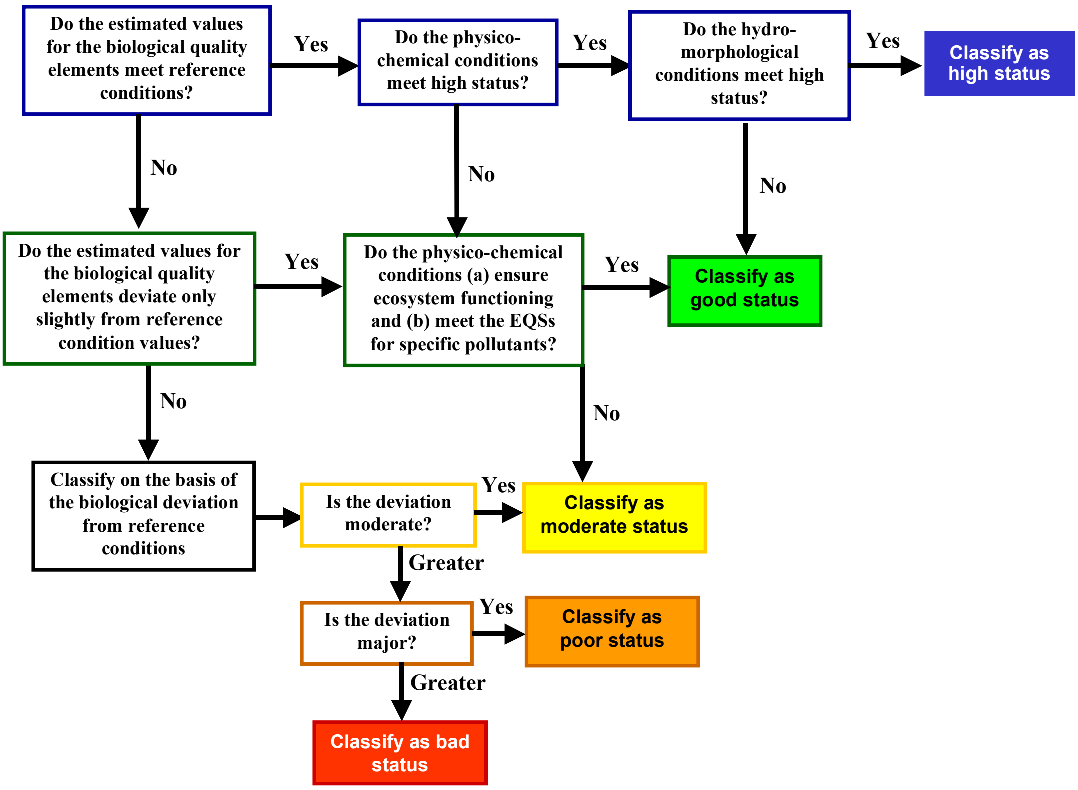

Figure 6. The relative roles of biological, hydromorphological and physico-chemical quality elements in classifying Ecological Status (Annex V 1.2) (Source: REFCOND & COAST guidance documents).

<u>Parameters indicative of the biological Quality Elements and most sensitive Quality Elements</u>

292. Member States must monitor parameters indicative of the condition of biological quality elements as part of their monitoring programmes. The Directive requires the assessment of the Ecological Status /Potential class of a water body to be based on the estimate of the condition of the Quality Element provided by these monitored parameters. In some circumstances, achieving a reliable assessment of the condition of a particular biological Quality Element may require consideration of the monitoring results for several parameters indicative of that Quality Element.

293. Figure 7 illustrates the relationship between biological quality elements and indicator parameters and their use in classification decisions. The example in the upper part of the figure illustrates the results for individual parameters of a biological Quality Element like phytobenthos with general sensitivity to a broad range of pressures (e.g. pressures resulting in morphological and hydrological changes as well as in changes to nutrient conditions). Parameters may be combined by, for example, averaging or weighting to estimate the status of the Quality Element.

294. The second example in Figure 7 illustrates the procedure of combining parameters, if pressure-related, multi-metric approaches are used. Under this approach, individual parameters indicative of the effects of a particular type of pressure on a biological Quality element are identified. Where several parameters responsive to the same pressure are identified, these may be grouped and the results for individual parameters in the group combined in order to increase confidence in the assessment of the impact of that pressure on the quality element. If several groups of parameters are identified, each indicating the effects of a different pressure on the quality element, the status of the quality element will be indicated by the results for the group that indicates the greatest impact on the element. However, if the parameters in a group are actually responding to the effects of a range of pressures on the quality element or there is low confidence in the results for a group of parameters, such pressure-related, multi-metric approaches may not be possible. In such cases, where the groups of parameters are not clearly signalling how the quality element has been affected by different pressures, the approach outlined above and the upper part of Figure 7 may be more appropriate.

The role of the general physico-chemical quality elements in the ecological classification

295. The Directive's normative definitions for Ecological Status describe the conditions required for the general physico-chemical quality elements and the specific pollutants at good status/potential. The general physico-chemical quality elements should not reach levels outside the range or exceed the levels established to ensure ecosystem functioning and the achievement of the values specified for the biological quality elements (see point (a) in the middle box in Figure 7). The concentrations of specific pollutants should not exceed environmental quality standards (EQSs) set in accordance with Annex V, Section 1.2.6 of the Directive (Figure 8).

296. The ranges and levels established for the general physico-chemical quality elements must support the achievement of the values required for the biological quality elements at good status or good potential, as relevant. Since the values for the biological quality elements at good status will be type-specific, it is reasonable to assume that the ranges and levels established for the general physico-chemical quality elements should also be type-specific. Several types may share the same ranges or levels for some or all of the general physico-chemical quality elements.

297. The Ecological Status/Potential of the water body is represented by the lowest value from the biological quality elements and physico-chemical quality elements as indicated in Figure 6. Thus good Ecological Status will only be attained if the monitoring results for both the biological quality elements and physico-chemical quality elements meet the conditions required for good Ecological Status/Potential (see WFD Annex V, 1.4.2.i, ii).

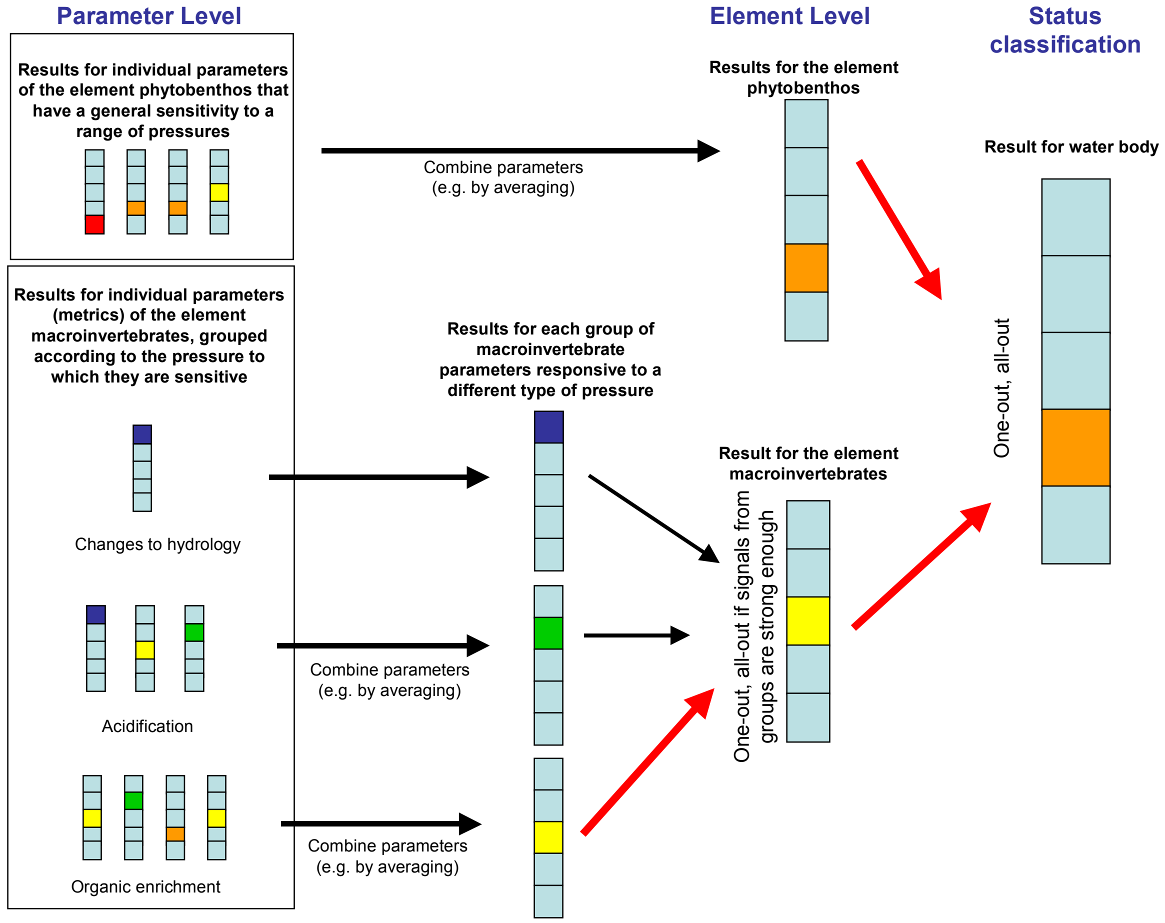

Figure 7. Examples of how indicative parameters may be combined to estimate the condition of biological quality elements. The one-out all-out principle is used at the quality element level.

298. In individual water bodies, there will be cases where the monitoring results for the biology are good but the results for the general physico-chemical quality elements appear, at face value, to be less than good. Such a situation could occur if one or more of the specific pollutants exceeds the EQS-values established, or if there is a time lag between the change of the general physico-chemical quality elements and the response in the biological quality elements. Furthermore, this situation could be common even though the physico-chemical ranges are thought to be valid, due to statistical errors in sampling and analysis. In these cases, Member States may decide to classify the body as less than good only when they have checked that the statistical confidence is adequate to say that the general physico-chemical quality elements are really less than good. Where it is not, Member States may take steps to improve confidence, for example, by doing more monitoring.

299. There may also be other cases where the levels or ranges proposed for a general physico-chemical quality element in a type are being exceeded as a result of anthropogenic effects, but no biological impacts are being detected. In such cases, it is recommended that a checking procedure should be undertaken. This procedure should be used to assess whether the established type-specific levels or ranges for the elements are

more stringent than is necessary to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements at good status/potential.

300. The mismatch between the biological monitoring results and the general physico-chemical monitoring results may also be because the biological methods being used in monitoring are not sensitive to the effects of anthropogenic changes in the condition of the physico-chemical quality element. In such cases, improvements to the biological methods should be made on an on-going basis with the aim of developing methods that are sufficiently sensitive. This improvement work should not stop after the first classification decisions are made.

301. Water bodies in which an established level or range for a general physico-chemical quality element is exceeded should be classified as moderate status/potential or worse unless the established level or range for the type is revised as a result of the checking procedures.

302. To support the proposed practical approach, the relevant box in the general Figure 6 on ecological classification should be expanded for clarification as illustrated in Figure 8.

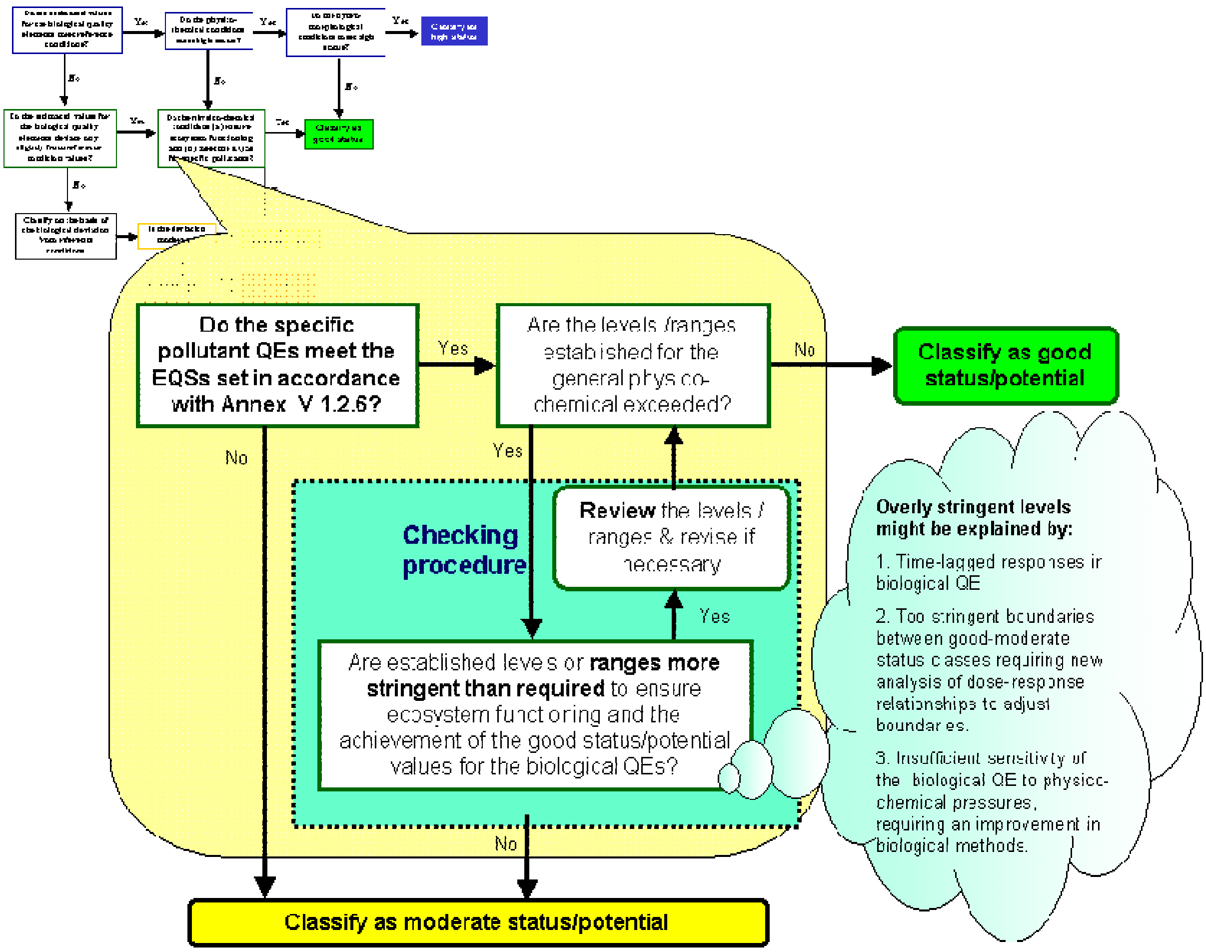

Figure 8. Elaboration of second box in the good Ecological Status line of the ecological classification diagrams (see Figure 6)

Conclusion

303. The analysis set out in the sections above concludes that the Directive requires the establishment of, and compliance with, specific values for the physico-chemical quality elements for the high and good Ecological Status classes as well as for the maximum and good Ecological Potential. For the lower Ecological Status/Potential classes (i.e. moderate, poor and bad status/potential) it only appears to require the establishment of, and compliance with, values for the biological quality elements. Where monitoring results indicate that the condition of the physico-chemical quality elements is worse than good, the status/potential class assigned to the water body must also be less than good, and should be determined with reference to the type-specific condition of the biological quality elements.

1.2. Urban Waste Water Treatment Directive (91/271/EEC)

1.2.1. Overview of UWWT Directive

304. The Urban Waste Water Treatment Directive (UWWT Directive) aims to protect the environment from adverse effects of urban waste water discharges and direct discharges from certain (food processing) industries. It sets treatment levels on the basis of the agglomeration size and the sensitivity of waters receiving the discharges.

305. Surface waters must be designated as sensitive areas if, inter alia, they are eutrophic or if they may become eutrophic in the near future if protective action is not taken (Annex II A(a)). Discharges from agglomerations of >= 10,000 population equivalent to sensitive areas require more stringent treatment for nitrogen and/or phosphorus. However, Member States do not have to identify sensitive areas if more stringent treatment is implemented over the whole of its territory (Article 5 (8)). The designation of sensitive areas needs to be reviewed at least every four years (Article 5 (6)), and for newly designated sensitive areas more stringent treatment, with nitrogen and/or phosphorus removal, must be in place within 7 years of their designation.

306. Sections of the UWWT Directive that particularly refer to eutrophication and surface water monitoring are: Article 2 (11) which defines eutrophication; Article 5 on the identification of sensitive areas and treatment requirements; and Annex II, which specifies criteria for identification of sensitive areas.

1.2.2. Conceptual understanding of eutrophication

307. Article 2.(11) of the UWWT Directive defines eutrophication as: "the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned".

308.. This definition implicitly defines eutrophication by the confluence of four criteria[80]:

- enrichment of water by nutrients;
- accelerated growth of algae and higher forms of plant life;
- an undesirable disturbance to the balance of organisms present in the water
- deterioration of the quality of the water concerned.

309. It focuses more on changes in the aquatic environment rather than a particular state of primary production. It can apply to waters of any natural trophic state if their ecology or water quality has been adversely affected or is at risk due to nutrients from urban waste water discharges. The term "anthropogenic" eutrophication can be used to make this distinction clear.

1.2.3. Methods specified for assessing eutrophication

310. The UWWT Directive does not specify any methods or guideline values for assessing eutrophication[81], which results in Member States developing their own assessment systems and criteria, and may consequently lead to different levels of protection of their water bodies.

311. Several Member States[82] have developed criteria based on the three elements in the definition: nutrient enrichment, algae or plant life growth and other undesirable effects (e.g. oxygen depletion).

312. When designating sensitive areas, consideration should be given to which nutrient should be reduced by further treatment.

- "*Discharges to lakes and streams reaching lakes/reservoirs/closed bays with poor water exchange. Whereby accumulation may take place, should have removal of phosphorus unless it can be demonstrated that the removal will have no effect on the level of eutrophication. Where the discharges from large agglomerations are made, the removal of nitrogen may be also considered*" (Annex II A (a, i)).
- *"Discharges to estuaries, bays and coastal waters with poor water exchange or receiving large quantities of nutrients should have removal of phosphorus and /or nitrogen unless it can be demonstrated that the removal will have no effect on the level of eutrophication"* (Annex II A (a, ii)).

1.2.4. Relevant Case Law

313. The European Court of Justice (ECJ) is dealing with cases brought by the European Commission against several Member States, which address the designation of sensitive areas. The Court has recently ruled on a case brought against France (decision number C-280/02, ECJ judgement on 23/09/2004)[83].

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80 See also §§ 18 of the ECJ judgement for the case C-280/02

81 Surface freshwaters intended for the abstraction of drinking water must have nitrate levels less than 50 mg NO_3/l, but this is well above concentrations likely to cause eutrophication.

314. It is related to the breach of the Directive requirements in relation to non-designation of sensitive areas and lack of infrastructure for 130 agglomerations discharging into sensitive areas. The ECJ ruling addresses the following points:

a. Broader interpretation of purposes of Directive 91/271/EEC (which is based on the legal base of the Directive, i.e. Article 130s (now Article 175 EC) in order to achieve the objectives of Article 130r (now Article 174 EC)). It was stated that:

- The objective pursued by Directive 91/271 goes beyond the mere protection of aquatic ecosystems and attempts to conserve man, fauna, flora, soil, water, air and landscapes from any significant harmful effects of the accelerated growth of algae and higher forms of plant life resulting from discharges of urban waste water.
- *"undesirability must also be considered to be established where there are significant harmful effects not only on fauna and flora but also on man, the soil, water, air or landscape*" (pt. 22 of the judgement).
- undesirable disturbances of the balance of organism present in the water are: "*species changes involving loss of ecosystem biodiversity, nuisances due to proliferation of opportunistic macro algae and sever outbreaks of toxic or harmful phytoplankton"* (pt. 23).

b. Important guidance on component parts of definition of "eutrophication" by

- clearly defining that eutrophication is characterised by the confluence of four main criteria and extensively explaining the meaning of those criteria.
- stating that "*for there to be eutrophication, there must be a cause and effect relationship between enrichment by nutrients and the accelerated growth of algae and higher forms of plant life on the one hand and, on the other hand, between the accelerated growth and an undesirable disturbance of the balance of organisms present in the water and to the quality of the water concerned"* (pt. 19).
- highlighting that criterion "deterioration of water quality" means not only deterioration of the quality of the water which produces harmful effects for ecosystems but also "*deterioration of the colour, the appearance, taste or odour of the water or any change which prevents or limits water use such as tourism, fishing, fish farming, clamming and shellfish farming, abstraction of drinking water or cooling of industrial installations*." (pt. 24)

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[82] e.g. UK, Ireland, Portugal.

[83] http://curia.eu.int/jurisp/cgi-bin/form.pl?lang=en

c. Need to decouple duty to designate sensitive areas from whether or not agglomerations with more than 10 000 population equivalents exist in catchment (pt. 69), but also considering that (according to pts. 40, 52, 69, 77, 87)

- it is not important to define what percentage of pollution goes from urban waste water discharges or from agricultural pollution since both of them may contribute to eutrophication of water body as 91/271/EEC and 91/676/EEC are complimentary. When urban wastewater discharges involve in combination to nitrate flows of agricultural origin, Member States have to designate water body in question as being as a sensitive area in accordance with the directive 91/271/EEC
- the significance of a nutrient loading to a water body should be not only importance of the percentage of that nutrient input but also of the absolute amount of nutrient in tonnes . The decision of its importance in the overall nutrient budget has to be taken on case-by-case basis.

315. It is evident that the interpretation of the European Court of Justice must be used as minimum requirement for the level of protection in environmental laws of the European Communities. The interpretation of terms and criteria in this and related judgements must be used as benchmarks for any assessment method applied under any EC Directive applicable to eutrophication. In particular, the outcome of the intercalibration exercise and the guidance provided by this document in relation to the WFD classification must meet, at least, the obligations that can be derived from this judgement.

1.3. Nitrates Directive (91/676/EEC)

1.3.1. Overview of the Nitrates Directive

316. The Nitrates Directive (91/676/EC) aims to reduce water pollution from nitrates stemming from agricultural sources and to prevent such pollution occurring in the future. The Directive requires Member States to set up water monitoring programmes, to identify waters affected by pollution or that could be affected by pollution if no action is taken, to designate vulnerable zones (areas that drain into identified waters), to establish action programmes for designated vulnerable zones (in order to reduce and/or prevent further pollution) and to establish codes of good agricultural practices. The codes are to be applied by farmers on a mandatory basis within vulnerable zones and implemented on a voluntary basis outside those zones. Member States can opt to apply action programmes throughout their national territory and are in this case exempted from the obligation to identify specific vulnerable zones.

317. Vulnerable zones cover all land draining to identified waters, including natural freshwater lakes, other freshwater bodies, estuaries, coastal waters and marine waters which are eutrophic or may become so in the near future if protective action is not taken (Annex I of the directive).

318. In order to designate and revise nitrate vulnerable zones, the eutrophic state of surface freshwaters, estuaries and coastal waters needs to be reviewed and reported every four years (Article 6).

319. Sections of the Nitrates Directive that refer to eutrophication and surface water monitoring are: Article 2(i), which defines eutrophication; Article 3, on the identification of polluted waters and designation of Vulnerable Zones; Article 5(6) on the monitoring programmes for the purpose of assessing the effectiveness of action programmes; Article 6, on water monitoring for the purpose of the first designation and revision of nitrate vulnerable zones; and Annex 1, which specifies criteria for identifying polluted waters.

1.3.2. Conceptual understanding of eutrophication

320. The Nitrates Directive has the same definition of eutrophication as the UWWT Directive except that it only relates to nitrogen compounds.

1.3.3. Methods specified for assessing eutrophication

321. The Nitrates Directive does not specify any methods or guideline values for assessing eutrophication, which has resulted in Member States developing their own assessment criteria, and may result in different levels of protection of their water bodies. However the European Commission has developed a draft monitoring guidance that includes some preliminary elements for setting eutrophication criteria.

1.3.4. Relevant Case Law

322. Three rulings of the European Court of Justice (ECJ) address specifically the issue of eutrophication and designation of nitrates vulnerable zones under the Nitrates Directive, the Judgement of 27 June 2002 in case C 258/00 *Commission v France,* the Judgement 11 March 2004 in case C 396/01 *Commission v Ireland*, and the judgement of 22 September 2005 in case C 221/03 *Commission v Belgium.*

323. In these cases, the Commission considered that the designation of nitrate vulnerable zones made by the Member State concerned did not adequately take account of the criterion of eutrophication in identification of polluted waters and designation of nitrate vulnerable zones, as required by Annex I.A of the Directive. In the cases related to France and Ireland it was argued by the Member State concerned that the obligation to identify waters and designate nitrate vulnerable zones in the context of the Nitrates Directive did not arise as phosphorus was the main factor causing eutrophication. The ECJ rejected this line of argument. For instance, paragraph 45 of ruling in the case concerning France, stated that *"restricting the scope of the Directive to exclude certain categories of waters owing to the supposedly fundamental role of phosphorus in the pollution of those waters is incompatible with both the logic and the objective of the Directive"*. This Case Law indicated that it is contrary to the Directive to take a restrictive approach in relation to the criterion concerning eutrophication.

In the case related to Belgium, the Member State argued that Wallonia only makes a small contribution to Eutrophication of the North Sea and for this should not be considered for designation of vulnerable zones.

The ECJ rejected this argument by among others stating *'(...), it must be observed that, according to a document supplied by the Belgian Government, Walloon agriculture contributes 19 % of the total nitrogen in the Meuse basin and 17 % of the total nitrogen in the Escaut basin. Those two rivers cross the Walloon Region and drain into the North Sea. It must be pointed out that, although minor, those contributions are by no means insignificant'* (paragraph 86 of the ruling).

1.4. Habitats Directive (92/43/EEC)

324. The Habitats Directive (92/43/EEC) requires Member States to designate Special Areas of Conservation (SACs) (Article 4.4) and Special Protection Areas (SPAs) (Articles 12 and 13) for habitats of plants and animals listed in Annexes I-IV of the directive. For the habitats and species of selected sites, measures must be implemented to maintain or restore to 'a favourable condition' (i.e. Favourable Conservation Status). The Conservation Status must be monitored for all habitats and species of Community interest, and this is not restricted to Natura 2000 sites. The monitoring of habitats can focus on 'typical species'.

325. The Conservation Status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations (Article 1 (i)). Although not explicitly mentioned in the Directive, the impact of point and diffuse pollution by nutrients on water quality is an important part of conservation status in aquatic habitats.

326. The Habitats Directive does not specify any methods for assessing eutrophication. However eutrophication is relevant to the Habitats Directive to the extent that it might affect protected species and habitats. Nutrient enrichment leading to eutrophication can have significant detrimental effects on specific aquatic species and habitats. For example, excessive growth of benthic algae from elevated phosphorus can threaten the habitat for the pearl mussel. More generally, changes in water quality can also help explain trends in biodiversity.

1.5. Shellfish Waters Directive (79/923/EEC)

327. The Shellfish Waters Directive seeks to protect and improve shellfish waters in order to support shellfish life and growth and thus to improve the high quality of shellfish products for consumption. The Directive sets physical, chemical and microbiological water quality requirements that designated shellfish waters must either comply with or endeavour to meet. The Shellfish Water Directive will be repealed by the WFD by 2013.

328. The Shellfish Water Directive does not require an assessment of eutrophication per se, however Article 6 does require a number of parameters to be monitored to check the quality required for shellfish waters. Some of these parameters are relevant to assessments of eutrophication – in particular dissolved oxygen and saxitoxins (produced by dinoflagellates).

329. The Annex of the Shellfish Water Directive requires that dissolved oxygen saturation is monitored monthly, with a minimum of one sample representative of low oxygen conditions on the day of sampling. However where major daily variations are suspected, a minimum of two samples should be taken in a day; 95-percent of the samples should be greater than 70 percent saturation. There are standards and monitoring frequencies specified for saxitoxin.

330. These standards are set to protect shellfish waters and shellfish populations against pollution. They are absolute and apply regardless of whether the values reflect human induced impacts or naturally poor but undisturbed conditions.

1.6. Freshwater Fish Directive (78/659/EEC)

331. The purpose of the Freshwater Fish Directive (78/659/EEC) is to protect or improve the quality of running or standing freshwaters capable of sustaining fish populations. It sets physical and chemical water quality objectives for salmonid waters and cyprinid waters. Member States must designate salmonid waters and cyprinid waters and ensure they meet the quality objectives. The Freshwater Fish Directive will be repealed by the WFD by 2013.

332. There is no direct requirement for an assessment of eutrophication in the Directive. However, standards are set to safeguard waters capable of supporting fish life from the harmful consequences resulting from the discharge of pollutant substances into waters (including the reduction of the number of fish belonging to a certain species). To enable the designated waters to comply with the Directive, Article 6 does require that designated waters are sampled at a minimum frequency and that the waters comply with the quality objectives set by the Member States (Article 3). Many of the parameters specified in Annex 1 of the directive are relevant to eutrophication, for example mandatory minimum values are set for ammonia and dissolved oxygen, and guideline values are specified for total phosphorus. The values set for phosphorus are expressed as indicative in order to reduce eutrophication.

1.7. Bathing Water Directive (2006/7/EC)

333. The EU Bathing Water Legislation seeks to protect the environment and public health, by reducing the pollution of bathing waters and protecting such waters from further deterioration. Bathing waters are classified as all surface freshwater and seawater, where bathing is authorised by competent authorities of Member Sates and is not prohibited.

334. Physical, chemical and microbiological parameters applicable to bathing waters are set by the Directive and all necessary measures taken to ensure that the quality of the bathing water conforms to the limit values (see Article 3 and Annex). Some concept of type-specific reference conditions is included in Article 8 of the Directive through the ability to derogate the Directive requirements where deviation from the prescribed value is caused by exceptional weather or geographic conditions (for certain parameters) or by natural enrichment of certain substances.

335. The old Bathing Waters Directive (76/160/EEC) does not require a direct assessment of eutrophication. However, there is a requirement to monitor several parameters relevant to the assessment of eutrophication, i.e. transparency (fortnightly) and dissolved oxygen, when the quality of the water has deteriorated. Furthermore, samples must be collected for ammonia, nitrates and phosphate, and nitrogen (Kjeldahl) when there is a tendency towards eutrophication of the water.

336. Directive 76/160/EEC was revised and updated through the new Bathing Water Directive 2006/7/EC. The new Directive is based on scientific knowledge on protecting health and the environment, as well as environmental management experience, provides better and earlier information for citizens about the quality of their bathing waters, and moves from simple sampling and monitoring of bathing waters to bathing quality management. The new Directive is fully integrated into the Water Framework Directive.

337. The new Directive does not maintain the monitoring requirements of the old Directive. It requires only monitoring of microbiological parameters: Intestinal enterococci and Escherichia coli, but there is a link to eutrophication parameters, in particular in Article 8 and 9 of the Directive:

- Art. 8: When the bathing water profile indicates a potential for cyanobacterial proliferation[84], appropriate monitoring shall be carried out to enable timely identification of health risks. When cyanobacterial proliferation occurs and a health risk has been identified or presumed, adequate management measures shall be taken immediately to prevent exposure, including information to the public.
- Art. 9: When the bathing water profile indicates a tendency for proliferation of macro-algae and/or marine phytoplankton, investigations shall be undertaken to determine their acceptability and health risks and adequate management measures shall be taken, including information to the public.

338. The new Directive repeals the old Directive (from 31 December 2014) but at present Member States are free to use both Directives.

1.8. Marine Strategy Framework Directive (2008/56/EC)

339. The Marine Strategy Framework Directive 2008/56/EC (MSFD) establishes a framework within which Member States shall take the necessary measures to achieve or maintain 'Good Environmental Status'(GES) in the marine environment by the year 2020 at the latest. GES is defined according to Article 3(5) as "*the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations*."

[84] Cyanobacterial proliferation' means an accumulation of cyanobacteria in the form of a bloom, mat or scum.

340. The Member States shall pursue this objective through the progressive elaboration of strategies for their marine waters. Further, GES shall be determined at the level of the marine region or subregion (specified in MSFD Article 4) on the basis of eleven qualitative 'descriptors' specified in MSFD Annex 1.

341. The descriptor 5 regards eutrophication, which is described as: "*Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters*."

342. Further, the Directive Annex III (Table 2 'Pressures and Impacts') includes two pressures (i.e. nutrient and organic enrichment) that need to be considered in the determination of GES and that influence compliance with the eutrophication descriptor.

343. The implementation of the MSFD is at a start and one of the main aspects of the work in the first phase will be the development of criteria and methodological standards for the descriptors of GES (July 2010 in accordance with Article 9(3)).

344. It is particularly important that this work consider the links, overlap and synergies with existing policies and Directives. A most important link is expected with the Water Framework Directive (WFD). Indeed the concept of Good Environmental Status in the Marine Directive is very similar to that of the Good Ecological Status in the WFD, and the marine Directive explicitly recognizes the need to develop approaches in accordance with the WFD. This is particularly relevant for the eutrophication.

1.9. National Emission Ceilings for Atmospheric Pollutants Directive (2001/81/EC)

345. The Emission Ceilings Directive (2001/81/EC) aims to limit atmospheric emissions of acidifying and eutrophying pollutants and ozone precursors in order to improve the protection of the environment and human health. The protection will be against the adverse effects of acidification, eutrophication and ground level ozone. The long-term objectives of the Directive are to establish national emission ceilings aiming at avoiding exceedances of critical loads and levels[85] and to protect all people against recognised health risks from air emissions.

346. The Emissions Ceilings Directive covers atmospheric emissions from Member States which arise as a result of human activity. It is expected that Member States will lower their annual national emissions of acidifying and eutrophying substances (i.e. sulphur dioxide, nitrogen oxides and ammonia) to levels not greater than those laid down in Annex I by 2010 (Article 4 and 5). Meeting these objectives is expected to result in a reduction of water and soil eutrophication by deposition of nitrogen.

347. There is no direct requirement for an assessment of eutrophication in the Directive. However, the Directive does refer to the quantitative relationship between the emission levels of pollutants and levels of

[85] The concept of critical load and level is defined in the Working Group on Effects under the LRTAP Convention, see: http://www.unece.org/env/wge/definitions.htm

eutrophication. This is based on the exceedance of critical loads at which level the pollutants have a significant adverse effect on the environment, in this instance causing eutrophication, acidification and the formation of ground level ozone.

348. Following the adoption of the Thematic Strategy on air pollution in September 2005, new objectives for eutrophication, acidification, ozone and health have been defined to be met in 2020. The NEC Directive will be reviewed accordingly in 2006. The objective for what concerns eutrophication is a reduction of 43 % of the ecosystems in which the critical loads are exceeded as to compare to 2000 situation.

2. OVERVIEW OF WORK ON EUTROPHICATION IN OTHER INTERNATIONAL POLICIES

349. The control of eutrophication is addressed by a number of international and regional conventions, agreements and policies. These include OSPAR, HELCOM, PARCOM, the Barcelona Convention, the Bucharest Convention, UNECE-LRTAP as well as several river basin conventions such as the Rhine, the Elbe, and the Danube Protection Convention. These are briefly described in Table 11. The rest of this section focuses on the approach taken by the marine conventions.

2.1. OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic

Aims of the OSPAR Convention

350. OSPAR is the mechanism by which 15 governments of the Western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. The mission is to conserve marine ecosystems and safeguard human health in the Convention Area by preventing and eliminating pollution; by protecting the marine environment from adverse effects of human activities and by contributing to the sustainable use of the seas. OSPAR's work is organised under six strategies, applying the ecosystem approach. There are obvious synergies between the objectives and measures taken in the context of OSPAR and those of the Water Framework Directive. The geographical scope of OSPAR is, however, broader, as it covers the whole maritime area.

The OSPAR Eutrophication Strategy

351. The OSPAR Eutrophication Strategy sets the objective to combat eutrophication in the OSPAR maritime area, in order to achieve and maintain by 2010 a healthy marine environment where eutrophication does not occur. The strategy builds on long-standing commitments of OSPAR Contracting Parties to achieve a substantial reduction at source, in the order of 50 % compared to 1985, in inputs of phosphorus and nitrogen into areas where these inputs are likely, directly or indirectly, to cause pollution (see also PARCOM Recommendations 88/2[86], 89/4[87] and 92/7[88]).

[86] http://www.ospar.org/v_measures/get_page.asp?v0=pr88-02e.doc&v1=4

Table 11. Summary of international and regional conventions addressing eutrophication

Name	General objective	Waters covered	Website
OSPAR Convention	To take steps to prevent and eliminate pollution and the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve the marine ecosystem and, when practicable, restore marine area which have been adversely affected.	North-East Atlantic Sea	www.OSPAR.org
Helsinki Convention (HELCOM)	To take measures to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance.	Baltic Sea	www.helcom.fi
Barcelona Convention (UNEP/MAP)	To take concerted actions to prevent and eliminate marine pollution and sustainable management of the Mediterranean.	Mediterranean Sea	www.unepmap.org
Bucharest Convention	To take all necessary measures… to prevent, reduce and control pollution in order to protect and preserve the marine environment of the Black Sea.	Black Sea	www.blacksea-environment.org
UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)	An international legally binding instrument to deal with problems of air pollution on a broad regional basis. Signed by 34 governments and the EC. Includes a protocol to abate acidification and eutrophication. The Working Group on Effects under the Convention is in charge of monitoring the impact of air pollution on health and environment (notably eutrophication and acidification).	Air Pollution (Europe)	www.unece.org/env/lrtap/welcome.html http://www.unece.org/env/wge/welcome.html
Convention for the Protection of the Rhine	Aims to strengthen cooperation between the Community and the Rhine riparian States in order to preserve and improve the ecosystem of the river. Council Decision 2000/706/EC	Rhine River Basin	http://europa.eu.int/scadplus/leg/en/lvb/l28115.htm
Danube River Protection Convention	Aims to achieve sustainable and equitable water management in the Danube Basin. Agreement to reduce pollution loads to the Black Sea. International Commission for the Protection of the Danube River (ICPDR) acts as the permanent secretariat. Supported by a communication from Commission -COM (2001) 615 - on Environmental Co-operation in the Danube.	Danube River Basin	http://www.icpdr.org/pls/danubis/danubis_db.dyn_navigator.show http://europa.eu.int/scadplus/leg/en/lvb/l28016.htm
Elbe River Protection Convention	Aims to prevent the pollution of the Elbe River and its drainage area. International Commission for the Protection of the Elbe River	Elbe River Basin	http://www.ikse-mkol.org/

[87] http://www.ospar.org/v_measures/get_page.asp?v0=pr89-04e.doc&v1=4

[88] http://www.ospar.org/v_measures/get_page.asp?v0=pr92-07e.doc&v1=4

352. PARCOM recommendation 89/4 deals with the set up of national action plans to reach the aims set out in PARCOM Recommendations 88/2. PARCOM recommendation 92/7 dealt with the implementation of appropriate reduction measures in the agricultural sector.

353. The implementation of the Eutrophication Strategy takes place within the framework of obligations and commitments of the various Contracting Parties under international agreements. This includes EC legislation to reduce nutrient discharges and emissions, including the Nitrates Directive, Urban Waste Water Treatment Directive, the Water Framework Directive and the Marine Strategy Framework Directive.

354. To assist Contracting Parties in identifying these areas in a consistent way and to periodically assess the eutrophication status of the OSPAR maritime area and progress made towards the Strategy's objective, OSPAR developed a common harmonised assessment framework: the Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area (Agreement 2005-3).

Eutrophication monitoring

355. OSPAR's respective assessment work is supported by monitoring under the Eutrophication Monitoring Programme and by monitoring to estimate waterborne and atmospheric inputs of nutrients to the OSPAR maritime area under the RID (Riverine Inputs and Direct Discharges) Study and the CAMP (Comprehensive Atmospheric Monitoring Programme) monitoring programme.

2.1.1. Eutrophication assessment

356. OSPAR has developed a harmonised assessment of eutrophication through the Common Procedure to identify the regions of the OSPAR Marine Area in which the recommendations mentioned above apply. OSPAR defines "eutrophication" as the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients as described in the OSPAR Common Procedure.

357. The Common Procedure consists of an initial screening procedure (a "one-off broad-brush approach") to identify obvious non-problem areas, followed by the application of the Comprehensive Procedure to identify whether other waters should be classified as (potential) problem areas or non-problem areas with respect to eutrophication. The Comprehensive procedure is applied as an iterative process, with periodic reassessments and feedback from its application being used to refine the procedure. The screening procedure has been finalised in 2004.

358. The Comprehensive Procedure (COMPP) consists of a set of assessment criteria that are linked to form a holistic assessment of eutrophication status (OSPAR Commission 2005-3). It is based on a conceptual

framework of the eutrophication process and a checklist of qualitative parameters for a holistic assessment. The widely used uniform assessment procedure with respect to yearly trends and elevated concentrations of DIN and DIP in winter**,** and silicate in salinity gradient (riverine influenced) waters is as follows:

a. Mixing diagrams and salinity-specific background concentrations:

> In marine coastal waters with salinity gradients yearly trends in winter nutrient concentrations are assessed by plotting the winter nutrient concentrations of each year in relation to the respective measured salinity values ("mixing diagrams"). In winter, defined as period when algal activity is lowest, DIN and DIP (but also silicate) show a conservative behaviour and, therefore, a good linear relationship with salinity (decreasing concentration with increasing salinity from coast to offshore).

b. Trends and increased concentrations compared with salinity-specific background concentrations:

> In order to compensate for differences in salinity at the various locations and during the various years, nutrient concentrations are normalised for salinity. This is done by calculating the winter nutrient concentration at a given salinity (e.g. 30) from the mixing diagram of a particular year. The salinity normalised nutrient concentration (with 95 % confidence interval) is plotted in relation to the respective year in order to establish trends in the winter nutrient concentrations and the assessment level (compared with background concentration).

359. The conceptual framework and these categories take into account interactions and cause and effect relationships. The conceptual framework is further discussed in section 2.2 along side a modified version of the COMPP holistic checklist.

360. Harmonised quantitative criteria linking assessment parameters have been developed for a sub-group of the checklist, as shown in Table 12. The results of this assessment are combined using a matrix to distinguish problem areas from non-problem areas, as shown in Table 13.

Table 12. Harmonised assessment parameters and related elevated levels (OSPAR 2005-3)

Note: Parameters found at levels above the assessment level are considered as "elevated levels" and entail scoring of the relevant parameter category as (+) (cf. 'score' table at Annex 5 of the Common Procedure). For concentrations, the "assessment level" is defined as a justified area-specific % deviation from background levels not exceeding 50 %.

Assessment parameters		
Category I	**Degree of nutrient enrichment**	
	1	**Riverine inputs and direct discharges[89] (area-specific)** Elevated inputs and/or increased trends of total N and total P (compared with previous years)
	2	**Nutrient concentrations (area-specific)** Elevated level(s) of winter DIN and/or DIP
	3	**N/P ratio (area-specific)** Elevated winter N/P ratio (Redfield N/P = 16)
Category II	**Direct effects of nutrient enrichment (during growing season)**	
	1	**Chlorophyll *a* concentration (area-specific)** Elevated maximum and mean level
	2	**Phytoplankton indicator species (area-specific)** Elevated levels of nuisance/toxic phytoplankton indicator species (and increased duration of blooms)
	3	**Macrophytes including macroalgae (area-specific)** Shift from long-lived to short-lived nuisance species (e.g. *Ulva*). Elevated levels (biomass or area covered) especially of opportunistic green macroalgae).
Category III	**Indirect effects of nutrient enrichment (during growing season)**	
	1	**Oxygen deficiency** Decreased levels (< 2 mg/l: acute toxicity; 2-6 mg/l: deficiency) and lowered % oxygen saturation
	2	**Zoobenthos and fish** Kills (in relation to oxygen deficiency and/or toxic algae) Long-term area-specific changes in zoobenthos biomass and species composition
	3	**Organic carbon/organic matter (area-specific)** Elevated levels (in relation to III.1) (relevant in sedimentation areas)
Category IV	**Other possible effects of nutrient enrichment (during growing season)**	
	1	**Algal toxins** Incidence of DSP/PSP mussel infection events (related to II.2)

89 Principles of the Comprehensive Study on Riverine Inputs and Direct Discharges (RID) (reference number: 1998-5, as amended).

Table 13 Examples of the integration of categorised assessment parameters (see Table 1) for an initial classification (OSPAR 2005-3)[14]

	Category I	Category II	Categories III and IV	Initial Classification
	Degree of nutrient enrichment Nutrient inputs Winter DIN and DIP Winter N/P ratio	Direct effects Chlorophyll *a* Phytoplankton indicator species Macrophytes	Indirect effects/other possible effects Oxygen deficiency Changes/kills in zoobenthos, fish kills Organic carbon/matter Algal toxins	
a	+	+	+	problem area
	+	+	-	problem area
	+	-	+	problem area
b	-	+	+	problem area[90]
	-	+	-	problem area
	-	-	+	problem area
c	+	-	-	non-problem area [91]
	+	?	?	potential problem area
	+	?	-	potential problem area
	+	-	?	potential problem area
d	-	-	-	non-problem area

(+) = increased trends, elevated levels, shifts or changes in the respective assessment parameters in Table 12
(-) = neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters in Table 12
? = not enough data to perform an assessment or the data available is not fit for the purpose

Note: Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated level, shift or change.

2.1.2. Procedures for assessing eutrophication in OSPAR and WFD

361. Procedures for assessing eutrophication are stipulated in the WFD and have been developed by OSPAR and HELCOM. A comparison of the criteria used to assess Good Ecological Status under the WFD and HELCOM, and non-problem areas under the OSPAR Common Procedure and the related OSPAR Ecological Quality Objectives is made in Table 14. The table shows considerable similarities between the quality elements used for WFD classifications and the parameters used by OSPAR/HELCOM. The classification of Ecological Status incorporates most factors involved in eutrophication (i.e. causative factors, direct effects, and indirect effects) with the exception of algal toxins. A further comparison between WFD quality elements and OSPAR/HELCOM criteria is made below:

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90 For example, caused by transboundary transport of (toxic) algae and/or organic matter arising from adjacent/remote areas

91 The increased degree of nutrient enrichment in these areas may contribute to eutrophication problems elsewhere.

Phytoplankton – the WFD requires 'composition, abundance and biomass of phytoplankton' for all water body categories with exception of rivers. OSPAR has identified area-specific phytoplankton indicator species as an important element of composition, has set abundance thresholds for these species; OSPAR and HELCOM have defined area-specific reference conditions and thresholds for chlorophyll a, as an operational indicator of phytoplankton biomass. Furthermore, HEAT uses water transparency as an assessment criterion for the eutrophication status.

Aquatic flora – the WFD requires the assessment of the 'composition and abundance of other aquatic flora' for all water body categories. OSPAR and HELCOM have agreed that shifts in species composition and aerial coverage of macrophytes/macroalgae should be assessed at an area-specific level (e.g. for the OSPAR Wadden Sea area or beaches and shallow waters of the Baltic Sea). Assessments seek to distinguish long-lived from short-lived nuisance species. In addition, HEAT is considering limited depth distribution of submerged aquatic flora as an effect of eutrophication.

Benthic invertebrate fauna – the WFD requires the assessment of the 'composition and abundance of benthic invertebrate fauna' for all water body categories. OSPAR has not developed this criterion in depth for the time being, and simply seeks to distinguish long-term changes in zoobenthos species composition. However, these changes can also be caused by other factors like bottom trawling which may have an overriding effect compared with eutrophication effects. Kills of benthic fauna due to anoxia events and toxic phytoplankton (if caused by eutrophication) are used as more qualitative (descriptive) assessment criteria for assessing (non)occurrence of these events without any quantitative consideration. HEAT is evaluating the composition of animal communities living on the sea floor as a yardstick for eutrophication such as increasing organic enrichment of sediments.

Fish – the WFD requires the assessment of the 'composition, abundance and age structure of fish fauna' for all water body categories with exception of coastal waters. OSPAR is considering the criterion of fish kills due to anoxia events and toxic phytoplankton caused by eutrophication. It is used as a more qualitative (descriptive) criterion for assessing (non)occurrence of these events without any quantitative consideration.

Other elements – the WFD requires also the assessment of hydromorphological and physico-chemical quality elements supporting the biological quality elements. OSPAR and HELOM have developed thresholds for nutrients (OSPAR and HELCOM: winter DIN and DIP concentrations, HELCOM: annual means for TN and TP; OSPAR winter N:P ratios), and for oxygen. OSPAR and HELCOM also take into account possible trends in riverine loads and direct nutrient inputs to the maritime area in the assessment. OSPAR recognises a set of supporting environmental elements but these are not used in the same way as in the WFD.

362. Assessments under the WFD cover all types of pressures, whereas the OSPAR COMPP and HEAT are focused on the impact of nutrient enrichment. A further difference between OSPAR COMPP, HEAT and the

WFD is the methodology by which the various elements are integrated in the final assessment. The WFD and HEAT compare the deviation of recent monitoring data from type-specific reference conditions to calculate an EQR, and base the Ecological Status on the quality element with the worst status (one-out all-out principle). The OSPAR COMPP uses area-specific/historical reference levels for each criterion and has an additive process across the four categories (causative factors, direct effects, indirect effects and other possible effects) to integrate the results of the parameters considered. The result is – as for the WFD – driven by the worst result within each category (nutrient enrichment, direct effects, and indirect effects). The initial outcome might be reviewed, taking into account the influence of environmental factors.

2.1.3. Water body typology

363. The OSPAR, HELCOM and WFD methods to assess eutrophication are based on recognition of differences between different types of waters. Typology forms the basis for classifications under the WFD since reference conditions for the biological elements are type-specific. Two systems for typing are prescribed and Member States must apply one of them. OSPAR has developed a procedure to derive a Characterisation of the OSPAR Convention area:

364. In order to enable area-specific reference conditions to be established, there might be a need for Contracting Parties to carry out an analysis of the relevant characteristics ("typology") for their parts of the OSPAR maritime area. Relating thereto, further relevant information can be found in the Quality Status Reports for the North Sea and the whole OSPAR maritime area (QSR 1993 and QSR 2000).

365. For transitional (e.g. estuarine) and coastal waters falling under the regime of the Water Framework Directive, the respective typology could be used also for the application of the Common Procedure. When carrying out the characterisation, Contracting Parties should focus on the overall purpose of the Common Procedure to identify the eutrophication status of various parts of the OSPAR maritime area.

366. If Contracting Parties see a need to (further) divide their waters outside the area of jurisdiction of the Water Framework Directive, the factors such as

a. salinity gradients and regimes,
b. depth,
c. mixing characteristics (such as fronts, stratification),
d. transboundary fluxes,
e. upwelling,
f. sedimentation,
g. residence time/retention time,
h. mean water temperature (water temperature range),
i. turbidity (expressed in terms of suspended matter),
j. mean substrate composition (in terms of sediment types), and
k. typology of offshore waters

can assist in the characterisation.

Table 14. Comparison of the normative definitions of good Ecological Status for WFD quality elements (coastal waters) (Annex V 1.1) with OSPAR Ecological Quality Objectives and HELCOM Ecological Objectives.

Quality Element	WFD	OSPAR COMMP	OSPAR EcoQO Objectives	HELCOM Ecological Objectives	HELCOM Eutrophication Assessment
Biological quality elements					
Composition, abundance and biomass of phytoplankton	The composition and abundance of phytoplanktonic taxa show slight signs of disturbance. There are slight changes in biomass compared to type-specific conditions. Such changes do not indicate any accelerated growth of algae resulting in undesirable disturbance to the balance of organisms present in the water body or to the quality of the water. A slight increase in the frequency and intensity of the type-specific planktonic blooms may occur.	No elevated levels (and increased duration) of region-specific phytoplankton indicator species. Maximum and mean chlorophyll a concentrations in during the growing season should remain below elevated levels. (Elevated if concentration > 50 % above background concentrations).	Region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration). Maximum and mean chlorophyll a concentrations during the growing season should remain below elevated levels, defined as concentrations >50 % above the spatial (offshore) and/or historical background concentrations.	Clear water, natural level of algal blooms	Mean summer area-specific chlorophyll a concentrations should remain below elevated levels, defined as mean concentrations less than maximum 50 % above reference concentrations

Quality Element	**WFD**	**OSPAR COMMP**	**OSPAR EcoQO Objectives**	**HELCOM Ecological Objectives**	**HELCOM Eutrophication Assessment**
Composition and abundance of aquatic flora (macroalgae and angiosperms)	Most disturbance-sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present. The level of macroalgal cover and angiosperm abundance show slight signs of disturbance.	Macrophytes including macroalgae: no shifts from long-lived to short-lived nuisance species (e.g. Ulva, Enteromorpha). No reduced depth distribution.	-	Natural distribution and occurrence of plants	Depth distributions of bladderwrack and eelgrass close to those of undisturbed conditions (maximum – 25 % deviation from reference conditions)
Composition and abundance of benthic invertebrate fauna,	The level of diversity and abundance of invertebrate taxa is slightly outside the range associated with the type-specific conditions. Most of the sensitive taxa of the type-specific communities are present.	No kills in zoobenthos due to oxygen deficiency and/or toxic algae) No long term changes in zoobenthos species composition.	There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.	Natural distribution and occurrence of animals, natural oxygen levels	Regional diversity of benthic invertebrates is within the natural variability for the assessed region
Composition, abundance and age structure of fish (T)	The abundance of the disturbance-sensitive species shows slight signs of distortion from type-specific conditions attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements.	No kills in fish due to oxygen deficiency and/or toxic algae).	There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.	-	-

Quality Element	**WFD**	**OSPAR COMMP**	**OSPAR EcoQO Objectives**	**HELCOM Ecological Objectives**	**HELCOM Eutrophication Assessment**
Chemical and Physicochemical quality elements					
General Physicochemical quality elements • Transparency • Thermal conditions • Oxygenation conditions • Salinity • Nutrients conditions	Temperature, oxygenation conditions and transparency do not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Oxygen levels should remain above region-specific oxygen deficiency levels (< 2 mg/l = acute toxicity; 2-6 mg/l = deficiency). Winter DIN and/or DIP concentrations should remain below elevated levels (defined as concentration >50 % above salinity related and/or region-specific background concentration). Winter N/P ratios should remain below elevated levels (defined as ratio >50 % above Redfield ratio (N/P=16 molar ratio))	Any decrease in oxygen concentration as an indirect effect of nutrient enrichment should remain above region-specific oxygen deficiency levels. Winter DIN and/or DIP should remain below elevated levels defined as concentrations >50 % above salinity related and/or region-specific background natural background concentrations.	Clear water, concentrations of nutrients close to natural levels, natural oxygen levels	Mean winter area-specific DIN and DIP concentrations should remain below elevated levels, defined as mean concentrations less than maximum 50 % above reference concentrations
Specific Pollutants		-	-	-	-

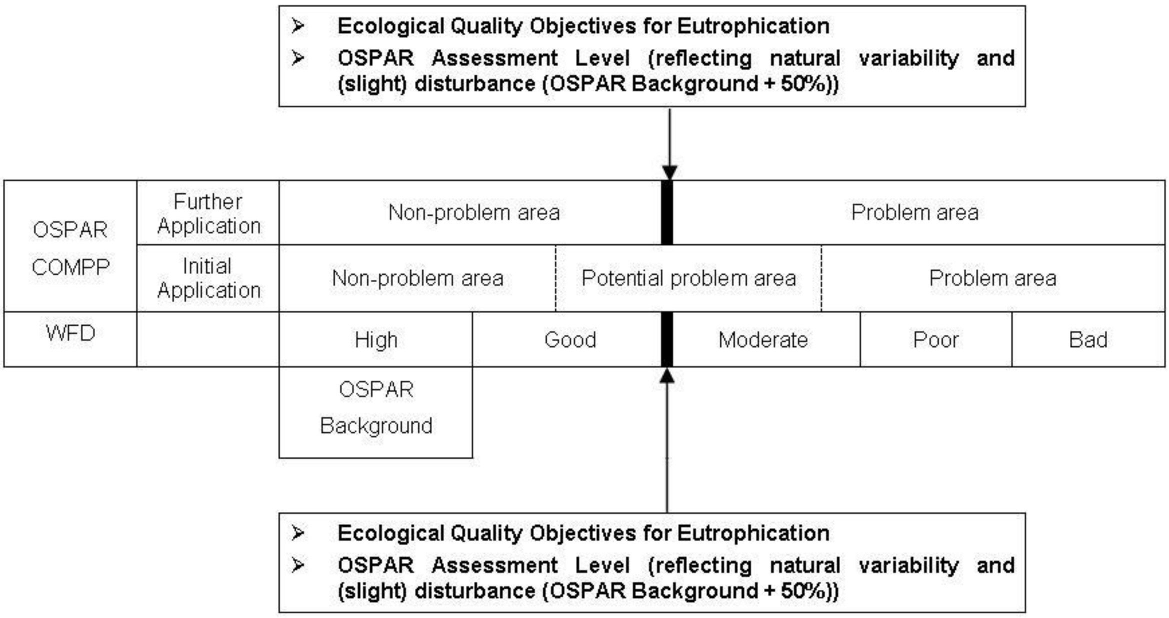
Quality Element	WFD	OSPAR COMMP	OSPAR EcoQO Objectives	HELCOM Ecological Objectives	HELCOM Eutrophication Assessment
Hydromorphological					
Tidal regime	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Supporting environmental factors such as physical and hydrodynamic aspects or climate (e.g. flushing, wind, temperature, light availability).	-	-	-
Morphological conditions	Conditions consistent with the achievement of the values specified above for the biological quality elements.	-	-	-	-

367. The background levels and elevated assessment levels determined for some elements of the OSPAR harmonised assessment criteria could be used to influence the setting of WFD reference conditions and classification boundaries, e.g. background levels potentially equal to WFD reference conditions and these could therefore correspond to the high-good boundary, and the elevated assessment level could correspond to the good-moderate boundary (OSPAR 2005). HEAT is based on the comparison of reference conditions and recent data resulting in a classification according to WFD.

2.1.4. Comparison of OSPAR and WFD class boundaries

368. A more detailed comparison of ecological classification under the WFD and classification under OSPAR COMPP was made by OSPAR (2005) and is shown in Figure 9.

369. The assessment of good Ecological Status under the WFD is similar to the assessment of non-problem areas in the OSPAR Common Procedure. A water body will fail to achieve good Ecological Status if any single quality element fails good status, similarly the OSPAR Common Procedure requires that none of the categories I, II, III & IV (causative factors, direct effects and indirect effects) show increased trends, elevated levels or adverse changes. However, there is not always a direct match in how different parameters are combined. Category II, for example, requires two objectives related to phytoplankton to be met (‘chlorophyll a’ and ‘indicator species’), which correspond to a single quality element (‘composition, abundance and biomass of phytoplankton’).



Note: Assessment levels are based on a justified area-specific % deviation from background levels not exceeding 50 %. OSPAR COMPP = the Comprehensive Procedure; WFD = the Water Framework Directive.

Figure 9. Relationship between the classification under the OSPAR Comprehensive Procedure, the integrated set of OSPAR EcoQOs for eutrophication and the Water Framework Directive. (OSPAR 2005: Publication No. 231) [14]

2.2. Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea

2.2.1. Aims of the Helsinki Convention[92]

370. The Helsinki Convention aims to protect the marine environment of the Baltic Sea from all sources of pollution, and to restore and safeguard its ecological balance. The Helsinki Commission operates through intergovernmental co-operation and is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" (known as the Helsinki Convention).

2.2.2. HELCOM work on eutrophication

371. The control of eutrophication is a major priority of HELCOM. It is widely acknowledged that excessive amounts of nutrients are entering the semi-enclosed Baltic Sea and disturbing the ecological balance of the fragile sea. Under certain hydrological and environmental conditions this leads to algal blooms, oxygen depletion and occasionally fish kills (e.g. 2002 in the Belt Sea and 2003 in the Gulf of Gdansk). In many coastal regions the perennial algal belts have been reduced and partly replaced by short-lived filamentous algal species.

372. Since mid 1980, HELCOM has adopted several HELCOM Recommendations to reduce the load of nutrients and oxygen consuming substances from point and non-point sources in the Baltic Sea catchment. In addition the 1988 HELCOM Ministerial Declaration sets goals for all Contracting Parties to reduce their anthropogenic waterborne nutrient loading by 50 % between 1987 and 1995. Furthermore, in 1992, the Baltic Sea Joint Comprehensive Environmental Action Programme (JCP) was established to facilitate and monitor the elimination of the 162 most polluting sources within the Baltic Sea catchment area – known as "hot-spots". By March 2008 sufficient abatement measures were taken in half of them (83) and they consequently were eliminated from the list of hot spots.

2.2.3. HELCOM Monitoring

373. The HELCOM monitoring system consists of several complementary programmes, The Pollution Load Compilation programmes (PLC-Air and PLC-Water) quantify inter alia emissions of nutrients to the air (nitrogen), discharges and losses to inland surface waters, and the resulting air and waterborne inputs to the sea. The COMBINE programme assesses nutrients and certain eutrophication effects in the marine environment, including examination of trends.

374. Pollution Load Compilations are periodically carried out in order to compile:

a. Total loads of nutrients on an annual basis (from rivers and coastal areas as well as point sources and diffuse sources discharging directly to the Baltic Sea); and

[92] For further information see: http://www.helcom.fi/groups/monas/en_GB/monas_main/

b. Waterborne discharges from point sources and losses from non-point pollution sources as well as natural background losses into inland surface waters within the catchment area of the Baltic Sea located within the borders of the Contracting Parties.

375. These are reported every six year starting in 1987 (PLC-1). The latest report (PLC-4, HELCOM 2004) covers the period 1994 - 2000 for riverine loads and both point and non-point sources in the Baltic Sea catchment area for the year 2000. The next report, PLC-5 will be based on data collected up to 2006 and finalised in 2009. This main objective of the PLC-5 report is to:

- quantify and describe the waterborne discharges from point sources and losses from non-point pollution sources as well as the quantified natural background losses into inland surface waters (source oriented approach) within the catchment area of the Baltic Sea
- quantify and describe the loads (from rivers, unmonitored and coastal areas as well as point sources) discharging directly to the Baltic Sea (load oriented approach);
- evaluate changes in the pollution load since 1994;
- explain to which extent changes are caused by human activities or natural variations; and
- overall evaluate the significance of various water protection measures applied in the Baltic Sea catchment area to reduce the pollution load from land-based sources.

376. This information is required to assess the effectiveness of measures taken to reduce eutrophication in the Baltic Sea catchment area as well as to interpret and evaluate the environmental status and related changes in coastal waters and the open sea.

377. Comprehensive HELCOM assessments were published every five years. For the purpose of an eutrophication assessment, background concentrations of nutrients in the open marine environment are used as one of the criteria for assessments. Ecological Quality Objectives (EcoQOs) for eutrophication have been developed.

2.2.4. Thematic HELCOM eutrophication assessment

378. HELCOM MONAS launched the project "Development of tools for a thematic eutrophication assessment (HELCOM EUTRO)" which aims at a Baltic Sea wide harmonisation of eutrophication assessment criteria and procedures including the establishment of reference conditions for different parts of the Baltic Sea in 2004. The project was based on monitoring data produced within the COMBINE programme, other national monitoring and research data, and they cover both, coastal areas and the open sea. The project developed a "HELCOM Eutrophication Assessment Tool" (HEAT).

379. During a second phase of this project "Towards an integrated thematic assessment of eutrophication in the Baltic Sea" the integrated HELCOM thematic assessment of the eutrophication status of the Baltic Sea

has been executed. The assessment linked sources, inputs, and concentrations of nutrients with primary and secondary eutrophication effects in the marine environment.

380. The assessment applied a common, harmonised approach in assessing eutrophication, the HELCOM Eutrophication Assessment Tool. HEAT is in accordance with the WFD and the relevant guidelines under the CIS process. The report "Eutrophication in the Baltic Sea – An integrated thematic assessment of nutrient enrichment in the Baltic Sea region" was published in March 2009 (Baltic Sea Environment Proceedings No. 115A). Figure 10, taken from the mentioned report, shows the relationships between the HELCOM Baltic Sea Action plan and other water policies and directives.

Policy driver	**Status classification**				
	Unaffected/Acceptable		Affected/Unacceptable		
HELCOM BSAP	Unaffected by eutrophication		Affected by eutrophication		
OSPAR	Non-problem areas		Potential problem areas and problem areas[93]		
MSFD	Good Environmental Status		Polluted		
WFD	High ES	Good ES	Moderate ES	Poor ES	Bad ES
UWWTD	Unpolluted/non-sensitive		Polluted/sensitive		
Nitrates D	Unpolluted		Polluted		

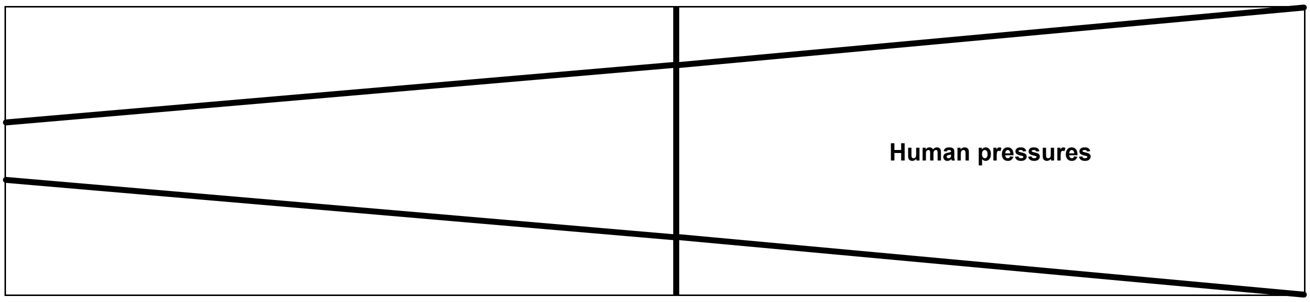


Figure 10. Relationships between the Baltic Sea Action Plan and some key European water policy directives with direct focus on eutrophication status. BSAP = Baltic Sea Action Plan; ES = Ecological Status sensu WFD. Based on HELCOM (2006).

The HELCOM Eutrophication Assessment Tool (HEAT)

381. HEAT, the HELCOM Eutrophication Assessment Tool, is a multi-metric indicator based tool. The development started with consideration of the OSPAR Common Procedure for the identification of the eutrophication status of the OSPAR Convention waters. It has been developed according the relevant principles of the EC Water Framework Directive. It is targeted for assessment of eutrophication in transitional, coastal and open marine areas. HEAT is based on the use of reference conditions determined according to the WFD principles and an acceptable deviation from these reference conditions which defines the boundary between good and moderate status. The assessment results are calculated as Ecological Quality

93 For potential problem areas, latest within five years of their classification, monitoring and assessment and/or research have to prove whether they finally classify as non-problem or problem areas.

Ratio and presented as one of five classes (high, good, moderate, bad, poor). HEAT comprises two assessment steps. The first step is an interim assessment for specific selected indicators and/or biological quality elements (such as phytoplankton, submerged aquatic flora, benthic fauna). By a second step, these individual assessment results are merged into an overall classification using the “one out, all out” principle as laid out in the WFD. HEAT will further be improved in order to meet the requirements of the Baltic Sea Action Plan and eutrophication relevant EC directives such as the WFD, Habitats Directive and the MSFD.

382. HEAT has successfully been tested for coastal and marine waters along the Baltic Sea. It was applied in 189 areas (163 in coastal waters and 16 in open sea areas). Only 13 (11 coastal areas and 2 open basins) were considered unaffected by eutrophication.

2.2.5. The Baltic Sea Action Plan aims at a Baltic Sea unaffected by Eutrophication

383. At the HELCOM Ministerial Meeting in Krakow in November 2007, all HELCOM Member States signed the Baltic Sea Action Plan (BSAP). It has four segments: eutrophication, biodiversity, hazardous substances and maritime issues. The eutrophication segment states “the overall goal of HELCOM is to have a Baltic Sea unaffected by eutrophication”. The aim is to reach HELCOM's vision for good environmental status in the Baltic Sea by achieving five ecological quality objectives to describe the characteristics of a Baltic Sea, which is unaffected by eutrophication:

- Concentrations of nutrients close to natural levels,
- Clear water,
- Natural level of algal blooms,
- Natural distribution and occurrence of plants and animals,
- Natural oxygen levels.

384. In order to make these objectives operational, indicators with target values, reflecting good ecological and environmental status of the marine Baltic environment, have been agreed upon. Clear water was chosen as the primary ecological objective with water transparency as the indicator.

385. For the achievement of the overall goal the Contracting Parties agreed on the principle of identifying maximum allowable inputs of nutrients. They further agreed on the need to reduce the nutrient inputs and that the reductions needed shall be fairly shared by all Baltic Sea countries.

386. In the Baltic Sea there are long time series for some measurements (salinity, temperature, transparency). This provides modellers with excellent reference data, and a number of models describe the Baltic Sea dynamics. Related to eutrophication the Baltic Sea, the MARE NEST model is a marine physical bio-geo-chemical model for the seven sub-basins (Bothnian Bay, Bothnian Sea, Gulf of Finland, Baltic proper, Gulf of Riga, Danish Straits and Kattegat) in the Baltic Sea. This model is linked to a model of the catchment area and to an economic model. HELCOM used the MARE NEST model to derive the figures on maximum allowable nutrient inputs and the needed reductions for waterborne inputs for each sub-basin and

to determine the respective country-wise nutrient reduction requirements which are laid out in the eutrophication segment of the Baltic Sea Action Plan. These data are provisional due to the best available knowledge at that time and the state of national nutrient data deliveries for the preparation of the BSAP. The figures are currently under revision. This process comprises the update of the available data on nutrients from Contracting Parties (e.g. by the 5th HELCOM Pollution Load Compilation and EMEP data an atmospheric nitrogen), and a further improvement of MARE NEST, e.g. by incorporation of more indicators in addition to water transparency.

2.3. Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution

2.3.1. Aims of the Barcelona Convention and the Mediterranean Action Plan

387. The Mediterranean Action Plan (MAP) was adopted by 16 Mediterranean countries and the European Community in 1975. In 1976 these Parties adopted the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention). Seven Protocols have completed the initial MAP legal framework intended to address different aspects of the environmental conservation in the Mediterranean Sea.[94] In 1995 Phase II of the MAP Programme and at the same time an amended version of the Barcelona Convention were adopted.

388. The assessment and control of marine pollution, the protection of the environment through prevention and reduction of pollution and, as far as it is feasible, the elimination of pollution, are amongst the main objectives of the Convention.

2.3.2. MED POL work on eutrophication

389. Within the MAP structure, the MED POL Programme is the pollution assessment and control component. It is responsible for the work related to the implementation of the protocols dealing with pollution from land-based activities and sources[95], dumping[96] and hazardous wastes.[97] MED POL assists Mediterranean countries in the formulation and implementation of pollution monitoring programmes, including pollution control measures and action plans to eliminate pollution from land-based sources

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94 Institutional and legal information and texts on the Mediterranean Action Programme, the Barcelona Convention and the Protocols cand be found at: http://www.unepmap.org/index.php

95 Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities, accessible at: http://195.97.36.231/dbases/webdocs/BCP/ProtocolLBS96_eng_P.pdf

96 Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircrafts, accessible at: http://195.97.36.231/dbases/webdocs/BCP/ProtocolDumping76_Eng.pdf

97 Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal, accessible at: http://195.97.36.231/dbases/webdocs/BCP/ProtocolHazardousWastes96_eng.pdf

390. Activities carried out within the programme have contributed to improving the information on the presence of nutrients in the Mediterranean. Many activities have taken place over different phases, according to the recommendations and decisions of the Parties to the Convention. They encompassed for instance the upgrading of technical facilities, the development of national monitoring projects or the construction of a data base on nutrient values that are available for a number of Mediterranean countries.

2.3.3. Monitoring under MED POL

391. The MED POL Programme has been responsible of the preparation of an **indicator-based monitoring strategy on eutrophication**,[98] finally endorsed by the Conference of the Parties in 2003. The MED POL Strategy of Eutrophication Monitoring in Mediterranean coastal waters uses a stepwise approach:

1. The first step of the implementation of the strategy in the short-term is the classification of the sites to be monitored within individual pilot projects, as being eutrophic or sensitive to eutrophication.

   Three different site typologies were proposed to provide a common approach for the selection of sites (an affected marine site together with a reference site, an off-shore fish farm and a coastal lagoon). In addition, the concerned countries would make use of other general criteria such as representativity, sensitiveness to eutrophication phenomena and availability of basic information on the main hydromorphological parameters as well as associated historical records of ecological events and socio-economical trends in land use.

   The monitoring parameters adopted were selected as to fulfil the minimum necessary scientific requirements and also to support the state indicators developed by the European Environment Agency as well as the TRIX index. A number of parameters to be monitored were also specified:

   - Temperature (C°) Dissolved oxygen (mg/L, %)
   - PH Chlorophyll a (μg/L)
   - Transparency Total Nitrogen (N μmole/L)
   - Salinity (psu)
   - Nitrate (NO_3-N μmole/L, μg/L)
   - Orthophosphate (PO_4-P μmole/L, μ g/L)
   - Ammonium (NH_4-N μmole/L, μg/L)
   - Total phosphorus (P μmole/L, μg/L)
   - Nitrite (NO_2-N μmole/L, μg/L)
   - Silicate (SiO_2 μmole/L)
   - Phytoplankton (total abundance, abundance of major groups, bloom dominance)

   Minimum requirements as regards the sampling strategy, frequency and spatial coverage were also defined.

98 The details of the programme and the background evaluation can be found in the document UNEP(DEC)/MED WG.231/14, accessible at: http://195.97.36.231/acrobatfiles/03WG231_14_eng.pdf

2. For a medium/long term strategy the development of new biological parameters/indicators of eutrophication was proposed. It was needed to introduce biological parameters both for the phytoplankton population dynamics and for the benthic component of the coastal ecosystem.

   In addition, the importance of historical data to reconstruct the story of the site and support the assessment and management of the area according to integrated coastal zone management approaches, recommended their collection and assessment, although was not considered mandatory.

392. The implementation of this strategy was revised in 2005[99].

2.3.4. Thematic eutrophication assessment

393. The Trophic Index TRIX, the assessment method adopted in the MEDPOL Programme, is defined by a linear combination of the logarithms of four state variables: chlorophyll *a* (ChA), oxygen as absolute percent deviation from saturation (aD%O), mineral nitrogen (min N) and total phosphorus (TP) (Vollenweider et al., 1998). The TRIX Index is a numeric expression which provides a direct measure of trophic levels, it works as a multimetric index, and moreover it offers the advantage of utilising, as components, environmental variables directly measured and routinely collected, and it is an index in compliance with WFD requirements. TRIX has also been applied to the assessment of transitional waters (for more information, see Chapter 5.4.1 of this Guidance).

394. The TRIX Index has been tested in different areas of the Mediterranean Sea, e.g. in the Adriatic and the Tyrrhenian Sea (Giovanardi & Vollenweider, 2004).

2.3.5. Overview of the state of eutrophication in the Mediterranean Sea

395. In 2007, MED POL presented an **overview of the state of eutrophication in the Mediterranean Sea**.[100] The information came from the responses from Mediterranean countries to a relevant questionnaire, the results of pilot projects carried out within the Monitoring Strategy, and a literature survey. All this information is used to present drivers and pressures related to eutrophication as well as eutrophication state and impact (DPSIR approach) in the Mediterranean by region or country. Remote sensing data are also used.

396. On the basis of the information received through the questionnaires, it was concluded that very few countries follow the MED POL monitoring strategy and that most countries prefer to follow their own monitoring strategies and assessment methods. Following this conclusion, the challenge for the MED POL and the countries is the harmonization of the monitoring strategies and assessment methods on a basin-wide scale.

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[99] See document UNEP(DEC)/MED WG.282/3, accessible at: http://195.97.36.231/acrobatfiles/05WG282_3_eng.pdf

[100] See document UNEP(DEPI)/MED WG.321/Inf.6, accessible at: http://195.97.36.231/acrobatfiles/07WG321_Inf6_eng.pdf

397. The Conference of the Parties in 2008 endorsed the MED POL proposal to continue eutrophication monitoring, building upon the strategies developed and tested in the initial phase through pilot projects. The strategies would be re-evaluated and if necessary modified after further implementation.

2.4. Bucharest Convention on the Protection of the Black Sea Against Pollution

2.4.1. Aims of the Bucharest Convention[101]

The Convention on the Protection of the Black Sea Against Pollution was signed in Bucharest on 21 April 1992 and ratified by all six legislative assemblies of the Black Sea countries (Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine) in the beginning of 1994. The basic objective of the Convention is to prevent, reduce and control the pollution in the Black Sea in order to protect and preserve the marine environment and to provide the legal framework for cooperation. One of the main specific objectives is to reduce and control the pollution from land-based sources.

2.4.2. Work on eutrophication

The decrease in the importance of agriculture as an economic powerhouse of the region has been clearly shown by decreasing trends in livestock numbers and a shift from major livestock farms to smaller-scale or subsistence-level farming. However, indicators suggest that this decline in agricultural productivity may have bottomed-out, so a gradual re-intensification of agricultural practices my begin in the near future.

Direct discharges from large municipal/industrial plants to the Sea are equivalent to only a small proportion of nutrients discharged to the Sea via rivers, of which the Danube is by far the most important. Available information also suggests that atmospheric deposition of nitrogen to the Sea may be of a similar order of magnitude to river loads, but there is considerable uncertainty over the data used, with a clear need for updating and harmonisation of monitoring protocols.

Based on the data reported by the Black Sea coastal states and the results presented in the 2007 Black Sea Transboundary Diagnostic Analysis, it is suggested that more than 80 % of the river-borne inorganic nitrogen load and around 50 % of the river-borne phosphate load enters the Sea from the Danube. However, the Danube has by far the most rigorous nutrient loads monitoring programme of all rivers, and it is likely that nutrient loads from other rivers are under-estimated by comparison. The importance of freshwater nutrient inflows to the Sea of Azov could not be estimated because of a lack of data for the Kerch Strait.

Between 1996 and 2005 there has been no evidence of a change in river-borne DIN loads to the Sea, albeit with a moderate (15 %) decrease in river-borne PO_4-P loads over the same period. However, the level of confidence associated with the PO_4-P lead decrease is very low, due to the large inter-annual variability.

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[101] For further information see: http://www.blacksea-commission.org/OfficialDocuments/Convention_iframe.htm

2.4.3. Monitoring of the Black Sea

In the frame of the Black Sea Integrated Monitoring and Assessment Programme nutrients are monitored in water, sediment and biota.

2.4.4. The Strategic Action Plan for the Protection and Rehabilitation of the Black Sea

The first Strategic Action Plan for the Rehabilitation and Protection of the Black Sea was signed in Istanbul on 31 October 1996, and amended in 2002. Based on the existing cooperation and the previous action plan, a new Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea was adopted in Sofia, Bulgaria on 17 April 2009. It focuses on concerted action to assist in the continued recovery of the Black Sea and describes the policy actions required to meet the major environmental challenges now facing the Sea, and includes a series of management targets. Ecosystem Quality Objectives (EcoQOs) have been developed as long-term management objectives. One of these objectives is to reduce eutrophication.

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ANNEX 2: INDICATIVE CHECKLISTS FOR WATER CATEGORY-SPECIFIC FEATURES OF THE IMPACT OF EUTROPHICATION

398. The following tables are the complete water category-specific checklists developed during the Eutrophication Workshop in Ispra in September 2004.

RIVERS – Checklist for a holistic assessment

The qualitative assessment parameters are:

a. The causative factors:

The degree of nutrient enrichment:
- With regard to inorganic/organic nitrogen
- With regard to inorganic/organic phosphorus

Taking account of:
- Sources (differentiating between anthropogenic and natural sources)
- Increased/upward trends in concentration
- Elevated concentrations
- Change in N/P ratios
- Fluxes and nutrient cycles (including internal nutrient loading, direct and atmospheric inputs).
- Changes in hydromorphology.

b. The environmental factors:
- Light availability (irradiance, turbidity, suspended load, shading)
- Hydromorphology (e.g. water depth, velocity, flood frequency, substrate type and mobility, stratification, deposition)
- Climatic/weather conditions (rainfall, temperature)
- Chemical status (e.g. suppression of algae growth by pesticides).

c. The direct effects of nutrient enrichment/eutrophication:

i. Phytoplankton;
- Increased biomass (e.g. chlorophyll a, organic carbon and cell numbers or volume)
- Increased frequency and duration of blooms
- Increased annual primary production
- Shifts in species composition (e.g. from diatoms to green algae or cyanobacteria some of which are nuisance or toxic species)

ii. Macrophytes;
- Increased biomass
- Shifts in species composition (from long-lived species to short-lived species, some of which are nuisance species)
- Reduced depth distribution

iii. Phytobenthos
- Increased biomass
- Increased aerial cover on substrate
- Shifts in species composition (e.g. from diatoms to green algae or cyanobacteria)

d. The indirect effects of nutrient enrichment/eutrophication

i. organic carbon/organic matter;
- Increased dissolved/particulate organic carbon concentrations
- Occurrence of foam and/or slime
- increased concentration of organic carbon in sediments (due to increased sedimentation rate)

ii. oxygen;
- Decreased concentrations and saturation percentage
- Increased frequency of low oxygen concentrations
- More extreme diurnal variation
- Occurrence of anoxic zones at the sediment surface ("black spots")

iii. Fish;
- Mortalities resulting from low oxygen concentrations
- Changes in species composition
- Changes in abundance
- Disruption of migration or movement

iv. benthic invertebrate community;
- Changes in abundance
- Changes in species composition
- Changes in biomass

v. Increased growth and biomass of benthic heterotrophic organisms, such as fungi and bacteria

e. Other possible effects of nutrient enrichment

i) Algal toxins (still under investigation, the recent increase in toxic events may be linked to eutrophication).

ii) Amenity values compromised e.g. clogging of pipes and filters, build up of iron deposits due to low DO, amenity value of the river.

LAKES – Checklist for a holistic assessment

The qualitative assessment parameters are:

a. The causative factors:

The degree of nutrient enrichment:

With regard to total and inorganic/organic nitrogen
With regard to total and inorganic/organic phosphorus
With regard to silicon

Taking account of:

Sources (differentiating between anthropogenic and natural sources)
Increased/upward trends in concentration
Elevated concentrations
Changed N/P, N/Si, P/Si ratios
Fluxes and nutrient cycles (including *internal nutrient loading,* across boundary fluxes, recycling within environmental compartments and riverine, direct and atmospheric inputs)

b. Typology factors and other pressures:

Typology factors (alkalinity, colour, depth, size etc.),
Other pressures (hydromorphological impacts and anthropogenic toxic substances)
Light availability (irradiance, mineral turbidity, suspended load)
Hydrodynamic conditions (e.g. stratification, flushing, retention time,)
Climatic/weather conditions (wind, temperature, wet and dry deposition)
Zooplankton grazing (which may be influenced by other anthropogenic activities)

c. The direct effects of nutrient enrichment:

i. Phytoplankton;

Increased biomass (e.g. chlorophyll a, organic carbon and cell numbers)
Increased frequency and duration of blooms
Increased annual primary production
Shifts in species composition (e.g. from *chrysophytes and* diatoms to flagellates */cyanobacteria*, some of which are nuisance or toxic species)

ii. Other aquatic flora, including macroalgae *(such as Characeans)*;

a) Submerged macrophytes:

Changes in biomass (can also be decreased in lakes due to light limitation)
Changes in species composition (, some of which are nuisance species)
Reduced depth distribution

b)phytobenthos;

Increased biomass and primary production, and changes in taxonomic composition

d. The indirect effects of nutrient enrichment

i. organic carbon/organic matter;

Increased dissolved/particulate organic carbon concentrations
Occurrence of foam and/or slime
increased concentration of organic carbon in sediments (due to increased sedimentation rate)

ii. oxygen;

Decreased concentrations and saturation percentage in bottom water and under icecover
Increased occurrence of low oxygen concentrations in bottom water and under icecover
Increased consumption rate
Occurrence of anoxic zones at the sediment surface (“black spots”)
Oversaturation of oxygen in surface water

iii pH increase in littoral zone and surface layers

iv. reduced top-down control of primary producers (reduced grazing by zooplankton and benthic fauna)

v Littoral and profundal macroinvertebrates;

Changes in abundance and species composition

vi. Fish;

Changes in abundance
Changes in species composition (from salmonids and coregonids to perchids and cyprinids)
Changes in age structure
Fish kills

COASTAL/TRANSITIONAL WATERS – Checklist for a holistic assessment

The qualitative assessment parameters are:

a. The causative factors:

The degree of nutrient enrichment:
- With regard to inorganic/organic nitrogen
- With regard to inorganic/organic phosphorus
- With regard to silicon

Taking account of:
- Sources (differentiating between anthropogenic and natural sources)
- Increased/upward trends in concentration
- Elevated concentrations
- Changes in N/P, N/Si, P/Si ratios
- Fluxes and nutrient cycles (including across boundary fluxes, recycling within environmental compartments and riverine, direct and atmospheric inputs)

b. The supporting environmental factors:
- Light availability (irradiance, turbidity, suspended load)
- Hydrodynamic conditions (stratification, flushing, retention time, upwelling, salinity gradients, deposition)
- Climatic/weather conditions
- Zooplankton grazing (which may be influenced by other anthropogenic activities)
- Coastal morphology
- Typology factors for coastal waters

c. The direct effects of nutrient enrichment:

i. Phytoplankton;
- Increased biomass (e.g. chlorophyll a, organic carbon and cell numbers)
- Increased frequency and duration of blooms
- Increased annual primary production
- Shifts in species composition (e.g. from diatoms to flagellates, some of which are nuisance or toxic species)

ii. Macrophytes including macroalgae;
- Increased biomass
- Shifts in species composition (from long-lived species to short-lived species, some of which are nuisance species)
- Reduced depth distribution

iii. Microphytobenthos;
- Increased biomass and primary production

d. The indirect effects of nutrient enrichment

i. organic carbon/organic matter;
- Increased dissolved/particulate organic carbon concentrations
- Occurrence of foam and/or slime
- increased concentration of organic carbon in sediments (due to increased sedimentation rate)

ii. oxygen;
- Decreased concentrations and saturation percentage
- Increased frequency of low oxygen concentrations
- Increased consumption rate
- Occurrence of anoxic zones at the sediment surface (“black spots”)

iii. zoobenthos and fish;
- Mortalities resulting from low oxygen concentrations

iv. benthic community structure;
- Changes in abundance
- Changes in species composition
- Changes in biomass

v. Ecosystem structure;
- Structural changes

e. Other possible effects of nutrient enrichment

i) Algal toxins (still under investigation, the recent increase in toxic events may be linked to eutrophication)

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance document No. 24
RIVER BASIN MANAGEMENT IN A CHANGING CLIMATE

EUROPEAN COMMISSION

environment

Disclaimer:

This document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Foreword

In the context of the WFD Common Implementation Strategy, an activity on Climate Change and Water was initiated in 2007 to produce guidance on how Member States should incorporate consideration of climate variability and change into the implementation of EU water policy. In 2008, the Water Directors discussed and agreed key policy messages on Climate Change and Water.[1] These focused on the following topics:

– EU water legislation and its ability to allow and support adaptation to climate change.

– The importance of integration with other policies.

– WFD and objective-setting under a changing climate.

– How adaptation is addressed in the 1st RBMPs.

– The role of adaptation in the 2nd and 3rd river basin management cycles.

This EU guidance builds upon these policy messages and is a mentioned as a priority action in the EC's White Paper on Adapting to Climate Change (2009).

It has been discussed with a wide range of stakeholders and experts in the framework of the Common Implementation Strategy, and it reflects the important role of water managers in adapting to climate change.

This guidance intends to give support to river basin managers in incorporating climate change in the next river basin management cycles. Further work may be needed and will be undertaken in the Common Implementation Strategy.

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1 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/climate_adaptation&vm=detailed&sb=Title

Executive Summary

Introduction

1. Europe's fresh, transitional and marine waters have been affected by centuries of deliberate management as well as by the unintended consequences of changes in land-use, water abstraction and pollution. Without proactive measures, the continent's water bodies may be further modified by growing pressures from the direct and indirect effects of climate variability and change.
2. Climate change is projected to lead to major changes in yearly and seasonal precipitation and water flow, flooding and coastal erosion risks, water quality, and the distribution of species and ecosystems. Models indicate that at a general level the south of Europe will show a significant drying trend and the north of Europe one of wetting. At a regional scale, the patterns of potential changes can be rather diverse. These changes will most likely become significant in the second half of this century.
3. The European Commission White Paper *Adapting to climate change; Towards a European framework for action* (COM/2009/147) calls for a more strategic approach to climate change adaptation across different sectors and levels of governance. It calls for guidance to integrate climate change adaptation into implementation of the EU water policy. This is also recommended by the European Water Directors.
4. Several existing European Union (EU) policies address water management issues. The most important are the EU Water Framework Directive (WFD) and its daughter directives, the EU Floods Directive, and the EU Water Scarcity and Droughts Strategy. Collectively, these provide legal instruments for protecting and restoring the water environment, as well as steps that can be taken to reduce risks to human health, cultural heritage and economic activity.
5. Although climate change is not explicitly included in the text of the WFD, the step-wise and cyclical approach of the river basin management planning process makes it well suited to adaptively manage climate change impacts. This approach means that we can revisit plans to scale up or down our response to climate change in accordance to monitored data, and can avoid over-investment now. On the other hand, it is important that long term climate projections are built in to the design of measures (driven by current pressures) that have a long design life and high costs. As such, inclusion of climate change in assessment of pressures is important.
6. In addition the river basin management planning process is the best mechanism through which to balance available water resources and demands, thus avoiding long term water scarcity, and provides clear links to the management of flood risk in catchments, which is specifically addressed through requirements in the Floods Directive.
7. The purpose of this Guidance Document is to illustrate ways in which preparations can be made for climate change within the second and third River Basin Management Planning (RBMP) cycles, including provision for floods and droughts. As a minimum, this will require Member States to clearly demonstrate how climate change projections have been considered in the assessment of pressures and impacts, monitoring programmes and appraisal of measures.
8. This Guidance Document describes guiding principles for adaptation, and relates each to steps in RBMP. The principles are intentionally broad to be applicable across all Member States regardless of regional variations in potential impacts. Where feasible, entry points have been identified within existing processes and frameworks. Examples

are provided to show how the principles might be applied in practice. This guidance document is not focused around climate change mitigation measures, although some principles related to integration of different sectors are also applicable to specific mitigation measures such as measures related to renewable energy. Moreover, there is a potential for win-win solutions contributing both to mitigation and adaptation.

9. The Guidance is conveyed in five blocks that explain: (1) how to handle available scientific knowledge and uncertainties about climate change; (2) how to develop strategies that build adaptive capacity for managing climate risks; (3) how to integrate adaptive management within key steps of the RBMP of the WFD; and how to address the specific challenges of managing future (4) flood risk and (5) water scarcity.

10. This Guidance is endorsed by Water Directors. It is aimed at those with responsibility for river basin management, including flood and drought risk management, for delivery of the second and third RBMP cycles (from 2015 until 2027). This will require a combined approach that balances action on monitoring and understanding climate-driven impacts, with implementing no regret actions to improve resilience and ensuring that long life-time investments are climate resilient.

Handling scientific knowledge and uncertainties about climate change

11. Projections of future climate change are obtained from global climate models. These use mathematical equations to characterize fundamental processes involving the transfer of heat, mass, momentum and water vapour amongst major earth systems (such as the ocean, atmosphere, hydrosphere and cryosphere).

12. Depending on the assumed greenhouse gas emissions scenarios and approximations used to represent some natural processes (such as cloud formation), climate change projections can diverge significantly over the second half of the 21st century. However, over the next few decades, the outlook for temperature is largely independent of the emissions scenario because it will be dominated by natural variability and the response of the oceans to past emissions.

13. Over the longer term, major changes in annual water availability are expected across Europe. In general, water availability is projected to increase in northern regions, although summer river flows may decrease. Southern and south eastern parts of Europe, which already suffer water stress, could experience reductions in water resources due to increased frequency and intensity of droughts. On the other hand, increasing intensities of heavy rain events are projected to increase peak river flows across some parts of the continent. Several European research projects focus on better predicting these future trends.

14. Although there are regional variations, upward trends in surface air and water temperatures are projected for Europe. However, temporary cooling is still expected to occur in individual years and decades due to natural climate variability. Projections of changes in precipitation and flows at the river basin scale are less certain, due to large natural variability in these quantities, as well as the limitations of climate models, and assumptions used to downscale information between climate and hydrological models.

15. Potentially all elements included in the definition of WFD qualitative and quantitative status of water are sensitive to climate change. This includes: water availability (river flows and groundwater levels); water demand (especially peak demands during droughts); intensity and frequency of extreme events (floods and low flow episodes); water quality (including temperature, salinity, nutrient and contaminant concentrations.

sediments); and biodiversity of aquatic ecosystems. However, disentangling the effects of climate factors from other changes will continue to be difficult.

16. Given deep uncertainty about regional climate change projections and realised impacts on aquatic ecosystems, RBMP should incorporate management strategies that deliver benefits regardless of the climate outlook. Robust and adaptive RBM measures are low regret, or reversible, incorporate safety margins, employ 'soft' solutions, are flexible, and mindful of the actions being taken by others to either mitigate or adapt to climate change.

17. In practice this means embracing uncertainty by analysing the performance of river basin management plans against the projections of a wide range of climate model and emissions scenarios. Through sensitivity testing it should then be possible to establish which individual or combinations of measures are most effective at achieving water management objectives.

Developing strategies that build adaptive capacity for managing climate risks

18. According to the Intergovernmental Panel on Climate Change (IPCC), adaptive capacity may be defined as the *ability to cope, adapt or recover from the effects of a hazard* (in this case, climate change). Examples of steps that can be taken to build adaptive capacity include: increasing knowledge of potential climate risks for individual river basins; strengthening data collection and knowledge exchange amongst key stakeholders; cross-sectoral integration and partnership working; awareness raising education and training.

19. National and regional climate risk assessments can provide valuable contextual information for individual river basins. Information inventories and meta-analysis can also help pool evidence of observed or anticipated water sector impacts at basin scales. Furthermore, existing work may point to potential transboundary impacts and adaptation options, or good-practice case studies and implementation experience that can be shared amongst neighbours.

20. Reviews of existing knowledge may highlight information gaps that can only be filled by extending data collection and monitoring programmes. However, any consideration of data requirements should be anticipatory of changed patterns of climate pressures and receptor responses. Likewise, long-term monitoring will be needed to track emerging risks and to evaluate the effectiveness of any adaptation interventions.

21. Meaningful and early stakeholder engagement can improve the chance of acceptance of measures and hence the delivery of an integrated, cross-sectoral adaptation strategy. This will also help to minimize potential cross-sectoral conflicts whilst maximising possible synergies between adaptation plans. Therefore, effective lines of communication and coordinated action should be established at all levels of management within the River Basin District (RBD).

22. All water related sectors should be well-informed about the possible impacts of climate change. This might require further training and professional development in climate change science, or forums to enable knowledge transfer between organisations, and broadening of the audience through the public participation processes of the WFD and the Floods Directive.

23. Transboundary river basins pose especially complex challenges with regard to the building of adaptive capacity for climate change. Joint bodies such as international river basin commissions should oversee the development of coordinated adaptation strategies and put in place mechanisms for implementing and monitoring measures.

This may require more technical capacity and foresight needed to undertake such tasks.

Integrating adaptation within key steps of River Basin Management Planning

24. As noted before, the underpinning rationale and processes of the WFD are amenable to the delivery of adaptation. In particular, the integrated approaches to land, water and ecosystem management, combined with the cyclical review process, are all consistent with the ideals of adaptive management. Steps in the RBMP process provide a convenient structure for incorporating adaptation to climate change through: risk appraisal, monitoring and assessment, objective setting, economic analysis and Programmes of Measures (PoMs) to achieve environmental objectives.

25. The Guiding Principles summarised below are intended to help river basin managers to take well informed decisions that are proportionate and robust, given acknowledged uncertainties in regional climate change impacts. Where feasible, "no-regret", or "win-win" measures should be adopted as these yield beneficial outcomes regardless of the eventual outcomes of climate variability and change.

26. As a minimum Member States should clearly demonstrate in the second and third cycle RBMP how climate change projections have informed assessments of WFD pressures and impacts; how monitoring programmes are configured to detect climate change impacts; and how selected measures are as robust as possible to projected climate conditions.

27. Apart from exceptional circumstances, it is not expected that, within the timeframe of WFD implementation (i.e., up to 2027), and within the metrics used for status assessment, that a climate change signal will be statistically distinguishable from the effects of other human pressures at a level requiring reclassification of sites. It is more likely that indirect pressures arising from human responses to climate change – both adaptation and mitigation - will have a greater impact (such as elevated water abstractions for irrigated agriculture, new flood defence infrastructure or effects on water quality and quantity of intense production of energy crops).

28. The following sections provide additional commentary on key guiding principles included in the Guidance. These 11 key guiding principles are considered most useful for river basin managers who want to get acquainted with principles of adaptation in water management in a general way. For additional guiding principles, and for more detailed commentary, suggested actions, case studies and examples the reader is referred to the main body of the guidance.

29. <u>Principle 1: Assessing direct and indirect climate pressures</u>. Member States are required to carry out a review of the impact of human activities on the status of surface and ground waters (e.g., point and diffuse source pollution, abstraction). Potentially all such pressures will be sensitive to climate change, therefore, it is helpful to distinguish between primary and secondary pressures. The former describe direct links between climate driver(s) and natural system response(s) (e.g., increased metabolic rates due to higher water temperatures, more frequent flushing of sewer outflows). Secondary pressures arise from indirect links to climate change due to societal responses (e.g., increase storage to avert water scarcity). Risk assessments that are too narrowly focused on existing pressures within river basins may overlook important but physically remote, indirect or longer-term drivers of water body status.

30. <u>Principle 2: Detecting climate change signals</u>. Monitoring data will be needed to identify and react to climate change signals as they emerge, so it is important to assess how

best use can be made of available data from existing networks, and that sites with relevant long data records are sustained over coming years as part of wider surveillance efforts. Knowledge of when and where climate change might be first detected can help target investigative monitoring and reporting of effects in the most vulnerable water bodies (i.e., "hot spots"). Climate change indicators can be deployed that improve the chance of early detection, and hence the lead-time for invoking adaptive measures.

31. Principle 3: Monitoring change at reference sites. Human activities and climate changes at the river basin scale may have similar outcomes in the quality elements used for status assessment. Therefore, robust information on changes at reference sites – locations that by definition are subject to limited anthropogenic modification – is the primary means of isolating the two sets of impacts.

32. Principle 4: Setting objectives. Although the use of exemptions is an integral part of RBMP, applying exemptions without justification in line with the WFD cannot be seen as a general strategy for coping with the consequences of climate variability and change. Therefore, climate change should only be used as justification for exemptions where there is convincing evidence and certainty that climate projections will combine with a lack of proportionate and feasible measures to require lower than default objectives to be set.

33. Principle 5: Forecasting the economics of water supply and demand. Sequential steps in the economic analysis of the WFD should be followed, but with the integration of potential additional pressures, impacts and constraints due to climate change. The value of water could be affected as the balance between supply and demand is reconfigured. Therefore, economic analyses should identify the most cost-effective combinations of measures under a plausible range of climate change and water supply-demand scenarios.

34. Principle 6: Checking the effectiveness of measures. Due to the fact that substantial financial resources will be invested within coming river basin management cycles, and that many measures will have a long lifespan and/or preclude future adjustments, Member States/RBD authorities have to screen for potential effects by undertaking a "climate check" of the PoMs. This check should involve a sensitivity analysis of the proposed measure or group of measures to evaluate long-term effectiveness and cost-efficiency under changing conditions. If it is found that the measure(s) are potentially sensitive to the anticipated climate change, then the measure should be re-evaluated and adjusted accordingly. Preferred options will be able to cope with a range of climate conditions or are sufficiently flexible to be adapted to changing conditions. The methodology of the climate check should be fully transparent and documented so that the process can be replicated should new or improved evidence of future climate risks become available. Monitoring programmes should also be in place to verify or amend the findings of the climate check.

35. Principle 7: Favouring robust adaptation measures. Proactive adaptation measures may be required if climate change threatens to jeopardise the achievement of WFD objectives. In practice, other, non-climatic pressures are more likely to be of concern over the course of the second and third RBMP cycles. Therefore, the first priority should be to establish/safeguard monitoring programmes that will help benchmark and track long-term climate change impacts as they materialise. Indeed, monitoring and reporting are crucial elements of any adaptive management system. However, if investments are being planned for infrastructure with long life spans it is prudent to favour measures that are resilient to a wide range of plausible climate conditions. Ideally these measures should also work with natural processes and realise multiple

benefits (e.g., for flood risk management, drought management, nature conservation, navigation and recreation.

36. Principle 8: Maximise cross-sectoral benefits and minimise negative effects across sectors. Robust adaptation measures will also make provision for the actions being taken by others to either mitigate or adapt to climate change. For instance, policies intended to reduce greenhouse gas emissions could lead to hydropower development or biomass cultivation with potentially significant consequences for aquatic ecosystems. On the other hand measures taken to improve water status through waste water treatment or reuse, artificial recharge of aquifers, inter-basin transfers, and so forth, imply higher energy consumption and greenhouse gas emissions. The main body of the guidance offers criteria to help select adaptation measures that are effective and cost-efficient, yet minimise side-effects, promote equity, and are technically and socially feasible within the implementation time-scale. Land use planning is an important tool in preventing long term negative effects.

37. Principle 9: Apply WFD Article 4.7. In the event that no *significantly better environmental options* exist, and all practicable steps have been taken to minimise the adverse effect of the proposed measure, WFD Article 4.7 may be invoked. This provides the possibility of exemption from achieving good status when a physical alteration to a water body is deemed to offer benefits that outweigh the costs to the environment.

38. Principle 10: Flood risk management: Start adapting flood risk management to potential climate change as soon as possible, when information is robust enough since full certainty will never be the case. Follow the guiding principles set out for the WFD.

39. Principle 11: Drought management and water scarcity: Use the Water Framework Directive as the basic methodological framework to achieve climate change adaptation in water scarce areas and to reduce the impacts of droughts.

Specific issues relating to flood risk

40. Future changes in the intensity and frequency of extreme precipitation events, combined with changing land use, are expected to cause an increase in flood risk across much of Europe. The Flood Directive shares many features of the WFD, such as the cyclical approach to risk assessment, preparation of management plans, and consultation process. However, what distinguishes the Flood Directive from the WFD is that the risk assessment places safety issues at the centre. Many of the above mentioned guiding principles are therefore directly applicable to flood management.

41. The Flood Directive further highlights the need for coordinated action on climate change throughout the RBD, particularly where there are transboundary or shared flood risk issues. Some information collected under the WFD is of relevance to flood management. The Preliminary Flood Risk Assessment also requires that past floods are taken into account, so efforts to homogenize and remove biases from river flow records will be helpful to trend detection more generally.

42. WFD and flood risk management objectives potentially overlap in several places with respect to climate change. For example, more frequent floods can have benefits for aquatic ecology, soil fertility, groundwater recharge and biodiversity. WFD Article 4.6 makes provision for temporary deterioration in the case of extreme floods, but should not be used by Member States as a means of avoiding obligations under the Directive.

As noted above, WFD Article 4.7 refers to possible exemptions for new infrastructure projects.

Specific issues relating to water scarcity

43. Climate change is expected to aggravate the structural problems that already lead to water scarcity in some European countries. However, a distinction should be made between drought and water scarcity: – the former refers to a temporary deviation of the natural water cycle from the long-term average; the latter to a long-term, systemic imbalance between water supply and demand. Both supply and demand have the potential to affect the status of water bodies as the frequency, duration and intensity of droughts could change in the future.

44. River Basin Management Plans required by the WFD offer considerable potential for addressing the consequences of drought and water scarcity issues. The planning process provides scope for analysing pressures, setting objectives and establishing cost-effective counter measures. For example, achieving good groundwater quantitative status may require rebalancing of abstraction and recharge of groundwater. Measures to achieve these objectives may include economic instruments such as water pricing, and other incentives to use water resources more efficiently. As with the Floods Directive, WFD Articles 4.6 and 4.7 may also be invoked, but in this case, for respectively unforeseen prolonged droughts and new infrastructure designed to tackle water scarcity.

45. Given the high degree of uncertainty in climate change projections and the growing pressure on water resources, it is essential that hydrometric networks are in place to monitor droughts, and that the causes for water scarcity are thoroughly diagnosed, e.g. to monitor water demand and long-term trends in water supply.

46. A further priority is to intensify efforts to manage demand and thereby reduce pressure on water supply sources, especially in times of droughts. The greatest scope for action is in reducing irrigation demands which usually account for the largest fraction of total demand in water scarce regions. Other measures include reducing leakage in water distribution networks, wastewater recycling, and market-based instruments. Further robustness can be built into water resource systems by integrating multiple sources of supply and demand in conjunctive schemes, whilst the potential consequences for water ecosystems have to be considered thoroughly.

47. The above common concerns underline the need for close coordination and active participation of all interested parties in the river basin and flood risk management process, extending beyond the traditional remit of water managers and engineers, to spatial planners, insurance providers, private and public stakeholders.

1 INTRODUCTION

European freshwaters, transitional and marine waters are already being affected by many human activities, e.g. due to land-use, water abstraction and pollution with nutrients and hazardous substances. There are many indications that water resources, which are already under stress from human activities, are highly susceptible to climate change impacts and that climate change may hinder attempts to prevent deterioration and/or restore some water bodies to good status. Climate change is projected to lead to major changes in yearly and seasonal water availability across Europe in the long run, and an increase in extreme river flows is projected for large parts of Europe.

However, on the basis of current knowledge, it is unlikely that within the timeframe of the Water Framework Directive (WFD) implementation (i.e. up to 2027), the effects of a climate change signal will be adequately distinguishable from other human pressures and natural variability to the extent that extensive changes in status become necessary. Only in relatively few particularly sensitive cases, is it likely that climate change could impact status assessment in the relatively short term. It is more likely that first climate change related effects on water status are to be expected from adding to the burden of existing anthropogenic pressures on water bodies, such as increased water abstraction because of higher summer temperatures, or increasing diffuse pollution due to increasing rainfall intensities.

What is the purpose of this Guidance?

The present Guidance Document focuses on **how climate change could be integrated into the 2nd and 3rd river basin management (RBM) cycles of the WFD also broadening the scope to floods and droughts**. This EU Guidance was identified as a priority action by the White Paper of the European Commission on "Adapting to climate change: Towards a European framework for action".

Across Member States, consideration of climate change has been introduced to river basin management processes in a largely qualitative way, if at all, for the **1st RBM cycle for the WFD**. In some cases, adaptation has tended to be considered towards the end of the river basin management process. For the 1st cycle, the Policy Paper of the Water Directors placed particular emphasis on ensuring that the Programmes of Measures are sufficiently adaptive to future climate conditions (so-called climate-check of the Programme of Measures, based on available knowledge, data and common sense).

For the **2nd and 3rd RBM cycles for the WFD**, it is expected that climate change should be fully integrated into the process of river basin management. As such the pillars of the approach to adaptation through river basin management under the WFD should be 1) effective long term monitoring (to enable climate change signals to be identified and reacted to in due course), 2) the assessment of the likely additional impact of climate change on existing anthropogenic pressures, and 3) the incorporation of this information into the design of measures (particularly for proposed measures with a long term design life). Thus, it is expected that as a minimum, Member States should clearly demonstrate how climate change projections have been considered in the **pressures & impacts assessment**, in the **monitoring programmes**, and in the **choice of measures**.

Regarding the Floods Directive, climate change should be considered in the first flood risk planning cycle within the preliminary flood risk assessment and based on available information, as well as in subsequent cycles of planning, when carrying out the revision and updating of the preliminary flood risk assessment and the flood risk management plans.

To whom is this Guidance addressed?

This Guidance is aimed at those with responsibility for river basin management, including flood and drought risk management, in particular for delivery of the 2nd and 3rd river basin management cycles of the WFD (from 2015 until 2027).

What to find in this Guidance?

The main chapters of this document (chapters 3-7) follow a similar pattern in terms of the structure of the guidance provided:

Guiding principles

Guiding principles are introduced in text boxes in the beginning of each chapter or key subchapter. The principles are meant to be generally applicable and intentionally broad to be valid across all Member States. The text boxes are followed by more detailed text explaining the principles.

↓

Suggested actions

Following the explanatory texts of the guiding principles, text boxes introduce more concrete and practical actions to be taken in the coming years in order to apply the principles.

↓

Examples

The guiding principles and suggested actions are complemented by examples which intend to show how the principles and actions might be applied in practice. Some of the examples are generic or fictive and no specific source of reference for further information can be given.

The Guidance starts with an overview of the EU policy framework relevant to water issues and climate change as well as reference to relevant adaptation initiatives in the Member States (*chapter 2*).

Chapter 3 provides a concise introduction to the use of models, projections and scenarios as key tools and information sources for those with responsibilities in river basin management to determine the likely impacts of climate change in river basins. Guiding principles are proposed on how to handle uncertainty from models, projections and scenarios in river basin management decision-making.

Going beyond the handling of available scientific knowledge and related uncertainties, *chapter 4* provides guidance on setting up a strategy for building adaptive capacity for management under climate change, serving as a reminder of key aspects such as awareness-raising, stakeholder involvement, proper staff training and cooperation between different levels of authorities and sectors.

Chapter 5 puts forward guiding principles for adaptation to climate change in relation to the key steps in River Basin Management under the WFD (pressure and impact assessment; monitoring and status assessment; objective setting; economic analysis; measures for adaptation related to the WFD).

Chapters 0 and 7 provide specific guidance on flood risk management and drought management under climate change.

Which guiding principles are put forward in this Guidance?

Table 1 gives an overview of the overall guiding principles proposed in the different blocks of this Guidance Document.

Table 1 Overview of guiding principles in this Guidance Document

Issue	Guiding principles
Climate modelling, projections, scenarios, potential impacts and uncertainty (chapter 3)	
Models, projections and scenarios (section 3.1)	1. Climate projections and scenarios should be used for improving river basin management planning. 2. It is crucial to have a clear understanding of the assumptions made and the uncertainties related to these assumptions. 3. The best climate change model or scenario for a certain region or river basin should be decided on a case-by-case basis, because there is no "one-size-fits-all" model or scenario for Europe.
Managing the water environment based on uncertainty of projections and scenarios (section 3.3)	4. Despite uncertainty in models, 'doing nothing' is not an option. For the next river basin management cycle, accept uncertainty where it is rational to do so and take first actions for adaptation to climate change. 5. Take best available scientific information into account. 6. Use a range of climate projections or scenarios in the analyses for river basin management planning in order to accept and work within the context of an uncertain future. 7. Prefer adaptation options which are robust against a range of future changes or postpone commitment to a particular projection of the future by building flexibility into your system.
How to build adaptive capacity for management under climate change? (chapter 4)	
Using ongoing research and adaptation activities to increase knowledge at river basin scale (section 4.2.1)	1. Link river basin management adaptation activities to national and regional climate change adaptation strategies and activities. 2. Check existing relevant science and research information on climate change modelling and impacts in the river basin. 3. Make use of good-practice examples coming, e.g. from existing research and implementation experience regarding adaptation strategies and measures. 4. Look beyond the borders of your river.
Data collection and building of partnerships (section 4.2.2)	5. Evaluate coverage of data (e.g. meteorological, hydrological, water quality, soil moisture data, stake, damage cost data, etc). 6. Use the WFD consultation process (Art. 14) to bring in sector-specific knowledge and data from key stakeholders. 7. Ensure communication and coordination on climate change adaptation issues between different levels of management within an RBD. 8. Work in cross-sectoral partnerships and across administrations. Ensure that climate change aspects are discussed between the relevant public administrations, in stakeholder meetings and discuss how relevant water-related sectors can contribute to adaptation. 9. Make sure to receive information related to the influence of

	climate change on other sectors which are directly related to water management (e.g. agriculture-water demands, water needs for energy production, etc). 10. Integrate cross-sectoral delivery of adaptation measures and coordinate activities with land use planning.
Broadening the audience and increasing its capacities - Awareness-raising, education and training (section 4.2.3)	11. Include the issue of climate change impacts in the river basin in your RBD awareness-raising activities as part of the WFD public participation process. 12. Establish staff training and capacity building programmes on climate change issues, e.g. to introduce staff to climate change modelling, scenarios and projections.
Looking beyond the borders (section 4.2.4)	13. Develop joint or coordinated adaptation strategies in transboundary RBDs.
Water Framework Directive (WFD) and adaptation (chapter 5)	
Assessing pressures and impacts on water bodies (section 5.3)	1. Assess, over a range of timescales, direct influences of climate change and indirect influences where pressures are created due to human activities adapting to climate change.
Monitoring and status assessment (section 5.4)	2. Maintain both surface and groundwater surveillance monitoring sites for long time series. Set up an investigative monitoring programme for climate change and for monitoring climate change "hot spots", and try to combine them as much as possible with the results from the operational monitoring programme. 3. Include reference sites in long term monitoring programmes to understand the extent and causes of natural variability and impact of climate change.
Objective setting (section 5.5)	4. Avoid using climate change as a general justification for relaxing objectives, but follow the steps and conditions set out in the WFD.
Economic analysis of water use (section 5.6)	5. Consider climate change when taking account of long term forecasts of supply and demand and favour options that are robust to the uncertainty in climate projections.
How to do a climate check of the Programme of Measures? (section 5.7.2)	6. Take account of likely or possible future changes in climate when planning measures today, especially when these measures have a long lifetime and are cost-intensive, and assess whether these measures are still effective under the likely or possible future climate changes. 7. Favour measures that are robust and flexible to the uncertainty and cater for the range of potential variation related to future climate conditions. Design measures on the basis of the pressures assessment carried out previously including climate projections. 8. Choose sustainable adaptation measures, especially those with cross-sectoral benefits, and which have the least environmental impact, including GHG emissions.
What to do if other responses to climate change are impacting on the WFD objective of good status? (section 5.7.3)	9. Avoid measures that are counterproductive for the water environment or that decrease the resilience of water ecosystems. 10. Apply WFD Article 4.7 to adaptation measures that are modifying the physical characteristics of water bodies (e.g. reservoirs, water abstractions, dykes) and deteriorate water status. 11. Take all practicable steps to mitigate adverse effects of

	counterproductive measures.
Flood risk management and adaptation (chapter 6)	
Overall guiding principle on flood risk management and adaptation (section 6.1)	1. Start adapting flood risk management to potential climate change as soon as possible, when information is robust enough, since full certainty will never be the case. Follow the guiding principles set out for the WFD.
Preliminary flood risk assessment (section 6.2)	2. Understand and anticipate as far as possible climate change impact on flood patterns. 3. Use best available information and data. 4. Homogenize time series, and remove bias as far as possible. 5. Understand and anticipate as far as possible increased exposure, vulnerability and flood risk due to climate change, for establishing areas of potential significant flood risk
Flood Hazard and Risk Maps (section 6.3)	6. When identifying the different flood scenarios, incorporate information on climate change 7. Present uncertainties surrounding climate change in maps transparently. 8. Use the 6-year review of flood maps to incorporate climate change information
Flood Risk Management Objectives (section 6.4.1)	9. Incorporate climate change in setting flood risk management objectives 10. Ensure coordination at catchment level, also respecting the Directive's coordination requirements at RBD/unit of management level
Awareness raising, early warning, preparedness (section 6.4.2)	11. Include climate change scenarios in ongoing initiatives and in the planning processes.
Measures (section 6.4.3)	12. Perform a climate check of flood risk measures 13. Favour options that are robust to the uncertainty in climate projections a. Focus on pollution risk in flood prone zones b. Focus on non-structural measures when possible c. Focus on "no-regret" and "win-win" measures d. Focus on a mix of measures 14. Favour prevention through the catchment approach 15. Take account of a long term perspective in defining flood risk measures (e.g. with respect to land use, structural measures efficiency, protection of buildings, critical infrastructure, etc). e. Include long-term climate change scenarios in land-use planning f. Develop robust cost-benefit methods which enable taking into account longer term costs and benefits in view of climate change. g. Use economic incentives to influence land use [Link insurance] 16. Assess other climate change adaptation (and even mitigation) measures by their impact on flood risk: h. Hydropower and flow regulation

	i. Link with water scarcity
Links to WFD (section 6.4.4).	17. Pay special attention to the requirements of WFD Article 4.7 when developing flood protection measures 18. Determine on the basis of robust scientific evidence and on a case-by-case basis whether an extreme flood allows for the application of WFD Article 4.6. 19. Pay special attention to the vulnerability of protected areas in view of changed flood patterns
Drought management and water scarcity and adaptation (chapter 7)	
Overall guiding principle on drought management, water scarcity and adaptation (section 7.2)	1. Use the Water Framework Directive as the basic methodological framework to achieve climate change adaptation in areas of water scarcity and to reduce the impacts of droughts.
River basin management plans as a tool for addressing water scarcity and droughts (section 7.2)	2. Make full use of the Water Framework Directive environmental objectives, e.g. the requirement to achieve good groundwater quantitative status helps to ensure a robust water system, which is more resilient to climate change impacts. 3. Determine, on the basis of robust scientific evidence and on a case-by-case basis, whether a prolonged drought allows for the application of WFD Article 4.6, and take into account climate change predictions in this case-by-case approach. 4. Pay special attention to the requirements of WFD Article 4.7 when developing measures to tackle water scarcity under a changing climate and which may cause deterioration of water status.
Monitoring and Detecting Climate Change Effects (section 7.3)	5. Diagnose the causes that have led to water scarcity in the past and/or may lead to it in the future. 6. Monitor water demand closely and create forecasts based on improved knowledge of demands and trends. 7. Collect as much high quality information as possible to anticipate changes in water supply reliability which may be imposed by climate change, in order to detect water scarcity early. 8. Distinguish climate change signals from natural variability and other human impacts with sufficiently long monitoring time series.
Adaptation measures related to water scarcity & droughts (section 7.4)	9. Take additional efforts to prevent water scarcity and be better prepared to tackle the impacts of droughts. 10. Incorporate climate change adaptation in water management by continuing to focus on sustainability (balance between water availability and demand). 11. Follow an integrated approach based on a combination of measures (compared to alternatives based on water supply or economic instruments only). 12. Build adaptive capacity through robust water resources systems. 13. Engage stakeholders to produce decisive measures to tackle water scarcity. 14. Assess other climate change adaptation and mitigation

	measures by their impact on water scarcity and drought risks.

2 WATER AND CLIMATE CHANGE – POLICY FRAMEWORK

Several existing EU policies and initiatives contribute to efforts for adaptation to climate change with regard to water issues. The most important ones are the EU Water Framework Directive (WFD) and its daughter directives, the EU Floods Directive, the Water Scarcity and Droughts EU Policy as well as the EC's White Paper on Adaptation (see following sections for details). These policies and initiatives refer to:

- Building resilience against the added risk of climate change by acting on existing anthropogenic risk,
- Using a cyclic management approach to include increasing knowledge over time on climate change impacts,
- Using the opportunity of implementation of existing initiatives to:
  - restore natural ecosystem function within catchments, in particular the ability of catchments to retain and slowly release water and to degrade pollutants,
  - reduce fragmentation and improve connectivity of habitats to allow species movements,
  - balance ecology and economic developments.

2.1 Introduction to WFD

The **Water Framework Directive** 2000/60/EC (WFD) establishes a legal framework to protect and restore the water environment across Europe by 2015 and to ensure the long-term sustainable use of water. Although climate change is not explicitly included in the text of the WFD, the step-wise and cyclical approach of the WFD river basin management process makes it well suited to handle climate change.

Climate change should be comprehensively considered in the different steps of the WFD implementation and RBM planning and implementation process, such as characterisation, analysis of pressures and impacts, economic analysis, monitoring, design of the programmes of measures and the default and water body objective setting processes (see chapter 5 of this Guidance).

In many cases, climate change impacts may put additional pressure on European water resources. From the Article 5 characterisation reports assessed for the Commission's WFD implementation report in 2007,[2] there were no indications that climate change pressures are significantly putting the achievement of good status at risk in the first RBM cycle. However, it is important that river basin management plans take account of the medium and long-term implications of climate change, as there is a large potential for synergies between WFD objectives and adaptation aims. **Thus the second river basin management plans due in 2015 should be designed to be robust to the impacts of climate change and climate variability.** As such, it must be ensured that measures are either flexible enough to be adjusted appropriately to changing climate conditions or that those of a fixed nature with a longer term design life incorporate climate projections in their design.

[2] COM(2007) 128 final, 'Towards sustainable water management in the European Union' and its Annex SEC(2007) 362

2.2 Introduction to Floods Directive

Besides the WFD, the **Floods Directive** 2007/60/EC also provides a framework for adaptation with regard to water issues. This Directive establishes a legal framework for the assessment and management of flood risks across Member States, aiming at reducing the adverse consequences of floods to the human health, the environment, cultural heritage and economic activity. The Directive requires Member States to produce the first flood risk management plans (FRMPs) in 2015 in those areas for which potential significant flood risk has been assessed. FRMPs should provide adequate and coordinated measures to reduce this flood risk, taking into account the possible impact of climate change. The core elements of the flood risk management cycle are **preliminary flood risk assessment**, **flood hazard and risk maps** and **flood risk management plans**.

In contrast to the WFD, climate change is explicitly included in the Floods Directive, and Member States are clearly expected to take into account the likely impacts of climate change on the occurrence of floods.[3]

In addition, for the implementation of the Floods Directive, co-ordination with the implementation of the WFD is required by its article 9 from the second cycle of the WFD river basin management plans (RBMP) and onwards. There is an opportunity through alignment to deliver alternative more cost-effective and sustainable catchment based approaches that deliver multiple benefits for flood risk management, water scarcity and drought management and river basin management outcomes. The requirement to coordinate the two Directives therefore establishes an appropriate framework for implementation, so that differing and conflicting interests can be properly balanced and maximum synergies gained.

Chapter 0 of this Guidance focuses on how to address the potential changes in flood hazards due to climate change from the first cycle and how - in view of potential increased flood risk - to limit the vulnerability and potential adverse consequences.

2.3 Introduction to water scarcity and droughts policy

The European Commission adopted an official Communication regarding water scarcity and droughts on 18 July 2007 (EC 2007b), which aims to further develop adaptation measures to address expected increasing impacts of water scarcity and droughts in next decades.

The Communication presents a range of possible options for managing the problems of water resource scarcity and drought, and quotes a certain number of good practices existing in various countries thereby stressing that water saving should become the priority; furthermore, it recommends drafting Drought Management Plans, provides support to establish a European Strategy, proposes to establish a European Drought Observatory (under development by JRC) and introduces the possibility of using European funds for countries suffering prolonged droughts.

The Communication recommends that all possibilities to improve water efficiency must be explored, and that policymaking should be based on a clear water hierarchy, i.e. additional water supply infrastructures should be considered as an option when other options have been exhausted. The Council endorsed the Communication and considered it as a fundamental and well-developed first set of policy options for future action, within the framework of EU water management principles, policies and objectives. In particular, the

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[3] Article 4 (FD) states that the preliminary flood risk assessment shall be based on among other things "impact of climate change on the occurrence of floods" from the first cycle, and article 14.4(FD) makes the consideration of the "likely impact on climate change on the occurrence of floods shall be taken into account in the reviews [of the preliminary flood risk assessment and the flood risk management plans]".

Council stressed that the WFD river basin management plans are the appropriate means to address water scarcity and droughts and that demand side measures should clearly be favoured over supply side measures to the extent possible.[4]

The Guidance at hand emphasises the importance of the common implementation of the WFD and its river basin management plans with the EU policy initiatives on scarcity and droughts. The EU Communication on water scarcity and drought therefore served as a building block for developing the guidance provided in chapter 7 of this document on drought management, water scarcity and adaptation. The follow-up report of the Communication on water scarcity and droughts (EC 2008) shows that, while progress has been made, a great deal still needs to be done in order to improve water demand management more widely across Europe and to avoid mismanagement of water resources, especially in areas of water scarcity.

2.4 EC White Paper on Adaptation

The White Paper of the European Commission "Adapting to climate change: Towards a European framework for action" (COM/2009/147) was issued in April 2009 and sets out a framework to reduce the EU's vulnerability to the impact of climate change.

As efforts are underway to reduce greenhouse gas emissions in the EU, there is further need to take adaptive action in order to deal with the unavoidable climate change and subsequent risks. The White Paper argues that adaptation is already taking place in a piecemeal manner across Europe, therefore a more strategic approach is needed to ensure that timely and effective adaptation measures are taken, ensuring coherency across different sectors and levels of governance.

Next to a number of other fields, the proposed EU framework of the White Paper includes objectives and actions to increase the resilience of EU water systems. Specific emphasis is given to the proper implementation of the WFD, the Floods Directive as well as the Water Scarcity and Droughts Strategy for the delivery of adaptation with regard to water.

The following specific water-related actions (on EU and Member State level) are proposed:

- Develop guidelines and a set of tools (guidance and exchange of best practices) by the end of 2009 to ensure that climate change is built into further implementation of River Basin Management for the WFD.
- Ensure that climate change is taken into account in the implementation of the Floods Directive.
- Assess the need for further measures to enhance water efficiency in agriculture, households and buildings.
- Explore the potential for policies and measures to boost ecosystem storage capacity for water in Europe.
- Look for possibilities to deliver adaptation action which deliver multiple-benefits for flood risk management, water scarcity and drought management and river basin management through better alignment of planning and implementation and catchment based approaches.
- Establishing a Clearing House Mechanism as a database on climate change impact, vulnerability and best practices on adaptation.

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[4] Water scarcity and droughts - Council conclusions, 13389/07 ENV 486 DEVGEN 170 AGRI 307, Brussels, 15 October 2007.

- Explore possible ways of improving policies and developing measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming'.
- Draft guidelines on dealing with the impact of climate change on the management of Natura 2000 sites.

2.5 Other relevant EU policies and legislation

The following EU policies are considered relevant for climate change adaptation and river basin management. Some of them include tools to incorporate climate change impacts, others still may need to be refined to contribute to climate change adaptation related to river basin management.

The **EU marine and coastal policy** is also relevant to adapting to climate change with regard to water issues. In particular the Marine Strategy Framework Directive (2008/56/EC), which requires the achievement of good environmental status of the EU's marine waters by 2020, provides an additional planning framework for adaptation. Effective implementation of this Directive will help increase resilience in the marine environment and facilitate adaptation efforts.

In addition, the White Paper on Adaptation asks for action to ensure that adaptation in coastal and marine areas is taken into account in the framework of the Integrated Maritime Policy as well as the reform of the Common Fisheries Policy.

Specific developments related to reducing the impacts of climate change by implementing **EU policy on renewable energy** (e.g. hydropower development, biomass production) may have impacts on aquatic ecosystems, particularly when such activities either do not recognise or take insufficient account of environmental protection as part of the multi-purpose uses of water bodies. On the other hand, requirements to protect the water environment might impact the potential of certain climate change mitigation measures. Therefore, a well-balanced approach of all relevant EU policy is needed to meet both climate and water protection objectives.

A well-balanced approach with **EU transport policy** is also needed to meet both climate mitigation and adaptation and water protection objectives. With emissions of greenhouse gases from transport still on the increase, a shift from high-carbon road transportation to low-carbon maritime and inland shipping is encouraged by EU transport policy as both modalities contribute relatively positively to reducing overall climate change impacts from transport. On the other hand, navigation on rain water fed rivers will become increasingly vulnerable to climate change impacts such as more varied precipitation patterns. A balanced approach should therefore ensure that both climate mitigation and adaptation and environment protection aspects are checked and reported for transportation projects with environmental implications as well as for environment projects with transport implications in environmental impact assessments (EIAs) and strategic environmental assessments (SEAs). Such a multi-disciplinary policy should guarantee actions that provide an optimum between mitigation and adaptation.

Agriculture can also make a contribution to adaptation. Thus, policy coherence with the **EU Common Agricultural Policy**'s provisions should be ensured with regard to adaptation objectives in water management.

In addition, proper soil management is expected to play a key role in the climate change efforts. Considering also the close interaction of the soil environment with the water environment, current **European policies for soil protection** should also be considered in the context of adaptation efforts in the water management sector (Soil Thematic Strategy (COM(2006) 231), proposed Soil Framework Directive (COM(2006) 232).

The **strategic environmental assessment (SEA)**, either alone or as part of a sustainability appraisal, can help to ensure that plans and programmes take full account of climate change issues. The SEA Directive (2001/42/EC) requires identification and evaluation of planned impacts on a number of environmental issues, including climatic factors; and, where appropriate, to put measures in place to minimise and respond to significant impacts identified[5]. Possible related SEA climate change objectives related to adaptation could include measures such as:

- Ensuring that drainage systems can cope with changing rainfall patterns/intensity
- Taking a precautionary and risk-based approach to developing in the floodplain
- Ensuring adequate future water supply and demand management
- Avoiding actions that limit future adaptation

More details on the possible role of SEA in climate change adaptation is provided in Annex VI.

The European Commission's communication on an **approach on the prevention of natural and man-made disasters** COM(2009) 82 final, was issued in February 2009 and sets out the framework for a strategy on prevention with links between the steps in the risk management cycle; prevention, preparedness, response, recovery and lessons identified to create conditions for developing a knowledge based disaster preventive policy at all levels of government. Between 1990 and 2007 the European Union witnessed a marked increase in the number and severity of both natural and man-made disasters. The loss of human life, the destruction of economic and social infrastructure and the degradation of already fragile ecosystems is expected to worsen as climate change increases the frequency and magnitude of extreme meteorological events, such as heat waves, storms and heavy rains.

2.6 Relevant adaptation initiatives in Member States

Annex VII of this Guidance refers to important information hubs on Member State level concerning national adaptation initiatives which may also refer to water measures (e.g. webportals on climate change and river basin management). The Commission will make further information on EU and Member State adaptation activities available at a central adaptation homepage: http://ec.europa.eu/environment/climat/adaptation/index_en.htm

A European Climate Change Adaptation Clearing House is under preparation by the EC that will contain the updates of national adaptation strategies in the future.

[5] A report published in Summer 2007 called "Strategic Environmental Assessment and Climate Change: Guidance for Practitioners" suggests how climate change issues can be considered in SEA. It presents information on the causes and impacts of climate change and how they can be described and evaluated in SEA. It also describes how adaptation and mitigation measures can be developed through SEA.

3 CLIMATE MODELLING, PROJECTIONS, SCENARIOS, POTENTIAL IMPACTS AND UNCERTAINTY

This chapter aims to provide first guidance on how to handle available scientific knowledge from models, projections and scenarios on climate change as well as related uncertainties for the purpose of river basin management.

It provides a concise summary of available global models, of projections and scenarios with emphasis on their strengths and weaknesses, as well as a general overview of the main predictions for climate change impacts on water resources across Europe. A set of guiding principles is proposed for decision-making and management of the water environment in the light of climate change and uncertainties.

This chapter refers to further sources of reading for those who are interested in climate modelling and projections. This chapter's aim is restricted to providing a general overview of the state of play of knowledge, which may serve as a sufficient basis for the subsequent chapters on EU water policy and climate change adaptation.

3.1 Models, projections and scenarios

Guiding principles

1. Climate projections and scenarios should be used for improving river basin management planning.
2. It is crucial to have a clear understanding of the assumptions made and the uncertainties related to these assumptions.
3. The best climate change model or scenario for a certain region or river basin should be decided on a case-by-case basis, because there is no "one-size-fits-all" model or scenario for Europe.

3.1.1 Global level

In order to grasp the potential range of future climate change, several **global climate projections** are conducted – in international coordination – each of them applying different emission scenarios as well as different global climate models.[6] The results are interpreted, described and published on a regular basis by the Intergovernmental Panel on Climate Change (IPCC). The IPCC recently published its fourth Assessment Report (AR4) "Climate Change 2007" (IPCC 2007). The publication of the 5th report (IPCC AR5) is planned for 2013 (WG I - Report on the Physical Science of Climate Change).

The new generation of global climate models (Atmospheric and Oceanic Global Circulation Models - AOGCM) are more reliable than their predecessors. *Important improvements are, amongst others, the consideration of relevant land surface processes and a database of the earth's surface qualities*. Additionally, the calculation of cloud formation processes has been revised and additional information is obtained as output due to the higher resolution of the new models. Further improvements of the next generation of global climate models are being planned. For example, there are plans to take land ice into account in the calculation of land surface processes.

[6] Please refer to Annex IV for concise definitions of the terms "projections", "forecasts" and "scenarios".

However, it should be kept in mind that global models are based on many simplifications and assumptions, so that their results bear a degree of uncertainty. In addition, the coarse spatial resolution of global models is insufficient for application in impact models and thereby for determining the effects of regional and local climate change. To overcome this limitation, regionalisation procedures are applied. By these, the global projections are "downscaled" to smaller grid elements of up to 25 km × 25 km; in individual studies the downscaling is even below this grid size, or adjusted to the locations of individual stations.

3.1.2 Climate change projections for the EU

Data-comprehensive analysis and synthesis of regional climate change on the European scale was carried out in the last decade by the EU projects PRUDENCE, STARDEX, the still ongoing project ENSEMBLES and the projects CECILIA and CLAVIER on Central and Eastern Europe (details on these research projects are provided in Annex II).

The project PRUDENCE has provided a series of high-resolution climate change projections for 2071-2100 for Europe, characterising the variability and level of confidence in these scenarios as a function of uncertainties in model formulation, natural/internal climate variability, and alternative scenarios of future atmospheric composition. The ENSEMBLES project has extended and updated this approach integrating climate change impact studies into an ensemble prediction system.

The STARDEX project has given a rigorous and systematic inter-comparison and evaluation of downscaling methods for the construction of regional scenarios of extremes. The aim was to identify the more robust techniques, and to use these to produce future scenarios of extremes for European case-study regions for the end of the 21st century. Large progress was made regarding the vital question as to whether extremes will occur more frequently in the future.

The EU project CECILIA provides detailed regional climate projections (and impact assessments) for Central and Eastern Europe, similarly to the EU project CLAVIER which focuses on Hungary, Romania and Bulgaria.

Summarised information on observed and projected climate change in the EU is also available from the European Environment Agency (please refer to EEA/JRC/WHO (2008) for a brief summary of key projected impacts).

3.1.3 National to local level

Currently, many national and European research activities are producing relevant and valuable results on climate change impacts on Europe's fresh, transitional and marine waters (many research projects that are relevant to climate change impact studies on water are briefly outlined in Annex II). Some Member States have also carried out their own more localised modelling (e.g. UK Climate Projections (UKCP09)). Please check Annex V for further web links on Member State local climate projections.

Although the results from research activities developed at local level can in some cases be very useful, it is recommended that the information used in the planning processes be obtained and validated at a national level by the competent authorities, so as to ensure adequate homogeneity in the treatment of different geographic areas. For instance, the Spanish Meteorological Agency (AEMET) has published Regionalized Scenarios for Climate Change Impact Assessment, and disseminated this data through its web site, in order to cope with the implementation of climate change strategies at all policy levels.

Quantitative projections of changes in precipitation and river flows at the river-basin scale remain, however, uncertain, due to the limitations of climate models, as well as scaling issues between climate and hydrological models. Nonetheless, in recent years, the resolution of regional climate model simulations has increased considerably. In addition, statistical correction methods have been developed which bring the models closer to a realistic simulation of, for instance, the amount and intensity of precipitation at the scale of river basins and small catchments.

Example 3a: Downscaling methods in France

Different statistical downscaling methods have been implemented and evaluated to generate local precipitation and temperature series, at different sites in France, based on the results from a variable resolution general circulation model[7]. These methods are being tested over various French river basins (Seine, Loire, Garonne), and could be used elsewhere.

Example 3b: Downscaling in the Thames Basin, UK

The Thames Estuary TE2100 project produced an integrated set of dynamically downscaled data for the Thames Basin over a 150 year period. This showed results from a runoff model driven by precipitation data from the same regional model, which was used to produce simulations of storm surge in the North Sea. This is a good example of high-resolution integrated modelling. It also fed into the UKCP09 marine projections.

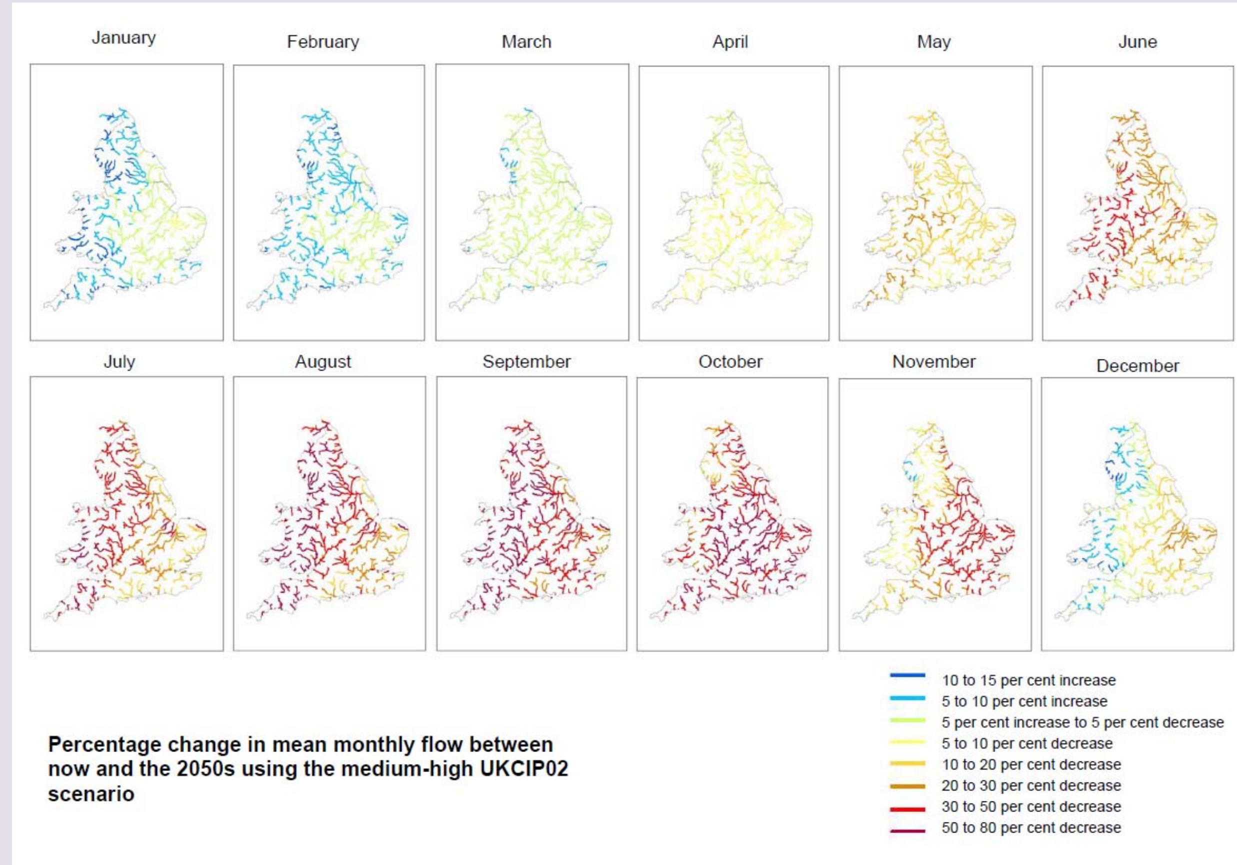
Example 3c: Change of flow between now and the 2050s in the UK

The figure below shows the results of estimation of river flows in the 2050s that were carried out using the Continuous Estimation of River Flows (CERF) model. This is a regionalised rainfall-runoff model developed by the Environment Agency of England and Wales and the Centre for Ecology and Hydrology. The model uses time series data of precipitation and potential evaporation demand to model time series of daily river flows.

The study is the first to use catchment-level models to look at river flows across the whole of England and Wales. Its finding that total annual river flow could drop by as much as 10–15 percent by the 2050s is a result of lower summer and autumn river flows and higher winter river flows.

These results show a possible decrease in mean monthly river flows during the summer and autumn months of around 50 percent, with a fall of up to 80 percent in some areas. They also show a corresponding increase in mean monthly river flows during the winter months of up to 15 percent.

[7] Boé et al, 2006 ; Déqué et al, 2007.



Percentage change in mean monthly flow between now and the 2050s using the medium-high UKCIP02 scenario

Example 3d: Bias correction methods in the Rhine Basin

By definition a model can only approximate reality and will therefore always be biased. Current climate model versions resemble reality much better that earlier versions. Nevertheless, their results cannot be used in impact models directly, unless they are corrected.

Focussing on precipitation output of various climate models and their application in hydrological models of the River Rhine, different statistical bias correction methods are being applied in current cross-bordering projects (KLIWAS, AdaptAlp, and RheinBlick2050). They are tested on different spatial scales, in topographical regions and with focus on mean and extreme values. The methods are also applicable in other catchments. From the KLIWAS project corrected data will be available for all national and international catchments of Germany.

Example 3e: Downscaling national-regional patterns in precipitation to a local level – Production of a local weather generator in Sweden

Within the project 'Extreme rainfall events in Sweden and their importance for local planning' two main tasks have been the focus: a) identifying trends of precipitation extremes in Sweden using daily precipitation observations from 220 stations during the period 1961-2004, and b) projecting future changes in the extremes over the next 100 years by using a weather generator developed for Sweden. Extreme precipitation is expressed in terms of eight indices, which are chosen from a much larger set of possible indices based on the discussion between the authors and the reference group of the project. They describe specific aspects of extreme precipitation considered to be important for Sweden. These also include indices quantifying means as well as dry conditions. All indices are calculated based on daily precipitation from measurements or simulations by the weather generator developed in this project.

The results for the trend analysis are generally in line with results from other studies concluding that regions at middle and higher latitudes are getting wetter and extremes are becoming more frequent and more intense. Separate trend analysis for the different seasons show that climate mainly gets wetter in winter, spring and summer, while decreasing trends could be observed at many stations in autumn.

By following the steps in the weather generator, future extreme precipitation at local scale in Sweden under the SRES A2-scenario is obtained and presented. As expected, the changes vary from station to station within a short distance, further demonstrating the need of downscaling from GCM scale to local scale. However, an overall trend of increased frequencies and intensity of the extremes can still be identified for the majority of the stations studied. The developed downscaling methodology is relatively simple but useful in deriving local precipitation changes including changes in the extremes for local application.

Sources:

Achberger, C. and D. Chen, 2006: Trend of extreme precipitation in Sweden and Norway during 1961-2001. Earth Sciences Centre, C72. Earth Sciences Centre, Göteborg University, Gothenburg, 58 pp.

Deliang Chen, Christine Achberger, Ulrika Postgård, Alexander Walther, Yaomin Liao, Tinghai Ou, 2008: Using a weather generator to create future daily precipitation scenarios for Sweden. http://www.msbmyndigheten.se/default 138.aspx?epslanguage=EN

3.2 Potential impacts of climate change on the status of water resources

Water is intricately linked with climate through a large number of connections and feedback cycles, so that any alteration in the climate system will induce changes in the hydrological cycle. Global warming augments the water-holding capacity of the air and amplifies evaporation. This leads to larger amounts of moisture in the air, an increased intensity of water cycling, and changes in the distribution, frequency and intensity of precipitation. Consequently, the distribution in time and space of freshwater resources, as well as any socio-economic activity depending thereon, is affected by climate variability and climate change. For the coming decades, global warming is projected to further intensify the hydrological cycle, with impacts that will probably be more severe than those so far observed (EEA/JRC/WHO, 2008).

All quality elements included in the definition of WFD qualitative and quantitative status of water may be sensitive to climate change. Over its impact on the quantitative and qualitative status of water resources, climate change affects the following variables:

- water availability (river flows and groundwater levels);
- water demand (esp. peak demands during periods of drought);
- intensity and frequency of floods and droughts, and of strong stream or low flow conditions;
- surface water quality, including temperature, nutrient and other contaminants content;
- biodiversity in aquatic systems;
- groundwater quality.

From the several national and European research activities there is limited empirical evidence to demonstrate impacts unequivocally, because of difficulties in disentangling the effects of climatic factors from other pressures. On the other hand, there are many indications that freshwaters that are already under stress from human activities are highly susceptible to climate change impacts and that climate change may significantly hinder attempts to restore some water bodies to good status in the long term.

- **Water availability and water demand**

Climate change is projected to lead to major changes in yearly and seasonal water availability across Europe in the second half of the century. According to current results, summer flows are projected to decrease in most of Europe, including regions where annual flows will increase. Annual river flow is projected to decrease in southern and south-eastern Europe and increase in northern Europe, but absolute changes remain uncertain. Climate change is projected to result in strong changes in the seasonality of river flows across Europe (EEA/JRC/WHO, 2008).

Regions in southern Europe which already suffer most due to water stress are projected to be particularly vulnerable to reductions in water resources due to climate change. In addition, higher temperatures are expected to lead to increased water demand, especially for irrigation and urban supply. This will result in increased competition for available resources (EEA/JRC/WHO, 2008).

In addition to river flows, groundwater would also be under pressure due to climate change. In particular, additional pressures will occur due to sea-level rise, shrinking land ice and permafrost areas, declining groundwater recharge (especially in southern European countries), more extreme peak flows and more prolonged low flows of rivers, and increased groundwater abstraction. Regions with higher precipitation may experience rises in groundwater levels that may affect houses and infrastructures (EEA/JRC/WHO, 2008).

- **Floods and droughts**

With an intensified hydrological cycle, the intensity and frequency of flood events are projected to increase in large parts of Europe, although estimates of changes remain highly uncertain. In particular, flash and urban floods triggered by intense local precipitation events are likely to be more frequent throughout Europe. Projections suggest that warming could result in less snow accumulation during winter and therefore a lower risk of early spring flooding (EEA/JRC/WHO, 2008). Some projections at river basin scale also suggest that the spring flooding period (related to snow melt) could occur earlier. In autumn, flood risks could increase because of reduced water storage (snow accumulation) (Etchevers et al., 2002).

Climate change is also projected to increase the frequency and intensity of droughts in many regions of Europe, as a result of higher temperatures, decreased summer precipitation, and more frequent and longer dry spells. The regions most prone to an increase in drought hazard are southern and south-eastern Europe (EEA/JRC/WHO, 2008).

- **Water quality and biodiversity in aquatic systems**

Water quality may be impacted by climatic changes in temperature and precipitation (EEA/JRC/WHO (2008)). A rise in water temperature will affect the rate of biogeochemical and ecological processes that determine water quality. This may result in:

- *Reduced oxygen content*. Increases in water temperature in streams and lakes will reduce oxygen solubility and increase biological respiration rates, which may therefore result in lower dissolved oxygen concentrations, particularly in summer low-flow periods and in the bottom layers of lakes. Higher temperatures and lower oxygen concentrations will cause stress for, and may reduce the habitats of, cold-water species such as salmonid fish in lakes and rivers.
- *Less ice cover*. earlier ice break-up and longer ice-free period in rivers and lakes.
- *More stable vertical stratification and less mixing of water in deep-water lak*es, which in turn will affect deep-water oxygen conditions, nutrient cycling and plankton communities.
- *Eutrophication.* A warmer climate would generally enhance the pollution load of nutrients in surface and groundwater. Higher temperatures would increase mineralisation and release of nitrogen, phosphorus and carbon from soil organic matter; higher rainfall intensity will increase run-off and erosion, which will result in

increased pollution transport. On the other hand, higher soil moisture deficits would reduce mineralisation. In addition, release of phosphorus from bottom sediments in stratified lakes is expected to increase, due to declining oxygen concentrations in the bottom waters.

- *Change in timing of algal blooms and increase of harmful algal blooms*.
- *Alterations to habitats and distribution of aquatic organisms*. The geographic distribution of aquatic organisms is partly controlled by temperature. Higher water temperatures can lead to changes in distribution (species moving northwards (in Europe) and to higher elevations) and may even lead to the extinction of some aquatic species. In the Mediterranean region, numerous ephemeral aquatic ecosystems are projected to disappear and permanent ones to reduce in size.
- *Climate-induced changes in sediment quality and quantity.* Sediments form an integral part of natural aquatic systems, providing a substrate for organisms and playing an essential role (e.g. through nutrient cycling). However, contaminants can become adsorbed to sediment. Climate-induced changes in extreme weather conditions (and associated processes such as currents and erosion) could expose and remobilise sediment-associated contamination, or could result in high-energy mass flows of eroded soil or remobilised sediment, in turn impacting aquatic ecosystems.

- **Groundwater quality**

Fresh groundwater bodies will become more vulnerable to pollution through reduced turnover times and accelerated groundwater flow. Saline intrusion in coastal aquifers, making the water unsuitable for drinking, may be exacerbated by future sea-level rise. Finally, further increases in groundwater temperature will raise the salinity of groundwater due to increased evapotranspiration losses, increased soil $CO2$ pressures and increased water — rock interaction (EEA/JRC/WHO, 2008).

Due to density effects a sharp fresh-water/sea-water interface separates freshwater from seawater. The position of this interface can be influenced by a rise of the sea level in two ways. First, this interface will rise with the sea level and second, increasing water abstraction e.g. in order to compensate the sea level rise by more intense drainage activities, can lead to an uplift of the interface between seawater and freshwater as well. This uplift of the interface can be accelerated in areas where freshwater is used for water supply or irrigation purposes and harm the quality in any extraction well.

In areas where river flow and groundwater recharge may decrease, e.g. in southern Europe, water quality could also decrease due to lower dilution of pollutants. Similarly, higher intensity and frequency of floods and more frequent extreme precipitation events are expected to increase the load of pollutants (organic matter, nutrients, and hazardous substances) washed from soils and overflows of sewage systems to water bodies.

Finally, in some estuarine and coastal water bodies including coastal lagoons, there may be local changes in ecology resulting from increased saline intrusion associated with sea level rise.

3.3 Managing the water environment based on uncertainty of projections and scenarios

Guiding principles

4. Despite uncertainty in models, 'doing nothing' is not an option. For the next river basin management cycle, uncertainties should be accepted where it is rational to do so and first actions for adaptation to climate change should be taken.

5. Best available scientific information should be taken into account.
6. A range of climate projections or scenarios should be used in the analyses for river basin management planning in order to accept and work within the context of an uncertain future.
7. Adaptation options should be preferred which are robust against a range of future changes or postpone commitment to a particular projection of the future by building flexibility into your system.

Understanding the sources of uncertainty

As indicated above, climate change models and projections are based on many simplifications and assumptions, so that their results bear various uncertainties. From the perspective of climate impact research, the various sources of uncertainty can be grouped into two categories:

(i) uncertainties related to incomplete knowledge about the system under investigation (e.g. due to measurement errors or simplifications in model formulations).

(ii) uncertainties inherent to the system under investigation (e.g. due to a chaotic behaviour of the global climate or the socio-economic system).

Current and future improvements in measurement networks and model formulations can only minimize uncertainties of category (i). It is presumably unrealistic to believe that uncertainties will be completely eliminated in future climate projections.

As there will never be a single "true" model, multiple model concepts should be used in a comparative way ("*multi-model-approach*"). For instance, in the case of floods, the different models and projections have shown in some cases a large error in the generation of high extreme values of precipitation, so that the estimated impacts based on them could have a great uncertainty. In some of these cases, a multi-model approach will provide more robust estimates of changes in extreme precipitation and flood events, as well as the opportunity to quantify uncertainty inherent to the use of different scenarios. In the case of coastal flooding, there may be a need for common scenarios as regards for instance sea level rise, which could facilitate planning. On the other hand, elements such as increased storminess have a local component that makes common scenarios have less sense for them.

Example 3f – The KLIWAS project – Analysing uncertainty

The interdisciplinary research programme KLIWAS (www.kliwas.de) integrates ecological, economical, water quality and water quantity aspects of climate change for rivers and coastal waters which are used as waterways. KLIWAS strictly follows a multi-model-approach. It uses and evaluates up to 30 climate model runs (including those of the EU-FP6-Project ENSEMBLES and new runs provided by the KLIWAS group), as well as different bias correction methods and hydrological models, in order to account for different sources of uncertainty and provide a reliable basis for the assessment of various adaptation options. With the purpose of model validation and monitoring of climate change effects, historical data bases are extended, too. A model chain is established, which couples climate models to hydrological/oceanographic, hydrodynamical/sedimentological, water quality, and ecosystem models.

At each step, uncertainty is analysed in detail to assess the level of understanding of the aquatic systems and their sensitivity to low flow, floods, and other aspects of "historical" and future climate change. Changes and possible adaptation measures of the waterways are evaluated taking all functions of rivers and coastal waters into account. Thus, varied WFD relevant information is provided.

The inevitable uncertainties of category (ii) are better addressed when more model simulations are included in a so called *ensemble* (*ensemble-approach*). Ensembles help to approximate the probabilistic characteristics of the modelled system. From the ensemble of simulations, relevant information can be extracted, e.g. by using scenario techniques. Nevertheless, difficulties arise when deriving conclusions from an ensemble of projections that are not really equally probable.

Handling uncertainty

In practical terms, decisions related to climate change, its impacts and adaptation options cannot be made on simple, single values but need to encompass the range of possible future climate projections. Thus, decision makers will have to handle a bandwidth of values or different scenarios and accept and be explicit about uncertainty.

This could be through looking at the range of projections from the different models to see which results are consistent and for which we can be confident about. As an example, if all models indicate that it will get wetter in June, then we might be more confident about this projection. If the relevant results are more varied, e.g. it may get wetter or drier, then it is important to choose adaptation options which will be effective across the range of potential future changes. This might involve increasing the resilience of the system, its adaptive capacity, and the use of no-regret measures rather than options which rely on the direction of change.

The selection and priority of measures should be based on the vulnerability of the system. Research can determine which sectors are impacted most severely by climate change and where measures are needed most urgently to prevent undesired effects, even if their exact extent is not yet known.

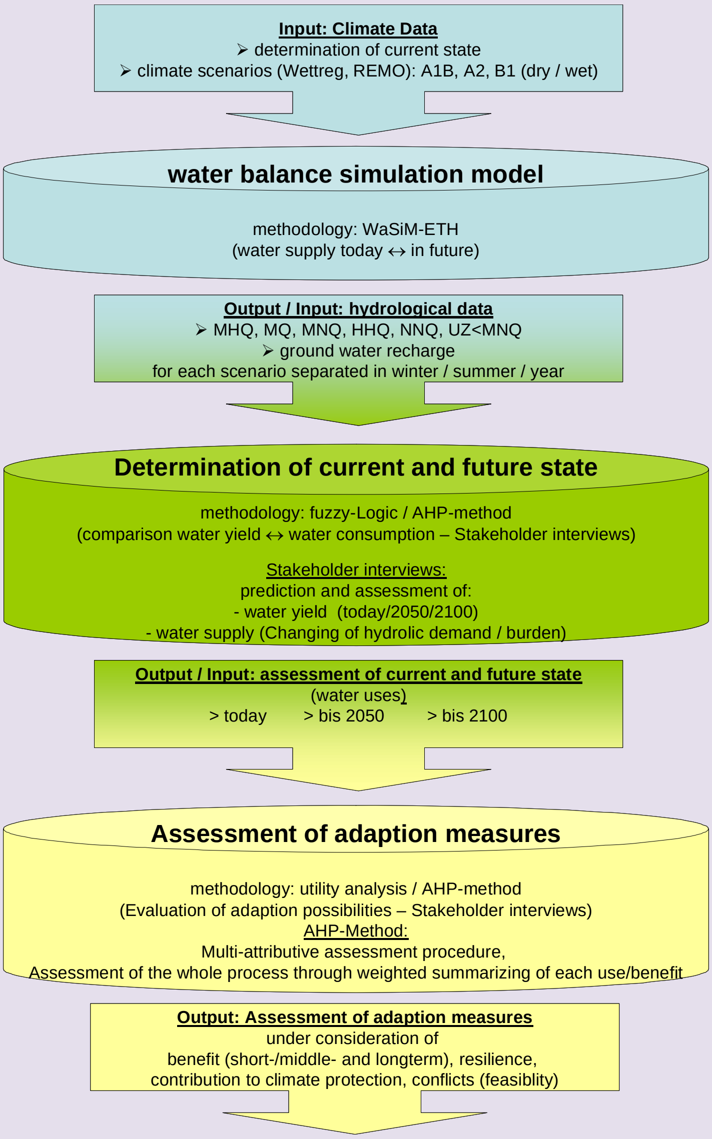
In general, adaptation to climate variability and change is both a technical and a social process of assessing and responding to present and future impacts, planning to reduce the risk of adverse outcomes, and increasing adaptive capacity and resilience in responding to multiple stresses. A key step is to make use of the best available science to identify conditions and risks, as well as their relevance for adaptation strategies and actions, to allow adapting to new boundary conditions due to climate change.

Any analysis carried out as part of river basin management planning should take into account the existence of uncertainty and, where possible, use a range of climate projections including a variety of emissions scenarios, global and regional climate models, and model runs. Thus, results will handle a range of possible impacts on pressures from climate change. Where these ranges are large, it is useful to consider the analysis as a narrative for likely future conditions. In many cases, it will be useful to take a bottom-up approach in terms of looking at potential measures and considering how each of these or combinations will perform against the range of possible climate futures modelled. In chapter 5.7, further guidance is given on how to choose measures that are robust and flexible vis-a-vis future climate conditions (including no-regret, win-win and low-regret measures).

Specific guidance on the issue of management of uncertainty is also given in chapter 0 on flood risk management in the context of uncertainty and chapter 7 on water scarcity and droughts. The example of the research and development project WASKLIM is presented below, which aims to develop a concise method that allows decision-making under uncertainty on the basis of adaptation capacities and vulnerabilities.

Example 3g: WASKLIM - Adaptation strategies in water management (state of play – June 2009)

The currently finished Research and Development Project aims to develop a concise method that allows decisions to be taken which include uncertainty on the basis of adaption capacities and vulnerabilities. Therefore, model simulations of the water balance (WaSiM-ETH), including simulations of scenarios for 2050 und 2100, have been performed for three pilot areas (based on regional models WettReg and REMO). In parallel, regional conferences in these pilot areas, questionnaires and expert interviews collected expert knowledge about the vulnerability of respective water uses. These results were fed into a fuzzy logic-based decision support system (DSS).



The combination of expert knowledge with the simulation results of further climate change effects creates the basis for the assessment of adaption measures.

The DSS results statements show which water uses have a higher need of adaptation action, as well as a pre-selection of suitable adaptation strategies.

The DSS delivers a useful building block for dialogue and participation processes. In a first step this approach requests an intensive reflection of the basic conditions for different water uses. This includes an analysis of the vulnerability of these uses, from the results of climate impact modelling. In a second step climate projections are added. In this way this approach shows the need of action through the overlapping of the spread of the modelling results and operating range given by the expert statements. How stable the priority and the recommendations are on specific adaption measures, which are outcomes of the DSS, are, can be tested by sensitivity analyses. Hence, the whole decision process can be made transparent and open for participation and public discussion.

Example 3h: The CC and Vulnerability Committee in Sweden based their work on the assessment of global climate change made by the UN's climate change panel, the IPCC.

In order to highlight vulnerability in a future climate, they are using a number of global scenarios for climate change. These comprise two global climate models and two global emissions scenarios from the IPCC. Based on these four scenarios, the Rossby Centre at the Swedish Meteorological and Hydrological Institute (SMHI) has made calculations using its regional models.

In consultation with the committee and various sectors, SMHI has developed around 40 specific climate indices as the foundation for assessing the future vulnerability of the sectors. A total of over 10,000 climate maps showing the development of the indices have been drawn up. The calculations have been made for various timeframes – 2020s, 2050s and 2080s. Data has also been produced for the trend over the past 15 years. They have constantly compared the future climate with the most recent complete reference period used in climatological contexts (1961–1990).

The scenarios analysed indicate dramatic changes in Sweden's climate at the end of the century. The winter climate near overall in Sweden will be similar to that which is currently found in northern France. Precipitation in almost the whole of the country will increase in the autumn, winter and spring. The summers will most likely be warmer and have a drier climate, particularly in southern Sweden. Torrential rain will become more intensive.

Finally, it should be kept in mind that in some Member States, "climate services" are set up to help bridge the gap between climate models/scenarios and decision-making. Examples are given in the box below.

Example 3i: "Climate services" in some Member States

UK:

There is considerable guidance on decision making, uncertainty and use of probabilistic climate projections in the UK. Please check: http://ukclimateprojections.defra.gov.uk

Germany:

Germany has a newly established climate service centre. Please check: http://www.climate-service-center.de/

France:

A French project called DRIAS, whose purpose is to give broad access to climate change scenarios and simulations for impact and adaptation studies, has been launched in 2009 (within the GICC program, managed by Météo-France).

Finland:

In Finland, the Watershed Simulation and Forecasting System (WSFS) is used for both hydrological climate change scenario simulations to estimate the impact of climate change on floods, droughts and water resources, and to assess the adaptation possibilities of water resources management. The results have been disseminated through publications, seminars and catchment specific project reports to stakeholders. WSFS is also used for real time hydrological forecasting and lake regulation planning, disseminated to stakeholders and even operated by stakeholders through internet (www.environment.fi/waterforecast), to be used in flood and water resources management.

The VACCIA-project (2009-2011) is based on data from intensively studied sites/sub-regions of the FinLTSER-network. The sites have a wealth of existing information, and are closely integrated into the local-scale economy and activities. This provides the link to the scale where realistic adaptation measures can be planned and assessed. The project will provide both detailed descriptions about the methodology and tools for making climate impacts and adaptation assessments, as well as an inventory of realistic adaptation measures for key ecosystem goods and services. This methodology and information can be used by stakeholders at local, regional, national and international scales.

In addition, FINESSI (http://www.finessi.info/finessi/index.php) is a web tool that allows the user to explore the possible impacts of climate change in Finland on chosen impact areas and at different time periods up to the end of the 21st century. The tool is intended for planners and researchers, but it may also be of interest to students and to members of the public. FINESSI offers a common platform for integrating observations of the present-day climate and environment with modelled information about future climatic conditions (scenarios) and their impacts. The impacts of climate change are presented for climate-sensitive systems and activities such as agriculture, water resources and natural ecosystems.

Czech Republic:

Useful information can be found on the following sites:

- CHMI (Czech Hydro Meteorological Institute): http://www.chmi.cz/cc
- National Climate Program of the Czech Republic: http://www.chmi.cz/nkp/nkp.html
- Ministry of the Environment: http://www.mzp.cz/

4 GETTING STARTED: HOW TO BUILD ADAPTIVE CAPACITY FOR MANAGEMENT UNDER CLIMATE CHANGE

4.1 Introduction

This chapter proposes a set of guiding principles that should help those with river basin management responsibilities in setting up a strategy for building adaptive capacity[8] to manage river basins districts under climate change.

The chapter serves to remind managers that they should consider aspects, which go beyond the handling of available scientific knowledge on climate change and related uncertainties (chapter 3), in order to carry out river basin planning and management in a changing climate (as described in the next chapters of this Guidance). "Softer" aspects of river basin management, such as awareness-raising, proper staff training and cooperation between different levels of authorities and sectors, also need to be considered in efforts to build up adaptive capacity for management under climate change.

The way climate change is incorporated in the river basin management cycle also needs to undergo public consultation (as part of the normal procedures according to WFD Article. 14), while at the same time, climate change may help in raising the public profile of sustainable water management. An efficient use of the WFD public participation process is especially relevant for climate change awareness raising in water management, but also for integrating valuable sector-specific stakeholder knowledge.

Please note: The following list of guiding principles addresses mainly those aspects that can be influenced by those with river basin management responsibilities. The development or modification of policies and regulations, which is an equally important condition for climate change adaptation, is not addressed here.

4.2 What is needed to build adaptive capacity?

Building adaptive capacity has many aspects. Below, information is presented about using available knowledge and data in a RBD, involving the relevant stakeholders and looking out for the wider audience, and getting started in an international river basin.

4.2.1 Using ongoing research and adaptation activities to increase knowledge at river basin scale

Guiding principles

1. Link river basin management adaptation activities to national and regional climate change adaptation strategies and activities.

   Such strategies are a source of relevant research, information and assessments. They are often based on detailed assessments of climate change impacts on water and in many cases include first evaluations of potential water adaptation measures. These adaptation strategies and the assessments of impacts can supplement the climate impact assessment of the WFD (Article 5, see chapter 5).

2. Check existing relevant science and research information on climate change

[8] "Adaptive capacity" can be interpreted as the "ability to cope, adapt or recover from the effects of a hazard" (in this case, climate change). The presence of adaptive capacity is considered a necessary condition for the design and implementation of effective adaptation strategies (IPCC (WGII), 2007).

modelling and impacts in the river basin.

This could include, for example, producing information inventories, meta-databases and web-pages. Please refer to chapter 3 and Annex I of this Guidance for a summary of key European information networks, an overview of key research projects and databases or toolkits on adaptation actions/measures.

3. Make use of good-practice examples coming, e.g. from existing research and implementation experience regarding adaptation strategies and measures.
4. Look beyond the borders of your river.

   Adaptation to climate change will be required across Europe. Possible future impacts in one river basin might represent the current situation in another one, and useful adaptation experience in other regions/RBDs with similar characteristics may exist. It is important to exchange knowledge and experiences with other regions/RBDs on a regular basis and integrate lessons learned.

In general, the knowledge gaps that can be addressed by water managers at the RBD level are not related to gaps in the science of climate change and water, but to *what the current state of knowledge means for their particular RBD.* This means that often river basin managers need to make use of available research and experience. In addition, relevant local knowledge should be developed to the fullest extent possible, such as predictions of climate change impacts in the basin for various future climate scenarios. Please check also the recommendations of chapter 3 on how to handle available scientific knowledge and uncertainties about climate change.

4.2.2 Data collection and building of partnerships

Gaining political backing and embedding climate change adaptation in river basin management planning requires the following two key features:

- Collecting appropriate data to improve decision making and develop a sound adaptation strategy.
- Identifying stakeholders and deciding on an approach to engagement as well as working in partnerships.

Collecting appropriate data to improve decision making and develop a sound adaptation strategy

Guiding principles

5. Evaluate data coverage (e.g. meteorological, hydrological, water quality, soil moisture data, stake, damage cost data, etc), particularly considering the following issues:

   - Does present data collection cover both current data and monitoring requirements as well as future requirements under changed climate conditions?
   - Is present data collection robust in the face of possible changes in underlying variables that define typologies and, therefore, reference conditions?
   - Does current data collection and monitoring provide adequate monitoring of climate change impacts? Does current data collection and monitoring provide monitoring of the effectiveness of adaptation measures?
   - Are historical data sets coherent and consistent in view of e.g. changes of

measurement methods over time? If problems of coherence are identified, can these be dealt with to achieve reliable historical data series?

6. Use the WFD consultation process (Article. 14) to bring in sector-specific knowledge and data from key stakeholders.

All in all, adapting to climate change implies new requirements regarding the type and the extent of data collected for river basin management. Long time series are judged essential for understanding the evolution of physical variables and selected species over time. On the issue of WFD monitoring under climate change, please refer to chapter 5.4 for more detailed guidance and suggested actions.

Identifying stakeholders and deciding on an approach to engagement – Working in partnerships

Guiding principles

7. Ensure communication and coordination on climate change adaptation issues between different levels of management within an RBD.
8. Work in cross-sectoral partnerships and across administrations- Ensure that climate change aspects are discussed between the relevant public administrations, in stakeholder meetings and discuss how relevant water-related sectors can contribute to adaptation.
9. Make sure to receive information related to the influence of climate change on other sectors which are directly related to water management (e.g. agriculture-water demands, water needs for energy production, etc). Keep in mind that, in the context of the RBMP preparation, it is not possible to carry out all studies necessary to determine the evolution of these factors for the different climate scenarios.
10. Integrate cross-sectoral delivery of adaptation measures and coordinate activities with land use planning.
    Establish links of river basin management planning to other national and regional planning activities and policies which are relevant to climate change impacts and adaptation in RBDs (e.g. municipality planning, spatial planning, land use planning). Within river basins and catchments, integrate adaptation actions with those of other sectors to develop a holistic plan that takes advantage of cross-sectoral adaptation benefits – eg reinstating floodplain wetlands that prevent flooding, retain water and provide wildlife habitat.

Meaningful and early stakeholder engagement can improve acceptance of decisions and measures and thereby increase the feasibility of the adaptation strategy. Evidence and analysis is often more accurate when carried out in conjunction with stakeholders.

Integration refers to all sectors in order to avoid negative cross-sectoral feedbacks of measures (or non-action in one sector) but also to the different levels of management within an RBD, including different kinds of authorities. Therefore, it is important to carry out a 'Stakeholder Mapping' exercise before seeking to engage stakeholders in the adaptation process in order to identify the full range of stakeholders. Based on the list of identified stakeholders, the availability of resources and preferences or experiences, an approach to stakeholder engagement should be decided. This would result in the production of an engagement strategy, setting out the objectives for and means of stakeholder engagement and a clear definition of the roles and responsibilities of each authority and stakeholder.

As concerns coordination with land use planning, it should be kept in mind that land use practices and land use planning have a major impact on water scarcity, floods and modification of water bodies. In several cases, co-benefits or win-win situations between the spatial planning and improving the ecological status are possible such as making room for the river (see Example 4b on the EU project ESPACE, Example 5r on making room for the river and Example 7d on Dutch planning of measures for sustainable freshwater supply including land use planning).

Example 4a – Institutional arrangements for assessing climate impacts on pressures in Austria

Austria is situated in a transitional zone with the high-precipitation area of the Alps on the one hand and the more drought prone eastern parts on the other hand. Within the alpine region an increasing future precipitation to the north and decreasing precipitation to the south is foreseen. However, due to high spatial variability of climatic conditions and hydrological processes the Alps are likely to show marked seasonal variations in precipitation.

An interdisciplinary working group of the Austrian Water and Waste Management Association (ÖWAV) and the Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW), involving different stakeholders, was set up to collect multidisciplinary information on possible effects of climate change on Austrian water management and to estimate its significance. The final results of the working group were presented to the public and published as the report *'Effects of Climate Change on the Austrian water management'* at the end of 2008[9].

An example of the output of this working group is the assessment of climate change effects on heavy rainfall events and floods. The FLOOD Risk II project revealed that so far there have been no significant changes for medium and large catchment areas (> 250 km²) but indicated a need for action in smaller catchment areas, where the risk of heavy rainfall events already exists. Nevertheless the resolution of existing climate models is not yet high enough to get resilient results for these small areas. In high mountainous areas additional factors like increases in sediment yield because of a rising permafrost base would have to be considered. Possible measures for the future could include:

- Guidelines for the Federal hydraulic engineering administration 2006 (RIWA-T) are considering freeboards for dams as additional safety measure against higher water levels because of climate change.
- Protect retention areas to reduce the effect of heavy rainfall events on peak flows.
- Measures to reduce soil erosion and leaching of fertilizer
- Measures to impact of increased operation of storm overflows.

Example 4b – EU project ESPACE

The European project ESPACE (North West Europe INTERREG IIIB Programme) set out to influence the philosophy and practice of spatial planning. The focus of the ESPACE (European Spatial Planning Adapting to Climate Events) project was on how adaptation to climate change can be incorporated into spatial planning systems with a special focus on water management issues. It was the first project of its kind to focus on increasing the awareness of the need to adapt to the impacts of climate change and to begin to provide some of the necessary policy guidance, tools and mechanisms to incorporate adaptation into planning systems and processes.

ESPACE was founded by a transnational group of 10 Partners spanning four North West European countries and bringing together representatives from all levels of civic society. A range of actions were undertaken by Partners to identify how to best adapt to climate change. These include actions

[9] Source online: http://publikationen.lebensministerium.at/filemanager/download/44661

looking at the most effective ways of raising awareness, the role of behaviour change in adapting to climate change, policy review through the use of innovative techniques and the development of tools and models.

URL: http://www.klimaprojekt-espace.bayern.de/

4.2.3 Broadening the audience and increasing its capacities - Awareness-raising, education and training

Guiding principles

11. Include the issue of climate change impacts in the river basin in your RBD awareness-raising activities as part of the WFD public participation process.
12. Establish staff training and capacity building programmes on climate change issues, e.g. to introduce staff to climate change modelling, scenarios and projections.

An important side-effect of awareness can be the facilitation of acceptance of adaptation measures among the different stakeholders. All water-related sectors should be encouraged to become well-informed about possible impacts of climate change in their sector. The main result is ensuring preparedness, for instance through the implementation of own risk-management or adaptation measures as a consequence of increased awareness.

An additional prerequisite for building adaptive capacity for river basin management in a changing climate is learning and building up knowledge in the relevant organisations as well as the transfer of relevant knowledge.

4.2.4 Looking beyond the borders

Guiding principle

13. Develop joint or coordinated adaptation strategies in transboundary RBDs.

Transboundary basins pose particularly complex challenges with regard to the building of adaptive capacity for climate change. Joint bodies, such as international river basin commissions, should be responsible for the development of joint or coordinated adaptation strategies for transboundary basins and for following up their implementation and evaluating their effectiveness. The bodies need therefore to have the capacity and means to effectively undertake these tasks.

Further adaption to climate change might require actions outside the national part of a river basin e.g. some measure need to be taken upstream. This might require bilateral agreements based on common understanding.

Example 4c – Towards an adaptation strategy in the Rhine[10] river basin

The 1999 Rhine Convention, together with existing EU and national legislation and policies and a strong political commitment in all countries in the Rhine catchment, provide a sound basis for

[10] Switzerland, Germany, France, the Netherlands, Luxemburg, the European Commission.

developing and implementing an adaptation strategy pertaining to the impacts of climate change. Activities regarding adaptation to climate change have started with an assessment. However, already in the 1990s, important measures have been taken regarding flood risk management, increasing the basin's adaptive capacity to respond to future expected climate changes.

Following the severe flooding in the Rhine in the years 1993 and 1995, the International Commission for the Protection of the Rhine (ICPR) developed and adopted a comprehensive "1998 Action Plan on Floods" covering the period until 2020. In the context of the implementation of the 1998 Flood Action Plan, the flood damage risk (defined as the product of damage potential (€) and the probability of flooding (1/year)) have been assessed. In addition, possibilities for reducing flood levels by implementing measures in the catchment area have been identified. The resulting information was published in the "Rhine Atlas 2001" as one of the elements aiming at increasing the populations "flood awareness". Furthermore, the flood forecasting system has been improved, in particular by improved cooperation between water management administrations and weather services.

The Action Plan aims to improve the protection of people and goods against floods and at the same time to improve the floodplains of the Rhine. Great efforts have been made towards implementing the Action Plan and almost all measures to be implemented by 2005 have been undertaken. Their positive effect is demonstrable. In 2007, Rhine Ministers confirmed the need to develop adaptation strategies for water management in order to be able to address effects of climate change, which are clearly discernable.

The implementation of the 1998 Flood Action Plan over the period 1995-2005 was evaluated in 2007. The assessments will be repeated once every 5 years, for the first time over the period 1995-2010.

Adaptation strategy for climate change impacts

A cornerstone of the adaptation strategy will be the ability to forecast possible impacts of climate change on the hydrology of the Rhine (flood levels and durations, low water levels and durations and water temperature). As a first step, an assessment of available information revealed changes in these parameters over the last 3-4 decades. A second step, the development of common scenarios for these parameters, will be finalised in 2010.

The eventual adaptation strategy will take account of experiences gained with implementing the 1998 Flood Action Plan as well as the wider experience of the ICPR in protecting the Rhine. Synergies between flood protection and ecosystem and water quality improvements will be sought to the extent possible. Furthermore, problems, for e.g. drinking water supply and navigation due to low water levels, will also be addressed.

In this process, the ICPR has a coordinating and guiding role. The actual implementation of measures (including financing them) is a responsibility of the countries in the catchment area.

Source: ICPR secretariat

5 WATER FRAMEWORK DIRECTIVE AND ADAPTATION

5.1 Introduction

5.1.1 Aim and focus of this chapter

This chapter describes guiding principles for adaptation to climate change and relates them to each of the steps in River Basin Management (RBM) under the WFD. Although the guidance is focused on how to respond within the structure of, and the timetable for, WFD implementation (i.e. up to 2027), the principles proposed would be appropriate for application to other forms of river basin management or for a continuation of river basin management in the longer term.

The WFD RBM steps, which are the focus of this chapter, are:

1. Risk assessment - the summary of significant pressures and impacts of human activity on the status of surface water and groundwater (Article 5);
2. Monitoring and assessment of the status of surface water (ecological and chemical) and groundwater (chemical and quantitative) (Article 8 and Annex V);
3. Objective setting - under Article 4 for surface waters, groundwater and protected areas, including in particular identification of instances where use has been made of exemptions (Article 4(4), (5), (6) and (7));
4. Economic analysis - a summary of the economic analysis of water use as required by Article 5 and Annex III.
5. Programme of measures to achieve the environmental objectives (Article 11).

Please note: Although public consultation is an important step in the WFD management cycle, it is not specifically addressed in this chapter but it is dealt with in chapter 4. Please also consider the guidance provided in chapter 3 on how river basin managers should handle available information and uncertainty from climate change models, projections and scenarios.

5.1.2 Climate change and the Water Framework Directive

Although the WFD does not explicitly mention risks posed by climate change to the achievement of environmental objectives (see also WFD introduction in chapter 2.1), there is a strong case for incorporating climate change within the RBM process[11]. Furthermore, the underpinning rationale and processes of the WFD are amenable to delivery of adaptation (Figure 1). In particular, the integrated approaches to land, water and ecosystem

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[11] See various sources, such as:

Joint Research Centre, 2005. *Climate Change and the European Water Dimension* – A Report to the European Water Directors. Chapter V. C. Climate Change, of Ecological Status and the Water Framework Directive.

European Environment Agency (EEA), 2007. *Climate change and water adaptation issues*. EEA Technical Report No. 2/2007, Copenhagen, 110pp

Wilby, R.L., Orr, H.G., Hedger, M., et al. 2006. Risks posed by climate change to delivery of Water Framework Directive objectives. *Environment International*, **32**, 1043-1055

EU Framework VI project Euro-limpacs: http://www.eurolimpacs.ucl.ac.uk/

Wilby, R.L. 2004. Impacts of climate change on reference sites used for ecohydrological restoration and research. *Ecohydrology and Hydrobiology*, **4**, 243-253.

management, combined with the cyclical review of progress, are all consistent with the ideals of adaptive management. Focusing on the resilience of healthy aquatic ecosystems to changing and degrading conditions provide a cost-effective and relatively easy way to achieve adaptation. As the WFD contains several elements that will support the resilience of aquatic ecosystems and the rational use of water resources, achieving its objectives will support adapting to climate change.

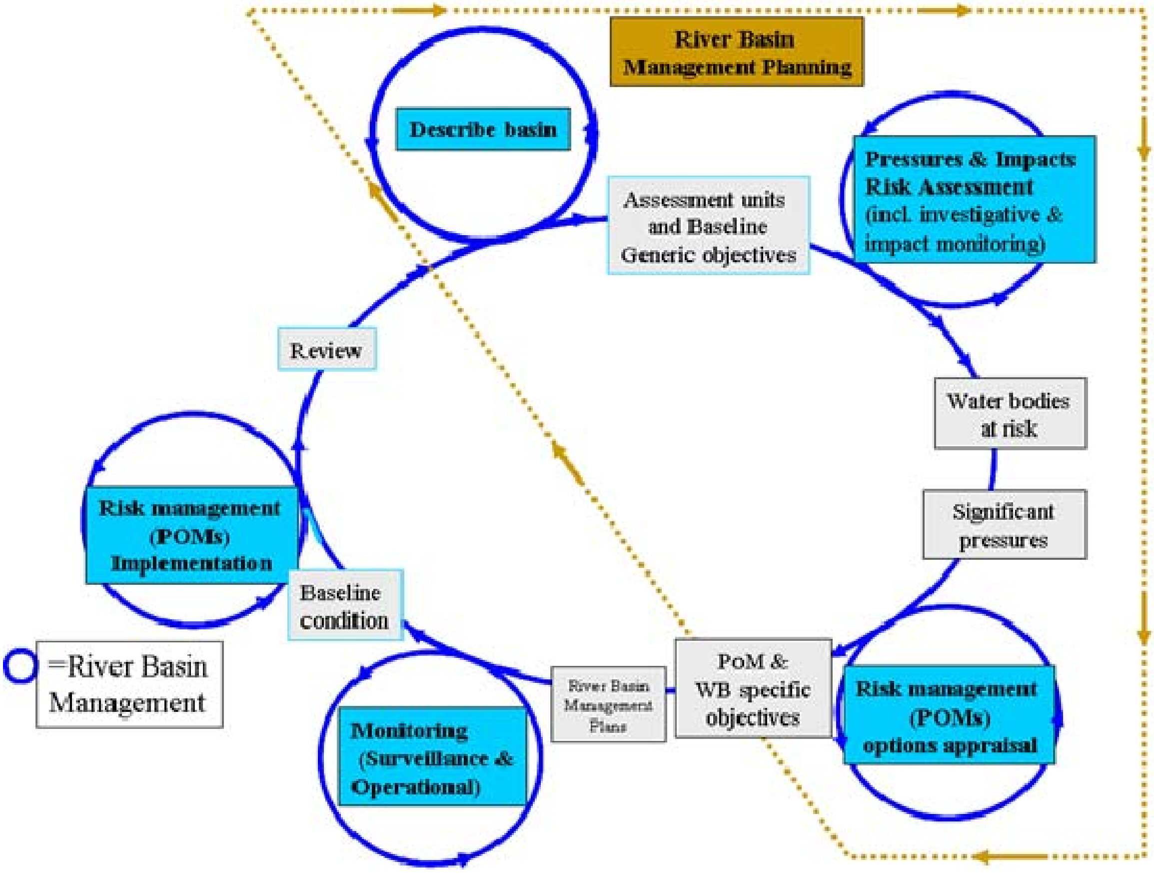

Figure 1 Schematic of RBM process and sub-processes under the WFD

Previous work has highlighted the climate sensitivity of:

- Anthropogenic pressures that affect likelihood of achieving good ecological status;
- Monitoring programmes;
- Water body typologies;
- Conditions at reference sites;
- Economic appraisal and cost-effectiveness of investments;
- Effectiveness of programmes of measures in achieving objectives;
- Synergies and conflicts due to mitigation and/or adaptation by other sectors;
- Stakeholder expectations and levels of engagement.

In addition, it should be kept in mind that climate change impacts upstream can have implications for the achievement of WFD objectives downstream, and therefore international cooperation as part of the WFD plays an important role. Please check recommendation of chapter 4 on the need to develop joint and coordinated adaptation strategies in the river basin management of international RBDs.

The guiding principles in this chapter are intended to help those with river basin management responsibilities address each of these sensitivities in a proportionate and robust manner, whilst acknowledging the inherent uncertainty of regional climate change projections. Where possible, "no-regret" or "win-win" measures are suggested; outcomes should be beneficial, regardless of the eventual nature of climate variability and change. Supporting activities are on-going to provide practical hints related to adaptation strategies, an example of which is the ClimateWater project (http://www.climatewater.org/) briefly described in Annex II.

5.1.3 Which steps in river basin management are most important in adaptation to climate change?

Some of the river basin management (RBM) steps are considered more critical than others in our ability to prepare for climate change, especially in the short term. Essential components for planning for climate change are judged to be:

- an ability to identify change as it happens through **monitoring;**
- ensuring that the likely scale of impacts of climate change on existing and projected future anthropogenic **pressures and risks** is understood, and
- developing and prioritising multiple-benefit catchment based solutions which restore or maintain the natural characteristics of catchments to build resilience to a range of possible climate futures. In this context, **measures** should be examined to ensure that they will not fail under future climatic conditions.

These parts of RBM should be the focus of Member States when considering how to deal with climate change.

It is thus expected that as a minimum, in the 2nd and 3rd cycle of RBM, Member States should clearly demonstrate:

- **how climate change projections have informed assessments of WFD pressures and impacts,**
- **how monitoring programmes are aligned to detect climate change impacts, and**
- **how choices of measures are as far as possible robust to future projected climate conditions.**

Apart from exceptional circumstances, **it is not expected that, within the timeframe of WFD implementation (i.e. up to 2027) and within the metrics used for status assessment, a climate change signal will be statistically distinguishable from the effects of other human pressures at a level requiring reclassification of sites**. It is more likely that indirect pressures arising from human responses to climate change will have a greater impact (such as elevated water abstractions for irrigated agriculture, or new flood defence infrastructure).

However, guidance is provided for cases where sufficient clarity from monitoring evidence shows this is the case. In most cases, climate change may add to existing human pressures and in case these pressures lead to a deterioration of status, this needs to be addressed via the Programme of Measures.

Likewise, climate change should not generally be used as a justification for exemptions, at least in the short term - it is considered that there will be few cases where sufficient scale and certainty in climate projections will combine with a lack of proportionate measures to require lower than default objectives to be set, but guidance is provided for where this is raised as an issue (see section 5.5). This is applicable to the upcoming RBM cycles.

5.2 Guiding principles for Water Framework Directive and adaptation

The principles set out in the table below provide guidance on how climate change adaptation should be considered in each of the steps of river basin management under the WFD.

Table 2 RBM steps and guiding principles for WFD implementation in a changing climate

RBM steps of WFD	Guiding principle	Summary of the guiding principles for the RBM steps
Assessing pressures and impacts on water bodies	1 Assess, over a range of timescales, direct influences of climate change and indirect influences where pressures are created due to human activities in adapting to climate change	*A more integrated approach to risk assessment is needed to counter changes in pressures that may arise from the direct impacts of climate change, as well as from autonomous and/or anticipatory measures taken by different groups to mitigate and adapt to climate change.*
Monitoring and status assessment	2 Maintain both surface and groundwater surveillance monitoring sites for long time series. Set up an investigative monitoring programme for climate change and for monitoring climate change "hot spots", and try to combine them as much as possible with the results from the operational monitoring programme. 3 Include reference sites in long term monitoring programmes to understand the extent and causes of natural variability and impact of climate change	*Good monitoring networks will be essential to identifying and reacting to climate change and so it is important that sites with long time series of data collection are not dropped from surveillance monitoring. In addition, knowledge of when and where climate change might be first detected could be used to target monitoring and reporting of effects in the most vulnerable water bodies, then to bring forward adaptation interventions as required. This is important for surface water and groundwater (including groundwater quantity monitoring).* *In order to detect climate change impacts early, the monitoring frequency needs to be higher than the WFD minimum for surveillance monitoring, as otherwise it will take a long time to gather robust time series.* *As climate change and human impacts at catchment scale may affect similarly the quality elements used for status assessment, information on coherent changes at reference sites, which by definition are sites with missing or very minor anthropogenic influence, is the primary proof that would enable disentangling the two kinds of impacts. So concurrent hydrometeorological data and data on quality elements are needed to better interpret mid and long-term changes in status.*
Objective setting	4 Avoid using climate change as a general justification for relaxing objectives, but follow the steps and conditions set out in the WFD	*There is a danger that anthropogenic climate change could be used as an excuse to set lower objectives for water bodies, even though formal attribution of a detected trend to anthropogenic climate change is unlikely at the scale of RBDs for several decades to come. Although the use of exemptions is an integral part of river basin management planning, applying exemptions without justification in line with the Directive cannot be seen as a general strategy to cope*

		with the consequences of climate change. In addition, there is need to assess the impacts of using exemptions for making water resources more resilient to climate change.
Economic analysis of water use	5 Consider climate change when taking account of long term forecasts of supply and demand and favour options that are robust to the uncertainty in climate projections	*Climate change will mean that the value of water will change as the balance between supply and demand is impacted. Economic analysis carried out in order to apply recovery of costs and judge the most cost-effective combination of measures should consider what these future conditions might be. However uncertainty surrounding projections means that we should look for solutions that will be able to perform over a wide bandwidth of climatic conditions.*
Measures for adaptation related to the WFD		
How to do a climate check of the Programme of Measures?	6 Take account of likely or possible future changes in climate when planning measures today, especially when these measures have a long lifetime and are cost-intensive, and assess whether these measures are still effective under the likely or possible future climate changes. 7 Favour measures that are robust and flexible to the uncertainty and cater for the range of potential variation related to future climate conditions. Design measures on the basis of the pressures assessment carried out previously including climate projections. 8 Choose sustainable adaptation measures, especially those with cross-sectoral benefits, and which have the least environmental impact, including GHG emissions.	
What to do if other responses to climate change are impacting on the WFD objective of good status?	9 Avoid measures that are counterproductive for the water environment or that decrease the resilience of water ecosystems 10 Apply WFD Article 4.7 to adaptation measures that are modifying the physical characteristics of water bodies (e.g. reservoirs, water abstractions, dykes) and may cause deterioration in water status 11 Take all practicable steps to mitigate adverse effects of counterproductive measures	

5.3 Pressure and impact assessment

Guiding principle

1. Assess, over a range of timescales, direct influences of climate change and indirect influences where pressures are created due to human activities adapting to climate change

European freshwaters are already being affected by many human activities, resulting in changes in land-use, pollution with nutrients and hazardous substances, and acid deposition. Healthy, free-flowing rivers respond to changes in land use and climate through dynamic movements and flow adjustments that buffer against impacts. However, many river basins are sufficiently impacted that their ability to absorb disturbances, such as changes in discharge and water stress, is severely limited.[12] Hence management of pressures and the restoration of natural functioning of river basins is an essential part of climate change adaptation.

Member States are required, under Article 5 of the WFD, to carry out a review of the impact of human activity (e.g. point and diffuse source pollution, abstraction) on the status of surface waters and on groundwater (see Annex II of WFD for technical specifications). Climatic change will have an influence on the extent of risk from these pressures. It will be essential not only to understand how the risk from these pressures will change over time without climate change but also to factor in how climate change will add to or reduce the level of risk in order to effectively plan appropriate measures. This will be particularly important where measures are planned that have a long lifespan or limited flexibility (for example large infrastructure projects such as reservoirs or water transfers).

Climate change should be integrated into the processes Member States use for assessing the risks from WFD pressures. As far as possible this should provide a quantitative assessment of the effect of climate change on the risks from pressures using European or Member State climate projection data. For the first cycle of river basin management the influence of climate change on the risks from WFD pressures (and the subsequent effectiveness of measures) may only be qualitative. However, quantitative analysis is needed to establish the severity and timescales over which changes may occur, and thereby improve risk assessments and prioritise adaptation work[13] in ongoing river basin management. More quantitative work is required prior to the implementation of measures which have a long lifespan and are inflexible to later adaptation. Although quantitative analysis may be needed and may take time, certain measures can already be taken that are likely to make a significant positive impact on the status of a water body: increasing the resilience of the water body is an important no-regret step in adapting to climate change (see section 5.7).

Potentially all of the WFD pressures will be sensitive to climate change. In this context, we need to distinguish between **"primary"** and **"secondary" pressures**. Primary pressures are linked to climatic impacts that affect natural systems or processes (e.g. temperature effects on metabolic rates, less precipitation due to climate change and, therefore, less water flow etc) and/or modify the effects of human pressures (e.g. more frequent flushing of combined sewer outflows). The following table summarises potential primary impacts of climate change

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[12] Climate change and the world's river basins: anticipating management options. M A Palmer, C A Reidy Liermann, C Nilsson, M Flörke, J Alcamo, P S Lake, and N Bond. Front Ecol Environ 2008; 6, doi:10.1890/060148

[13] Environment Agency, 2008. *Water for life and livelihoods. Annex H – Adapting to climate change*. Rio House, Bristol, 24pp.

on water bodies. Secondary pressures are understood as pressures due to a human activity adapting to climate change, e.g. increased water storage, leading to a secondary effect of higher concentrations of pollutants downstream.

Table 3 Examples of primary climate change impacts on water status[14]

Parameters	Examples of primary impacts of climate change
Hydrological-hydromorphological	Changing river flows, lake levels and retention times, and sea levels lead to coastal erosion Hydrological connectivity of slopes, channels, and coastal zones Long-term bed-load and channel change Geomorphological processes creating dynamic/diverse habitats Sediment transport changes associated with climate change Changes in groundwater demand and recharge system induced or enhanced by climate change
Physico-chemical	Changes in water temperature and dissolved oxygen Decreased dilution capacity of receiving waters Increased erosion and diffuse pollution More frequent flushing of combined sewer outflows Potential remobilisation of sediment- and soil-associated historic contamination Photoactivation of toxicants Exceedence of water quality standards Salt water intrusion (both into groundwater and upstream into estuaries and tidal river systems)
Biological-ecological	Changing metabolic rates of organisms Changing ecosystem productivity and biodiversity Climate space of plant and animal distributions Fish migration patterns and dispersal corridors Increased eutrophication and occurrence of algal blooms Changes in aquatic fauna and flora including those at reference sites Changes in species assemblages in designated areas More rapid decline in faecal indicator organisms and pathogen populations Increased microbiological activity Decreasing groundwater levels may have adverse effects on depending terrestrial ecosystems

Note: Impacts may be considered at three levels: i) Hydrological/hydromorphological, ii) physico-chemical, and iii) biological-ecological. The power to attribute these impacts directly to climate change fades in the same order and will forever remain very weak at the biological level.

[14] Taken from Wilby, R.L., Orr, H.G., Hedger, M., et al. 2006. Risks posed by climate change to delivery of Water Framework Directive objectives. *Environmental International*, **32**, 1043-1055.

Management actions taken to address one pressure (or combinations of pressures) may increase the risks of not achieving WFD objectives for other pressures. Likewise, measures taken to mitigate emissions of greenhouse gases or to adapt to unavoidable climate change could indirectly affect or introduce new pressures to water bodies. Some actions may lessen pressures; others may increase pressures (as with greater water demand for bio-fuel production). **It is likely that such secondary pressures (i.e. pressures from human uses of water adapting to climate change) will have the biggest effect on water status on the short-term.** The following table lists possible secondary climate change impacts and effects on water quality.

Table 4 Examples of secondary climate change impacts and effects on water quality

Secondary climate change impacts	Effects
Reduced nitrogen emissions to air	Smaller area of acidic deposition and area of ecosystems adversely affected by excessive nitrogen (eutrophication).
Increased bio-fuel production	Increased groundwater acidification caused by enhanced acid deposition to forestry and removal of soil cations during harvesting; impacts on ground and surface water quality through increased fertilizer and pesticide use as well as more intensive agricultural practices on currently set-aside or extensively used agricultural land.
Increased water supply and storage	River regulation and inter-basin transfers change thermal and chemical composition of downstream waters. Dams modify river habitats and hamper fish migration. In the case of increased water recycling, higher concentrations of persistent pollutants due to water re-use.
Increased hydropower production	Changes in environmental flow of regulated rivers (secondary impacts from the Renewables Directive like proposals for new hydropower development and increased use of hydropeaking) Hydropower is an important renewable energy opportunity, but may impact on the achievement of good ecological status through changing flow patterns and modifying channel structures. Hydropower guidance should be followed to minimise these risks.
Longer growing seasons	Changing cropping patterns, increased agricultural pesticide and fertilizer use cause negative impacts on water quality; changes in soil tillage; diffuse runoff quality; increased water demand for irrigation; increased vegetation cutting and weed clearance in navigable water bodies.
Changing fire management regime	Controlled burns in headwaters; contamination of groundwater resources; increased export of organic carbon, sediments and toxics.
Measures to reduce flood risk	Improved urban water quality thanks to sustainable urban drainage systems, or upgrading of sewerage systems to cope with higher rainfall intensity; increased saline intrusion due to managed retreat of coastal defences.
Removal of obstacles to assist movement	Increased risk of spread of invasive species.

Risk assessments that are too narrowly focused on existing pressures within river basins may overlook important, but often remote or indirect, drivers of change. This underlines the need for a more integrated approach to river basin management and for engagement with a much broader constituency of stakeholders and planning processes (e.g. development planning, flood risk management planning). In many respects, indirect influences on pressures could be invoked (and therefore impact water body status) earlier than direct climate change impacts projected from, for example, higher temperatures or lower rainfall.

In general, however, this Guidance Document does not intend to summarise the large quantity of research evidence that is emerging and continuing to develop on the subject of climate change impacts on the water environment. It is recommended that those with responsibilities in river basin management familiarise themselves with the main sources of this information and keep up to date with relevant findings as they develop, in order to determine the likely impacts in their river basins. The findings of JRC and EEA, together with Member States own research institutions as well as results of key European projects (see Annex II of this Guidance) should be consulted.

Suggested actions

- Consult the findings of key research institutes (such as the EEA, JRC and national institutes (e.g. UK Climate Impacts Programme)) and of national and EU-funded research projects to develop your understanding of the potential climate change impacts on the water environment in your country or river basin.
- Identify direct climate change impacts on the risk from WFD pressures and, where possible, integrate into existing approaches for the quantitative risk assessment of pressures.
- Identify pressures that could be indirectly affected by climate change mitigation or adaptation policies considering also developments in other sectors, using expert opinion, local knowledge, literature reviews or targeted research.
- Estimate the time-scale(s) over which direct and indirect climate change factors might influence pressures on water bodies. Include consideration of longer term timescales (up to 2050 at the minimum) in order to understand and plan for longer term challenges.
- Report on how these pressures could influence achievement of WFD objectives and identify corresponding measures.

Example 5a – Direct climate change impacts on river water quality

An appraisal is undertaken to determine the potential impact of climate change on the water quality of rivers receiving consented discharges from sewage treatment works (STWs). Projected changes in monthly river flows for the 2020s are used to calculate final concentrations of phosphate, ammonia and dissolved oxygen via a simple mixing model applied to river reaches. The effects of water temperature on rates of reaction in rivers and on the solubility of dissolved oxygen, as well as effects on the flow and quality of discharges from STWs are also taken into account. The model then calculates the length of river falling into each of the five classes used for the WFD.

The modelling suggests only a small percentage of rivers should be downgraded when comparing river lengths in each water quality class in the 2020s with those in 2000. The reductions are due mainly to reduced dilution of current discharges from sewage treatment works, manifested by less desirable concentrations of phosphate and dissolved oxygen. Assuming the permanent loss of the river lengths downgraded from Good Status, the cost of the climate impacts can then be expressed as a Net Present Value. These damages can be weighed against the costs associated with programmes of measures to reduce pressures, such as more stringent consents for point discharges from STWs.

Example 5b – Decrease of the river flows within the Adour Garonne basin, France

Climate projections made by Météo France show that river flows could decrease by 25% as an annual average by 2050, for the entire Adour Garonne (AG) district. This decrease of the flows could reach 36% during spring and summer. The water status could be largely influenced, due to the combination of higher temperatures and decrease of the river flows. At the same time risks from anthropogenic pressures could increase. For example, projections by the "Statistics project for the population of AG district" showed a population increase of up to 20% by 2030. This could increase the conflict between water uses and users. New measures will be necessary to mitigate these effects and integrate climate change constraints.

Example 5c – Salmon already in "hot water"

Climate projections suggest most rapid warming in southern and eastern parts of the UK. The same regions are also expected to witness the earliest signs of depressed groundwater flows in summer. Indeed, rising air and water temperatures are already beginning to affect salmon distributions through changes in behaviour and physiological harm at different life-cycle stages. Synergistic effects of drought, over-abstraction, low dissolved oxygen concentrations, and higher salinity further reduce thermal tolerances of fish in estuaries.

Under the present conditions there is on average only one day per summer when water temperatures would deter migration upstream, but approximately one week during which conditions in the tidal river delay migration. As summer air temperatures increase the window of opportunity for fish to pass through the estuary becomes narrower, and hence the loss of fish rises. Without interventions, the viability of the salmon population is threatened in some "Low, Small/Medium Calcareous" rivers within a few decades.

Example 5d – Development of a numerical model in a transboundary aquifer

One of the objectives of the Scaldwin[15] project is the study and management of two transboundary groundwater layers or aquifers: the carboniferous limestone aquifer (shared between France and Belgium), which suffers from overexploitation, and the groundwater in the Dutch-Flemish polder area, which suffers from saltwater intrusion. The carboniferous limestone aquifer has a high economic value as a drinking water resource. The possible salinization in the Dutch-Flemish polder area will have a negative impact on the agricultural activities. For the latter, a joint numerical groundwater model will be developed, which will allow to us to gain an insight into the future distribution of fresh and saltwater under influence of climate change and sea level rise.

Example 5e – Increasing nitrogen loading in Southern Finland

A set of climate change scenarios suggest an increase of 2.8–4.7 ºC in annual mean temperature and 10.1–23.6 % increase in annual precipitation in southern Finland for period 2070–2100. The considerable increase in winter (December-February) temperatures (3.4–6.2 °C) and precipitation (26–56 %) predicted by the different scenarios influence strongly the hydrological regime, especially snow accumulation and snow melt in spring. According to model results such changes would increase the annual inorganic N load from catchments by 10–70 %. This is due to higher mineralization rate and increased water flow through the catchment soils. The predicted changes are more pronounced in an agricultural lowland catchment than in the forested one, particularly during the dormant period, from November to February. Efficient catchment scale mitigation measures are needed, especially on

[15] http://www.nweurope.eu/index.php?act=project_detail&id=3871

the agricultural sector, to prevent eutrophication of surface waters in future climate conditions.

Example 5f – River flow modelling in the Blsanka river basin, Czech Republic

Several rivers are located in a low precipitation region in the Czech Republic and their hydrological conditions have deteriorated during the last two decades, which are probably already affected by impacts of initial stages of climate change. The main problems occur during drought periods, when river discharges drop below minimum ecological flows, the river water is excessively polluted by waste water discharges from urban areas and the water resources are insufficient for meeting water use requirements for the purposes of agriculture, which is very important economic sector in this region.

In order to make decisions about effective measures, it was necessary to derive volumes of water, which are missing during drought events (deficit volumes) to ensure effective dilution of waste water and for maintaining the required ecological flows to keep the ecological function of the stream. Results of the application of deficit volume method (Tallaksen & Lannen, 2004) by using the EXDEV computer program showed that the storage capacity for ensuring ecological flows during the period 1969 – 2008 would be 510 megalitres (deficit in 2007). Including scenarios for climate change in the model suggests that the deficit volume will increase in range from 3260 megalitres (according to scenario RCAO B2) to 5750 megalitres (scenario HIRHAM A2) until the year 2085.

5.4 Monitoring and status assessment

Guiding principles

2. Maintain both surface and groundwater surveillance monitoring sites for long time series. Set up an investigative monitoring programme for climate change and for monitoring climate change "hot spots" and try to combine them as much as possible with the results from the operational monitoring programme.
3. Include reference sites in long term monitoring programmes to understand the extent and causes of natural variability and the impact of climate change

5.4.1 General remarks

Implementation of the WFD is based on objective and transparent criteria and procedures as agreed in the Common Implementation Strategy, e.g. for defining surface water body types, reference conditions, and quality class boundaries. Furthermore, it is based on robust monitoring data. Although climate change has the potential to impact on virtually all quality elements included in the definition of WFD ecological status, this does not affect the principles of water status assessment, which remain valid.

There is some evidence that anthropogenic climate change is having a significant impact on physical and biological systems globally and in some continents[16]. However, apart from exceptional circumstances, **it is not expected that, within the timeframe of WFD implementation (i.e. up to 2027) and within the metrics used for status**

[16] Cynthia Rosenzweig et al., Attributing physical and biological impacts to anthropogenic climate change, Nature, Vol 453| 15 May 2008

assessment, a climate change signal will be statistically distinguishable from the effects of other human pressures at a level requiring reclassification of sites.

In a few cases, climate change could impact status assessment in the relatively short term and influence the water body type and/or reference conditions. It is more likely that climate variability and change will work alongside pressures from human activities, which have to be addressed with measures to achieve good status. However, some general principles on how to deal with climate change induced changes, if they occur, are given below.

In the future, there will be certain areas in Europe that will be the first to clearly identify climate change impacts requiring an of assessment whether additional measures need to be taken to achieve good status. There are now a number of cases where tentative links to climate change are claimed (see examples below). It is essential that in these cases, sufficient monitoring is taking place that is linked to meteorological monitoring, and that both have a long enough time series reaching at least 20 years to avoid over-interpretation of any short term observed trends.

5.4.2 Monitoring

Monitoring will be essential to understanding and appropriately responding to climate change across Europe. After all, an appropriate river basin management response to climate change impacts can only be based on a **sufficiently robust long-term monitoring network of reference sites linked to meteorological data**. Otherwise, one may run the risk that designed measures may not tackle the real pressure.

Whilst monitoring programmes under the WFD are generally not designed for the need to identify and monitor climate impacts, all long-term monitoring programmes will inherently contribute to the detection and understanding of any climate change signals. It is very important to take a consistent and long term approach. Monitoring programs should be planned carefully with a long-term perspective and carried out consistently preventing major changes in the station network or methodologies such that comparisons can be made between years (this is the basic idea of any surveillance monitoring). It is very important to avoid abandoning monitoring stations which already have a long term consistent record, especially in the context of climate change. Notwithstanding the above, it may be possible when designing monitoring programmes to target reference sites (see 5.4.4) or "hot spots" of predicted climate change impact when adding new stations.

As a first approximation, climate change is expected to "squeeze" climate space occupied by high-elevation and coastal-zone ecosystems[17]. The former are already experiencing reduced snow/ice storage and amplification of extreme rainfall events; the latter rising sea levels and ocean temperatures. Other climate change impacts will be manifested through changes in disturbance regimes involving fire, pests, disease and competition from invasive species. These drivers will interact with existing pressures such as pollution, exploitation of natural resources, or land-cover change. Therefore, the resulting climate change "hot spots" might be regarded as a composite of the climate projection, distribution of existing pressures, and underlying pattern of vulnerable habitats and species.

Knowledge of *when* and *where* climate change might be first detected could be used to target monitoring, conservation efforts and resources[18,19]. Until now, attributable human-

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[17] Walmsley, C.A., Smithers, R.J., Berry, P.M., Harley, M., Stevenson, M.J. and Catchpole, R. (Eds.) 2007. *MONARCH – Modelling Natural Resource Responses to Climate Change – a synthesis for biodiversity conservation*. UKCIP, Oxford, 100pp.

[18] Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853-858.

induced climate change impacts have occurred in air and water temperature dependent responses (such as timing/volume of snowmelt, species' distribution and phenology)[20]. The risk of extreme heat-waves has already increased[21]; detectable changes in heavy precipitation could emerge by the third cycle of RBM under the WFD[6]. Where there are no economically or technically feasible means of countering such trends and their biological impacts, reducing other pressures to "buy time" may be the only rational option.

Please refer also to chapter 4 for further guiding principles on data collection to improve decision-making in river basin management under climate change as well as chapter 7.3 on monitoring for detecting climate change impacts on quantitative elements of water resources.

Suggested actions

- Do not systematically redesign monitoring programmes around climate change but, as part of general good practice, plan monitoring programmes carefully to take a long-term perspective, and apply consistently without changing the station network or methodologies. Do not abandon stations which already have a long-term consistent record.
- Notwithstanding the above:
- Where possible establish more intensive monitoring of vulnerable water bodies to better understand the pace and mechanisms of change, and use these sites as sentinels of climate change. In cases where the minimum WFD monitoring frequency is applied, assess whether this is sufficient; in order to early detect climate change impacts, the monitoring frequency needs to be higher than the WFD minimum for surveillance monitoring, as otherwise it will take a long time to gather robust time series.
- Encourage a monitoring programme that includes long-term, concurrent meteorological, water quality and biological monitoring of reference sites to improve evidence of causative links between climate variability and local ecological status.
- Compile register of species-dependent hydro-climatic thresholds and damage functions. Intensify monitoring of most vulnerable species/ecosystems to better understand the pace and mechanisms of change, and use indicator species to track impacts with/without adaptation.

Example 5g – Additional monitoring needed for detecting climate change induced changes to salt marshes

The salt marshes of the Dutch, German and Danish Wadden Sea, and the marshes of the British East Coast (classified as type K2 – polyhaline sheltered coastal waters) are highly dynamic natural ecosystems with tidal channels, sands, mud flats, salt marshes, beaches, dunes and a transition zone to the North Sea. They form the upper parts of the intertidal zone and are the interface between

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[19] Scholze, M., Knorr, W., Arnell, N.W. and Prentice, I.C. 2006. A climate change risk analysis for world ecosystems. *Proceedings of the National Academy of Sciences of the United States of America*, **103**, 13116-13120.

[20] See e.g. EU research projects Euro-limpacs and CLIME

[21] Stott, P.A., Stone, D.A. and Allen, M.R. 2004. Human contribution to the European heatwave of 2003. *Nature*, **432**, 610-614.

mainland (the embankments) and the sea. Besides being highly valuable habitats, foreland marshes give a self-regulating protection of the embankments for coastal flood defence. The presence of a salt marsh in front of a seawall will thus improve safety of the hinterland and reduce the cost involved in seawall maintenance.

The Dutch have shown that the elevation of their foreland marshes is currently able keep pace with current 2.5 mm/yr rise in sea level. The threshold value for the intertidal flats seems to be a (relative) sea level rise of 6.0 mm/yr. Beyond this threshold intertidal flats start to disappear and even protection from erosion (e.g. by brushwood groynes) will no longer be sufficient. Although salt marshes may receive sufficient sediment to compensate for (relative) sea-level rise, lateral erosion of the salt-marsh edge can result in a net loss of salt-marsh area. A poor vegetation cover in the pioneer zone in front of the marsh can provide less protection of new sediment, with a subsequently lower net sedimentation. The effect leads to cliff erosion. This erosion can be intensified by strong winds, high tides and increased wave height, which in turn may be caused by climate change and human activities like land claim, dredging and canalization.

Because of possible large-scale climate change-induced effects it is important to use trilaterally (Denmark, Germany, Netherlands) harmonized criteria for monitoring the salt marshes. The following parameters are monitored every five years trilaterally: location and area, vegetation types, land use/management, geomorphology and drainage. Changes in geomorphology due to climate change will take at least decades to happen. But once a threshold has surpassed, after for instance a few decades, rapid changes in the vegetation cover can occur. It is likely that the common (WFD) monitoring will be sufficient to detect climate change-induced changes at the physical level (i.e. area of salt marsh and the relative soil levee), but additional monitoring may be required in order to establish the relation between ecological changes and climate change.

5.4.3 Surface water body types

Water bodies are "typed" by a set of obligatory (e.g., topographic, geological, physical, hydrological) and optional (e.g., water depth, mixing characteristic, nutrient status) descriptors. A number of these descriptors are climate sensitive. As any typology is a simplification compared to the natural continuum, some water bodies always remain on type boundaries and could, in theory, migrate from one type to another as a consequence of gradual climate change or sequence of extreme events. Over longer time horizons there is even the prospect that some sites could shift between different categories of water bodies, such as a lake to transitional water category. Any refresh of characterisations would have to be mindful of the fact that natural climate variability could result in temporary migrations between types. So there is an open question surrounding the length of the sampling period needed to confidently re-assign a water body from one type to another.

In order to keep the number of water bodies with ambiguous types at the minimum, typologies should be created as close as possible to the naturally occurring patterns using, e.g. clustering or other multivariate techniques. If the type of some water bodies will still change as a result of CC, these water bodies should be transferred to the appropriate type and the corresponding reference conditions applied to them.

Ecosystems of some types of water bodies, e.g. large shallow lakes, are more physically controlled and thus more sensitive to climate change.

Suggested actions

- Undertake a risk assessment to determine the extent to which climate change could trigger transitions between categories and types within rivers, lakes, transitional, coastal and artificial water bodies.
- Where possible establish more intensive monitoring of vulnerable water bodies to

better understand the pace and mechanisms of change, and use these sites as sentinels of climate change.

Example 5h – Change of water body type

A low-lying, near coastal lake was initially typed as "High alkalinity, Very shallow" because the $CaCO_3$ concentration is more than 50 mg/l, and the mean water body depth is less than 3 m. Certain objectives (and standards) apply to this type which help define its management.

According to the UKCP09 scenarios (http://ukclimateprojections.defra.gov.uk), between 61 and 87 mm of relative sea level rise is expected over the next 20 years (for high and low emissions scenarios respectively). Consequently, in this hypothetical case, after a series of stormy winters nearby coastal defences and dykes are permanently breached and sea water periodically enters the lake under very high tides. The morphology of the lake is unchanged but the water is now brackish. In the absence of new coastal defences, the site is now characterised as "Brackish, Very Shallow". Objectives and management may have to shift to suit this new type of lake.

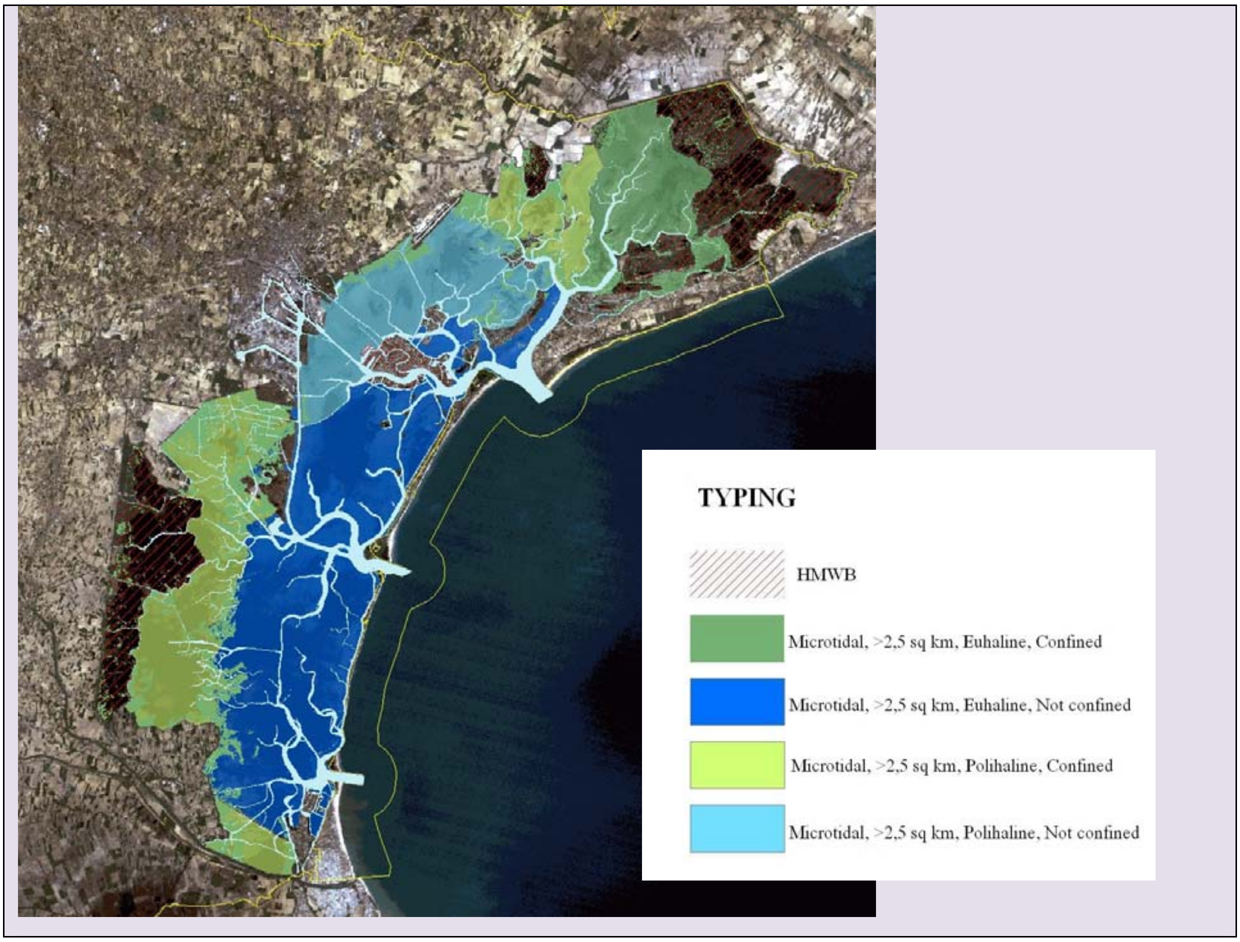
After a few more decades of net sea level rise, and near permanent connection to the sea, the water body is characterised as a "Transitional lagoon". Once again, objectives and management may have to shift to suit the new conditions.

Example 5i – transitional water in Mediterranean Ecoregion: the Venice lagoon (Italy)

Physical descriptors used for transitional water types in Italy are annual average salinity and tide range (the other descriptors are optional, such as the degree of confinement). In the Adriatic sea, three possible effects of climate change can be considered: rising mean sea level, increasing sea temperatures, and "tropicalisation" of temperatures and rainfall.

Tides and Sea level: The Venice lagoon is micro-tidal and it is not likely that the projected sea level rise will be more than 2 m (current tide range is around 1 m): therefore, there are not likely to be any migrations to a meso-tidal lagoon type. Furthermore, in the Mediterranean Ecoregion depth is not a descriptor for the transitional water typology, therefore any changes in the sea level will not cause any direct migration between types.

Salinity, sea level and rainfall: changes in salinity can be caused by an increasing sea level or by an increasing/decreasing rainfall. Venice lagoon (fig. 1) is now polyhaline around the edge (salinity: 20-30 psu) and euhaline close to the inlets (salinity: 30-40 psu) and the observed trend shows a marinisation process within the lagoon. The projected increase in sea level could increase this process and the polyhaline areas could shift to euhaline type. A reduction in mean rainfall over the basin could reduce fresh water inflows to the lagoon and cause the same migration between types. Conversely, increasing rainfall and fresh water inflows can favour migration toward polihaline types, despite the current marinisation process.



5.4.4 Reference sites

The objectives of the WFD include that water bodies should not deteriorate and that they should achieve "good status" by 2015[22]. For surface waters, "good ecological status" (or "good ecological potential" in the case of heavily modified and artificial water bodies) is defined by reference conditions for different water body types. Reference conditions should be set based on objective criteria, preferably by measuring ecological status in unimpacted sites (with agreed pressure criteria for what is unimpacted). Monitoring of reference sites will be essential to understanding and appropriately responding to climate change across Europe (see also section 5.4.2). In fact, a **sufficiently robust long-term monitoring network of reference sites, i.e. sites with missing or very minor anthropogenic impact, linked to meteorological data** will be the only direct way of detecting responses of water bodies to climate change impacts. Only if such monitoring reveals long term coherent changes in the status of reference water bodies over large geographical areas, it will be a proof of changing reference conditions. In practice, as the intercalibration exercise showed, MS use slightly different criteria for selecting reference sites. Use of best available sites instead of real reference sites should be marked as such and defined as an alternative benchmark (e.g. good status).[23] If the conditions at reference sites change, it will be really important to find

[22] Good chemical and ecological status for surface water bodies; good chemical and quantitative status for groundwater bodies.

[23] The procedure on how to define alternative benchmarks is described in CIS Guidance Document No. 14: Guidance on the Intercalibration Process 2008-2011.

out the causes and decide whether the site can still be used as a reference site or not. Such a decision should be supported by results of a sufficiently robust long-term monitoring network linked to meteorological data, including a demonstration of the specific impact of climate change.

Unless biological systems are already close to thermally and hydrologically induced "tipping points"[24], climate trends are expected to play a minor role in early WFD river basin management cycles; natural variability in annual and seasonal climate will be far more significant. Therefore, status definitions should be sufficiently wide ranging to accommodate natural variations within types. Given the brevity of many monitoring programmes, short-term trends in ecological status should be interpreted with extreme caution.

In general, reference conditions and default objectives should not be changed due to climate change projections over the timescales of initial WFD implementation (up to 2027) unless there is overwhelming evidence to do so.

Where there is judged to be significant risk that climate change (and possibly having regard for climate change related policy) would lead to failure to achieve the objectives set for 2015, 2021, 2027 or beyond, this should be noted in the river basin management plan since it is relevant information to the plan user and may assist in considerations of optimization of scarce resource use between locations and objectives earlier in the plan than when non-compliance projected to occur.

For the upcoming WFD cycles, the following actions are suggested in case monitoring data show strong evidence that conditions at reference sites are changing:

Suggested actions

- In order to achieve better distinction between climate change pressures and other human pressures, maintain robust long-term, concurrent meteorological, water quality and biological monitoring to improve evidence of causative links between climate variability and local ecological status. Maintain monitoring programmes at sites with a long history of monitoring in order to give the longest possible time series.
- Use homogeneous climate indices (for instance the NAO, Central England Temperatures or England and Wales Precipitation series) to contextualise biological samples taken under different conditions (i.e., hot-dry, cool-wet, etc). Use paleo-environmental reconstructions and other proxy evidence to represent the full range of conditions experienced at reference sites over multiple decades.
- Undertake periodic reviews of conditions and pressures at reference sites to assess whether the site can still be used as a reference site.
- Prioritise to distinguish climate change impacts from those caused by other anthropogenic pressures.
- Be aware of the challenges associated with attribution of environmental changes to anthropogenic climate change and avoid over-interpretation of observed trends.
- Focus on how climate variability and change will work alongside pressures from human activities and use the degraded water status because of these various pressures as the starting point for planning of measures.

[24] For example, increasing water temperatures combined with lower flows in summer could have lethal and non-lethal impacts on aquatic species such as salmon. See: Solomon, D.J. 2008. *The thermal biology of brown trout and Atlantic salmon: A literature review*. Environment Agency Southwest Region, 40pp.

Example 5j – Understanding biological changes[25]

Macro-invertebrate data for an upland region show declines in species diversity, inter-annual stability, and abundance since the 1980s at circumneutral (and to a lesser extent at acidic forest or moorland) sites. The declining biodiversity appears to coincide with reduced atmospheric deposition of acidifying substances, and rising stream pH at all sites. In other words, decades of industrial regulation and pollution control do not appear to have yielded intended environmental outcomes.

Further analyses of the macro-invertebrate data reveal strong correlations with winter air temperatures and the North Atlantic Oscillation (NAO) index. A long-term trend towards more positive phases of the NAO (typified by warmer wetter winters and increased runoff) since the 1960s is associated with lower abundance of macro-invertebrates in spring. It is too early to say whether such behaviour in the NAO is a manifestation of human-induced climate change. However, the data show the extent to which the "bandwidth" of invertebrate abundance can vary from year to year and decade to decade. The data further imply declining abundance (ignoring in-migration) under warmer future conditions. This example would justify further monitoring.

Example 5k – Impacts on fish distribution and abundance in the Baltic Sea

Changes in marine species observed in the Baltic Sea do not fit into the general pattern of northward shift due to increasing temperature. In this sea, salinity is one of the predominant factors that influence species presence. Salinity ranges from high (close to oceanic values) at the boundary of the North Sea to almost fresh water in the Bothnian Bay (northernmost part between Sweden and Finland). In general, the Baltic aquatic ecosystems are dominated by marine species in the western parts near the North Sea boundary, with predominantly brackish and freshwater species in the central parts. A small change in salinity could change the distribution of species. Changes in salinity are driven by climate-induced changes in precipitation and salt water inflow from the North Sea. It appears that changes have already been large enough to affect the composition of the Baltic Sea biota.[26]

Salinity in the Baltic has decreased steadily since the mid 1980s due to increased freshwater input (precipitation) and a reduction in the frequency of inflow events from the North Sea, which bring in more saline, oxygenated water. Projections for the future climate of the Baltic are for continuing increases in precipitation and decreases in inflows from the North Sea, therefore the distribution and abundance of cod and other marine species is likely to continue to diminish. Their position in the ecosystem may be taken over by more brackish and freshwater species, such as whitefish, pikeperch and perch[27].

Example 5l – Divergence in comparability to reference site for Lake Ijsselmeer

1. Characterisation: Lake Ijsselmeer is a large (114.000 ha), shallow lake (av. 4,6 m) in open connection with Lake Ketelmeer (3200 ha, 3,6 m) and Lake Zwarte Meer (1800 ha, 1,8 m). Lake Ijsselmeer was classified as M21 (large lakes > 10,000 ha, > 3 m depth, even though it is not

[25] Durance, I. and Ormerod, S. 2006. Climate change effects on upland stream invertebrates over a 25 year period. *Global Change Biology*, **13**, 942-957.

[26] A general description of effects caused by climate change are available at: Swedish Environmental Protection Agency (2005). Changes Beneath the Surface, Monitor 19. An In-Depth Look at Sweden's Marine Environment. 192 p. ISBN: 91-620-1246-0.

[27] MacKenzie et al., 2007 as cited in EEA Report No 4/2008 Impacts of Europe's changing climate - 2008 indicator-based assessment.

stratified), the others as M14 (<10,000 ha, < 3 m depth). Due to sea-level rise, the fixed water-levels used in the lakes at present will have to be raised in future, with a maximum raise of 1,5 m. This will change the average depth and the chances of stratification-like conditions occurring.

2. Reference conditions: The water level rise proposed changes the lakes to such an extent that the present reference lakes may become no longer applicable. Lake Peipsi in Estonia/Russia, is currently used as a reference site for Lake Ijsselmeer, however it is shallower and its discharge is not affected by sea-level rise because of the postglacial uplift (rebound) in its part of Europe. The change in water levels and stratification will be monitored to allow a change in reference site to take place if it is shown to become necessary in due course.

Example 5m – Impacts on biodiversity in the Adour Garonne River Basin, France

The following study is a study from "Groupement d'Experts Intergouvernementaux sur l'Evolution du Climat" (GIEC) this study was done by Cemagref (Eric Rochard 2008), which is an international body of research specialists of climate change. The Study realised for the Adour Garonne River basin is part of an overall study on impact of climate change over 200 European river basins. This study is providing reference conditions starting in 1900. The study shows that the major impacts of climate change on rivers and fish species are expected in the middle and long term. Models propose 4 scenarios till 2100. The study clearly highlights already existing impacts of climate change starting from the reference date 1900.

One case study demonstrates that the temperature of water has increased by 1°C over the last 20 years on the Garonne Estuary, due to climate change and associated events such as heat waves and droughts. The increase of the temperature has been monitored over a long period of time about 20 years. At the same time there was no increase of anthropogenic pressures (no additional abstractions, discharges etc.) in the same area. This increase of temperature has contributed to the disappearance of the fish "eperlan" in the estuary of the Garonne river and of the "Flet" the have been replaced by "anchois" due to the decrease of fresh water in the Estuary.

At the same time, a lot of invasive species (fauna and flora) are appearing in the Adour Garonne district, such as the "Bull frog", the "ecrevisse de Louisianne", the myrophilla from Brazil. All these species are modifying the biodiversity by the disappearing of local species (Eperlan, anchois,…) and the appearance of these invasive species. The quality indicator based on the endemic fishes and invertebrate species for the Garonne river will be modified in the years to come. The invasive species less valuable from an ecological point of view contribute to a diminishing biodiversity and at the same time have an impact on some parameters of GES (Fishes, invertebrates). A decrease of the biomass has also been identified by the CEMAGREF study.

The changes in species of fishes in invertebrate will have to be monitored carefully in the years to come in order to see if it could have an impact on the reference conditions of the Garonne river.

These impacts on biodiversity, GES and reference conditions are mainly due to the increase of the temperatures for the entire Garonne river and of the salinity in the Estuary and its progression up stream. Models driven by data starting in 1900 already show the impacts of climate change on the river basin which are expected to increase exponentially till 2100. At the same time the increase of the salinity combined with the ground water depletion is a factor of deterioration of the ecological status of the Garonne aquifer linked to the river. The salt intrusion is having an effect of the ecological status of this aquifer.

Reference: GIEC's study CEMAGREF 2008 case study of Adour Garonne river basin

5.5 Objectives setting

Guiding principle

4. Avoid using climate change as a general justification for relaxing objectives, but

follow the conditions set out in the WFD

Article 4 of the WFD expects Member States to achieve good surface water status and good groundwater status at the latest 15 years from the date of entry into force of the WFD, but provides for the possibility for exemptions to this rule. Paragraph 5 of Article 4 allows Member States to achieve less stringent standards where achievement of these objectives would be infeasible or disproportionately expensive. Paragraph 6 of Article 4 allows for temporary deterioration in the status of bodies of water only in circumstances where the extreme event is "exceptional or could not reasonably have been foreseen". Paragraph 7 of Article 4 allows for new modifications to the physical characteristics of water bodies leading to status deterioration under certain conditions.

Climate change has the potential to impact on the feasibility or expense of achievement of objectives. The EU Water Directors have endorsed that, whilst the use of exemptions is an integral part of river basin management under the WFD, exemptions without justification in line with the Directive cannot be seen as a general strategy to cope with the consequences of climate change. At the same time, the use of exemptions can have negative consequences for making water resources more resilient to climate change impacts.

Whilst it is expected from projections that there may at some point be unavoidable changes to water status due to climate change, there is still significant uncertainty (particularly relating to climate models) over the timing and nature of these changes. Largely it will still be difficult to distinguish the climate change signal from natural variability or other human impacts over the timeframe of the WFD (up to 2027). It is thus necessary to base decisions on the basis of clear monitoring evidence (see principle 2), and not to proactively aim for less stringent objectives based on modelled assumptions of future climate.

However, there may be cases where there is sufficient evidence that the expected scale of climate change impacts on pressures is large enough that the measures needed to meet default objectives would be too expensive or technically infeasible. Where climate change is brought forward as the underlying reason for exemption due to excessive cost or unfeasibility, a clear and robust evidence base as for exemptions in other cases and consistent with other aspects of the approach to climate change should be provided. Within this evidence, DETECTION of a trend alone will be insufficient to invoke a change of policy and process, and ATTRIBUTION of the trend to anthropogenic climate change will be required. Detail on the process and difficulties associated with attribution of changes to anthropogenic climate change are provided in the literature[28]. Put simply, for positive attribution to take place, the observed data should sit outside the range of natural climate variability and be inexplicable other than through the impact of anthropogenic climate change.

The evidence base should also be clear about the inherent uncertainty in climate projections and include consideration of costs and benefits over a range of timescales and potential climatic futures. The full range of potential measures and combinations of measures should be considered.

The process for assessing the need for less stringent environmental objectives should therefore link closely with the economic analysis of measures. Guidance on including adaptation to climate change in economic analysis is given below in section 5.6.

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[28] Hegerl, G.C., Karl, T.R., Allen, M., Bindoff, N.L., Gillett, N., Karoly, D., Zhang, X.B. and Zwiers, F. 2006. Climate change detection and attribution: Beyond mean temperature signals. *Journal of Climate*, **19**, 5058-5077.

In addition, as extreme events, such as droughts, floods and surge tides may occur more frequently under a changing climate, robust scientific evidence should determine on a case-by-case basis whether they can be considered as exceptional or that they cannot reasonably be foreseen, as referred to in Article 4(6) of the WFD (see also relevant discussion on "exceptional floods" in chapter 0) and prolonged droughts in chapter 7.2.

Finally, the implementation of specific adaptation measures, for instance infrastructure projects, might invoke exemptions according to Article 4(7) of the WFD more often. As explained in section 5.7, certain adaptation measures to climate change can be counterproductive to WFD aims, e.g. storage basins. Such measures need to meet the conditions set in Article 4.7 of the WFD on new modifications (see CIS WFD policy paper on Article 4.7 exemptions).

Suggested actions

- Manage the expectations of stakeholders in terms of how significant an impact climate change will be in the timescale of the WFD.
- Closely monitor and at each cycle review characterisation for any specific water bodies for which lower than default objectives were considered due to climate change.
- When considering impacts of climate change as a basis for justifying exemptions, first establish climate change as the most probable cause of any observed changes.
- Under a changing climate, when disproportionate costs are used as a reason for an exemption, provide a robust evidence base that considers costs of measures and benefits over a range of timescales and climate projections.
- Assess the consequences of using exemptions on making water resources more resilient to climate change.

5.6 Economic analysis

Guiding principle

5. Consider climate change when taking account of long term forecasts of supply and demand and favour options that are robust to the uncertainty in climate projections

Changing climatic conditions do not change the requirements and steps in the implementation of the economic analysis of the WFD. There is still the need to follow the sequential steps for the economic analysis of the WFD, but with the integration of potential additional pressures, impacts and constraints due to climate change.

Annex III of the WFD sets out that economic analysis should be carried out for recovery of costs of water services (and that this should take account of long term forecasts in supply and demand for water in the RBD) and for judging cost effective combinations of measures. Figure 2 below gives a reminder of how economic analysis should be integrated into the RBM decision making; this approach remains the same under changing climate conditions.

Member States have taken markedly different approaches to economic analysis and so the way in which consideration of climate change might be incorporated will vary. However it is recommended that, whatever methodology is used, the required long term forecasts in supply and demand for water incorporate scenarios for climate change. In addition, in assessing combinations of measures, options should be sought that can be shown to perform (and be cost effective) under a wide bandwidth of scenarios for future climate change (see also chapter 5.7 of this Guidance).

Also the justification of lower objectives because of disproportionate cost should consider these long term climate changes. The cost-benefit ratio might change over time and not taking action at an early stage might increase the overall costs for adaptation, e.g. reducing water abstraction for irrigation might be seen as disproportionate because of the loss in income of farmers. However, if water becomes even more scarce, the costs for farmers quitting their business might be higher in the long run. Equally, requiring farmers to install winter storage reservoirs for irrigation could increase costs if they will not be allowed sufficient water to fill them within the payback period of the asset.

Suggested actions

- Carry out an assessment of the impact of climate change on the long term forecast on supply and demand in your river basin district. Integrate these projections into the economic assessment of water use.
- Carry out sensitivity testing based on climate change projections within cost benefit assessment of measures. Give preference to those measures that are robust or flexible to a range of possible climatic futures.

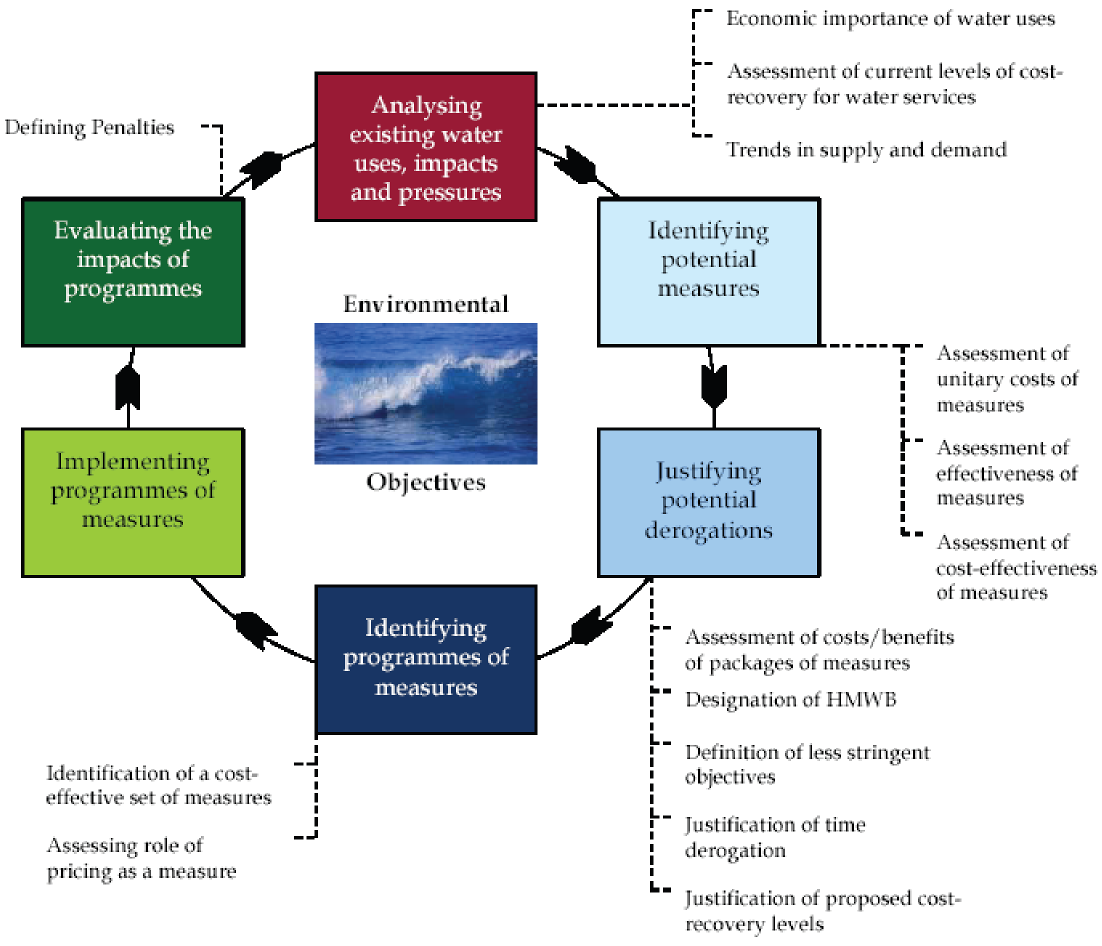


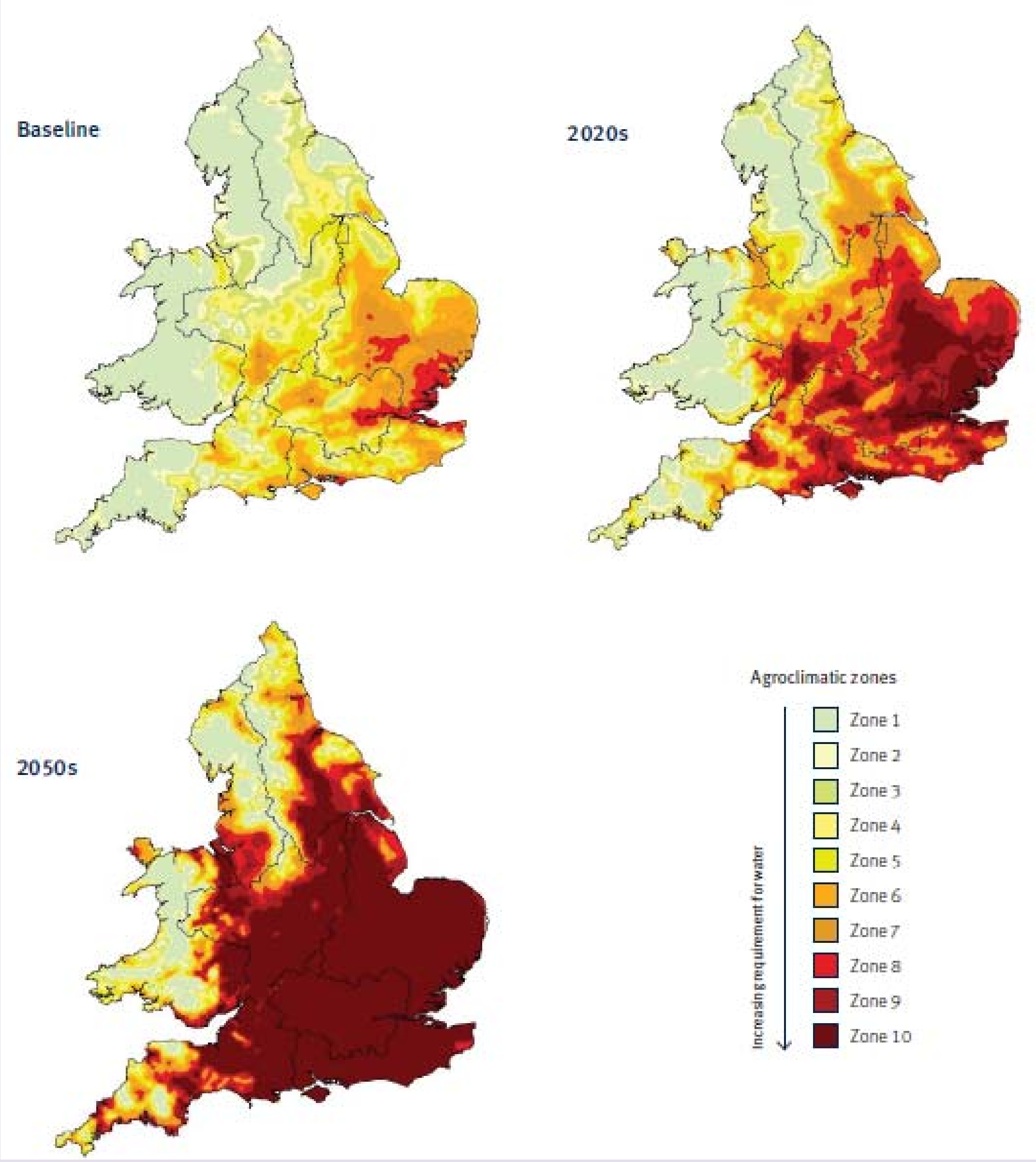
Figure 2 Integration of economic analysis in the RBM decision making process for WFD[29]

Example 5n – assessing future agricultural water use in England and Wales

The most significant use of water by the agricultural community is for irrigation. Demand for irrigation is concentrated mainly in East Anglia and parts of the Midlands. Despite currently only accounting for around one percent of total abstraction, irrigation is concentrated into a few months when water resources are most scarce, and little of the water is returned to the environment. On a hot dry day in summer, there can be more water abstracted for irrigation in some catchments than for public water supply.

For agriculture, the potential impact of climate change on increased demand is expected to be high. The figure below shows that potential irrigation requirements could increase dramatically, and could move northwards and westwards in the UK as a result of climate change. By the 2020s, central England and eastern margins of Wales could experience conditions similar to those currently typical of the south and east of England. By the 2050s we expect to see a substantial increase in the demand for agricultural irrigation under all of the scenarios we considered. These projections can be fed into economic analysis when considering the economic importance of water use and hence the cost effectiveness of future measures (e.g. winter storage reservoirs or efficient irrigation) to avoid environmental deterioration.

[29] CIS WATECO Guidance Document 1 on the Economics Supporting the WFD.



Example 5o – Comparison of options for managing abstraction pressures

Under current conditions abstraction pressures within a particular river basin district mean that good ecological status is not being achieved and measures are needed in response. Both development of new water supplies and introduction of new demand management measures are being considered. Incorporating climate change scenarios in the water resources zone model gives that by 2050 the river basin district is likely to become between 10 and 30% drier. Combinations of measures are developed on the basis of current pressures. There is a marginal difference in cost between the two least cost options - a) a new reservoir and introduction of metering, and b) the slightly cheaper possibility of a new reservoir and leakage reduction in the supply network. These are then sensitivity tested against the projected future water resources availability. Whilst both have flexibility to be adjusted through time to enable them to perform over the full range of projected climatic futures, the costs for adjusting option b) rise much more sharply than for option a). On this basis option a) is chosen.

In cases with metering already introduced and/or relatively high leakage rates, the choice would be different. Leakage reduction can be an important instrument worthwhile for realizing sustainable water use.

5.7 Measures for adaptation related to the WFD

5.7.1 Introduction

What to find in the following sections on measures?

After laying down principles for taking climate change into account in other steps of river basin management (RBM) under the WFD (see previous sections in this chapter), let us focus on related adaptation measures, including the role climate change may have on the WFD programmes of measures.

In a first step (section 5.7.2), we will discuss the need to assess the WFD programmes of measures or individual measures with regard to the impact changing climate conditions may have on their effectiveness for achieving the WFD objectives. The aim should be to enhance the robustness of the programmes of measures against changing climate conditions.

Beyond ensuring the robustness of individual measures and programmes of measures, there might be a need to take specific actions to achieve good water status.

Although, as already explained, it is unlikely that climate change has such impacts on water bodies that it will jeopardise the achievement of the WFD objectives on the short term and that related measures have to be taken, some guidance at general level will be provided in case this may happen.

In addition, when the Programme of Measures (for the 2nd and 3rd cycle) contains major investments for the long term (e.g. building new or upgrading urban waste water plants), climate change needs to be incorporated, even when it is unlikely that significant climate change impacts will occur in the next river basin management cycles. But climate change projections for the longer term may show significant impacts, thus it may be beneficial to already adjust the measures that are taken now (or in 2020) to the long-term predicted changes.

In section 5.7.3, we will discuss the influence of adaptation measures which serve other purposes related to water (e.g. guarantee water supply, flood protection, sustain tourism, etc.) which may impact on achieving WFD objectives. These measures are more and more being planned. Also water management measures for mitigating climate change may have an influence on achieving WFD objectives. These potential impacts and influences have at least to be considered in the planning process.

The following sections do not aim at collecting all measures that are available for adapting to climate change related to the WFD, but rather focus on the consideration of adaptation measures by those with river basin management responsibilities based on current knowledge and tools, and on measures resulting from the principles set out in the previous sections of this chapter. Instead of being overambitious about the details of adaptation achievements in the long-term, this chapter **concentrates on measures and actions that can be taken already in the 2nd and 3rd RBM cycles of the WFD to start adapting our water resource environment to climate change.**

Please note...

The pressures and impact analysis as required by WFD and mentioned in previous sections of this chapter provides relevant input to the climate change vulnerability of a given area, especially on the short term (i.e. the 6 years WFD planning cycle). However, a longer term vulnerability assessment is needed to assess the effectiveness of the Programme of Measures (5.7.2).

As stated earlier, the WFD offers important tools for adapting to climate change impacts, but sometimes it is not easy to distinguish regular water management issues and measures from adaptation measures.

Specific measures related to flood protection and drought management and the interlinkages with the WFD are addressed in Chapters 0 and 7.

Check also Annex I of this Guidance for a non-exhaustive list of key sources of information on adaptation measures and actions with regard to water in Europe.

5.7.2 How to do a climate check of the Programme of Measures?

Guiding principles

6. Take account of likely or possible future changes in climate when planning measures today, especially when these measures have a long lifetime and are cost-intensive, and assess whether these measures are still effective under the likely or possible future climate changes.
7. Favour measures that are robust and flexible to the uncertainty and cater for the range of potential variation related to future climate conditions. Design measures on the basis of the pressures assessment carried out previously including climate projections (as explained in section 5.3).
8. Choose sustainable adaptation measures, especially those with cross-sectoral benefits, and which have the least environmental impact, including greenhouse gas emissions.

Due to the fact that substantial financial resources will be invested within the next river basin management cycles, and that many measures and investments will have a long lifespan and will not necessarily include the possibility of adjustments, Member States/RBD authorities have to screen the potential effects of climate change and to undertake a "climate check" of the Programmes of Measures (PoMs).

The overall aim of the climate check is to ensure that the PoMs are sufficiently adaptive to future climate conditions. The climate check should provide a form of sensitivity analysis for the selection of measures that are effective, robust and cost-efficient under changing conditions. Additionally, it should ensure that the measures are beneficial to the objectives of the river basin management plans both now and in the future.[30] See example 5t for assessing measures for adaptation, identifying advantages and disadvantages and defining whether and under which circumstances a measure could be classified as relevant for water management in RBMPs.

In the subsequent RBM cycles, the Programme of Measures needs to undergo a climate check as a default and firmly based on scientific evidence, notwithstanding the fact that knowledge and new data are constantly evolving (CIS-WFD, 2008-3).

Generally, only measures that are robust to climate change impacts and do not increase the burden of climate change should pass the climate check and should be considered in future RBMPs. The flow chart of climate checking measures is illustrated in Figure 3.

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[30] Already in the first RBMPs, there have been some activities in the Member States on climate checking of PoMs. A survey with responses from 21 EU Member States plus Norway during the summer 2008 is available. See report CIS WFD (2008). Progress report on incorporating climate change in the first River Basin Management Plans. November 2008.

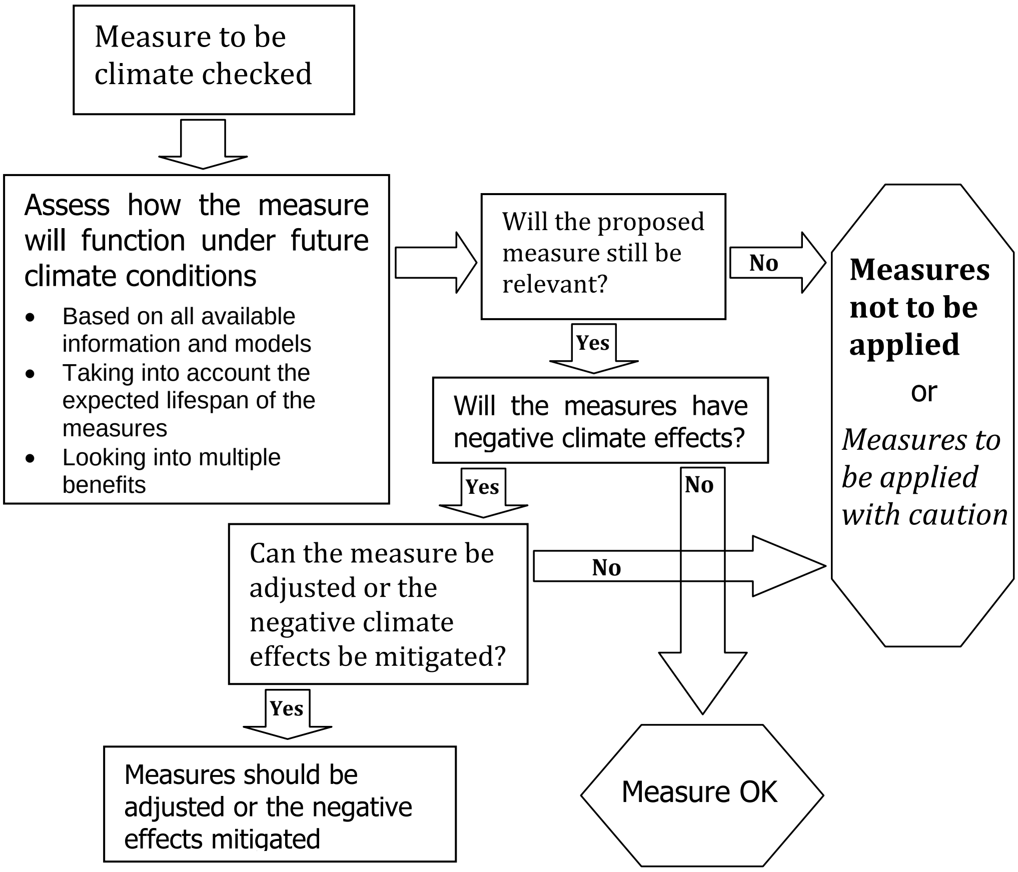

Figure 3 Climate checking of measures

Each climate checking of PoMs should involve an evaluation on the level of individual measures, or on categories of measures, so as to determine if the respective measures are robust to future changes.

First, the sensitivity of the measure should be evaluated against the anticipated future climate conditions as each measure or group of measures has its own sensitivity. In cases where the measure is sensitive to the anticipated future climate conditions, it has to be re-evaluated and potentially adjusted so that it is more robust to future climate conditions.

Because of often limited knowledge and a certain level of uncertainty concerning the impacts of climate change on the water bodies, **the best option is to favour measures that can cope with a range of future climate conditions and are sufficiently adaptive to these.** This will minimise risks associated with implementing measures whose effectiveness at achieving WFD objectives could be compromised by climate change even in the face of high uncertainties.

If the sensitivity/vulnerability of a measure with respect to its intended effectiveness is **high**, it has to be checked, whether this vulnerability affects the overall advantageousness of the measure. To ease the process, more detailed analysis should concentrate on measures that are likely to be affected by climate change.

It is crucial to document the process and methodology of the climate check of measures in the RBMPs. This allows repeating the check at a later stage when more or better projections become available. The documentation of the climate check should be followed by appropriate monitoring to evaluate the results of the check.

Suggested actions

- Evaluate sensitivity of measure against future climate conditions
- Use an appropriate range of future climate projections when checking measures, including uncertainties. The limitation of the range of projections is given by the feasibility of the sensitivity assessment.
- Document the process and methodology of the climate check of measures in the RBMPs.

5.7.3 What to do if other responses to climate change are impacting on the WFD objective of good status?

Guiding principles

9. Avoid measures that are counterproductive for the water environment or that decrease the resilience of water ecosystems.
10. Apply WFD Article 4.7 to adaptation measures that are modifying the physical characteristics of water bodies (e.g. reservoirs, water abstractions, dykes) and may cause deterioration in water status.
11. Take all practicable steps to mitigate adverse effects of counterproductive measures.

There is an opportunity for many adaptation measures to support the achievement of WFD objectives. These are for example measures that give room for the river for flood protection which also will improve hydromorphological conditions (see Example 5r for more examples).

There are however some adaptation measures that will actually be counterproductive for the water environment, and these should be avoided as much as possible. **In case there is no chance to avoid those measures, they need to meet the conditions set in Article 4.7 of the WFD on new modifications** (see CIS WFD policy paper on Article 4.7 exemptions). Application of the Article 4.7 conditions may still lead to the conclusion that better environmental options exist for the planned measures, which have to be undertaken instead of the planned measure.

In case no better environmental options exist, all practicable steps to mitigate the adverse effect of the concerned adaptation measure have to be taken. Article 4.7 (WFD) provides a possibility to be exempt from achieving good status because of a new physical alteration of a water body, when the benefits of, for instance, taking measures to improve public safety are deemed more important than the benefits for the environment.

It may also occur that certain climate mitigation measures have adverse effects on the water environment, and then the same guiding principles apply. This may be the case for e.g. hydropower development, improved inland waterway transport and biomass cultivation.

Example 5p – Modelling measures and climate change impact in Sweden

Various measures for reducing nutrient load have been modelled using the HBV-NP model in the Rönneå catchment (1900 km^2) of Southern Sweden. It was stated that water quality objectives can be reached by different strategies, which will affect different polluters and social sectors. However, no single measure to reduce the nutrient load was enough in itself, but a combination of measures would be necessary. The cost-effective strategy could reach the goals at 20% of the cost compared to the most expensive strategy examined (Arheimer et al., 2005). The cheapest measures were then allocated where they were simulated to be most effective, and included changes in farming practices (with an increased use of spring crops, catch crops, fertilization in spring and buffer strips), construction of wetlands on arable land close to large point sources, and upgraded waste water treatment facilities in rural private households.

The impact of climate change was examined for the phosphorus load and for the implementation of the examined present cost-effective combination of measures. The modelling was based on the ECHAM4/OPYC3 B2 scenario, downscaled with the RCA3 model and a complementary scaling procedure. Hydrology and phosphorus concentrations were simulated for the time period 1961–2100, using the ICECREAM model for arable leaching and HBV-NP model for integrated catchment analysis including all sources, erosion and major turnover processes at the catchment scale. The results show a 10% increase in phosphorus load with present land use and emissions in a future climate (Fig. 1). When incorporating the cost-effective measures in the model, the total transport is reduced by 28% compared to the present situation, but as climate change impact evolves, the effect of the measures is significantly reduced (Rosberg and Arheimer, 2007). In 2090, only 12% of the reducing effect remains, and it can be concluded that the chosen measures are rather climate dependent. Thus, climate change must be considered when establishing future objectives and programmes of measures according to the Water Framework Directive. Climate-proof measures should be high-lighted.

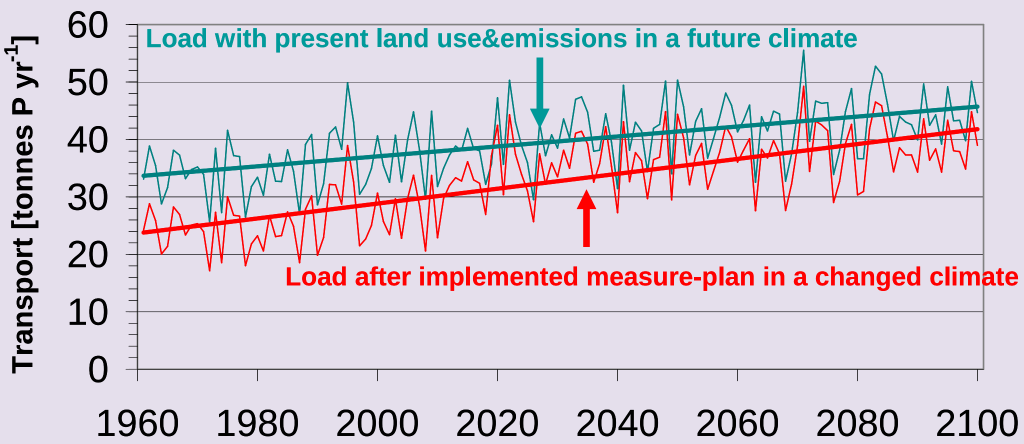

Figure 1. *Simulated phosphorus load in the Rönneå River in a changed climate based on present land use and emissions, and a cost-effective programme of measures, respectively. Trend lines are given (from Rosberg and Arheimer, 2007).*

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-Rosberg, J. and Arheimer, B. 2007. Modelling climate change impact on phosphorus load in Swedish rivers. In: Water Quality and Sediment Behaviour of the Future: Predictions for the 21st Century, IAHS Publ. 314:90-97.

Example 5r - Sectoral adaptation measures that may positively interact with the WFD environmental objectives

Sector	Adaptation measures/actions
Flooding	*Strengthening existing protection, construction of new protection structures* e.g. construction of new dykes and dams or tidal barriers; enhancing capacity of sluices and weirs and adapting the design

	factor for flood protection measures
	Making room for water/increasing natural retention and storage capacity e.g. construction of artificial side channels, reconnection of old river arms: and increasing water transport and retention capacity of floodplains
	Risk-based planning and building resilience
	Forecasting and early warning systems
	Protection against urban flooding including upgrading of storm drain capacity; increasing soil infiltration and water retention use of wetlands
Water scarcity and droughts	*Water demand management* e.g. putting price tag on water; improving water conservation and water efficiency, raising public awareness of water-saving behaviour
	Supply management and increase reuse and alternative sources e.g. development of water infrastructure, rainwater and greywater harvesting, appropriate use of irrigation reservoirs, matching different water qualities to different uses
	Water allocation and planning including making new housing development water neutral, drought management plans (DMPs) and ensuring environmental flow
Other sectoral adaptation measures	*Spatial planning, land use changes and urban development e.g.* Water assessment for new spatial development and transboundary flood management through spatial planning
	Agriculture e.g. reducing water demand and improving water use efficiency: changing farm practices on irrigation, soil moisture conservation practices; reducing fertiliser and pesticide use.
	Water services in water resource planning the impact of climate change on water availability and water demand have to be taking into account and demand management measures on water conservation and saving may need to be strengthened.
	Energy e.g. different location for power plants (cooling water) and evaluation of the impact of climate change on hydropower production and dam safety
	Navigation e.g. providing sufficient water depth in times of low water flow. But also navigation use might in turn benefit certain aquatic species; any requirement for increased water storage to support navigation infrastructure might similarly be combined with habitat creation initiatives; integrated sediment management planning could aim to offset any potential new dredging requirements by identifying measures, such as buffer strips, which aim to prevent additional sediment (and associated nutrients, pesticides, etc.) entering the watercourse.

Example 5s – Mitigation and adaptation to climate change in the Seine Nord Europe Canal Project

The Seine Nord Europe Canal is to be the link of the Central European Seine Scheldt Waterway. The high-capacity river network in northern France is to be connected to 20,000 km of European high capacity waterways, in particular in Belgium, the Netherlands and Germany.

The Seine Nord Europe project has been specifically designed to cope with the possible challenges created by changes in meteorogical and climate conditions. Possible trends in water and temperatures parameters have been integrated in the design, building and exploitation phases of the project, including:

- adaptation to water availability (e.g. waterproofness; optimisation of water management;

water storage)

- adaptation to extreme temperature changes, impact on infrastructures quality (e.g. dams)
- adopting mitigation measures on the canal building project (e.g. life cycle carbon footprint; reduced road emissions; energy neutrality or energy positive through renewable generation).

Example 5t – Criteria to help selecting adaptation measures

Criterion	Sub-criteria	Guiding questions to be asked
Effectiveness of adaptation	Adaptation function	Does the measure provide adaptation in terms of reducing impacts, reducing exposure, enhancing resilience or enhancing opportunities?
	Robustness to uncertainty	Is the measure effective under different climate scenarios and different socio-economic scenarios?
	Flexibility	Can adjustments be made later if conditions change again or if changes are different from those expected today?
Side-effects	No regret	Does the measure contribute to more sustainable water management and bring benefits in terms of also alleviating already existing problems?
	Win-win (or win-lose)?	Does the measure entail side-benefits for other social, environmental or economic objectives? E.g. does it • contribute to closing the gap between water availability and demand? • affect the delivery of other WFD objectives (e.g. river flow)? • create synergies with mitigation (e.g. does it lead to decreased GHG emissions)?
	Spill-over effects	Does the measure affect other sectors or agents in terms of their adaptive capacity? Does the measure cause or exacerbate other environmental pressures?
Efficiency/ costs and benefits	Low-regret	Are the benefits the measure will bring high relative to the costs? (If possible, consider also distributional effects (e.g. balance between public and private costs), as well as non-market values and adverse impacts on other policy goals)
Framework conditions for decision-making	Equity and legitimacy	Who wins and who loses from adaptation? Who decides about adaptation? Are decision-making procedures accepted by those affected and do they involve stakeholders? Are there any distributional impacts of the climate change impacts or of the adaptation measures?
	Feasibility of implementation	What barriers are there to implementation? • Technical • Social (number of stakeholders, diversity of values and interests, level of resistance) • Institutional (conflicts between regulations, degree of cooperation, necessary changes to current administrative arrangements)

		Priority and urgency	How vulnerable are the water uses, the ecosystem and the region? Are there other trends to consider, e.g. demographic trends? When are the climate change impacts expected to occur? At what timescales does action need to be taken?	

6 FLOOD RISK MANAGEMENT AND ADAPTATION

6.1 Introduction

Why is it important to take climate change into account in flood risk management?

Although no significant general climate-related trend in extreme high river flows that induce floods has yet been detected[31], **there seems to have been an upward trend in flood occurrence in at least some European rivers in the recent past**. For instance, in Europe twice as many river flow maxima occurred between 1981 and 2000 than between 1961 and 1980[32]. In the Nordic countries, snowmelt floods have occurred earlier because of warmer winters[33]. In Portugal, changes in precipitation patterns have resulted in larger and more frequent floods during autumn, but also to a decline in the number of floods in winter and spring[34].

In general, the upward trend in flood occurrence is not ubiquitous and certainly cannot be unambiguously related to climatic changes[35], as long-term trends in hydrological variables are often masked by the significant inter-annual to decadal variability. Also, confounding factors such as land-use change and water management practices have considerably changed the natural flows of water, making it difficult to detect climate change-induced trends in the occurrence and intensity of floods. Even high flows in the rivers combined with high or higher levels in the sea have led to higher frequencies of flooding in coastal areas. Moreover, in the case of extreme floods, given the small probability of occurrence, it is necessary to use long time series to detect trends.

Nonetheless, **future changes in the intensity and frequency of extreme precipitation events combined with different land use policies are likely to cause an increase in flood hazard across much of Europe**, although in the more northern and mountainous areas the risk of snowmelt floods and ice jams in spring may actually be reduced owing to rising temperatures[36] (EEA/JRC/WHO 2008). Due to intensified precipitation patterns, the likelihood of larger intensity of flash floods and pluvial floods across Europe is becoming bigger. The nature of flood hazards may also change; for instance, it is foreseen that in Finland flood risk related to lakes and reservoirs may increase in the South, whilst fluvial floods may decrease. In many places the expected impacts on large river systems are still very uncertain. A number of studies have attempted a quantitative assessment of changes in flood hazard due to climate change in a number of European river catchments[37].

Despite these uncertainties, for countries such as Sweden, Finland and UK, where more in-depth vulnerability studies on climate change impacts on flood risk have been carried out, the conclusion is often that although the information is uncertain it is robust enough to warrant that adaptation action can already be started.

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31 Becker and Grunewald, 2003; Glaser and Stangl, 2003; Mudelsee et al., 2003; Kundzewicz et al., 2005; Pinter et al., 2006; Hisdal et al., 2007; Macklin and Rumsby, 2007

32 Kundzewicz, 2005

33 Hisdal et al., 2007

34 Ramos and Reis, 2002

35 Kundzewicz et al., 2005

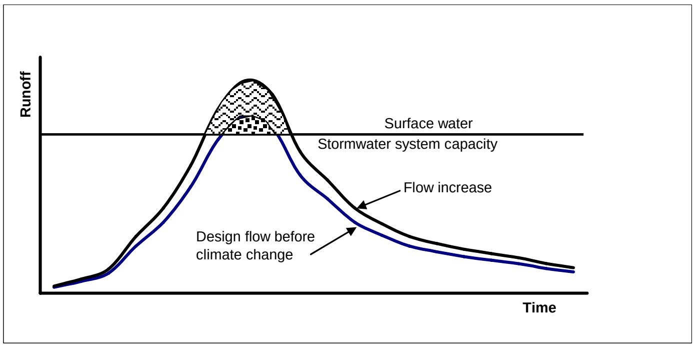
36 Dankers and Feyen, 2008; Dankers and Feyen, 2009

37 e.g., Booij, 2005; Dankers et al., 2007; Graham et al., 2007; Kay et al., 2006; Lehner et al., 2006; Lenderink et al., 2007; Shabalova et al., 2003; Dankers and Feyen, 2008

Since there are major variations from year to year, studies are required over long time periods in order to be able to draw relatively reliable comparisons. The scenarios may also differ both in impact and certainty depending on whether the timeframe is mid-term (e.g. 2030) or long term (e.g. 2100). It is necessary to use reference periods while interpreting and validating the scenarios. The effects of climate change on the probability of floods can furthermore only be calculated in detail based on a river basin approach.

Due to climate change, the probability of different types of floods is likely to change, and it may lead to increased flood risk if additional measures are not taken. Due to marked differences between different types of floods - e.g. coastal floods, flash floods and urban floods - measures to be considered throughout the flood risk management cycle should correspond to the challenges of these distinct types (see Annex III for details on these challenges).

An illustration of the uncertainties of changed flood risk with climate change is that although precipitation may change by a certain percentage, the associated increase in flood damage may be even more difficult to assess.



A small change may end up...

Heavy rain in the city of Fredrikstad: Number of houses flooded after 15 % increase in precipitation nearly doubles!

Historical 20 yr-rain June 25, 1988
Historical 50 yr-rain July 10, 1979

Rain	Number of houses	Change (number)	Change (%)
20-yr	22		
20-yr + 15 %	41	19	86
50-yr	62		
50-yr + 15 %	115	53	85

Modelled by Halvor Hardang
Master thesis 2007, UMB

Figure 4 Relationship between increase in runoff and potential damage.

When engineers plan the stormwater/sewage system, part of the stormwater is designed to run on the ground surface under heavy precipitation, because it is too expensive to include rare precipitation episodes in the drainage system. As a result, a small increase in rainfall intensity may increase surface runoff several times. Hence, inundation of houses is likely as the climate changes (Figure: O. Lindholm and B.C. Braskerud). For instance, in a part of the Norwegian city Fredrikstad (close to the Swedish border) a 50-year rain usually floods 62 houses. With an increase in precipitation of only 15%, 115 houses will be flooded due to overload of the combined stormwater/sewer system (Modelled by Halvor Hardang, Master thesis 2007, Norwegian Univ. of Life Sciences).

What can you find in this chapter?

As explained in chapter 2, the key steps of the flood risk management cycle in the Floods Directive are preliminary flood risk assessment, flood hazard and risk maps, and flood risk management plans.[38]

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[38] Note that the PFRA does not necessarily have to be carried out where an area is already subject to mapping and planning (Art 13.1.b).

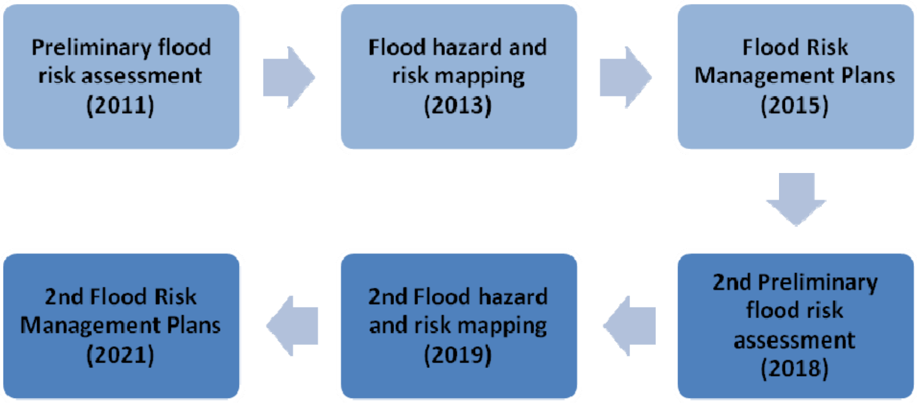

Figure 5 Steps of flood risk management cycle in Floods Directive

Climate change also needs to be taken into account throughout the full flood risk management cycle. Different examples are given below. The Floods Directive furthermore needs to integrate risk management throughout the implementation cycle, which among other things requires a multi-hazard approach, and for instance that the risk assessment places safety issues at its core.

This chapter of the Guidance follows these main steps of the Floods Directive to explain how climate change should be incorporated. The Floods Directive states that the preliminary flood risk assessment (Article 4, FD) shall be based on, among other things, the "impact of climate change on the occurrence of floods" from the first cycle, and article 14.4 (FD) states that the "likely impact on climate change on the occurrence of floods shall be taken into account in the reviews [of the preliminary flood risk assessment and the flood risk management plans]".

The need for EU and MS action to ensure that climate change is taken into account in the implementation of the Floods Directive was emphasised in the EC White Paper on Adaptation.

The purpose of this informal document is to provide guidance to river basin managers and flood risk managers on how best to take climate change into account in river basin management, already from the 1st implementation cycle of the Floods Directive.

In addition to the guiding principles in the sections below, one overall guiding principle covering all steps of the implementation of the Directive, as well as the full flood risk management cycle, can be highlighted:

Overall guiding principle

1. Start adapting flood risk management to potential climate change as soon as possible, when information is robust enough, since full certainty will never be the case. Follow the guiding principles set out for the WFD.

A general question to be considered in the implementation of the Floods Directive is if the potential changes to flood risks induced by climate change require a changed flood risk management approach. Examples are: changes of duration, intensity and frequency of floods, intensified coastal flood risks (related to both sea level rise and increased storm surges), floods in ephemeral rivers (in particular in drying regions), changed patterns in snowmelt, ice-jam floods and more regulated rivers due to hydropower production. Flood risk management should take into account the impact of climate change on the hydrological behaviour of the catchment, both in natural (reference) and altered (modified) conditions -

for instance rivers regulated for hydropower production or with flood defences - since it may change the floods regime; this requires the integration with the river planning process under the WFD. Risk reduction responses may also include different approaches to land use planning, the role of climate change in civil protection policies, and learning to live with and adapt to floods preventing them is not possible.

6.2 Preliminary Flood Risk Assessment

Guiding principles

2. Understand and anticipate as far as possible climate change impact on flood patterns
3. Use best available information and data
4. Homogenize time series, and remove bias as far as possible.
5. Understand and anticipate as far as possible increased exposure, vulnerability, and flood risk due to climate change, for establishing areas of potential significant flood risk.

The FD established that the potential impacts of climate change must be considered within the preliminary flood risk assessment from the first planning cycle, based on the available information.

There are likely to be challenges and limitations on the degree of consideration of climate change in undertaking the preliminary flood risk assessment (PFRA), particularly in the first cycle, given the qualitative rather than quantitative information that may be available or readily derivable. This knowledge is foreseen to be improved in the second cycle (after the first flood maps and flood risk management plans).

Working with models, scenarios and projections

Chapter 3 of this Guidance discussed the use of different climate models, scenarios and projections. A set of guiding principles on decision-making and management of the water environment under uncertainty of models and projections was put forward. Those guiding principles are also valid for flood risk management.

Improving trends detection

One of the most difficult things to predict is changes in trends. Based on available information, scenarios are built with a significant amount of uncertainty around them. For climate change, the horizon of the scenarios is often 50 to 100 years, while climatologists even look at 2300. On the other hand, no or little information about land use scenarios more than 30 years ahead is available and geographically the scale is rather rough. Maps with arrows and shaded zones indicating where changes are expected are difficult to put into GIS-systems for scenario calculations. The same is valid for demographic changes: long term perspectives indicate birth, death and migration rates but local evolutions find only very limited expression in these tables. The issue of field significance and regional consistency for trend detection in hydrological extremes is addressed in one of the examples below.

In general, it is proposed to improve trend detection methods, using the information gathered over the Floods Directive implementation cycles detecting trends of changing flood patterns.

To enable improved trend detection it is also important to continue monitoring of occurring floods in the coming years. The PFRA requires that past floods be taken into account.

Existing information on past floods (as of today) is one important component, but it will also be important to collect information on new floods that will occur, and which will be considered as "new old" floods in the next implementation cycle. In this context, it is proposed to develop a structure for gathering information on past floods, to enable a large, consistent and comparable set of data to be used for the detection of climate change signals concerning all types of floods and adapted to the rules and guidelines of INSPIRE (2007/2/EC).

It is also important to work further on homogenizing and removing bias from timeseries of past floods, in order to detect climate change signals. One example is an increase of high probability floods (low return rates) in certain Austrian rivers since the 1960s, which is however attributed to structural measures related to the straightening of rivers rather than climate change.[39] It is also important to use time series that are as long as possible as well as relevant for the type of flood event investigated.

Using information availability under WFD

In particular, the following information derived under the WFD is of particular relevance for the purpose of assessing climate change related aspects of the Floods Directive:

- Flow levels to assess changes in normal flow regimes.
- Physical modification of water bodies, sediment transport, etc.
- Characteristics & impacts of human activities, e.g. information on polluted soil, identification of point and diffuse sources, etc.

In particular, all those signs and signals due to climate change, such as spatio-temporal irregularity of flow regime and available water resources, can be used to improve flood knowledge, and must be taken into account in the preliminary flood risk assessment.

Furthermore, coordinated implementation of the two directives will enable information exchange and use to be optimized and for relevant information gaps to be identified.

Working with "readily available information" on climate change impacts on flood risk

Article 4.2 of the Floods Directive states that the PFRA shall be carried out "based on available or readily derivable information, such as records and studies on long term developments, in particular impacts of climate change on the occurrence of floods". The identification of such information at different scales (RBD/UoM, national, EU) is therefore important.

In addition, identifying the kind of information which it would be beneficial to develop at different scales, can help guiding research projects in the timescales relevant:

- more information on "paleo" floods/past floods to support long-term trend assessments.
- further information to be made available via GMES, notably for reviews.
- elevation maps needed for both maps/PFRA.

Using best available information - links to insurance industry

[39] Blöschl G., Merz R. (2008). Bestimmung von Bemessungshochwässern gegebener Jährlichkeit – Aspekte einer zeitgemäßen Strategie (Estimating Design Floods of a Given Return Period – Facets of a Contemporary Strategy). Wasserwirtschaft 11 (2008): 2-11.

In the view of climate change increasing flood risk-related pressures, it is in everyone's benefit to share data, and from the insurance industry's perspective there is no competitive advantage in not sharing data with all stakeholders involved. Transparency of information therefore needs to be improved, not the least from the side of the insurance sector. The role of insurance in the recovery phase of the flood risk management cycle is important in several countries. Despite several good examples of information exchange, changes to the insurance culture may be needed and the information needs to be made available to local authorities as well as flood risk managers. The detailed and high quality information of insurance and reinsurance industries gathered during the recovery phase of a flood is of help for water managers and local authorities to improve their plans for the prevention, preparation and protection phase, which is important for all stakeholders.

Information exchange with the insurance industry should therefore be reinforced, for the purpose of using the expertise available for risk assessment throughout the flood risk management cycle, including collection of data for hazard mapping, and improving prognosis and decision making under uncertain conditions, including economic development.

Example 6a: HORA – Flood Risk Zoning Austria

HORA is an Austria-wide risk zoning system (www.hochwasserrisiko.at) for natural disasters, presently prioritising floods and earthquakes. This project has been jointly implemented by the Federal Ministry for Agriculture, Forestry, Environment and Water Management and the Association of Austrian Insurance Companies (Verband der Versicherungsunternehmen Österreich VVO) on more than 25,000 river kilometres. A central finding of the 2002 flood, caught up from the study "FloodRisk", was that besides raising people's risk awareness, indicating the limits of active measures of risk protection and the necessity of the adapted use of endangered areas, a "risk partnership" between state, insurance companies and individuals would play an even greater role in the future. HORA is playing an important part in this cooperation and is a unique project in Europe in the cooperation between the state and the private sector. The beneficiaries of this cooperation are to be the citizens of this country when it comes to providing important information, for example on the risk of flooding of one's home or of an industrial enterprise, an infrastructure facility, etc. In addition to obtaining easy and quick information about any risk of flood via a digital internet hazard map, which serves as a first risk assessment as well, this tool can also be used to optimise and set priorities in the required flood control at the municipal, provincial and federal levels.

For the Federal Ministry for Agriculture, Forestry, Environment and Water Management, the project is not only a milestone in the field of risk communication, but also reflects Austria's leading role in the water sector. HORA advances parts of the EU Flood Framework Directive which require more information for the public. What counts for the insurance companies is, apart from higher risk awareness of the people, improved realisation and assessment of potential dangers as a basis of insurability.

Making most of the review of the preliminary flood risk assessment in view of climate change

According to the Floods Directive, there is a need to review the PFRA (Art. 4 and 5) every 6 years. All relevant data should be made use of, with a view of identifying potential changes or trends induced by climate change.

To ensure climate change is properly considered in the reviews of the preliminary flood risk assessment, including the subsequent identification of areas of potential significant flood risk, it is recommended to:

- always use latest available (yet robust) information
- identify "climate change hot spots" which should be subject to more detailed checks and which can serve as trend detection areas and indicators of the vulnerability of certain regions. The need for reassessments shall be considered in each review

period.

- exchange information between MS on climate change impacts, not just between MS sharing water courses but also at a wider scale, so as to raise awareness on changes noted.

Transparency on how to deal with "worst case" scenarios in assessment of potential significant flood risk

In general, when acting under uncertainty it is recommended that many scenarios are investigated and considered. An assessment of potential significant flood risk requires that some kind of "worst case scenario" be considered as a point of reference regarding the worst situation that can be expected, although the measures taken in the planning process may be based on more realistic scenarios. However, for flood risk management planning it may not be practicable to use the worst case climate scenarios as considered by IPCC (such as new ice age, 18 m SLR etc), and the term should be used with care and in such a way that is still useful for planning purposes. Flood risk assessment should typically use a scenario comprising river discharges, sea levels and weather conditions that are considered to have a small though realistic possibility within 100 to 200 years. The extreme discharges, sea levels, etc. may be higher than the design conditions of man-made flood defences.

The latest available climate change information should be taken into consideration. The "worst case" scenario should be clearly described. The periodic review cycles required by the Floods Directive will provide an opportunity to take into account new scientific results regarding climate change.

The term scenario in this context is used for climate change issues and must not be confused with scenarios according to Article 6 (3) FD, which cannot be considered under PFRA.

Taking climate change into account when assessing the effectiveness of existing man-made flood defense structures

The Preliminary Flood Risk Assessment requires both an assessment of the effectiveness of existing man-made flood defence structures and taking into account climate change related impacts on floods, depending on the need of the Member States.

The "worst case" scenario mentioned in the previous paragraph should be one basis for assessing man-made flood defence structures, depending on how this term is defined and assessed. It should be noted that also without climate change there is a potential risk in areas behind man-made structures.

Suggested actions

Understand and anticipate as far as possible climate change impact on floods

- Monitor changes to flood patterns by gathering comprehensive information on past floods - consider development of a "past floods database at European level"
- Develop a structure for gathering information on past and new floods
- Improve trends detection, using the information gathered over the implementation cycles detecting trends of changing flood patterns

Use best available information

- Anticipate and improve readily available information

- Use monitoring under WFD on flows, physical modifications, pressures and impacts, etc.
- Consider what is "available and readily derivable information" today and what is foreseen to be "available and readily derivable information" in 2011, 2018, etc. (taking into account for instance the forthcoming 5th IPCC AR).
- Exchange information with the insurance industry, as well as land use and spatial planners
- Make the best use of review cycles of PFRA
- Continue further best practice exchange on how to incorporate climate change information in the PFRA at European level

Homogenize time series, and remove bias as far as possible

- Remove bias from timeseries and use timeseries that are as long as possible

Understand and anticipate as far as possible increased vulnerability and flood risk due to climate change

- Take climate change into account when assessing the effectiveness of existing man-made flood defence structures
- Be transparent in the use of "worst case" scenarios – take latest available climate change information into consideration

Example 6b: Trend detection in France

Regional methods for assessing field significance and regional consistency for trend detection in hydrological extremes have been developed and applied to France (Renard et al, 2008). The impact of climate change on hydrological regimes is still an open question: one possible cause of this could be the lack of statistical methods to detect trends in data affected by a very high variability. The results of the study emphasize some of the challenges related to the detection of changes in a non-stationary climate. For example, preliminary analyses showed that many stations from the initial data set were affected by significant changes, but most of these changes could be explained by non-climatic factors, principally measurement problems. Such biases are unlikely to be specific to France and might be encountered in any river flow series.

Example 6c – Detecting and attributing flow changes in southern Germany

The KLIWA project (www.kliwa.de) was set up to look at adaptation strategies for flood protection in southern Germany. As first step, long-term meteorological and hydrological measurement data from Bavarian and Baden-Württemberg weather stations were analysed and trends were determined. The climate conditions in Southern Germany, which have an impact on the entire water balance, have changed noticeably in the past century, especially during the last three decades. In specific regions the trends that have been observed through monitoring exceed the natural margin of deviation, derived from long measurement time series, for some of the variables examined (air temperature, precipitation (regional precipitation, heavy-precipitation 24h and more)). The results agree with the explanation that the global and regional climate is human-induced, but do not yet provide certainty of attribution of changes in extreme floods of river flows to anthropogenic climate change.

Example 6d: Available and readily derivable information in Finland

The Finnish Environment Institute (SYKE) has abundant hydrological data files, e.g. several daily discharge series which have started in the 19th century. These data series have been used in statistical analyses to find out trends in a large set of hydrological variables, including those related to floods. In general, the flood regime in Finland has not yet changed significantly, although the spring peaks have moved to an earlier date on many locations.

SYKE has also developed The Watershed Simulation and Forecasting System (WSFS), which is operationally used for forecasting various hydrological variables for all river basins in Finland. The inputs of the model are precipitation and temperature, the simulated components include snow accumulation and melt, soil moisture, evaporation, groundwater, runoff and water levels of the main rivers and lakes.

Extensive data files and advanced modelling tools give good possibilities to study also the impacts of climate change to floods. These kind of studies have already been performed, and the work is continuing.

In the present stage of these studies, climate change impacts on floods in Finland by 2010-39 and 2070-99 have been evaluated on 67 sites to get a general overview of changes in floods on national scale. This assessment was done with WSFS modelling tools using climate scenarios from both global and regional models. The flood magnitudes of 20 and 100 year floods and their changes were estimated with frequency analysis. The results can be used to identify areas where climate change may potentially increase the flood risk. (According to these results the floods in Finland may decrease in many areas but increase especially on large central lakes and their outflow rivers.)

The general trend of the effects of climate change will be taken into account when the flood risk in the watershed is assessed in the first PFRA. Not just the change in the peak flow but also the change in the seasonal distribution of floods has to be taken into account. In some watersheds the increase of winter floods may rise the flood risk significantly. More detailed studies may be used later during the following rounds of the implementation of the directive.

6.3 Flood Hazard and Risk Maps

Guiding principles

6. When identifying the different flood scenarios, incorporate information on climate change
7. Present uncertainties surrounding climate change in maps transparently.
8. Use the 6-year review of flood maps to incorporate climate change information

The Floods Directive requires 6-yearly reviews of the flood mapping. Probabilities may change in that timeframe, partly because of climate change but also because of other drivers (mostly shifting probabilities; see further explanations below); the 6-year planning cycle allows for the incorporation of these changes. An extra effort is needed to deal with uncertainties in the mapping phase. By taking on board the changes in flood extent of the different scenarios, the management response as set out in the plans should change accordingly, thus providing a sign on how the cyclical implementation of the directive is useful for climate change adaptation.

It is highly recommended to include additional information which Member States consider useful (see Article 6.5.d) for flood prone zones regarding climate change and its effects, for example water velocity maps, water depth, and possible fast occurring changes of stream routes in plan view, as well as slower changes resulting of meander migration. With reference to Article 6.5.d (FD), Member States may consider it useful to analyze and map the role of sediment load, especially in flash floods and taking into account possible increases in soil erosion in watersheds.

Further development of analytical methods to assess flood hazards in a changing climate and cartographic methods may help to display probabilities and uncertainty in flood-mapping products. Further development of mapping methodologies will also be important for different types of floods where flood patterns are expected to change with climate change: pluvial floods (urban/rural), coastal floods, extreme river floods, flash floods, ephemeral floods, ground water floods, ice jam and frazil ice floods, etc. (see Annex III for further information of different types of floods).

For all scenarios it is important to inform map users about the uncertainties. In electronic format maps, this could for instance be done by means of pop-up text. Further information exchange is needed on how to best do this in a consistent manner across the RBD. For instance in transboundary RBDs, it is also important to inform map users about the uncertainties.

Medium probability (at least 100 years return periods)

Due to the effects of climate change, within a period of 6 years there may be changes in intensity and extent of floods and potential changes; what constitutes a medium scenario flood, for instance a 100-year probability flood, may change within the 6 year cycle. Flood maps should take account of this as much as possible if conditions and scenarios change.

Low-probability or extreme events

Most probably, in some parts of Europe, this kind of events may increase in severity; in consequence, considering climate change impact on this scenario is crucial. As high return periods may become more uncertain, this uncertainty needs to be managed.

Low probability events are mainly extrapolations of measurements outside the range of events that occurred in recent history (read: since beginning of measurements). In most simulations and scenarios the extreme events seem to become more severe regarding their consequences. Combinations of uncertain conditions under future circumstances combined with the uncertainty in the scenarios describing future conditions (climate change, land use, etc.) make it difficult to include them in the risk approach (what probability do they get?). While protection against more or less frequent events is a largely adopted solution, a cost-benefit analysis may prove that this approach is not efficient for worst-case scenarios. Measures to minimize the consequences will be different for these worst-case events.

With the flexibility provided by the Floods Directive, the possibility is given to choose between "extreme event" and low-probability scenario. This implies that, for instance in the description of a worst case scenario, ignoring the 'exact' probability avoids discussions focusing on this kind of detail and allows to address the issue of real importance: how to deal with such an event when it happens?

It is thus proposed that the extreme event scenario could be used for anticipating changes to floods related to climate change, in the case that it is not possible to estimate with any accuracy the expected flow changes corresponding to low probability.

High probability flood events

Depending on local / regional circumstances it may be appropriate to include high probability floods in the maps, on the grounds that climate change is also likely to increase the frequency and intensity of events in this category. In some areas they may not differ much from 100-year flood in extent.

One reason for this is the added communication value of hazards and risks related to for instance 20- or 5-year floods.

It is very important that the information from the high probability event scenarios be taken into consideration in the water resources management and disaster risk reduction adaptation efforts. The more frequently a flood event occurs, the more important it is to take robust flood management measures to ensure the increased resilience of society against frequently upcoming events.

It is recommended to review the need for including mapping of high probability events, where this is not already done - in each review cycle, in the light of the possible impact of climate change.

Suggested action

- Make sure best available information (see above under Preliminary Flood Risk Assessment) is taken into account when flood scenarios are reviewed every 6 years.
- Present uncertainty related to climate change in a transparent manner in flood maps.

6.4 Flood Risk Management Plans

6.4.1 Flood Risk Management Objectives

Guiding principles

9. Incorporate climate change in setting flood risk management objectives
10. Ensure coordination at catchment level, also respecting the Directive's coordination requirements at RBD/unit of management level.

The Floods Directive requires Member States to set the flood risk management objectives, "focussing on the reduction of potential adverse consequences of flooding and, if considered appropriate, on non-structural initiatives and/or the reduction of the likelihood of flooding". The Flood Risk Management Plans shall in consequence include measures to achieve these objectives. The objectives of the WFD shall also be taken into account when establishing measures. The likely impact of climate change on floods shall also be taken into account in the review of the plans (FD Article 14 (4)). Member States will decide which types of objectives are set. In the light of the importance of potential impacts of climate change on floods, and the need to anticipate these as far as possible, it is recommended that climate change is taken into account already in setting the objectives for the first cycle of implementation of the FD, and some recommendations be given in the context of further information exchange in relation to the development of Flood Risk Management Plans.

In addition, it is necessary to pay special attention to the environmental objectives of WFD Article 4.1 to see how to best ensure the positive synergies between the two Directive, as some types of floods as well as some types of flood management measures (such as wet land restoration) can also have beneficial aspects for increasing the climate change resilience of ecosystems such as the ecology of the river and floodplain, soil fertility, groundwater recharge, and biodiversity.

When setting the objectives, the safety aspects of flood risk management need to be emphasised in view of climate change, in particular as regards civil protection measures.

Comprehensive policy frameworks exist for planning and decision making, such as Integrated Flood Management[40]. Those are based on risk management principles that recognize explicitly the residual risks on the floodplains while taking a comprehensive perspective of floods, river health, as well as benefits and risks of floodplain use.

Suggested actions

- Indicate how climate change plays a role in setting flood risk management objectives.

6.4.2 Awareness raising, early warning, preparedness

Guiding principle

11. Include climate change scenarios in ongoing initiatives and in planning processes.

Chapter 4 of this Guidance put forward a set of guiding principles that may help those with responsibilities in river basin management in building adaptive capacity for coping with climate change in the upcoming river basin management plans. These principles are also valid for flood risk management and are here complemented with recommendations specific to the flood risk management process.

Education and awareness raising

With climate change, flood awareness is likely to increase, and this needs to be managed in a constructive way, to make sure the right level of concern leads to the right management decisions. Awareness-raising campaigns can be considered as addressed to the public, to local authorities and politicians, and to other sectors influencing flood risk management. Increasing the awareness of increased flood risks, and how to cope with floods, in the education system is also important.

The awareness about the fact that the public can expect less ordinary events coupled with more extreme flood events needs to be raised. This should include education about: the source – pathway – receptor chain and all aspects of safety from prevention to recovery.

Education and other public awareness-raising measures would therefore be crucial for preparedness, prevention and protection, and as such can be important measures in future FRMPs.

Involvement of stakeholders

A holistic approach needs all public and private stakeholders to be involved. It is important to raise awareness, but also to help identify acceptable optimal flood risk management measures. An important example is to involve local planning authorities in the process (see further text on land use).

[40] Refer: http://www.apfm.info/pdf/concept_paper_e.pdf

Full use should therefore be made of the consultation mechanism (Article. 9) to ensure active involvement of interested parties in the river basin and flood risk management process, regarding the climate change related role of significant drivers and risk receptors.

Make sure potential changes to flood risk are built into multi-hazard disaster risk reduction civil protection/emergency measures

Climate change may in many areas lead to an increase in number and intensity of hydrometeorological hazards, including weather-driven events like floods. This will create situations where urgent response civil protection interventions will become more necessary. Improving early warning systems, enhancing preparedness on EU and Member State level of simultaneous events, improved preparedness of population and further climate proofing of civil protection, including coordination and funding, will be important to take into account in the planning for future civil protection. Flood risk management therefore also needs to take increased pressures on civil protection due to climate change more into account in planning. Cooperation between flood risk management authorities, water management authorities and emergency response authorities may need to be improved in some cases.

Suggested actions

- Include climate change related flood risk changes in ongoing education initiatives to improve flood risk awareness and preparedness.
- Improve institutional awareness of potential climate change related impacts on flood risk, for instance ensure that authorities responsible for climate change adaptation and flood risk management coordinate with river basin management.
- Ensure all interested parties are involved in the consultation process for the Flood Risk Management Plans.
- Increase the resilience of civil protection and disaster management infrastructure in view of climate change.

Example 6e: "Early warning and preparedness"

It is better to be prepared by preventing floods and other consequences caused by climate change. **Early warning** is one important complementary measure to take, but it does not replace the need for preventing climate change in the first place. Early warning is also one of the measures that are efficient under current and all possible future climate change conditions: a no-regret measure. The effect of early warning increases when floods can be predicted earlier. Flash floods and cloudbursts cannot be predicted very accurately, neither their geographical occurrence or their time scale. The rise on larger European rivers can be predicted further in advance, thus allowing for a larger range of actions. Coastal water levels are in general predictable a few days in advance, but a determining factor for flooding to happen is usually the behaviour of defences (dunes, dikes, quay walls, etc.), as it is the case for dike-protected areas along rivers. Breaching causes an immense volume of water flowing into the hinterland with high flow velocities close to the breach.

Preparedness means that all plans and procedures are ready and usable on any moment, that inspections of the current situation are carried out and reparations are done when necessary. In the emergency and response stages, all effort needed to minimize loss of life and damage and that can be considered realistic should be prepared and carried out. The review is adapting the procedures and improving the preparedness phase because the question, with and without considering climate change, is never: "will there be a next event?" but "when will the next event occur?". A red line through all these phases is communication: communication about preparations made by public authorities and about what people can (or have to) do during the preparation phase; communication as 'take action' commands in the emergency and response phase; and explanation of lessons learned and new insight (e.g. in the severity of climate change) in the review. Communication is not a matter of specialists only and is, in the preparedness and review phase, more a dialogue with all stakeholders than one-way-communication about model results.

6.4.3 Measures

Summary of guiding principles

12. Perform a climate check of flood risk measures

13. Favour options that are robust to the uncertainty in climate projections
    a. Focus on pollution risk in flood prone zones
    b. Focus on non-structural measures when possible
    c. Focus on "no-regret" and "win-win" measures
    d. Focus on a mix of measures

14. Favour prevention through the catchment approach

15. Take account of a long term perspective in defining flood risk measures (e.g. with respect to land use, structural measures efficiency, protection of buildings, critical infrastructure, etc).
    e. Include long-term climate change scenarios in land-use planning
    f. Develop robust cost-benefit methods which enable taking into account longer term costs and benefits in view of climate change.
    g. Use economic incentives to influence land use [Link insurance]

16. Assess other climate change adaptation (and even mitigation) measures on their impact on flood risks:
    h. Hydropower and flow regulation
    i. Link with water scarcity

The guiding principles are explained one-by-one in more detail in the following paragraphs. Please check also section 5.7 for guiding principles and elaboration on measures for adaptation related to the WFD.

Guiding principle

12. Perform a climate check of flood risk measures

As for other aspects of water management referred to in this guidance, climate change checking of flood risk management measures is crucial. No-regret or low-regret measures should be favoured when considering options (see also guidance provided in chapter 5.7 on measures in general). It will be crucial to consider questions such as "Are planned measures to be taken by 2015 still the best to be taken, knowing that the situation may change in 2050 (especially when a dyke has a lifetime of 50 years)?"

Although changes may not appear in the planning period (2015-2021 for instance) but for instance in 2050, the effects of the mitigation and prevention measures often have a longer lifetime, and all measures included in the flood risk management plans should therefore be climate checked.

Further examples are given below.

Guiding principle
13. Favour options that are robust to the uncertainty in climate projections

Assessing potential future flood risk is a core task of flood risk management, and the process carries many inherent uncertainties. As climate change only forms part of the flood risk, which also comes from a range of other drivers that have uncertainty attached to them, an assessment of the various factors causing such uncertainty, including climate change, is necessary to manage uncertainties.

The assessment of flood risks and planning to reduce them in view of climate change impacts must be done in an uncertain context. In this particular context, the precautionary principle has to be applied.

Pollution risk in flood prone zones

An area which is heavily polluted requires that the FRMP includes a management response if the area is in a flood zone. Today the hypothesis may be that the area will not be flooded so often, and the management response may be limited as knowledge exists on how to handle the situation under such a hypothesis.

The flood risk management should take into account, however, that the area might flood much more often due to climate change, therefore possibly increasing the flood hazard, and the choice of management mechanisms may be different. This may for instance affect the choices made between building permanent defences, relocating the installation out of the floodable area, or even remove the polluted soil.

Non-structural measures

In recent years, flood management policy has shifted from defensive action towards management of risk and enhancing societies' ability to live with floods via increased use of non-structural flood protection measures. Spatial planning, including regulation of floodplain development and relocation, can consider more 'room for rivers' and could have effects for both floods and low water. Non-structural measures, which do not involve large structural components, can be rated as more flexible, less committing and more sustainable than hard measures. Yet, the latter may be indispensable in certain circumstances[41]. Technical flood protection measures are often necessary to handle the effects of rare major events. Water managers are thus faced with the challenge to **design a site-specific mix of both types of measures, which may be altered or are robust to changing conditions**.

No regret and win-win measures

Another way of dealing with uncertain impacts of climate change is to prioritise "no regret" or "win-win" measures. In this context the flexibility of measures is an important criteria. Dykes that can be increased in height during a flood event are one example.

Example 6f: Promoting "no-regrets" options in view of climate change

During the pilot Catchment Flood Risk Assessment and Management (CFRAM) studies in Ireland, analysis was undertaken, including flood mapping, of two possible future scenarios based on

[41] Kundzewicz, 2002

projections of the impacts of changes in climate and land use. An objective was set within the option appraisal framework to promote adaptability to the effects of such changes within any measures under consideration for adoption within the Flood Risk Management Plan, and the temporal coherence of the Plan was evaluated to promote a 'no-regrets' approach. While the process implemented during the pilot stage will be refined, it is considered that the approach promoted adaptability to climate change within flood risk management.

A win-win measure may furthermore be a measure that at the same time reduces flood risk and has other positive aspects such as improvement of the quality of the aquatic environment, which is the case of wetlands or sustainable urban drainage. Other examples are flood reducing measures having positive effects on generating green energy, recreation, landscape quality etc.

A tool-box of for instance different good practices on sustainable urban drainage could be usefully developed.

The development of a 'catalogue' of possible "no-regret" measures (measure feasible under actual climate conditions and different climate scenarios) at the European level with examples from different parts of Europe, could facilitate the identification of such options.

Mix of measures

Faced with the situation that adaptation activities are necessary, but scenarios are still uncertain, the best option may be to identify the most optimal mix of measures. The catchment approach section below indicates one such example, but this can also entail a mix of non-structural measures such as education, change of private property owners' responsibilities, economic incentives, better forecasting, improved collaboration, as well as improvement/introduction of structural measures.

Guiding principle

14. Favouring prevention through the catchment approach including the need for transboundary cooperation on prevention

The so called "catchment approach" to flood risk management may be favoured in the face of climate change to ensure all possible flood hazard reduction measures are taken across the catchment, so as to decrease the pressures on structural flood defences downstream. An explanation of what is meant by the "catchment" approach, and why this approach is beneficial in view of climate change as no-regret options, is given below.

The catchment approach to flood risk management can offer real benefits and advantages to flood risk managers. The catchment approach provides the appropriate spatial unit of management: the basin or sub-basin. The catchment forms the arena for risk and hazard mapping and enables the causes and effects of flooding to be examined and linked. This, in turn, helps identify where and how floods arise and have their impacts. Ultimately, this supports the identification and selection of measures for reducing flood risk to people and business and the environment.

For example, river flooding may occur in communities because of a combination of local and upstream factors. By identifying and describing the flood processes within the catchment, these factors can be revealed. Examples of measures that can be combined to reduce flood risk included planning to avoid flood risk areas; building flood resilient properties; better flood warning systems; soft and hard engineering in highly urbanised areas; natural flood management techniques such as wetland restoration and renaturalisation of river flows; sustainable urban drainage schemes and at-risk property removal.

The process is particularly suitable for climate change adaptation measures and water resource management plans, both strongly linked to economic, social and environmental sustainability. For example, some flood risk management is likely to consider natural flood management, i.e. the restoration of natural features of the environment that contribute to storing or slowing flood waters. Several of these measures, such as the reconnection of rivers to flood plains or the restoration of wetlands, slow the flow of water downstream and lead to a more natural flow regime within a catchment. In addition to the flood risk benefits, these approaches can deliver a wide range of environmental and biodiversity benefits, assist the climate change adaptation agenda, contribute to electricity production from hydro developments and support industries reliant on a regular supply of clean water.

By improving understanding of flooding processes and the links between rural and urban areas, as well as those between neighbouring and distant member states, a catchment approach can help direct resources to cost effective options so as to reduce flood risk, which can also have the potential to deliver a wide range of coincident benefits.

Guiding principle:

15. Take account of a long term perspective in defining flood risk measures (e.g. with respect to land use, structural measures efficiency, protection of buildings, critical infrastructure, etc).

Ensure land use / spatial planning is robust in view of climate change

In view of climate change, more efforts are needed to ensure flood risk is considered in spatial planning and in other local land use management. Locating a new housing project close to a lake or river which is likely to become flooded even more often in the future may not be a way of reducing potential flood damage in the future, and it may be very costly. Such decisions are taken today, and even if the increased floods of increased sea/water levels are not a threat today, the project is clearly supposed to be located at that place also in 2050 or 2080, when climate change is expected to have more severe effects. Relocation of such assets at a later date may not necessarily be a cost-effective option. Likewise, the decision on whether to give more room to the river (by moving dykes for instance) instead of increasing the height of a dyke - which also involves a land use decision - is a measure with a long expected life time. Also in the shorter term, if building in a flood-prone area cannot be avoided, then the importance of building flood resilient buildings is an example of a measure with long term effects.

It is therefore crucial that flood risk management and spatial planning should even today closely take into account climate change scenarios, and for these links to be legally strengthened. Flood Risk Management Plans shall furthermore take into account spatial planning and land use, and may include promotion of sustainable land use practices.

Member States may include measures towards this aim in the FRMPs:

- MS may include changes or clarifications of the legal situation regarding building in flood-prone areas (in some cases stronger legislative basis for spatial planning),
- New buildings or new infrastructure should be built so that already built-up areas will be safer and protected against floods.
- Considerations of moving assets (economic, humans, critical infrastructure…) away from high flood risk areas – relocation.

Short-term vs. long-term considerations in cost-benefit assessment

Identifying long-term changes in the climate patterns now can help prevent that "regret decisions" are taken that will increase vulnerability in the future. These actions will benefit in the long-term perspective. One example is land-use decisions (see above).

When taking climate change into account in the consideration of measures, it is also important to consider the uncertainty associated with climate change objectives, and also the temporal planning of measures (i.e., sequenced projections of measures to be implemented over time).

This is also the case when carrying out cost-benefit assessment for flood risk management measures. It is furthermore important to properly take into account (and evaluate) the long term costs and benefits, and not just consider the short term, especially since benefits will be long term but costs short term. An important example relates to loss of agricultural land, where the benefits to society of long-term food security should be included rather than simply using the market (private) value of land.

Use of economic incentives

Risk awareness can be increased with the help of economic instruments, including the use of insurance premiums to send the right incentive price signals regarding the potential flood risk of an individual property in flood zones. Apart from giving an incentive for building in a flood-resilient manner, insurance policies are of course an important instrument at the end of the "safety chain", as they help to restore flood damage. Therefore, the future role of insurance in view of climate change and floods needs to be considered.

Guiding principle
16. Assess other climate change adaptation (and even mitigation) measures on their impact on flood risks

Hydropower and flow regulations

New modifications to water bodies (hydropower dams for instance) may change flood risks and there is a need to coordinate and exchange information between WFD and FD management.

Existing dams can also contribute to flood risk management. This should be recognised in flood risk assessment and management.

Dams and reservoirs, if properly planned and managed, can be considered as an important part of integrated water management schemes under climate change conditions. Multifunctional dams may contribute to water storage (for drinking water supply), flood protection, hydropower, stabilisation of discharge downstream in times of drought for ecological purposes, maintenance of water abstraction and discharge for power plants, navigation, recreation, fishery and nature protection."

Such dams are subject to operation licenses (also called concessions in some countries) for hydropower schemes in which the regulating national authorities establish the conditions under which a power plant shall be operated at different moments of the year and sometimes even of the day. This license/permit contains detailed conditions for river flow regimes and minimum and maximum water levels to respect according to the season, so that for example enough storage space is in the reservoir to absorb the spring flood. The WFD also requires that such permitting regime of impoundments are regularly reviewed.

Storage power plants have an important effect in reducing local floods, but run-off-river power plants can also have a positive effect, especially on smaller and medium flood events. The way the water flows are regulated in such rivers should take potential changed flood patterns into account, to make sure flood risk isn't increased, but rather decrease in the way the flow is managed.

Example 6g: Hydropower in Sweden

In most of the major rivers in Sweden there are cascades of dams and hydro power plants built for electricity production. The dams and the hydropower plants are owned by the electricity producers. Permission for the facilities and for the water regulation is given by environmental courts after a trial where concerned interests are scrutinized and balanced. The power plants are run in cooperation with other dam and other plant owners within the river. A secondary effect of the river regulations has been that floods and inundations occur less frequently, especially in spring time (related to snow melt).

A committee, with representatives from authorities and the power and mining industries, has been established with the assignment to study the vulnerability of the existing dams to climate change. Comprehensive work is ongoing with development of methods and analysis of effects on the magnitude of the 100-year flood and the design flood for dams based on data from several regional climate simulations from different European research institutes. The committee work increases the understanding of possible effects on the magnitude of floods in a changing climate as well as the related uncertainties.

Example 6h: Hydropower in Norway

In Norway, regulated rivers often host several dams and power plants which are operated by different owners. The operation license granted by the government for each power plant (including the related dams and dikes) regulates a coordinated flow regime for the whole river basin according to various needs, such as flood mitigation and protection of fish, to ensure safe ice conditions on the river for transport in winter, appropriate water volume in waterfalls for tourists, and so as to keep the fjords as much as possible ice-free. In the context of climate change, the melting glaciers combined with more intensive precipitations in winter increase the risk of winter and spring floods. Increasing the storage capacity of water will hence become a key issue, since the security of the electricity supply could be compromised if the reservoir levels have to be kept low in order to absorb winter and spring floods, while people need electricity to heat their houses during the cold winter season, 99 % of which comes from hydropower. Therefore in Norway water management is the responsibility of a special governmental agency, the Norwegian Water Resources and Energy Directorate, which assumes the integration of various water needs into an adequate operation licenses for all hydropower plants.

Example 6i: Managing multifunctional dams

The Czech Republic and Germany are sharing inter alia the transnational Elbe River Basin. As a consequence of the severe flood event in summer 2002, both countries agreed to assess and better integrate the Vltava / Moldau Dam Cascade and the Dams in Germany into the transnational flood protection scheme as stipulated in the Flood Protection Action Plan of the International Commission for the Protection of the Elbe. The snow melt flood in early spring 2006 bolstered the strategic approach to adaptively manage multifunctional dams in a national and transnational setting.

Link with water scarcity

For those areas where the hydrological regime might become more irregular and for which therefore more extreme droughts and floods are expected, two opposed responses can follow: volume increase of retained water resources behind dams to reduce drought severity, and greater free volume available behind dams to reduce flood discharges. Reservoir safety and management will in these situations require further attention.

Specific attention to this is therefore needed in flood risk management plans, including in different awareness-raising and preparedness measures.

Suggested actions

- Further development and exchange of good practices on adaptation measures related to flood management.
- Ensure land use / spatial planning is robust in view of climate change.
- Improve economic models to enable taking into account long-term costs and benefits in planning.
- Increased use of economic incentives, such as the cost of insurance being linked to flood risk of individual properties.
- Review permits for impoundments (see WFD) to make sure possible climate change related flood risks can be mitigated.
- Consider occurrence of multiple hazards in flood risk management, example of increased incidents of ephemeral floods.
- Develop tool-boxes and examples of "no-regret" and "win-win" measures, and exchange this information across the EU.

6.4.4 Links to WFD

Guiding principles

17. Pay special attention to the requirements of WFD Article 4.7 when developing flood protection measures
18. Determine on the basis of robust scientific evidence and on a case-by-case basis whether an extreme flood allows for the application of WFD Article 4.6.
19. Pay special attention to the vulnerability of protected areas in view of changed flood patterns

WFD Article 4.7 New modifications

As mentioned in chapters 5 and 5.7 of this Guidance, the implementation of specific adaptation measures, for instance infrastructure projects, might invoke WFD Article 4(7) (exemption for new modifications) more often in the view of climate change. Article 4(7) requires the identification and consideration of alternatives, i.e. "significantly better environmental options".

Proper consideration of the possible impact of climate change in the implementation of the Floods Directive will benefit the application of these objectives. The Flood Risk Management Plans should make reference to the application of these provisions in the WFD, in view of the need to take into account the environmental objectives in the FRMP (Article. 7, FD).

WFD Article 4.6 Temporary deterioration

The Guidance Document No. 20 on Exemptions to Environmental Objectives states that "It is most likely that "extreme flood" events falling under category (a) [low probability or extreme events] will require the application of a 'temporary deterioration'. However, floods with a higher probability of occurrence may also be regarded as "extreme floods" in circumstances where the impacts of such floods are equally exceptional or reasonably unforeseen."

What is an "exceptional flood" may change as a result of climate change, and flood risk managers must anticipate more extreme events. When use is made of Article 4.6 to justify temporary deterioration of status following a flood event, it is therefore important that all required conditions of Article 4.6 (WFD) are complied with, and that the implementation of the Floods Directive takes into account climate change in a way that facilitates the compliance with these provisions. As agreed by Water Directors in the same Guidance document, "In no way does the application of exemptions under the WFD give a Member State a possibility to make an exemption from the obligation of implementing all aspects of the Directive on the assessment and management of flood risks."

Further guidance on what constitutes exceptional floods in the context of climate change, changing the patterns of floods as regards location, intensity, and duration may be developed, as well as a practical guidance on how to comply with the conditions set out in Article 4.6 as regards for instance taking all practicable steps to avoid further deterioration.

The Flood Risk Management Plans shall make reference to the application of these provisions in the WFD, in view of the need of taking into account the environmental objectives in the FRMP (Article. 7, FD).

Protected areas and drinking water abstraction areas (WFD Articles 6-7)

The WFD protected areas are indicators in the Floods Directive for environmental impacts, and need to be considered in mapping and planning. The relevance for climate change is the impacts of more frequent flooding or flooding over longer periods of time of drinking water abstraction areas. It is therefore recommended that the FRMP includes measures such as:

- Increased incidents of high probability floods could help cleaning up; however the normally beneficial effects of floods could be reduced. There are uncertainties on the effects which need to be considered in flood risk management plans.
- There may however be a higher likelihood of contamination due to flood events of water bodies used for drinking water abstraction; the safety and availability of drinking water needs to be taken into account in FRMP. Subsequently, more resilience against the negative effects of floods is needed with climate change.
- There is also a higher likelihood of contamination of ready-to-eat fruit and vegetable crops, both directly from flooding and indirectly from less extreme events which cause contamination of irrigation water, due to increased sewer overflows for example.
- This is a learning process and this issue needs to be addressed in particular in the update of plans.

How to deal with uncertainties of flood risks needs to be fully taken into account when managing the protected areas and a process of joint/holistic management needs to be built, involving both water quality and flood risk managers.

Suggested actions

- Take into account guidance and expertise on catchment approach and non-structural measures when investigating "better environmental options" according to Article 4.7

WFD.

- Include information on exceptional floods giving rise to the use of Article 4.6 WFD, which is consistent and coherent with the information and measures included in FRMP.

7 DROUGHT MANAGEMENT AND WATER SCARCITY AND ADAPTATION

7.1 Introduction

This chapter deals with addressing specific effects of climate change in areas exposed to water scarcity and drought. In these regions, water is an essential and scarce resource. Many economic sectors are strongly dependent on water availability, and therefore a major challenge of water management is to balance water supply[42] and demand; this challenge will be aggravated by climate change.

Water scarcity and drought have been broadly documented as phenomena which are likely to be impacted by climate change in European countries (EC 2007a, IPCC 2008, EEA 2008), but climate change is only one of many pressures which must be faced by water management in these areas. If climate change produces a further reduction in water availability, the impacts in these regions may be very strong; therefore special consideration should be given to including climate change in hydrological planning.

As explained in chapter 2, an official Communication was issued regarding water scarcity and droughts (EC 2007b), which is one of the bases for the guidance provided in this chapter. As well as being in the focus of policy, water scarcity and droughts are also the subject of several European research projects concerning, for instance, management options under water stress (see Annex II).

In order to discuss adaptation in water management, it is essential to differentiate between the terms "drought" and "water scarcity".

The term "**drought**" refers to a temporary deviation from long-term average or normal conditions in a hydrological context with regard to water supply. It usually originates in a considerable reduction in precipitation over a significant period of time and with a substantial spatial extent. Through interconnection within the natural water cycle, changes in other climate or land surface conditions can also cause droughts, e.g. through an increase in ambient air temperature and consequently higher evapotranspiration rates. The propagation of droughts through the water cycle may cause temporary shortages in water supply; their impacts depend on vulnerability and coping capacities on the demand side. Climate change can affect the gradual change of average conditions, as well as the frequency and magnitude of deviations from them, thus affecting the occurrence of drought events.

The term "**water scarcity**" indicates a long-term imbalance between water supply and demand in a region (or in a water supply system) possibly characterized by a semi-arid or arid climate and/or enhanced by a fast increase of water demand, associated with population growth and/or an extension of irrigated agriculture. Climate change may create or intensify water scarcity problems in a region, either through a reduction in water supply or through an increase in water demand.

7.2 River Basin Management Plans as a tool for addressing water scarcity and droughts

In addition to the guiding principles in the sections below, one overall guiding principle covering drought management, water scarcity and adaptation can be highlighted:

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[42] Water supply refers to the quantity of water generally available and not only to water supply for a specific use, e.g. urban water supply.

Overall guiding principle

1. Use the Water Framework Directive as the basic methodological framework to achieve climate change adaptation in water-scarce areas and to reduce the impacts of droughts.

Guiding principles

2. Make full use of the Water Framework Directive environmental objectives, e.g. by the requirement to achieve good groundwater quantitative status to ensure a robust water system, which is more resilient to climate change impacts.
3. Determine, on the basis of robust scientific evidence and on a case-by-case basis, whether a prolonged drought allows for the application of WFD Article 4.6, and take into account climate change predictions in this case-by-case approach.
4. Pay special attention to the requirements of WFD Article 4.7 when developing measures to tackle water scarcity under a changing climate and which may cause deterioration of water status.

The River Basin Management Plans required by the WFD offer considerable potential to address drought consequences and water scarcity issues. This becomes even more valid under a changing climate, in which additional stress is put on water resources.

First of all, the planning process required by the WFD provides the right way of analysing pressures, setting objectives and putting cost-effective measures in place. There are many links between climate change adaptation measures related to water scarcity and droughts and the WFD environmental objectives, such as good groundwater quantitative status, sufficient surface water quantity to sustain ecological status, and also broader objectives such as rational water use. Specifically, the WFD requirement to achieve good groundwater quantitative status includes ensuring a balance between abstraction and recharge of groundwater. Also by the requirement of achieving good ecological status for surface waters, a river site-specific minimum flow needs to be established, which sustains the achievement of the site-specific objectives with respect to aquatic life. Measures to achieve these objectives have to be reported in the River Basin Management Plans. Such measures include the economic tools mentioned in Article 9 of the WFD (e.g. water pricing policies providing adequate incentives to use water resources efficiently).

It is recommended to consider the option of developing a specific drought management plan (DMP) to prevent and alleviate drought impacts (see CIS guidance on this topic[43]). The main objective of drought management planning is to minimize the adverse impacts on the economy, social life and environment when drought occurs, but also to provide prevention strategies for avoiding those impacts in the first place.

In case of exceptional or unforeseen prolonged droughts, the WFD allows for a temporary deterioration of water status. This should be reported in the river basin management plans, including related measures that will be taken in such situations, as well as restoration measures. Specifically, Article 4.6 of the WFD defines that "Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause or force majeure which are exceptional or could

43 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/scarcity_droughts/version_report_fvpdf/_EN_1.0_&a=d

not reasonably have been foreseen, in particular extreme floods and prolonged droughts, ...", provided that the conditions of Article 4.6 are met including among others taking all practicable steps to prevent further deterioration in status.

In addition, the requirements of the WFD Article 4.7 should be applied to any adaptation measures that modify the physical characteristics of water bodies, especially measures related to the development of new water infrastructure to tackle scarcity in a changing climate (see chapter 5.7.3 for guidance on the application of Article 4.7).

7.3 Monitoring and Detecting Climate Change Effects

Guiding principles

5. Diagnose the causes that led to water scarcity in the past and/or may lead to it in the future.
6. Monitor water demand closely and forecast it, based on improved knowledge about demands and trends.
7. Collect as much high quality information as possible to anticipate changes to water supply reliability, which may be imposed by climate change, in order to detect water scarcity early.
8. Distinguish climate change signals from natural variability and other human impacts with sufficiently long monitoring time series.

Water scarcity relates to long-term imbalances, hence it is not something that comes and goes and changes fast. Climate change may aggravate existing problems of scarcity and may raise problems that are just below surface (e.g. areas in which the demand/availability balance is close to friction). Water scarcity should therefore be "diagnosed" based on past and future water demands. Given the high degree of uncertainty of climate projections and the relevance of challenges imposed by climate change in semi-arid regions, it is essential that the climate change adaptation process be based on high quality information.

The monitoring of precipitation and its transformation into available resources should be used as starting point for monitoring water scarcity under climate change. In this context, it is also necessary to establish monitoring of water uses as well as monitoring of demand. The early detection of droughts requires an advanced monitoring system based on high-resolution hydrometric networks and a system of objective indicators.

The hydrometric networks will have to be adapted to track the impact of climate change on water resources (see also guidance on monitoring under the WFD in chapter 5.4). Hydrometric networks were designed primarily to obtain average values and seasonal and interannual variability of precipitation and streamflow series on the assumption of stationarity. Currently, it is difficult to obtain even those average values, given the deep human intervention on the hydrological cycle in water scarce regions. However, it is critical to identify the impact of climate change on water resources in a natural regime for the gradual establishment of adaptation policies and for monitoring their implementation.

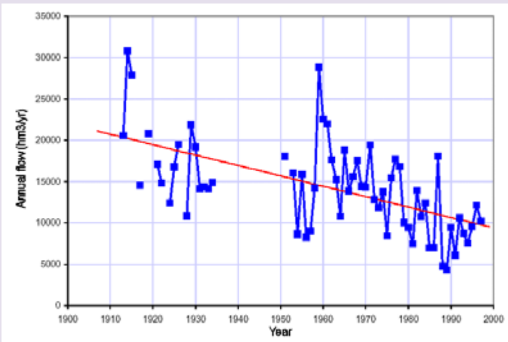
In areas suffering from water scarcity, the balance between demand and supply is already broken. When this current unsustainable balance between water supply and demand is aggravated by climate change, more areas or more catchments will be subject to water scarcity. Therefore, the intensification of monitoring should be accompanied by the development of a comprehensive set of indicators, which can assess the impacts of water scarcity and of eventually increased droughts.

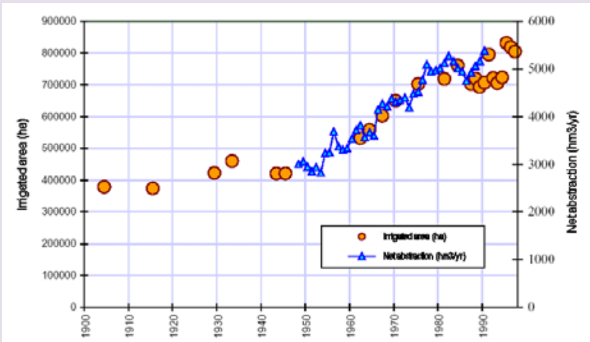
Suggested actions

- Adapt the hydrometric networks to track the impact of climate change on water resources, providing enough redundancy to obtain accurate estimations of naturalised streamflow series from observation, closing the water balance in each sub-basin.
- Establish already now a monitoring system of water uses as well as demand monitoring.
- Develop a comprehensive set of indicators at appropriate temporal and spatial scale which can link phenomena in order to predict drought and water scarcity impacts.
- Diagnose water scarcity based on past water demands and improve knowledge about past and current water demands and on future trends, incorporating climate change projections.
- Analyze how predicted changes in mean annual runoff will change supply reliability and how those changes will affect the socioeconomic system behind the water resources system.

Example 7a – Trend detection in the lower Ebro river

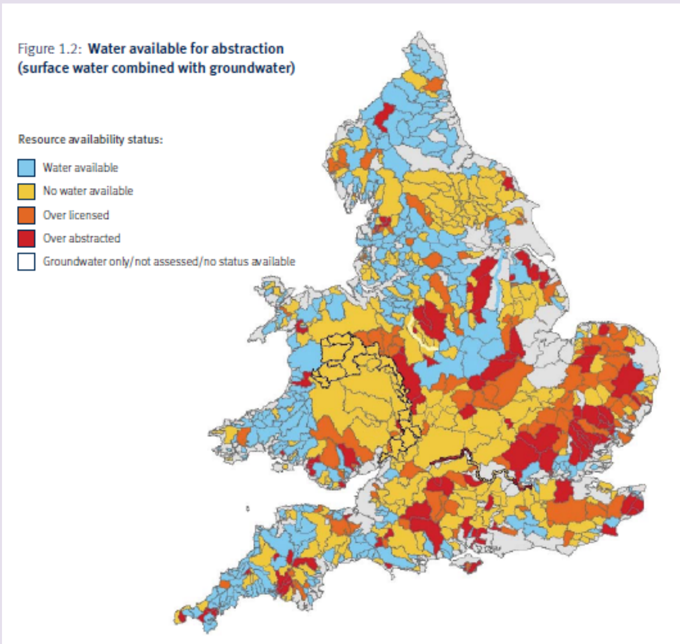
The subject of natural flows in the lower Ebro has been one of intense controversy throughout the years. The observed flows at the most downstream station of the Ebro river in Tortosa (figure on the left) show a decreasing trend which has been attributed to climate change. However, the analysis of a series of natural flows obtained through rainfall-runoff modelling, combined with the observed record at Tortosa and the storage fluctuations in the reservoirs allows an estimation of water consumption in the basin, which correlates quite well with the historic development of irrigated areas in the basin as shown in the figure on the right. Only a very dense monitoring network would be able to assess whether a decreasing trend of natural flows in the Ebro river is really occurring.





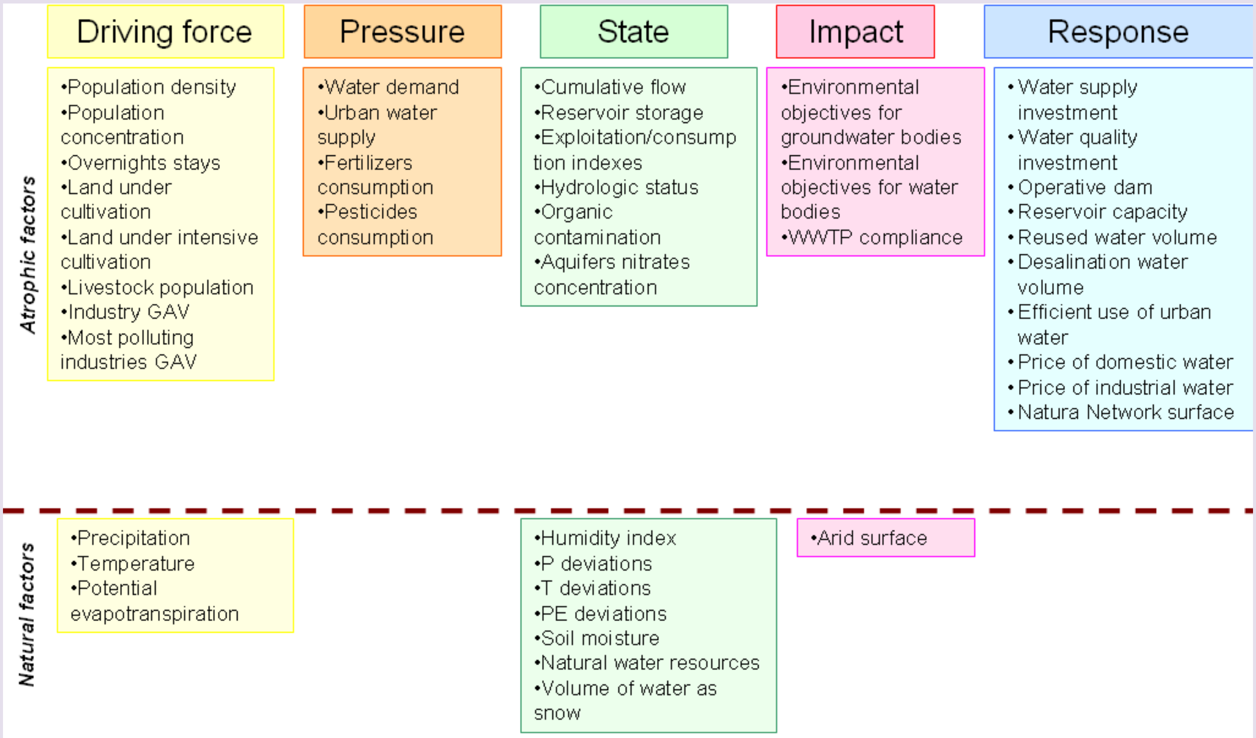
Example 7b – Monitoring of water availability for abstraction developed for the U.K.

We assess the availability of water resources for licensing as part of a programme of Catchment Abstraction Management Strategies (CAMS). CAMS consider the rainfall reliably received, the water requirements of the environment and the amount of water licensed for abstraction. They show us where water is potentially available for abstraction. In 2008, we completed assessments for 119 CAMS, and for the first time, we now have consistent information on potential resource availability on a catchment scale for all of England and Wales (Figure below):



Example 7c – Structure of indicators developed by Spain

The Integrated System for Water Information developed by Spain provides support for the system of drought indicators which are used to detect and declare risk of water shortage in water supply systems. The figure below shows the complexity of the structure of the system of indicators, which combines natural and anthropogenic factors.



7.4 Adaptation measures related to water scarcity & droughts

Guiding principles

9. Take additional efforts to prevent water scarcity and be better prepared to tackle the impacts of droughts.
10. Incorporate climate change adaptation in water management by continuing the focus on sustainability (sustainable balance between water availability and demand).
11. Follow an integrated approach based on a combination of measures (compared to alternatives based on water supply or economic instruments only).
12. Build adaptive capacity through robust water resources systems.
13. Involve stakeholders for engagement to realise decisive measures to tackle water scarcity.
14. Assess other climate change adaptation and mitigation measures on their impact on water scarcity and drought risks.

Most problems anticipated as a result of climate change are in fact an aggravation of current structural problems due to already existing imbalances between water supply and demand. Climate change will imply more radical measures than those already necessary without climate change. Climate change adaptation policies are targeted to prevent or correct these problems, and therefore they will be equally effective in addressing currently existing water management problems. Accordingly, the determined implementation of adaptation strategies will produce beneficial results in a wide range of climate change scenarios. In particular, efforts to prevent water scarcity (including actions on water user awareness raising) and to be better prepared to tackle impacts of occurring droughts should be further intensified.

From the viewpoint of the development of the program of measures (POMs) in RBMPs, taking climate change into account in regions with limited natural water availability should lead to an intensification of policies for demand management as a way to more efficient water management. It is important to always keep the long term in perspective. Some solutions which are perceived as adequate for a stationary scenario may not be so in the long term, under climate change effect.

The first option should always be to intensify actions on demand management to reduce pressure on the water supply sources, especially in times of drought. The greatest scope for action is in irrigation demands, which usually account for the largest fraction of total demand in water scarcity regions. The POMs should include the information and education of citizens to promote or impose the use of domestic water-saving techniques and the intensification of programs for avoiding leakage in water distribution networks and reducing public demand. In a scenario of potential reduction of natural resources, supply-enhancement measures could also be used, promoting non-conventional water resources including wastewater recycling. Under the possible changing conditions in climate change scenarios, it is essential to diagnose the causes that led to water scarcity in the past or may lead to it in the future (see section 7.3) and to set up appropriate regulations to restore a sustainable balance. For this task, the use of market-based instruments should be assessed to address problems caused by water scarcity. It is essential to perform an economic assessment of water use and water value, promoting the efficient use of water by installing individual meters and establishing a pricing policy that penalizes excessive water consumption. But most importantly, monitoring of demand is needed to inform the decisions on supply measures versus water demand management measures.

Suggested actions

- Use the social awareness of the climate change problem as an opportunity to identify the best solution to current challenges in the management of water resources and to correct major environmental problems
- Continue with the options proposed in the Communication on WS&D of 2007: putting the right price tag on water, allocating water and water-related funding more efficiently, improving drought risk management, considering additional water supply infrastructures, fostering water efficient technologies and practices, fostering the emergence of a water-saving culture in Europe, improving knowledge and data collection, etc.

Climate change adaptation will require the progressive reduction of water consumption and the reallocation of water availability to those uses that are deemed socially as more appropriate. These changes cannot be improvised and water managers and decision-makers in water scarcity regions should not wait until the effects are evident to start building adaptive capacity in their river basins (see also chapter 4 for guiding principles on building adaptive capacity).

In a climate change context, the traditional concept of water resources planning should be revised. It will no longer be an activity primarily aimed at increasing the availability of water resources to meet growing demands. **Water resources planning should rather strive to develop effective ways of managing the growing scarcity of the resource, mostly through demand management measures**.

Moreover, synergies with other fields of water management have to be used more consistently. For example, maintaining certain minimum water flows also under changing (climate) conditions is necessary for both achieving the environmental objectives as well as ensuring the function of rivers as waterways for transportation. Early co-ordination in selecting and planning of adaptation measures could therefore serve both purposes.

Water use efficiency varies tremendously across regions and across different users (i.e. agriculture, households, industry). Some member states already successfully reduced domestic and industrial water use through water-saving policies. Demand management needs to consider that cost-efficiency of additional measures therefore differs for different user groups and regions.

It is also important to enhance the performance of water supply systems by increasing their robustness. Robustness can be built into water resources systems through the expansion and diversification of supply sources and their integration in combined systems. The sources of water supply from different origin can have very different characteristics. Resources of different nature (e.g. surface and groundwater) show highly significant differences in terms of variability and reliability. Even the same kind of resources (such as the regulation of surface water), but for different locations, will show the logic differences in terms of hydrological conditions on each site and the characteristics of their hydraulic systems. Systems that integrate a large number of supply sources can best respond to situations of scarcity through integrated water resources management, using every resource for the purposes that is more appropriate depending on its amount, regularity and reliability. The integration of different kinds of water demands in conjunctive systems allows the satisfaction of the most important demands through the use of strategic reserves or the exchange of water rights. In the long term, investment in improving the performance of water supply systems delivers adaptation benefits.

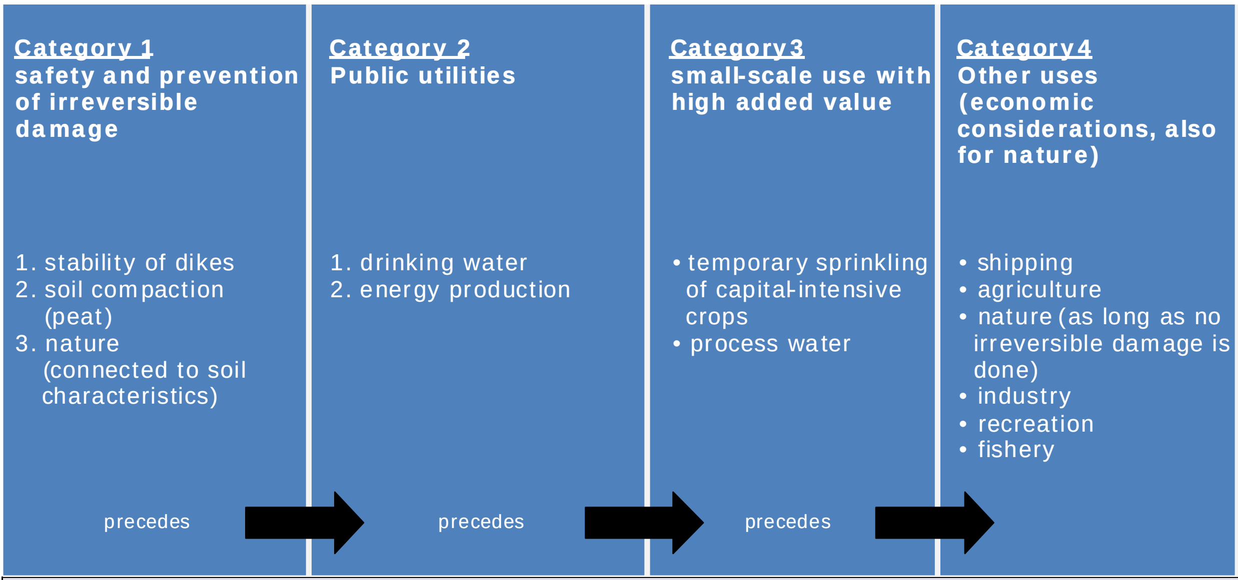
Suggested actions

- Strengthen the institutions in charge of water management to prepare them for the challenges that lay ahead. If necessary, adjust their role from traditional water supply to water demand management
- Build robustness into your water resources system by integrating multiple sources of supply and water demands in conjunctive systems and by improving and enlarging water transportation and distribution infrastructure to achieve the best possible allocation of available resources in future water markets
- Discuss adaptation measures related to water scarcity and droughts in a transboundary and interdisciplinary context

Example 7d: Two-track approach for sustainable freshwater supply in the Netherlands

Existing freshwater supply agreements in the Netherlands will remain in force until 2015. Under normal circumstances, policy is geared towards meeting users' needs wherever possible; as yet, no big problems are expected until 2015, again under normal circumstances. In periods of water shortage (in warm and dry summers), water will be distributed on the basis of the list of priorities and the damage to be contained.

In the planning period 2009 - 2015, the central government will be making long-term decisions on freshwater supplies and salinisation control, including any infrastructure measures and land use planning this may require (see chart below). In the coming planning period, possible solution



strategies are to be worked out with the regions. The key aspects of this new strategy are greater levels of regional self-sufficiency and optimisation of the freshwater distribution in the main and regional water systems. For this too, the central government, the regions and the users will be hammering out solutions in the coming planning period. With the help of long term scenarios, it will be investigated what can be achieved with current policy. In case of a tipping point, a broad range of possible measures is looked at, including moving specific functions as agriculture or nature to water abundant areas. Solutions and areas will be considered as a cohesive whole and the (spatial) consequences for regional systems and functions (drinking water, agriculture, nature and shipping) made transparent.

Example 7e: Successful water demand management in Germany

Domestic drinking water use has been reduced by about 30% in Germany since the 1980ies due to changes in consumer behaviour and technological innovations. This was realized through a combination of various factors:

- A number of studies on future water demand published in the 1970s predicted a tremendous increase in water use for the upcoming decades
- This information was acknowledged by a growing public concern about environmental issues during the 1980s
- In a lose but nevertheless close interaction different actors, i.e. governmental bodies and public authorities, NGOs and water utilities promoted water saving and provided consumers with information about water saving
- A water-saving culture became part of day-to-day life and changed people's habits ranging from lawn watering and rainwater harvesting to tooth brushing.
- Obligatory water meters and water pricing according to consumption were already in place, forming water-saving incentives for private households.
- Manufacturers responded quickly with water-saving innovations for washing machines, dish washers, toilet flushers, shower taps, etc.

Meanwhile, the success of water saving causes extra costs and efforts in drinking water supply and wastewater disposal, e.g. for additional disinfection in case of longer residence times of drinking water in mains, more frequent flushing of sewers, or increased treatment efforts in case of higher concentrations of wastewater contaminants.

Glossary

ACCC	Austrian Climate Portal
AEMET	Spanish Meteorological Agency
AG	Adour Garonne district, France
AOGCM	Atmospheric and Oceanic Global Circulation Models
AR4	Fourth Assessment Report of the IPCC
AR5	Fifth Assessment Report of the IPCC
BMLFUW	Federal Ministry for Agriculture, Forestry, Environment and Water Management
CAMS	Catchment Abstraction Management Strategies
CC	Climate Change
CEE	Central and Eastern Europe
CERF	Continuous Estimation of River Flows
CES	Climate and Energy Systems
CFRAM	Catchment Flood Risk Assessment and Management
CHMI	Czech Hydro Meteorological Institute
DMP	Drought Management Plan
DSS	Decision Support System
EDO	European Drought Observatory
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ERA	European Research Area
ESPACE	European Spatial Planning Adapting to Climate Events
EWP	European Water Partnership
FD	Floods Directive
FRMP	Flood Risk Management Plan
GHG	Greenhouse Gas
GIEC	Groupement d’Experts Intergouvernementaux sur l’Evolution du Climat
GIS	Geographic Information Systems
GMES	Global Monitoring for Environment and Security
ICPR	International Commission for the Protection of the Rhine
IPCC	Intergovernmental Panel on Climate change
MS	Member State
NAO	North Atlantic Oscillation
PFRA	Preliminary Flood Risk Assessment
PoM	Programme of Measures
ÖWAV	Austrian Water and Waste Management Association

RACCM	Regional Assessment of Climate Change in Mediterranean
RBD	River Basin District
RBM	River Basin Management
RBMP	River Basin Management Plan
SEA	Strategic Environmental Assessment
SMHI	Swedish Meteorological and Hydrological Institute
SRES	Special Report on Emissions Scenarios
SSG	Strategic Steering Group
STW	Sewage Treatment Works
SUDS	Sustainable Urban Drainage Systems
SYKE	Finnish Environment Institute
WFD	EU Water Framework Directive
WFD-CIS	WFD Common Implementation Strategy
WSFS	Watershed Simulation and Forecasting System
UKCP09	UK Climate Projections
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change

Annex I: Adaptation actions/measures – Sources of information

The evidence base for adaptation is not wide, as work is still at an early stage. However, with the establishment of national adaptation strategies and in many cases webportals on climate change adaptation, there is a increasing amount of information and case studies that may be used for establishing an overview of relevant adaption actions/measures for the specific RBD and the specific pressures.

There are a number of inventory gathering adaptation case studies which, to some extent, describe the experience with implementation:

- **EEA and its Topic Centre on Water** have in 2008 and 2009 worked on a report describing good practice examples in relation to adaption in water management (to be published in the second half of 2009). The report's main objective is to compile examples of measures/actions that are relevant for WFD purposes and that can be considered good-practice for adaptation to climate change. It aims to support the efforts of incorporate climate change aspects into their river basin management planning.
- Other **databases for adaptation measures** and concepts are:
  - UNFCC Database of submissions on adaptation planning and practices under the Nairobi work programme: The database provides a query mask to select measures according to country, geographical scale, sector and type of measure http://maindb.unfccc.int/public/adaptation_planning/
  - AMICA-CLIMATE is a European Interreg IIIC initiative which has tried to make the adaptation process more transparent http://www.amica-climate.net/online_tool.html
  - UKCIP Adaptation action case studies. National approach which is a good example of hands-on guidance to become active http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=286&Itemid=423

Adaptation tools and Decision Support Systems (DSS) available online (examples):

- Adaptation toolkit for local councils: "Developing a local authority Climate Change Action Plan"
- Communication strategies for CC: http://www.sustainable-scotland.net/climatechange/index.asp?pg=8

Annex II: Summary of information resources and relevant research

EXAMPLES OF INFORMATION NETWORKS IN EUROPE

This section gives indications to those with river basin management responsibilities of key sources of further guidance and information concerning adaptation to climate change in Europe, especially with regard to water issues.

Common Implementation Strategy of the WFD (WFD-CIS)

The European Commission and Member States established a Strategic Steering Group (SSG) on Climate Change and Water under the Common Implementation Strategy. The SSG convened in Sep 2007 for the first time. Since then it aimed at integrating adaptation to climate change into the WFD implementation process. The guidance at hand is a product of the preparatory work of the SSG.

UNECE

The United Nations Economic Commission for Europe established a Task Force on Water and Climate under the Convention on the Protection and Use of Transboundary Water courses and International Lakes. The Task Force produced Guidance on Water and Climate Adaptation[44] for decision makers and water managers, in particular at the transboundary level. The Guidance provides a framework to develop step-by-step an adaptation strategy taking into account usual barriers. It provides also an overview of potential adaptation measures. In addition, a Task Force on Extreme Weather Events has been established, which prepares Guidelines on Water Supply and Sanitation in Extreme Weather Events (deals with extreme weather events due to Climate Change and their impact on drinking water supply and waste water treatment).

EWP

The European Water Partnership (EWP) is in the process of setting up a European Dialogue on Climate Change Adaptation and Water[45]. This Dialogue will focus on raising awareness, exchanging experiences and best practices between all stakeholders and the set up of concrete projects to help make sure Europe is safe from climate change. It will be a focal point for coordination in Europe, as well as towards the outside world.

Clearing House

The European Commission is for the moment exploring the possibilities of establishing a Clearinghouse on climate impacts and adaptation. The aim is to develop both the software and information architecture for a planned repository ('Clearinghouse') on adaptation. In the future this could be one of the major sources of information on adaptation measures.

ADAM Digital Compendium on Adaptation

This Digital Compendium[46] acts as a portal for the dissemination of the transdisciplinary analysis results carried out in the EU ADAM project[47] (see also section on relevant research projects below). It comprises an adaptation catalogue with possible adaptation measures including information on the extent, feasibility, efficiency, and cost effectiveness of these

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[44] http://www.unece.org/env/water/water.and.climate.htm

[45] http://www.ewp.eu/projects/water-and-energy-climate-cca

[46] http://www.digital-compendium.adamproject.eu/

[47] ADAM - Adaptation and Mitigation Strategies: supporting European climate policy. http://www.adamproject.eu/

measures. It is accompanied by key messages about what supports and what hinders adaptation together with a set of learning examples, and a macro-economic analysis estimating the monetary effects of climate change and adaptation for different European countries.

RELEVANT RESEARCH PROJECTS

Integrated research on the functioning of climate and on understanding climate change impacts represents a key component of decision-making regarding adaptation and mitigation. This includes studies on the past evolution of the earth and marine system, including polar regions, and prediction of their future evolution including observations, experimental studies and advanced modelling and taking into account the anthropogenic forcing. Scientific outputs are recognised to be essential for the development of effective adaptation and mitigation measures to climate change and its impacts. For examples, advanced climate change models at the global and regional scales are developed and used to better design measures at various scales. In relation to climate change impacts on water, these models enable study of changes in atmospheric composition for all components of the water cycle. Different approaches are being investigated to translate the output from the climate models to the river basin scale, for example to design risk based approaches to tackle climate related hazards such as droughts, storms and floods.

Research on climate change is closely linked to policy developments at EU level as highlighted in the White Paper on adaptation to climate change and on-going discussions about integration of adaptation and mitigation measures in the river basin management planning of the Water Framework Directive. Scientific outputs are also contributing to international policies and debates, in particular through inputs to IPCC assessment reports and UNFCCC documents. In this context, projects of the 6th Framework Programme (2002-2006)[48] and of the on-going 7th Framework Programme (2007-2013)[49] largely contributed to gathering knowledge relevant to climate change adaptation in the context of the WFD river basin management planning. Research areas are exemplified by projects described below (the list is obviously far from being exhaustive – an updated list of projects in support of climate change research is available[50]), highlighting their potential to be linked to policy developments.

Research into climate change scenarios

PRUDENCE and ENSEMBLES projects

Research on climate change scenarios and predictions have been ongoing and expanding in the last few decades. For example, the PRUDENCE project (2001-2004)[51] has provided a series of high-resolution climate change scenarios for 2071-2100, including an analysis of the variability and level of confidence in these scenarios as a function of uncertainties in model formulation, natural/internal climate variability, and alternative scenarios of future atmospheric composition. A continuation of this research line is illustrated by the ENSEMBLES project (2004-2009)[52], which integrates climate change impact studies into an ensemble prediction system, quantifies the uncertainty in long-term predictions of climate change and

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[48] In particular projects funded under the 'Global Change and Ecosystems' sub-priority

[49] In particular projects funded under the 'Environment (including climate change)' theme

[50] *European Research Framework Programme: Research on climate change, 2009,* European Commission, EUR 23609

[51] Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects - http://prudence.dmi.dk

[52] ENSEMBLE- based Predictions of Climate Changes and their Impacts - http://www.ensembles-eu.org/

provides a reliable quantitative risk assessment of long term climate change and its impacts. It includes the production of Regional Climate Scenarios for Impact Assessments and the formulation of very high resolution Regional Climate Model Ensembles for Europe.

STARDEX project

"Statistical and Regional dynamical Downscaling of Extremes for European regions" (STARDEX, 2002-2005)[53] has given a rigorous and systematic inter-comparison and evaluation of statistical, dynamical and statistical-dynamical downscaling methods for the construction of regional scenarios of extremes. The aim was to identify the more robust techniques and used these to produce future scenarios of extremes for European case-study regions for the end of the 21st century. Large amounts of progress were made to answering the vital question as to whether extremes will occur more frequently in the future.

CECILIA project

The FP6 project CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment)[54] has as primary mission to improve the understanding of local climate change in Central and Eastern Europe and its impacts into forestry, agriculture, hydrology and air quality. It thus provides detailed regional climate projections (and impact assessments) for Central and Eastern Europe.

CLAVIER project

The FP6 project CLAVIER (CLimate ChAnge and Variability: Impact on Central and Eastern EuRope)[55] aims to make a contribution to successfully coping with climate change challenges, by studying in detail three representative CEE Countries: Hungary, Romania, and Bulgaria.

CIRCA ERA-Net

Climate impact analysis and adaptation response must be informed by a coherent body of research and it is CIRCLE´s prime objective to contribute to such efforts by networking and aligning national research programmes in the 19 CIRCLE partner countries.[56] The Implementation of a European Research Area (ERA) for climate change is CIRCLE's final goal. The objectives include learning from each other, exchange knowledge and experience, planning and most important establishing transnational research programmes and joint calls. There were 3 regional calls: Nordic, Mediterranean, and Mountainous areas.

Research into climate change impacts on the aquatic environment and water cycle

CLIME project

Research on climate change impacts on aquatic ecosystems has already started within the 5th Framework Programme, e.g. the CLIME[57] project developed a suite of methods and models for improved management of lakes and catchments under future as well as current climatic conditions. The most up-to-date regional climate scenarios, and existing catchment and lake models were used in the project to address issues that were central to the implementation of the Water Framework Directive. Particular attention was paid to two water quality issues that are likely to become increasingly important, namely leaching of highly coloured water from

[53] STARDEX (http://www.cru.uea.ac.uk/)

[54] CECILIA (http://www.cecilia-eu.org/)

[55] CLAVIER (http://www.clavier-eu.org/)

[56] CIRCLE ERA-Net (http://www.circle-era.net/)

[57] CLIME: Climate and Lake Impacts in Europe (http://clime.tkk.fi/)

peatland catchments and increased productivity of some lakes and the increasing frequency of algal blooms.

KLIWAS project

With focus on larger central European rivers including the Elbe, Rhine and the Danube, the interdisciplinary research programme KLIWAS[58] started in 2007. It integrates ecological, economical, water quality and water quantity aspects of climate change for rivers and coastal waters which are used as waterways. KLIWAS strictly follows a multi-model-approach. It uses and evaluates all available climate model runs (including those of the EU-FP6-Project ENSEMBLES and new runs provided by the KLIWAS group) as well as different hydrological models in order to provide a reliable basis for the assessment of various adaptation options. With the purpose of model validation and monitoring of climate change effects, historical data bases are extended, too. A model chain is established, which couples climate models to hydrological/oceanographic, hydrodynamical/sedimentological, water quality and ecosystem models. At each step, uncertainty is analysed in detail to assess the level of understanding of the aquatic systems and their sensitivity to low flow, floods and other aspects of "historical" and future climate change. Changes and possible adaptation measures of the waterways are evaluated taking all functions of rivers and coastal waters into account. Thus, various WFD relevant information is provided.

EURO-LIMPACS project

Research to understand and quantify the impact of climate change (CC) on freshwater ecosystems at the catchment scale has been active through the EURO-LIMPACS[59] project, which examined CC interactions with other key drivers and pressures related to aquatic systems at multiple time scales up to secular trends. The project provided a high level of expertise on CC impacts on aquatic ecosystems which is reflected in a Position Paper (addressed to policy-makers) on "Impact of climate change on European freshwater ecosystems: consequences, adaptation and policy". Scientific achievements combined analyses of long term data sets, the reconstruction of past trajectories from sediment archives, experimental approaches in the laboratory and in mesoscosms, model and scenario developments, and the development and testing of Decision Support Systems (DSS). The results from this research are expected to assist in: (1) assessing the potential impacts of global change at the local to regional scales freshwater lakes, rivers and wetlands across the wide range of European climates, geomorphology types, land-use, and human impact; (2) developing a unified system of ecosystem health indicators related to the impact of CC; (3) reviewing the effect of CC on restoration strategies for freshwater ecosystems and (4) understanding the interaction of CC with key water quality problems such as hydromorphological change, eutrophication, acidification, and long range atmospheric transfer of toxic pollutants. A new FP7 project (REFRESH) will follow on from Euro-limpacs and focus on an assessment of the practical measures that might be taken by managers to mitigate or adapt to the impacts of CC on freshwater ecosystems.

WATCH project

Specific research on climate change impacts on the global water cycle is carried out under the WATCH project[60] which unites different expertises (hydrologists, climatologists, water use experts) to examine the components of the current and future global water cycles, evaluate

[58] KLIWAS (www.kliwas.de)

[59] http://www.eurolimpacs.ucl.ac.uk

[60] www.eu-watch.org

their uncertainties and clarify the overall vulnerability of global water resources related to the main societal and economic sectors. The project is developing a number of global and regional datasets to facilitate the assessment of changes in the water cycle, including case studies in river basins located in the EU. In parallel a conceptual modelling framework is being developed to provide consistent modelling results and transfer information between scientists and stakeholders. This will include methodologies to handle biases in climate model output and quantify the resulting uncertainties in estimates of future components of the global water cycle. WATCH aims to increase our understanding of drought and large scale flood development and their propagation for the past and future climates through studies at different scales (global, regional, river basin). Five test basins, within Europe, are being used to translate water resources applications from the global water cycle system to river basins.

CIRCE project

The assessment of climate change impacts on water resources is also being studied in focused aquatic environment, e.g. the Mediterranean area through the CIRCE project[61]. In particular, research is carried out to investigate how strongly climate variations induce significant changes in the hydrological cycle, e.g. increasing atmospheric water vapor, chancing precipitation patterns and intensity, and changes in soil moisture and runoff. The project collects data from observations to quantify those changes and to develop a regional climate model able to analyze the conditions in the Mediterranean area. The investigations concern surface water, groundwater, coastal aquifers and the interactions between them. Both water quantity and quality issues are taken into account. The final goal of this project is to produce an assessment (RACCM – Regional Assessment of Climate Change in Mediterranean) to be used to deepen the understanding of the impact of climate change on water resources and to suggest potential adaptation measures.

ACQWA project

A more focused research is reflected by the on-going ACQWA Project[62] which investigates the consequences of climate change in mountain regions where snow and ice is currently an important part of the hydrological cycle. Numerical models are used to predict shifts in water amount by 2050, and how these changes will impact upon socio-economic sector such as energy, tourism and agriculture. There will be focused studies on governance issues and ways of alleviating possible conflicts of interests between economic actors competing for dwindling water resources. Following a first phase of research in the data-rich European Alps, the models and methods will be applied to non-European regions such as the Andes and the Central Asian mountains, where climatic change and changing snow, ice and water resources will be a source of concern but also of opportunity in the future.

CES project

In the Nordic Region a specific research program has been set up to further investigate the risks, potentials and adaptation measures for the renewable energy resources in the context of climate change, the CES standing for Climate and Energy Systems (http://www.os.is/page/ces_forsida). It is including hydropower, wind power, bio-fuels and solar energy and is in many ways a follow up on the Climate and Energy (CE) Nordic-Baltic research project (2003-2006), both funded by Nordic Energy Research (www.nordicenergy.net) and the Nordic energy sector.

The goal of the CES project is to look at climate impacts closer in time and assess the development of the Nordic electricity system for the next 20-30 years. It will address how the

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[61] http://www.circeproject.eu

[62] Assessing Climate change impacts on the Quantity and quality of Water – www.acqwa.ch

conditions for production of renewable energy in the Nordic area might change due to global warming. It will focus on the potential production and the future safety of the production systems as well as uncertainties. The key objectives are summarized as:

- Understanding of the natural variability and predictability of climate and renewable energy systems at different scales in space and time.
- Assessment of the risks due to changes in probabilities and nature of extreme events.
- Assessment of the risks and opportunities due to changes in production of renewable energy.
- Development of guiding principles for decisions under climate variability and change.
- Development of adaptation strategies.
- A structured dialog with stakeholders.

Research into mitigation / adaptation options and costs

AquaStress project

Mitigation / adaptation options to respond to climate change conditions have been developed, tested and evaluated within the AquaStress integrated project[63], leading to the definition of mitigation options exploiting new interfaces between technologies and social approaches, as well as economical and institutional settings. Particular emphasis has been given to methods, tools and guidelines – e.g. for groundwater modelling, groundwater recharge, improved crop policies - to facilitate a holistic approach to manage water supply and water demand. Several lessons can be derived from the AquaStress experience on improved approaches to integrated and participative water management, which is considered fundamental for adaptation to changing conditions.

ADAM project

Adaptation and mitigation strategies in support of European Climate Policy have also been investigated within the framework of the ADAM project[64] which developed long-term policy options / scenarios that could contribute to the EU's 2°C target and targets for adaptation. The project made significant contributions to climate change policy developments through regular policy briefs, highlighting that Green House Gas emissions could be technically reduced in Europe by up to 80% by 2050. This is obviously only indirectly linked to river basin management developments but it has nevertheless consequences on the way integrated water resource management will have to evolve over the forthcoming decades.

NeWater project

Increasing uncertainties due to the accelerating pace and greater dimension of changes (e.g. climatic and demographic changes) and their impact on water resource management have been investigated by the NeWater Integrated project[65]. The central issue of the NeWater project was the requirement for a transition from currently prevailing regimes of river basin water management to more adaptive regimes in the future. NeWater identified several key elements of the water management system, amongst others governance, sectoral integration, information management, and risk mitigation. Research focused on processes of transition of these elements to more adaptive processes of Integrated Water Resources

[63] http://www.aquastress.net

[64] ADAM website

[65] NEWATER: adaptive integrated water resources management - www.newater.info

Management (IWRM). Seven river basins (Amudarya, Elbe, Guadiana, Nile, Orange, Rhine and Tisza) were selected as case study areas to establish the link between practical activities and advances in thematic research and tool development. The project has developed a book on Climate Change Adaptation in the Water Sector and twelve publicly available synthesis products which are of direct interest to policy implementation and development, including databases, guidelines on uncertainty in adaptive management, , evaluation of water resources scenarios in the case studies, a guidebook on adaptive water management, etc. All the reports and tools are available on the project webpage.

AQUAMONEY project

Besides the development of mitigation/adaptation strategies, an important element is the economic valuation of identified measures. In this respect, research has contributed to develop scenarios and quantify environmental and resource costs and benefits linked to adaptation to climate change within the framework of the AQUAMONEY project[66].

ClimateCost project

Efforts are being pursued with the recently launched ClimateCost project[67] which builds up on results of AQUAMONEY and ADAM to further develop climate change and socio-economic scenarios with quantification of related costs, including an assessment of physical effects and economic damages of major catastrophic events.

ClimateWater project

Specific inputs for the identification of gaps that would have possible effects on the implementation of the WFD in combating climate impacts on water are being studied by the ClimateWater project[68]. Based on an analysis and synthesis of data on the likely water related climate change impacts, the project will identify adaptation strategies that were developed in Europe and globally for dealing with the CC impacts on water resources and aquatic ecosystems (preventing, eliminating, combating, mitigating). Research needs in the field of 'climate impact on the water cycle and water users' will be identified with special regard to enable the ranking of adaptation action in the light of the magnitude of impact on water resources and the urgency of the action needed.

Scoping report on Climate Change in Inland Waterways

In 2009, the UK's Inland Waterways Advisory Council published a 'scoping report' on how inland waterways in England and Wales can assist in mitigating for and adapting to the effects of climate change – in particular, greater winter rainfall, drier summers, higher temperatures and more frequent extreme weather events. Secondary effects also examined included adaptation to changes in sediment run-off, transport and accumulation and changes in flora and fauna. The report highlights the most likely impacts of climate change and the potential consequences for inland waterways in England and Wales. It then identifies and assesses a range of potentially appropriate measures through which changes in use of the waterways could contribute to reducing the extent of climate change (mitigation) and management of waterways can be modified to prepare for the anticipated or recorded effects of climate change (adaptation). The report is available at:

http://www.iwac.org.uk/downloads/reports/IWAC_Climate_Change_Inland_Waterways_Apr09.pdf

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66 http://www.aquamoney.ecologic-events.de/

67 ClimateCost website

68 ClimateWater – Bridging the gap between adaptation strategies of climate change impacts and European water policies - http://www.climatewater.org

Research on droughts and water scarcity

XEROCHORE project

Besides research on management options addressed by AquaStress (see above section), specific research needs on droughts are being discussed in the XEROCHORE Support Action[69] which is currently establishing the state of the art of drought related national and regional policies and plans and will lay down a roadmap that will identify research gaps on various drought aspects (climate, hydrology, impacts, management, policy) and steps to take in order to fill them. In particular, support to European Drought Policy will be provided through expert recommendations about impact assessment, policy-making, drought in the context of integrated water resources management and guidance on appropriate responses for stakeholders. The large consortium (over 80 organisations) is closely linked to the European Drought Centre and the CIS Working Group on Water Scarcity and Drought, which has basically led to the development of an internationally recognised exchange platform on drought issues between the research and policy communities. This is strengthened by links established with relevant RTD projects which include drought components, e.g. WATCH, CIRCE, as well as the recently launched MIRAGE project on Intermittent River Management[70]. It is expected that the exchange platform, now established and developed within the XEROCHORE project, will be further strengthened by the European Commission through the clustering of projects dealing with climate change and water security (including drought aspects) from 2010 onward.

European Drought Observatory

The Joint Research Centre of the European Commission is developing a prototype of the European Drought Observatory (EDO) in the frame of the Seventh Framework Programme for Research, Technological Development and Demonstration. EDO will provide information on drought monitoring, detection, forecasting, and assessment in a multi-scale approach, integrating various information systems that provide information on droughts on international, national, regional, and local level in Europe through interoperability arrangements based on INSPIRE principles. EDO will enable a consistent assessment of droughts in Europe, allow for inter-comparison of different methodologies applied throughout the continent, and foster exchange and collaboration among partners in research and application.

Research on floods

FLOODsite project

The project most relevant to flood research carried out within the years 2004-2009 at EU level in support of the Flood Directive is certainly the FLOODsite Integrated Project[71]. The project was interdisciplinary integrating expertise from across the environmental and social sciences, as well as technology, spatial planning and management. The notion of 'integrated' flood risk management now goes towards a change of policy from one of flood defence to flood risks being managed, but not eliminated. The project has developed robust methods of flood risk assessment and management and decision support systems which have been largely tested in pilot sites. Regular contacts with the CIS Working Group on Floods have enabled to inform the policy community about progress on flood risk management. Over than 100 research reports are available for public upload on the project website.

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[69] An Exercise to Assess Research Needs and Policy Choices in Areas of Drought, http://www.feem-project.net/xerochore

[70] Ref. MIRAGE

[71] FLOODsite project 'Integrated Flood Risk Analysis and Management Methodologies' - http://www.floodsite.net

FLASH project

Flash flood events and predictive scenarios have been studied by the FLASH[72] project in five countries (Israel, Italy, Greece, Spain and Cyprus) on the basis of the collection and analysis of lightning data and precipitation observations. Research is continuing on how to reduce loss of life and economic damage through the improvement of the preparedness and the operational risk management for flash floods and debris flow generating events as currently undertaken by the IMPRINTS project[73], which also studies how to contribute to sustainable development through reducing damages to the environment. The project will produce methods and tools to be used by emergency agencies and utility companies responsible for the management of these extreme events and associated effects. Impacts of future changes, including climatic, land use and socioeconomic will be analysed in order to provide guidelines for mitigation and adaptation measures.

CRUE ERA-Net

CRUE ERA-Net[74] has also completed 7 projects about "Risk assessment and risk management: effectiveness and efficiency of non-structural flood risk management measures", while a second call is related to flood resilient communities.

Research perspectives

Modelling capabilities should be improved and appropriate tools should be developed to advance the capability to assess climate effects on water resources and uses. New research areas (resulting from the 2009 FP7 call for proposals) will investigate novel observation methods / techniques and modelling and socioeconomic factor analyses to reduce existing uncertainties in climate change impact analysis and to create an integrated quantitative risk and vulnerability assessment tool. In particular, impacts on key strategic sectors such as agriculture and tourism will be investigated as well as macroeconomic implications of water availability in terms of regional income, consumption, investment, trade flows, industrial structure and competitiveness with focus on Southern Europe, North Africa and the Middle East.

In terms of perspectives, research should look into the evaluation of climate change adaptation and mitigation measures across multiple water-dependent sectors, and investigate interactions among water and other environmental compartments (sediment, soil, air). At present, scientific information about water-related impacts of climate change is not sufficient, especially with respect to translation of climate model output to river basin scale (matching the scale of the WFD River Basin Management Plans), water quality, aquatic ecosystems and groundwater, including their socio-economic dimensions. Research into climate change impacts on the water cycle from the global to the regional scale is essential to improve the understanding and assessment of key drivers and their interactions, in order to better manage and mitigate risks affecting the water cycle and to reduce uncertainties in policy responses. This also includes research related to disaster risk reduction to improve understanding and modelling of extreme events related to the hydrological cycles at scales that are relevant to decision making (possibly linked to policy).

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[72] www.flashproject.org

[73] Improving Preparedness and Risk Management for Flash Floods and Debris Flow Events - http://www.imprints-fp7.eu/

[74] CRUE ERA-Net (www.crue-eranet.net)

ANNEX III: Challenges of selected types of floods

The specific challenges of coastal floods and sea level rise

Due to climate change and the resulting sea level rise, the actual probabilities of coastal flooding will increase without additional measures. Compared to many other sources of flooding, the probabilities will remain rather low but the consequences when it happens are enormous. Only in the North Sea region, about 16 million people live behind coastal flood defences. Especially for estuaries, the combined effects of high discharge probability and storm tides at sea are both influenced by climate change. A moderate exceptional storm tide and discharge can lead to really exceptional water levels in estuaries. Such flood events can also have additional effects of changes in salt/fresh water boundaries. Some studies, for instance in Norway[75], also show that the tsunami risk is also increasing with climate change, as climate change increases risk of landslides which could trigger floods in coastal areas.

To reduce the flood risk in coastal areas, different measures could be considered in the flood risk management plans and an adapted approach to coastal flood risk management may be required. Issues that may need more consideration are::

- Non-structural (spatial planning) measures like restrictions for new developments in coastal flood-prone lowlands and building regulations to reduce the vulnerability against flooding
- Multifunctional uses of flood defences (e.g., the Dutch "Delta-Dike-Approach")
- Not "black/white" solutions, but important trade-off and balances of objectives to be found
- Win/win areas for instance for industrial activities to be sought
- Relocation of highly vulnerable activities.

Dealing with flash floods, torrent floods, debris flows and land slides/erosion due to floods

The 4th IPCC assessment report predicts that climate change will increase the occurrence of flash floods across the EU. This leads to a number of new challenges to flood risk management. For instance different or reinforced protective measures against sediment and debris deposits may be needed. Flash floods can rapidly change river flows and debris flows. Those very dynamic hydromorphological processes are well known in the alpine catchments. But as these processes are difficult to foresee on the one hand and may cause major damages on the other hand, they are complicating flood risk management. Flash floods with debris flow and sediment deposits may change river course permanently or temporarily, which will have an impact on hydromorphological condition of rivers and lakes. In practice there may not be any boundary between torrential flood (usually transporting solid material), debris flows and land slides as far as risk management is concerned. The above mentioned increases risk of landslides which could trigger tsunamis. This is another issue which may require attention (see also information on research related to flash floods in Annex II).

Measures that should be included in the flood risk management plans:

- Reinforced awareness raising among politicians of land slide hazards
- Identification of flash floods "hot spots" such as fans (alluvial fans, dejection cones, etc), and rapid changes in plan view of active channels (avulsions and sediment deposition or erosion related processes) to raise awareness of flood risk managements and land use planners.

Urban floods

It is broadly recognised that climate change will result in an increase in peak rainfall intensities and the frequency with which high intensity rainfall events will occur. Heavy rain and snow induced by climate change could cause significant damage in urban areas. A recent model study estimates the impact on a Swedish city and suggests there could be an increase in the number of surface floods by 25-45 % during this century. There may also be a non-linear response increase of precipitation vs increase in surface run-off (see example introduction chapter 6). If this rainfall is combined with thunderstorms, additional problems such as electrical failures could worsen the consequences because pumping facilities may stop. For example, low intensity rainfall events would cause no direct harm to the urban drainage system. However, they may worsen the effect of events that follow due to saturation of the area. Very high intensity and extreme rainfall events would be likely to cause increased basement floods and surface floods, as well as sewer overflow. The prediction of future flooding could help its implementation, particularly in urban areas where risks are higher. [76]

The impact of increased surface water flood risk in urban areas is likely to be compounded by urban creep (which results in faster runoff from impermeable areas and less infiltration) and the increasing value of the assets likely to be affected. Techniques to enable the identification of areas susceptible to 'pluvial' flooding are evolving as well as management approaches to deal with surface water flood risk but awareness of the potential problem needs to be raised across Member States underpinned for instance by guidance on appropriate responses.

Surface water flooding can also occur in conjunction with fluvial or tidal flooding affecting urban areas and the risk of these types of flooding is also likely to increase with climate change. It is therefore necessary to try to **identify the different sources of likely flood risk in any urban area and their likely interaction**. Such an understanding of flooding mechanisms is often the key to identifying appropriate and cost-effective solutions.

Flood risk management of urban floods should include taking climate change projections into account when identifying where urban water systems have a low capacity and identifying their most vulnerable locations. To manage urban floods in view of climate change, specific consideration are required in relation to the design and dimensions of water run off systems, and management of reservoirs and infrastructure such as underground parkings.

Suggested actions

- Assessment of the likely variation in projected increase in peak rainfall intensity across Member States due to climate change.
- Recognition of the potential significance of surface water flooding in urban areas in terms of damage potential and risk to life to promote awareness raising within Member States.
- Guidance or examples of good practice on appropriate techniques to assess the significance of surface water flood risk in conjunction with other flood risks together with guidance on possible approaches to surface water management in urban areas.

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[76] Olsson, J., Berggren, K., Olofsson, M. *et al.* (2009). Applying climate model precipitation scenarios for urban hydrological assessment: A case study in Kalmar City, Sweden. *Atmospheric Research.* 92: 364-375

- Further information exchange on examples of "no-regret" or "win-win" measures in view of Climate Change between Member States and internationally.

Annex IV: Definitions of projections, forecasts and scenarios

"Climate Projection" means the calculation of the future climate by means of a climate model, where assumptions about the future development of the greenhouse-relevant emissions – the so called "emission scenarios" (emission of greenhouse gases) – are used at each time step as forcing.

When a projection could be branded "most likely" it would become a **"forecast or prediction"** (according to IPCC[77]). However, as current climate projections are based on hypotheses of future GHG emissions and also because the climate system's behaviour is not sufficiently well known, it is not possible to assign a high level of confidence to projections. Thus, contrary to weather forecast, the term "forecast" is not used for climate simulations.

As it is virtually impossible to foresee the exact development of climate and land use for a longer time, scenarios are often used to assess several possible future outcomes. A **"Climate Scenario"** is defined (also according to IPCC) as "a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold. A projection may serve as the raw material for a scenario, but scenarios often require additional information. A set of scenarios is often adopted to reflect, as well as possible, the range of uncertainty in projections." Thus, the definition of a scenario includes the steps of (1) evaluation of uncertainty and (2) a deliberate decision about what "futures" are assumed in a study.

Scenarios may be derived from projections, but are often based on additional information from other sources." An important point is the clear distinction between scenarios and forecasts. Scenarios cannot predict the exact temperature or the water demand for a specific day in the future. They can, however, help to estimate how the mean behaviour of a system may change under certain circumstances.

Nowadays the so-called SRES Emission Scenarios (Special Report on Emissions Scenarios) presented by the IPCC are primarily used as a basis for the climate scenarios. They comprise a total of three scenario families (see box below) providing an assessment of the future emission development and of the resulting greenhouse gas concentrations. Here the difference is basically made between the economic and demographic development and the degree of globalisation. The impacts of political agreements to limit climate-relevant trace gas emissions (such as the Kyoto Protocol) are not considered in the scenario calculations.

[77] http://www.ipcc-data.org/ddc_definitions.html

A1: The *A1 scenario family* (divided into the scenarios A1FI, A1T and A1B on the basis of the ratio of fossil energies used) assumes a faster economic growth and a rather homogenous world with increasing cultural and social contacts between the different regions of the world. Differences in the per capita income reduce more and more, and the technological development progress is fast and efficient. The global population will peak in the middle of the current century.

A2: The *A2 scenarios* describe a very heterogeneous world oriented towards economy. Population growth continues at undiminished speed, and per capita incomes converge only in some regions and only at a very slow pace.

B1: Like the A1 family, the *B1 scenarios* anticipate fast globalisation, albeit under the assumption of economic structures transforming into a service and information technology oriented society. Here, an extensive introduction of clean and resource-efficient technologies is relevant for the evolution of greenhouse gas concentrations.

Annex V: Member State local climate projections

Below web links to local climate projections of some Member States are provided

Member State	Links to Member State local climate projections
Belgium	Climate projections for Flanders (in framework of Environment Outlook Flanders 2009) http://www.environmentflanders.be (available December 2009)
Germany	http://cera-www.dkrz.de/WDCC/ui/Index.jsp The CERA database includes (among others) data from regional dynamical and statistical downscaling.
The Netherlands	http://www.knmi.nl/research/climate_services/ http://www.knmi.nl/climatescenarios/documents/WR23mei2006.pdf http://www.knmi.nl/climatescenarios/documents/KNMI_2009_EN.pdf For the Rhine currently the project Rheinblick2050: http://www.chr-khr.org/en/projects/rheinblick2050
UK	http://ukclimateprojections.defra.gov.uk

Annex VI: Role of the SEA Process in climate change adaptation

Table 5 SEA Process: How climate change should be considered in the process?

Stage A: Setting the context & objectives, establishing the baseline & deciding on the scope.

- Describe the current and likely future climate change baseline.
- Identify the likely significant problems and constraints caused by climate change
- Develop climate change objectives and indicators that take account of future climate change (see below).
- Consult with SEA Consultation Bodies such as the Environment Agency on Flood Risk.

Stage B: Developing and refining alternatives and assessing effects

- Suggest plan alternatives to deal with key climate change related problems
- Assess the effects of plan alternatives on the climate change objectives and indicators
- Refer to Strategic Flood Risk Assessment in the Environmental Report
- Integrate climate change adaptation into the final plan

Stage C: Preparing the Environmental Report

- Explain in the Environmental Report how climate change issues and uncertainty have been identified and managed

Stage D: Consulting on the draft plan or programme and the Environmental Report

- Consult authorities responsible for climate change management and others to provide advice on good practice (see Stage A)

Stage E: Monitoring the significant effects of implementing the plan or programme on environment

- Monitor if adaptation has been put in place/implemented • Be prepared to respond to any adverse

Table 6 Aspects of climate change - Example Possible Indicators Example Information sources

Climate/weather changes

- Sea level
- Precipitation
- Temperature
- River flows (both extremes)
- Flood levels in rivers
- Extreme events such as heatwaves
- Climate change scenarios, scoping studies, sectoral studies
- Climate monitoring and predictions
- • Land use change, flood risk

Local impacts of climate/ weather changes • Average annual flood incidence/ damage drought orders • No. cases of subsidence • River flows and water quality • • Environment Agency – flood risk maps, river flows, water quality
Adaptation Measures • % developments with Sustainable Urban Drainage Systems (SUDS) • No. or % homes/roads in floodplain • Household water use • • Environment Agency

Annex VII: National adaptation strategies

Member State	NAS adopted	Impacts, vulnerability & adaptation assessments	Links
Austria	(expected in 2011)	Identification of first measures for climate change adaptation in Austria (Identifikation von Handlungsempfehlungen zur Anpassung an den Klimawandel in Österreich) Austrian Climate Research Programme (ACRP) StartClim (national climate research programme)	Information about the Austrian Activities developing the national adaptation strategy http://klimaanpassung.lebensministerium.at Climate Change and Adaption http://www.klimawandelanpassung.at/ The Austrian Climate Portal (ACCC) - Klimawandel und Anpassung http://www.accc.gv.at/anpassung1.htm
Belgium	(expected in 2012)	ADAPT-project CCI-HYDR-project	ADAPT-project (integrated decision tool for adaptation measures, Belgian Science Policy) http://dev.ulb.ac.be./ceese/ADAPT/home.php CCI-HYDR-project (CC impacts on hydrological extremes along rivers & urban drainage systems, Belgian Science Policy) http://www.kuleuven.be/hydr/CCI-HYDR.htm
Bulgaria			Second National Action Plan on Climate Change http://www2.moew.government.bg/recent_doc/international/climate/NAPCC_Final_English.doc
Czech Rep.			Fourth National Communication on the UN Framework Convention on Climate Change / http://www.env.cz/AIS/web-en.nsf/pages/Climate_Change National Allocation Plan of the Czech Republic 2008 - 2012 / National Program to Abate the Climate Change Impacts http://www.env.cz/AIS/web-en.nsf/pages/Climate_Change Project Czech Carbo http://www.usbe.cas.cz/czechcarbo/ National Climate Program of the Czech Republic http://www.chmi.cz/nkp/nkp.html
Denmark	2008		The Danish Climate Adaptation Strategy http://www.kemin.dk/en-US/climateandenergypolicy/dkpolicy/climateadaptationstrategy/Sider/climateadaptationstrategy.aspx Klimatilpasning http://www.klimatilpasning.dk/
Estonia	(expected in 2009)	ASTRA project	Astra Project (Developing Policies & Adaptation Strategies to Climate Change in the Baltic Sea Region) http://www.astra-project.org
Finland	2005	Finland's National Adaptation Strategy FINADAPT project ISTO programme VACCIA project EUROLIMPACS	Finland's National Adaptation Strategy http://www.mmm.fi/attachments/ymparisto/5h0aZ7Iid/Finlands_national_adaptation_srtrategy_julkaisu.pdf FINADAPT http://www.ymparisto.fi/default.asp?contentid=227544&lan=EN ISTO programme: http://www.mmm.fi/en/index/frontpage/ymparisto/ilmastopolitiikka/researchprogrammeonadaptationtoclimatechange.html VACCIA project: http://www.environment.fi/syke/vaccia EUROLIMPACS: http://www.environment.fi/syke/euro-limpacs
France	2007	French research programs on climate change: GICC (Management and Impacts of Climate Change), ANR	Stratégie nationale d'adaptation au changement climatique http://www.ecologie.gouv.fr/adaptation-au-changement.html GICC

Member State	NAS adopted	Impacts, vulnerability & adaptation assessments	Links
		(National Agency of Research) A National Observatory of Climate Change Impacts (ONERC), which belongs to the Ministry of Sustainable Development (General Directorate Energy and Climate), has coordinated various studies and publications related to climate change impacts and adaptation. It has driven the elaboration of the NAS (2007) and is responsible for the elaboration of the national CC adaptation plan (2011).	http://www.gip-ecofor.org/gicc ANR http://www.agence-nationale-recherche.fr/AAP-260-CEP.html ONERC http://www.ecologie.gouv.fr/-ONERC-.html
Germany	2008	KomPass Competence Centre; Klimazwei; KLIMZUG KLIWAS -Impacts of climate change on waterways and navigation – options to adapt	German Strategy for Adaptation to Climate Change http://www.bmu.de/english/climate/downloads/doc/42841.php KomPass http://www.anpassung.net/ Klimazwei Research Programme http://www.klimazwei.de/ KLIWAS http://www.kliwas.de
Greece			Ministry for Environment http://www.minenv.gr/4/41/e4100.html
Hungary	2008	VAHAVA project	National Climate Change Strategy 2008-2025 (adopted in March 2008) http://www.kvvm.hu/cimg/documents/nes080214.pdf
Iceland		VO project	Iceland's Climate Change Strategy http://eng.umhverfisraduneyti.is/media/PDF_skrar/Stefnumorkun_i_loftslagsmalum_enlokagerd.pdf
Ireland		ERTDI programme; CCRP (Climate Change Research Programme)	Ireland National Climate Change Strategy 2007-2012 http://www.environ.ie/en/PublicationsDocuments/FileDownLoad,1861,en.pdf Environmental Protection Agency http://www.epa.ie
Italy			ISPRA http://www.isprambiente.it/site/en-GB/
Latvia	(expected in 2009)	ASTRA project	Ministry of the Environment http://www.vidm.gov.lv/eng/ Astra Project (Developing Policies & Adaptation Strategies to Climate Change in the Baltic Sea Region) http://www.astra-project.org
Liechten-stein			Energieplanungsbericht 2006 / Vision 2050 http://www.energie.zh.ch/internet/bd/awel/energie/de/themen/energieplanung.htmlde
Lithuania		ASTRA project	Astra Project (Developing Policies & Adaptation Strategies to Climate Change in the Baltic Sea Region) http://www.astra-project.org
Malta			Malta Environment and Planning Authority http://www.mepa.org.mt/home?l=1
Nether-lands	2008	Delta committee; ARK Programme; CcSP Knowledge for Climate	Delta committee advice http://www.deltacommissie.com/en/advies Proposed Delta Act and Progamme http://www.verkeerenwaterstaat.nl/english/topics/water/water_and_the_future/delta_committee/

Member State	NAS adopted	Impacts, vulnerability & adaptation assessments	Links
			National programme for spatial adaptation to climate change – ARK en:http://www.vrom.nl/pagina.html?id=2706&sp=2&dn=7222 nl:http://vrom.nl/pagina.html?id=2706&sp=2&dn=7502 Knowledge for Climate http://www.knowledgeforclimate.org/
Norway	2008	NORDADAPT project, NORKLIMA project	Klimatilpasning i Norge http://www.regjeringen.no/upload/MD/Vedlegg/Klima/Klimatilpasning/Klimatilpasning_redegjorelse150508.pdf Community Adaptation and Vulnerability in Norway (NORADAPT) http://www.cicero.uio.no/projects/detail.aspx?id=30182&lang=EN
Portugal		SIAM project Portuguese National Adaptation Strategy	Climate Change in Portugal: Scenarios, Impacts, and Adaptation Measures - SIAM www.siam.fc.ul.pt/siam.html Portuguese National Adaptation Strategy (2009) http://www.maotdr.gov.pt *Note*: Guidelines for a specific strategy on climate change adaptation for the water sector are being prepared and are expected in 2010.
Romania			Ministry Of Environment www.mmediu.ro
Spain	2006	ECCE; Impacts on coastlines	Plan Nacional de Adaptación al Cambio Climático (PNACC) http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/pnacc.htm A Preliminary Assessment of the Impacts in Spain due to the Effect of Climate Change http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/eval_impactos.htm Impactos en la costa española por efecto del cambio climático http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/imp_cost_esp_efec_cc.htm
Sweden	2009	SWECLIM project; SWECIA project; CLIMATOOLS project; Swedish Climate Bill http://www.regeringen.se/content/1/c6/12/27/78/4ce86514.pdf; Sweden facing climate Change en:http://www.sweden.gov.se/content/1/c6/09/60/02/56302ee7.pdf	se:http://www.regeringen.se/sb/d/9434/a/89363 A Coordinated Climate and Energy Policy http://www.regeringen.se/sb/d/11759 Sweden facing climate change - threats and opportunities/Final report from the Commission on Climate and Vulnerability http://www.sweden.gov.se/sb/d/574/a/96002 Swedish regional climate modelling programme – SWECLIM http://mistras.internetborder.se/mistra/english/researchresults/researchprogrammes/completedprogrammes/sweclimswedishregionalclimatemodellingprogramme.4.1eeb37210182cfc0d680007760.html Climate, Impacts and Adaptation – SWECIA http://www.mistra.org/mistra/english/researchresults/researchprogrammes/activeprogrammes/mistraswedciaclimateimpactsandadaptation.4.a791285116833497ab800017356.html Climatools research programme http://www.foi.se/FOI/Templates/ProjectPage____5846.aspx Climate adaptation in the municipality of Sundsvall http://www.sundsvall.se/livsmiljoochnatur/miljoochklimat/forandratklimat/klimatanpassning/klimatanpassasundsvalldagslaget.5.4b51bfdc121be5d407e8000684.html Climate adaptation in Sweden (Swedish Meteorological and Hydrological Institute) http://www.smhi.se/ http://www.smhi.se/sgn0106/if/rc/modfigures.htm http://www.smhi.se/sgn0106/if/rc/RC.htm

Member State	NAS adopted	Impacts, vulnerability & adaptation assessments	Links
Switzer-land		OcCC avtivities	Changements climatiques: conséquences en Suisse http://www.bafu.admin.ch/klima/00469/00810/index.html?lang=fr Advisory Body on Climate Change (OcCC) http://www.occc.ch/index_e.html
United Kingdom	2008	UK National Risk Assessment UKCIP studies	Climate Change Act 2008 http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf UK Climate Impacts Programme (UKCIP) http://www.ukcip.org.uk/ UK Climate Projections http://ukclimateprojections.defra.gov.uk

Note: The information in this table reflects the state-of-play as of October 2009. In case of problems in accessing the indicated webpages, please consult the following webpage for possible updates: http://www.eea.europa.eu/themes/climate/national-adaptation-strategies

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EUROPEAN COMMISSION

environment

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance Document No. 25

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FOREWORD

The EU Member States, Norway and the European Commission in 2000 have jointly developed a common strategy for implementing Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive. In particular, one of the objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above mentioned strategy, a drafting group was established in 2007 with the aim of preparation of technical guidance for the chemical monitoring of sediment and biota. This drafting group has been coordinated by Italy, France and the Joint Research Centre, and involved a range of experts from other Member States and from stakeholder organisations.

Monitoring of sediment and/or biota can be used together with the water matrix to provide a coherent and comprehensive picture of the status of the water bodies within each river basin district. The initial screening or certain chemicals in the monitoring programme will help to identify areas of concern and areas where additional effort is needed, such as increased intensity of sediment, biota, or water monitoring or direct measurements.

The Water Directors have examined and endorsed this Guidance during our informal meeting under the Spanish Presidency in Segovia (27-28 May 2010). We would like to thank the Drafting Group for preparing this high quality document. We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive and its daughter Environmental Quality Standards Directive.

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

We also commit ourselves to assess and decide upon the necessity for reviewing this document in the light of scientific and technical progress and experiences gained in implementing the Water Framework Directive and Environmental Quality Standards Directive.

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1. SCOPE OF THE GUIDANCE

1.1. Legal background - Sediment and biota chemical monitoring under the Water Framework Directive

Directive 2008/105/EC (Environmental Quality Standards Directive) defines the good chemical status to be achieved by all Member States in 2015 and gives, together with the Water Framework Directive 2000/60/EC (WFD), the legal basis for the monitoring of priority substances in sediment and biota.

For the majority of the substances of the list of priority substances (33) and 8 certain other pollutants included in the Directive, the establishment of Environmental Quality Standards (EQS) at Community level has been limited to concentrations in the water column. As regards hexachlorobenzene, hexachlorobutadiene and mercury, however it was considered impossible to ensure protection against indirect effects and secondary poisoning at Community level by EQS for surface water alone. It is therefore appropriate to establish EQS for biota at Community level for these three substances. In order to allow Member States flexibility in their monitoring strategy, they should be able either to monitor and apply EQS for biota, or to establish stricter EQS for surface water providing the same level of protection.

Furthermore, Member States should have the possibility to establish EQS (for the existing 33 priority substances + 8 certain other pollutants) for sediment and/or biota at national level and apply those EQS instead of the EQS for water set out in the Directive. Such EQS should be established through a transparent procedure, involving notifications to the Commission and other Member States, so as to ensure a level of protection equivalent to the EQS for water established at Community level. Moreover, sediment and biota remain important matrices for the monitoring of certain substances with significant potential for accumulation. In order to assess long-term impacts of anthropogenic activity and trends, Member States should take measures, subject to Article 3(3) of the EQS Directive, with the aim of ensuring that existing levels of contamination in biota and sediment will not significantly increase.

Article 3 of Directive 2008/105/EC states that:

“2. Member States may opt to apply EQS for sediment and/or biota instead of those laid down in Part A of Annex I in certain categories of surface water. Member States that apply this option shall:

a) apply, for mercury and its compounds, an EQS of 20 µg/kg, and/or for hexachlorobenzene, an EQS of 10 µg/kg, and/or for hexachlorobutadiene, an EQS of 55 µg/kg, these EQS being for prey tissue (wet weight), choosing the most appropriate indicator from among fish, molluscs, crustaceans and other biota;

b) establish and apply EQS other than those mentioned in point (a) for sediment and/or biota for specified substances. These EQS shall offer at least the same level of protection as the EQS for water set out in Part A of Annex I;

c) determine, for the substances mentioned in points (a) and (b), the frequency of monitoring in biota and/or sediment. However, monitoring shall take place at least once every year, unless technical knowledge and expert judgment justify another interval; and

d) notify the Commission and other Member States, through the Committee referred to in Article 21 of Directive 2000/60/EC, of the substances for which EQS have been established in accordance with point (b), the reasons and basis for using this approach, the alternative EQS established, including the data and the methodology by which alternative EQS were *derived, the categories of surface water to which they would apply, and the frequency of monitoring planned, together with the justification for that frequency"*

e) *and that:*

"3. Member States shall arrange for the long-term trend analysis of concentrations of those priority substances listed in Part A of Annex I that tend to accumulate in sediment and/or biota, giving particular consideration to substances numbers 2, 5, 6, 7, 12, 15, 16, 17, 18, 20, 21, 26, 28 and 30, on the basis of monitoring of water status carried out in accordance with Article 8 of Directive 2000/60/EC. They shall take measures aimed at ensuring, subject to Article 4 of Directive 2000/60/EC that such concentrations do not significantly increase in sediment and/or relevant biota.

Member States shall determine the frequency of monitoring in sediment and/or biota so as to provide sufficient data for a reliable long-term trend analysis. As a guideline, monitoring should take place every three years, unless technical knowledge and expert judgment justify another interval"

Furthermore monitoring of sediment and biota can also be used to describe the general contaminant status, and supply reference values for local and regional monitoring. Analyses of sediment and/or biota can be a cost-effective approach for initial screening of areas for contamination, to compare contaminant concentrations in different areas and to identify possible sources of contaminants. In using sediment and biota as a first level screening for certain chemicals in the monitoring programme, water measurements may be downscaled. The initial screening will help to identify areas of concern and areas where additional effort is needed, such as increased intensity of sediment, biota, or water monitoring or direct measurements.

1.2. Aim and structure of the guidance

This guidance document addresses the different requirements for compliance checking and temporal trend monitoring for biota and sediment, taking into account the obligations of the EQS Directive. The recommendations included in the guidance take into account current scientific knowledge and they should allow a harmonised implementation of sediment and biota monitoring across Europe.

The recommendations given in this guidance are addressed to surveillance, operational and investigative monitoring and should be applied to the current list of Priority Substances (33) + 8 other pollutants, and to specific river basin pollutants which tend to accumulate in sediment or biota.

Chapter 3 gives recommendations for the matrix selection for the monitoring of chemical pollutants in different water bodies

There are some general parts of the monitoring strategy that are similar to sediment and biota, for example the application of the QA/QC Directive (Commission Directive 2009/90/EC); these issues are addressed in Chapter 4 of the guidance.

For compliance checking against EQS values, harmonisation of the different tools of monitoring programmes is needed: e.g. site selection, sampling strategy, selection of species (for biota), choice of analytical methods. These aspects are described in Chapter 5 for sediment and in Chapter 6 for biota.

Chapters 4, 5 and 6 contain also general recommendations:

- to assess compliance with the no deterioration objective of the WFD;

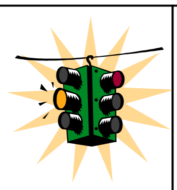
- to assess long-term changes in natural conditions and to assess the long-term changes resulting from widespread anthropogenic activities.

The assessment of the long-term impacts of anthropogenic activities includes the determination of the extent and rate of changes in concentrations of environmental contaminants.

Chapter 7 describes complementary methods for monitoring.

The guidance has been harmonised with the technical guidance document on EQS derivation (TDG-EQS) that is in course of publication [EC, 2010].

Since the WFD also covers the protection of transitional, coastal marine and territorial waters for chemical status, thus this guidance includes specific recommendations on these types of water categories



Look out!

The guidance for chemical sediment and biota monitoring will have to be adapted to regional and local circumstances.

1.3. Guidance documents for chemical monitoring

The Common Implementation Strategy of the Water Framework Directive entails the development of guidance documents in relation to the implementation of this directive. The guidance documents have been created to meet the request of Member States for further documentation of technical details important for harmonised implementation of environmental monitoring. The aim of these types of documents is to give further detail and thus facilitate the implementation of the WFD in the Member States, while also enhancing the degree of harmonisation, taking into account best available techniques, standard procedures and common practices.

Look in:
CIRCA public document library – guidance documents

http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents&vm=detailed&sb=Title

Relevant for the purpose of the present guidance document is Guidance Document No. 19 [EC, 2009] prepared by the Chemical Monitoring Activity Expert Group. Guidance Document No.19 provides recommendations on the strategy for matrix selection and analytical aspects for analysis of water, sediments and biota under the WFD.

Thus both guidance documents are closely related and should be consulted together.

Another useful document will be the TGD-EQS in course of publication [EC, 2010] in which there is described the methodology for the derivation of EQS in water, sediment and biota.

Moreover, it is worth mentioning CIS Guidance Document No. 7 [EC, 2003], which contains general aspects of monitoring requirements under the WFD and CIS Guidance Document No. 15 [EC, 2007] which provides specific recommendations for groundwater monitoring.

Other useful guidelines relevant in the field of sediment and biota monitoring have been published in the context of OSPAR, HELCOM, MedPol Conventions and SedNet

2. TERMS AND DEFINITIONS

Selected terms and definitions of specific importance for chemical monitoring under the WFD are listed here. All other terms already agreed upon and defined elsewhere in the WFD and associated documents are used without amendment, but are not listed.

Analysis of covariance: (ANCOVA) is a general linear model with one continuous outcome variable (quantitative) and one or more factor variables (qualitative). ANCOVA is a merger of ANOVA and regression for continuous variables. ANCOVA tests whether certain factors have an effect on the outcome variable after removing the variance for which quantitative predictors (covariates) account. The inclusion of covariates can increase statistical power because it accounts for some of the variability.

Analysis of variance: (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. In its simplest form ANOVA gives a statistical test of whether the means of several groups are all equal, and therefore generalizes Student's two-sample t-test to more than two groups. ANOVAs are helpful because they possess a certain advantage over a two-sample t-test. Doing multiple two-sample t-tests would result in a largely increased chance of committing a Type I error. For this reason, ANOVAs are useful in comparing three or more means.

Bioaccumulation Factor: (BAF) See EQS guidance 2010.

Bioconcentration Factor: (BCF) See EQS guidance 2010.

Certified reference material: (CRM) reference material characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability.
[ISO Guide 35:2006]

Composite sample: two or more samples or subsamples mixed together in appropriate proportions, from which the average result of a designed characteristic may be derived from the same stratum or at the same sediment thickness. The sample components are taken and pre-treated with the same equipment and under the same conditions.

Two or more increments or sub-samples mixed together in appropriate proportions, either discretely or continuously (blended composite sample), from which the average value of a desired characteristic may be obtained.

[ISO 5667-12:1995 Water quality – Sampling - Part 12: Guidance on sampling of bottom sediments ISO 11074 2:1998].

Environmental specimen banking: ESB may be defined as the storage, under appropriate conditions, of material from which information about the state of the environment may be obtained afterwards.

Grab sample: samples taken of a homogeneous material, usually water, in a single vessel. Filling a clean bottle with river water is a very common example. Grab samples provide a good snap-shot view of the quality of the sampled environment at the point of sampling and at the time of sampling. Without additional monitoring, the results cannot be extrapolated to other times or to other parts of the river, lake or ground-water.

Lentic: refers to standing or still water. It is derived from the Latin *lentus*, which means sluggish. Lentic ecosystems can be compared with lotic ecosystems, which involve flowing terrestrial waters such as rivers and streams. Together, these two fields form the more general study area of freshwater or aquatic ecology.

Limit of detection: (LOD) means the output signal or concentration value above which it can be affirmed, with a stated level of confidence that a sample is different from a blank sample containing no determinand of interest.
[Commission Directive 2009/90/EC]

Limit of quantification: (LOQ) means a stated multiple of the limit of detection at a concentration of the determinand that can reasonably be determined with an acceptable level of accuracy and precision. The limit of quantification can be calculated using an appropriate standard or sample, and may be obtained from the lowest calibration point on the calibration curve, excluding the blank.
[Commission Directive 2009/90/EC]

Lotic: refers to flowing water, from the Latin *lotus*, past participle of *lavere*, to wash. Lotic ecosystems can be contrasted with lentic ecosystems, which involve relatively still terrestrial waters such as lakes and ponds. Together, these two fields form the more general study area of freshwater or aquatic ecology.

Octanol-water partition coefficient: (k_{ow}) indicates hydrophobicity of a chemical substance.

Quality: all the features and characteristics of a measurement result that bear on its ability to satisfy given requirements of quality.
[EN 14996:2006]

Quality assurance: all those planned and systematic actions necessary to provide adequate confidence that a product will satisfy given requirements of quality.
NOTE This include AQC, audit, training, documentation of methods, calibration schedule, etc.
[EN 14996:2006]

Quality control: operational techniques and activities that are used to fulfil requirements for quality.
[EN 14996:2006]

Random sampling: form of sampling whereby the chances of obtaining different concentration values of a determinand are precisely those defined by the probability distribution of the determinand in question.
[ISO 5667- 6:2005 Water quality-Sampling- Part 6 Guidance on sampling of rivers and streams]

Reference material: (RM) material, sufficiently homogeneous and stable with respect to one or more specified properties, which has been established to be fit for its intended use in a measurement process.
[ISO Guide 35:2006]

Sample: a limited quantity of something which is intended to be similar to and represent a larger amount of that thing(s).

Sampling frequency: Sampling frequency defines the number of samples per second (or per other unit) taken from a continuous signal to make a discrete signal.

Sampling point: precise position within a sampling site from which samples are taken.

[ISO 5667- 6:2005 Water quality-Sampling- Part 6 Guidance on sampling of rivers and streams. Modified definition]

Sampling station: a well delimited area, where sampling operations take place.
[IUPAC 2005 *Pure and Applied Chemistry* 77, 827–841]

Sampling strategy: The result of the selection of the sampling points within a sampling site.
[IUPAC 2005 *Pure and Applied Chemistry* 77, 827–841]

Soil adsorption coefficient: (koc) Soil adsorption coefficient normalised by soil organic carbon content. Usually measured for environmental chemicals according to OECD Test guideline 106.

Statistical sampling: sampling whereby the samples are taken at predetermined intervals (in space or time).
[ISO 5667- 6:2005 Water quality-Sampling- Part 6 Guidance on sampling of rivers and streams. Modified definition]

Test portion: The amount or volume of the test sample taken for analysis, usually of known weight or volume.

Uncertainty of measurement: a non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.
[Directive 90/2009/EC]

Uncertainty arising from sampling: The part of the total measurement uncertainty attributable to sampling.
[EURACHEM/CITAC:2007 Measurement uncertainty arising from sampling: A guide to methods and approaches]

List of abbreviations

HELCOM	The Baltic Marine Protection Commission also called Helsinki Commission.
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR Convention.
MEDPOL	The Med Pol Programme (the marine pollution assessment and control component of MAP) is responsible for the follow up work related to the implementation of the LBS Protocol, the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (1980, as amended in 1996), and of the dumping and Hazardous Wastes Protocols.
SEDNET	European network aimed at incorporating sediment issues and knowledge into European strategies to support the achievement of a good environmental status and to develop new tools for sediment management.

3. COMPOUND AND MATRIX SELECTION FOR SEDIMENT AND BIOTA MONITORING

3.1. Introduction

The WFD classification of the chemical status of a water body is based on compliance with EQS. Directive 2008/105/CE sets the environmental quality standards for 41 substances in the water matrix, but also gives an option to the Member States to derive EQS for sediment and/or biota. The frequency of monitoring of priority substances in the water column (whole water or dissolved) differs from those in sediment and biota and it is clear that the choice of the matrix to be monitored will be strategic in terms of costs and resources for compliance checking. The minimum frequency required for water monitoring of priority substances is once per month (once every 3 months for river-basin-specific pollutants), but for sediment and biota the monitoring frequency can be once per year unless technical knowledge and expert judgement justify another interval.

The main aim of the WFD is the achievement of good chemical status for all water bodies, but, Member States can decide the matrix for certain substances.

For instance, sediment is a recommended matrix for the assessment of chemical status for some metals and hydrophobic compounds in marine and lentic water bodies. In dynamic lotic water bodies, however, sediments do not often provide an appropriate matrix for compliance checking because of high variability. Furthermore, in such water bodies, sediments can either be too perturbed to be representative or in some cases absent. In these cases this assessment could be made by measurement of the concentrations in suspended solid matter (SPM). In large lowland rivers, freshly deposited sediment collected by sedimentation traps can be used instead of SPM. In the latter case the equivalence between SPM and freshly deposited sediment must be verified.

For the purpose of trend monitoring, sediment, or alternatively SPM, and biota are the most suitable matrices for many substances because they integrate, in time and space, the pollution in a specific water body; the changes of pollution in these compartments are not as fast as in the water column and long-term comparisons can be made. Directive 2008/105/EC gives an indication of the substances that should be taken into consideration for trend monitoring as well as for the frequency of monitoring of those substances.

3.2. Physico-chemical properties of chemical pollutants

The choice of the matrix to be monitored depends firstly on the physico-chemical properties of the substances. The priority list of the WFD contains several (classes of) substances which have a low solubility in water, a corresponding high octanol/water partition coefficient (log K_{OW}; see Table 1) and a high potential for bioaccumulation and bioconcentration.

Look in:
Directive 2008/105/EC

Art 3, paragraph 3: Member States shall arrange for the long-term trend analysis of concentrations of those priority substances listed in Part A of Annex 1 that tend to accumulate in sediment and/or biota, giving particular consideration to substances numbers 2, 5, 6, 7, 12, 15, 16, 17, 18, 20, 21, 26, 28 and 30, on the basis of monitoring of water status carried out in accordance with Article 8 of Directive 2000/60/EC. They shall take measures aimed at ensuring, subject to Article 4 of Directive 2000/60/EC, that such concentrations do not significantly increase in sediment and/or relevant biota.

3.3. Selection of compounds to be monitored in sediment

The prime criterion for the selection of organic compounds to be monitored in sediments is their physico-chemical preference for the solid phase, i.e. a poorly soluble character in water. The more hydrophobic (water repulsing) a compound is, the less soluble it is in water, and therefore more likely to adsorb to sediment particles. A simple measure of the hydrophobicity of an organic compound is the octanol–water partition coefficient (K_{ow}), which is a good predictor of the partitioning potential of the contaminant in the organic fraction of the sediment (K_{oc}).

As a rule of thumb, compounds with a log K_{ow}>5 should *preferably* be measured in sediments, or in suspended particulate matter (SPM), while compounds with a log K_{ow}<3 should preferably be measured in water. For instance, HCB (hexachlorobenzene; log K_{OW}=5.7) should not be preferably monitored in water, but in sediment or in suspended particulate matter, because of its preference to adsorb to sediment particles (i.e. organic carbon).

Atrazine, on the other hand, with a log K_{OW}~2.5, should be monitored in water and not in sediment, due to its high water solubility.

For compounds with a log K_{ow} between 3 and 5, the sediment matrix or suspended particulate matter is *optional* and will depend on the degree of contamination. If the degree of contamination for a hydrophobic compound is unknown or expected to be low, sediment should be an additional monitoring matrix (due to accumulation).

3.4. Selection of compounds to be monitored in biota

The prime criterion for the selection of compounds to be monitored in biota is their physico-chemical preference for this matrix (e.g. various metals and lipophilic compounds); the metabolisation and depuration efficiency of the different species should also be taken into consideration for biota monitoring (see Chapter 6).

According to the monitoring programmes and plenty of scientific studies, the most common substances analysed in marine biota are organochlorinated compounds (especially PCBs, DDT and its metabolites and organochlorinated pesticides), PAHs (only in mussels because they are partially metabolised in fishes), TBT, and trace metals that tend to accumulate.

3.4.1. Organic compounds

For organic substances, monitoring in biota should be performed when the biomagnification factor (BMF) is >1 or when the bioconcentration factor (BCF) is >100; if no valid measured BMF or BCF (BAF) is available, a log K_{ow}>3 can be considered as an indicator for bioaccumulation potential.

The BMF is the ratio of the concentration of a substance in an organism compared to the concentration in food (prey) items. The BCF is the ratio of the concentration of a substance in an organism to the concentration in water.

It should also be ensured that there is no mitigating property such as rapid degradation (ready biodegradability or hydrolysis half-life <12h at pH 5-9, 20°C). If this is the case, then biota monitoring is not recommended. Information on molecular size can be an indicator of limited bioaccumulation potential of a substance, as very bulky molecules will pass less easily through cell membranes.

3.4.2. Metals

Biomagnification of metals in aquatic organisms is rarely observed and, if it does occur, it usually involves the organo-metallic forms of metals (e.g. methylmercury); a lack of biomagnification should not be interpreted as a lack of exposure or an absence of concern for trophic transfer. Even in the absence of biomagnification, aquatic organisms can bioaccumulate relatively large amounts of metals and this can become a significant source of dietary metal to their predators.

For metals, a BCF should not be used; this is because the model of hydrophobic partitioning, giving a more or less constant ratio C_{biota}/C_{water} with varying external concentration, (does not apply to metals). Further indications for metals are included in the TGD-EQS [EC, 2010].

3.5. Criteria for matrix selection

Based on the rule of thumb mentioned above, a distinction has been made between *preferred* (P), *optional (O)* and *not* recommended *(N)* matrices for the monitoring of priority substances in Table 1.

- Preferred (P): Monitoring should be performed in this matrix.
- Optional (O): Monitoring can be performed in this matrix, but also in other compartments/matrices; the choice will also be made on the basis of the degree of contamination of a particular matrix.
- Not recommended (N): Monitoring in this matrix is not recommended unless there is evidence of the possibility of accumulation of the compound in this matrix.

For metals, because of the high variability of these compounds, this distinction cannot be made except when they are in the form of organometals (e.g. methylmercury).

In some cases, sediment and biota are both preferred matrices and the choice should be made on the basis of local contamination and on the basis of the EQS derived.

These criteria are not mandatory and Member States can choose the appropriate matrix on the basis of their knowledge, provided they keep in mind the indications of Directive 2008/105/EC.

Table 1 Monitoring matrices for the priority substances and certain other pollutants listed by the EQS Directive

The substances in red are those suggested by Directive 2008/105/EC for sediment and biota trend monitoring. The values of the log K_{OW} are taken from the Chemical Monitoring Guidance n.19. The values of BCF are taken from the datasheets of the priority substances in the public section of the CIRCA forum (http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/i-priority_substances/supporting_background/substance_sheets&vm=detailed&sb=Title).

P = preferred matrix, O = optional matrix., N = not recommended, n.a. = not applicable

Priority Substance	*BCF*	*Log K_{OW}*	*Water*	*Sediment/SPM*	*Biota*
Alachlor	*50*	*3.0*	*P*	*O*	*N*
Anthracene	*162-1440*	*4.5*	*O*	*O*	*O*
Atrazine	*7,7-12*	*2.5*	*P*	*N*	*N*
Benzene	*13*	*2.1*	*P*	*N*	*N*
Brominated diphenyl ethers [a]	*14350-1363000*	*6.6*	*N*	*P*	*P*
Cadmium and its compounds		*n.a.*	*n.a.*	*n.a.*	*n.a.*
C10-13-chloroalkanes	*1173-40900*	*4.4-8.7*	*N*	*P*	*P*
Chlorfenvinphos	*27-460*	*3.8*	*O*	*O*	*O*
Chlorpyrifos (-ethyl, -methyl)	*1374*	*4.9*	*O*	*O*	*O*
1,2-Dichloroethane	*2-<10*	*1.5*	*P*	*N*	*N*
Dichloromethane	*6,4-40*	*1.3*	*P*	*N*	*N*
Di(2-ethylhexyl)phthalate (DEHP)	*737-2700*	*7.5*	*N*	*O*	*O*
Diuron	*2*	*2.7*	*P*	*N*	*N*
Endosulfan	*10-11583*	*3.8*	*O*	*O*	*O*
Fluoranthene	*1700-10000*	*5.2*	*N*	*P*	*P*
Hexachlorobenzene	*2040-230000*	*5.7*	*N*	*P*	*P*
Hexachlorobutadiene	*1,4-29000*	*4.9*	*O*	*O*	*P*
Hexachlorocyclohexane [b]	*220-1300*	*3.7-4.1*	*O*	*O*	*P*
Isoproturon	*2,6-3,6*	*2.5*	*P*	*N*	*N*
Lead and its compounds		*n.a.*	*n.a.*	*n.a.*	*n.a.*
Mercury and compounds [c]		*n.a.*	*N*	*O*	*P*
Naphthalene	*2,3-1158*	*3.3*	*O*	*O*	*O*
Nickel		*n.a.*	*n.a.*	*n.a.*	*n.a.*
Nonylphenols [d]	*1280-3000*	*5.5*	*P*	*P*	*O*
Octylphenol [d]	*471-6000*	*5.3*	*P*	*P*	*O*
Pentachlorobenzene	*1100-260000*	*5.2*	*N*	*P*	*O*
Pentachlorophenol	*34-3820*	*5.0*	*O*	*O*	*O*
Polyaromatic Hydrocarbons [e]	*9-22000*	*5.8-6.7*	*N*	*P*	*P*
Simazine	*1*	*2.2*	*P*	*N*	*N*
Tributyltin compounds	*500-52000*	*3.1-4.1*	*O*	*O*	*P*
Trichlorobenzenes	*120-3200*	*4.0-4.5*	*O*	*O*	*O*
Trichloromethane	*1,4-13*	*2.0*	*P*	*N*	*N*
Trifluralin	*2360-5674*	*5.3*	*N*	*P*	*O*
DDT (including DDE, DDD)		*6.0-6.9*	*N*	*P*	*P*
Aldrin		*6.0*	*N*	*P*	*P*
Endrin		*5.6*	*N*	*P*	*P*
Isodrin		*6.7*	*N*	*P*	*P*
Dieldrin		*6.2*	*N*	*P*	*P*
Tetrachloroethylene		*3.4*	*O*	*O*	*N*
Tetrachloromethane		*2.8*	*P*	*N*	*N*
Trichloroethylene		*2.4*	*P*	*N*	*N*

[a] *Including Bis(pentabromophenyl)ether, octabromo derivate and pentabromo derivate*
[b] *HCH (all isomers) - BCF (lindane)*
[c] *methylmercury*
[d] *Nonyl- and Octylphenols do not follow the classical K_{ow} partition, because they can establish hydrogen bonds by the phenolic hydroxyl.*
[e] *Including Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)-pyrene. For these compounds the metabolisation in higher trophic levels should be taken into account.*

4. SAMPLING STRATEGY: GENERAL REQUIREMENTS AND COMMON ASPECTS OF SEDIMENT AND BIOTA MONITORING

The main purpose of any measurement is to enable decisions to be made. Fitness for purpose is therefore the most important requirement of any sampling strategy. The fitness for purpose of a sampling design, however, can only be judged from reliable estimates of its uncertainty and its impact on the monitoring objectives. Current practice in the estimation of uncertainty in environmental monitoring follows the general principles set out in the "*Guide to Expression of Uncertainty in Measurement*" [ISO 1993] whose underlying philosophy has been endorsed in all standardisation documents issued by International and National Standardisation bodies. The notion of "uncertainty" is closely related to other concepts of measurements such as "accuracy", "error", trueness, bias and precision [EURACHEM, 1995]. In this context the following important differences are to be recalled [EURACHEM, 2007]:

- Uncertainty is a range of values attributable on the basis of a measurement result and other known effects, whereas "error" is a single difference between a result and "true value".
- Uncertainty includes allowances for all effects that may influence results (i.e. both random and systematic errors); precision only includes the effects that vary during the observations (i.e. only some random errors).
- Uncertainty is valid for correct application of measurement and sampling procedures, but it is not intended to make allowances for gross operator errors.

It is therefore apparent that the act of taking a sample introduces uncertainty into a measurement result. In addition, sampling protocols are never perfect, as they cannot anticipate every possible eventuality at the moment of sampling.

In the context of this guidance, the main sources of uncertainty related to sediment and biota monitoring are the natural spatial and temporal variability within the sampling site (or population) as well as the measurement process including the act of sampling, sub-sequent steps of sample pre-treatment and storage until the actual measurement. Natural variability and the act of sampling itself are certainly the most important and least controllable contributors.

While sampling and measurement can be assessed to a certain degree using classical tools for quality control and measurements such as field blanks, reference materials, intercomparisons and so forth, the influence of the natural variability can only be dealt with if sufficient information on the system is available in the planning phase of a monitoring programme. The higher the complexity or heterogeneity of the studied water body, the higher the number of samples to be investigated and hence the more expensive the monitoring becomes.

In this context the proper definition of the scope and objectives of the monitoring programme are of pivotal importance, because they are crucial factors to define the sampling site, frequency, duration and methodology, including sample pre-treatment and subsequent measurements and tests. A leitmotif is that the monitoring should be designed in such a way that possible errors occurring during sampling and measurement can be statistically detected.

A preliminary or exploratory sampling programme can be useful to provide relevant information for designing the final sampling programme. In exploratory studies, data may be statistically analysed in several ways for several purposes. However there should still be a clear understanding of what must be measured from what population and how the samples are to be selected. The sampling strategy is an intrinsic component of the data, and may limit their use and interpretation.

Quantitative objectives for a selected primary purpose should therefore also be established for exploratory studies.

4.1. Statistical considerations

CIS WFD Guidance Documents No. 7 [EC, 2003] and No. 19 [EC, 2009] already give some general indications with regard to underlying statistical principles. It is not simple to decide frequency, number and time periods of sampling during the planning of the monitoring program without the aforementioned preliminary/exploratory campaign. But, it is clear that in the course of a monitoring programme further adaptation may be necessary.

Although sediment and biota are less influenced by fast changes in water quality, they are subject to random or systematic/seasonal variations. This needs to be considered, too. The derived statistical parameters such as the mean value, standard deviation, highest observed value or percentiles can only be estimates of the “true value”, which usually deviates from these data. In the case of randomly distributed values, which follow a normal or log-normal distribution, estimates become more reliable with an increased number of repetitions.

In case of systematic (e.g. cyclic) variations of the system under investigation, the choice of the sampling time is crucial in order to either capture the entire cycle or to cover maximum and minimum values.

4.1.1. Quantitative objectives

As mentioned above, a proper definition of the monitoring objectives is vital. For a correct estimate of frequency, length of time series, density of sampling grid, etc., a quantification of the objectives is necessary. In this context one may distinguish between two types of monitoring studies, which however frequently overlap in reality:

- temporal monitoring studies, aiming at the detection of temporal trends in the investigated matrix. Since sediment and biota are generally buffered in their reaction time to chemical stress (if compared to the water column), longer time series in general covering several years are needed to detect significant changes;

- spatial monitoring studies, aiming at the identification of spatial distribution pattern and anomalies. With sediment and biota monitoring being less subject to short-term variability, normal distribution may be assumed.

The ISO Standard 5667-1:2006 [ISO, 2006] gives appropriate indications on how to determine the necessary number of samples for the various purposes of monitoring. Some recommendations from this standard set are worth mentioning here:

- while random variations usually follow a normal or log-normal distribution, systematic variations are either following trends or cyclic patterns or a combination of both;

- the predominant type of variation (random vs. systematic) may vary for the same matrix for different compounds;

- if random variations are predominant (see preliminary investigations), the moment of sampling is less important;

- if cyclic variations are predominant, a systematic and regular sampling pattern is to be preferred;

- in case of doubt, random stratified sampling is the best compromise. In any case statistical considerations should be at the basis of decisions concerning the number of samples to be taken.

For normal distributions, the confidence interval *L* of the mean value of *n* results at probability of *K* can be calculated as:

$$L = \frac{2 \cdot K \cdot c}{\sqrt{n}}$$, with being the standard deviation of the distribution

Example: With a *confidence interval* of 10% around the mean value, a *confidence level* of 95% and a *standard deviation* of 10%, the *number of samples* to be taken is calculated as: $10 = \frac{2 \cdot 1.96 \cdot 20}{\sqrt{n}}$, hence *n* = 61 Samples. This is translated for instance into the sampling of 1 to 2 samples per week, if the monitoring period is one year.

The careful definition and description of the objectives of the monitoring study includes:

- the choice of the sampling matrices with a strict definition of the sampling units and a description of what they represent in time and space (this description is a prerequisite for an appropriate interpretation of the results);

- the definition of the required sensitivity of the programme, i.e. the smallest change to be detected for temporal studies or smallest difference between areas for geographical studies;

- the definition of the statistical power to detect such a difference at a specified significance level.

The definition of the sensitivity and statistical power of the programme is essential in order to properly estimate, for example, the number of samples per sampling occasion, length of the time-series, sampling frequency etc., required for the investigation. This power will decrease as sources of variance (analytical variance, natural environmental variance) increase.

As a consequence, in order to calculate, for example, the number of samples and the sampling frequency required to fulfil those objectives, an estimate of the sample variance is needed. Expected variance estimates could, perhaps, be extracted from similar ongoing monitoring programmes or, what is more reliable, be assessed from a pilot project using the same sampling strategy, sampling matrices etc., as the currently planned monitoring programme.

The necessary or possible power of a monitoring programme will vary with the purpose of the investigation and with the contaminant, matrix and area being investigated. It is thus not possible to give fixed values for all situations. It is the duty of the programme manager to specify the size of the changes the monitoring programme is expected to identify and at what power, or for those implementing the programme to estimate what it is possible to achieve. It is, however, essential that the quantitative objectives are determined before any monitoring programme is started.

A quantified objective for temporal studies could, for example, be stated as follows:

- *To detect a 50% decrease within a time period of 10 years with a statistical power of 80% at a significance level of 5%.* (A 50% decrease within a time period of 10 years corresponds to an annual decrease of about 7%).

And for spatial studies, for example as follows:

- *To detect* differences *of a factor 2 between sites with a power of 80% at a significance level of 5%.*

A significance level of 5% means that we are prepared to accept a risk of 5% to conclude from our data that there is a trend or difference when there actually is not. Similarly, a power of 80% means that we accept a risk of 20% to conclude that there is no trend or difference when there really is one. Statistical power and methods to estimate power are discussed in detail in Cohen [1988].

In the case of temporal monitoring studies, if no trend is found, it is essential to know whether this reflects a stable situation or indicates that the sampling strategy is too poor to detect even major changes in the contaminant load to the environment. One approach to solving this problem would be to estimate the power of the time series based on the 'random' between-year variation. Alternatively the lowest detectable trend could be estimated at a fixed power to represent the sensitiveness of the time series. It should be stressed that the power estimate must be interpreted with great caution. A matrix showing a very high power is not necessarily a good matrix for monitoring. If the matrix analysed does not respond to the environmental changes being monitored, the between-year variation would probably be low and consequently the power high. Another problem is that a single outlier could ruin an estimate of the between-year variation. Bearing these difficulties in mind, and as an example for the purpose of trend monitoring, the quantified objective could be stated as follows:

- to detect an annual change of 5% within a time period of 10 years with a power of 90% at a significance level ( ) of 5% with a one-sided test.

It has to be stressed though, that statistically significant trends do not guarantee that detected temporal trends are a result of a causal relation between concentration and time. If the samples are biased or not comparable over time, or if relevant confounding co-variants are not accounted for, "false-trends" may occur.

The statistical assessment of trends also always requires experts whose experience allows them to undertake a more accurate evaluation of the analysis results.

4.1.2. Representativity

4.1.2.1. The sample matrix

A first important aspect is the representativity of the sampling matrix in relation to the contaminant load and exposure at the studied monitoring site. It is therefore essential to describe very clearly what the suggested sampling matrices represent in terms of contaminant load or exposure. In addition to factors such as availability, sampling costs etc., it would be useful to provide additional information on, for example, concentration factors, bioaccumulation rates, metabolic capacity and, for biota, excretion rates.. Various tissues within the same species vary considerably with respect to the above-mentioned factors i.e. they may represent totally different ranges of time and space. They may also react to changes in the environment very differently.

Similar considerations apply when considering the use of sediment as a monitoring matrix. The concentrations of both organic and inorganic contaminants in sediment are very dependent upon the bulk properties (e.g. particle size distribution, and organic carbon content) of the sediment. Concentrations are much higher in fine grained sediment than in the sand or coarser fractions. A spatial survey of contaminant concentrations in sediment is often very strongly influenced by the spatial distribution of muddy sediment. Normalisation techniques have been developed to minimise the influence of differences in bulk composition between sediment samples and to reduce the potential for "false trends" in temporal data series arising from changes in bulk composition unrelated to contaminant inputs. The application of normalisation techniques needs to be planned as part of the preparation of samples prior to analysis, or to ensure that the appropriate determinands for normalisation are included in the suite of analytes.

4.1.2.2. Spatial representativity

A second aspect to be considered is the representativity of the sample in relation to the spatial variability of the sampling site. Questions such as: "*How many sampling sites do we need in order to appropriately represent a region?"* will inevitably be raised when monitoring contaminants. Any firm advice from a statistical point of view needs estimates on spatial heterogeneity. For spatial studies the objectives have to be clearly specified (e.g. spatial trends, differences between regions etc) and made quantitative.

A variogram may be used to describe the spatial correlation structure [Cressie, 1993; Davis, 1986]. Normalisation processes to reduce between-sample variance should be applied to field data before such a variogram is constructed, particularly for analyses of sediment.

In practice, such variograms are not available or may not be available for all monitoring areas, and some pragmatic approach, based on prior experience may be necessary. This emphasises the need obtain useful information from preliminary monitoring.

4.2. Data analysis

Data must be expressed as mean values and standard deviation, reporting also the number of analysed samples (*n*) and the range of measured values. This information should be complemented by additional information of possible relevance to the context of the monitoring (percentiles, trend analyses, etc.)

In any case data analysis should be performed in a transparent way with appropriate statistical methods to reveal and compare status and trends at local, regional, national and European scales.

Differences between periods and or sites can be tested by one- or two-way analysis of variance (ANOVA) or by multivariate methods such as cluster analyses (CA), principal component analyses (PCA) or positive matrix factorisation (PMF). Multiple Pearson correlations can reveal significant relationships between chemicals and co-linearity of regressions can be tested by covariance analyses (ANCOVA). Chemical concentrations trends can also be assessed by correlating their variations with time and Spearman's rank correlation used to assess their predictable co-variance; the Spearman's rank correlation statistical test has been widely applied to evaluate individual contaminants at site, regional and national scales.

4.2.1. Method used for trend analysis of time series

The main goal of trend analysis is to test objectively whether there is a meaningful systematic change in the time series, assessed against some measure of the random noise in the observations. The output from this component will usually be the probability that the test statistic of the method used could have arisen by chance when there is no trend. If this is less than some pre-specified value (e.g. 5 %), the result is considered to be significant, that is: the null hypothesis of no trend is rejected. What constitutes a meaningful change will depend on the objectives of the assessment, and is a major consideration in the choice of method as discussed in section 4.1.1.

For the trend assessment the following four separate but complementary components are identified:

1. graphical presentation of the time series with a summary line to indicate the general trend, presenting time series grouped by region, by substance, or by originating country, could provide a further opportunity to identify common trends, or common data anomalies, e.g., a consistent extreme value in a given year;

2. a formal test of trend, with trend defined in an appropriate way for the context of the assessment;

3. a quantification of the tendency to increase or decrease;

4. a power analysis which reflects the detectability of a possible trend.

The statistical method used to assess trends should be:

- robust, i.e., both routinely applicable to many data sets, and as insensitive as possible to statistical assumptions (e.g. Normal distribution) and problematic numerical features such as extreme data values, partial bulking of samples, and values less than LOD;

- intuitive, i.e., for the results of the analysis to be understandable without a detailed understanding of statistical theory;

- revealing i.e. to provide easy access to several layers of information about the major features of the data-both those of direct interest, such as evidence of simple trends, and the more negative features, such as missing years, years with all results below the limit of detection, extreme values, and so on.

In the context of trend assessment the method should be sensitive to the kinds of changes that are of concern in the assessment. Not all tests are equally effective at detecting all patterns of change. For a very focused test, this may be a disadvantage if all patterns of change are of interest, or an advantage if the focus is on patterns of interest. Three groupings of patterns of change may be considered to be of interest:

1. linear trend,

2. monotonic non linear trends,

3. non-monotonic trends.

Hence, if the purpose of the assessment is to detect monotonic trends and it has to be robust in the sense that it is unaffected by isolated extreme values, the Mann-Kendall test would be appropriate. If the purpose is to detect all trends, then the choice is between the compound Mann-Kendall test and the smoothers, with a final decision depending on the weight given to the other factors.

The statistical procedures currently used by OSPAR for trend detection in Northern seas are described in the “CEMP Assessment Manual for contaminants in sediment and biota”. [OSPAR, 2008]. The method used by OSPAR involves the use of a weighted smoother, and assessment for significant linear and non-linear trends. Fitting a weighted smoother is straightforward if the statistical weights are known beforehand. The statistical weights should be inversely related to the total environmental and analytical variance each year. Appropriate methods for estimating them will depend on the QA information available.

The weighting is a function of the performance of the laboratories in annual external Quality Assurance schemes (Laboratory Performance Studies). In the absence of external QA performance data the data points are all given equal weight.

For a mixture of theoretical and practical reasons, the OSPAR Commission found it appropriate to adopt three different *approaches to data analysis, based upon the length of the available time series:*

- 3-4 years compute the average of the median log-concentrations.
- 5-6 years fit a linear regression to the median log-concentrations and test the significance of the linear trend.
- >6 years fit a smoother to the median log-concentrations and test its significance, followed by tests of the significance of the components of linear and non-linear trend.

Although a linear regression model could have been fitted to data for 3 or 4 years, the power of this test would be low. Further*, where significant trends did occur, they would be more likely to reflect short-term trends than long-term changes. For these reasons, a simple summary of the average level was thought to be more useful. Similarly, it seems inappropriate to attempt to describe non-linear trends in time series with fewer than 6 years.*

Essentially, for each dataset with data for 6 or more years, the method is to summarise trends using a smoother; a non-parametric curve fitted to median log-concentrations. This summary is supported by a formal statistical test of the significance of the fitted smoother, and by tests of the linear and non-linear components of the trend.

Few statistical assumptions are required for the fitted smoother to be valid. Mainly, the annual contaminant indices should be independent with a constant level of variability. For the statistical tests to be valid, there is a further assumption that the residuals from the fitted model should be lognormally distributed. The theory and methodology are described in detail in Nicholson et al. [1998].

4.3. Quality Assurance/Quality Control

The quality and comparability of analytical results generated by laboratories appointed by competent authorities of the Member States to perform sediment and biota chemical monitoring pursuant to Article 8 of Directive 2000/60/EC should be ensured.

Commission Directive 2009/90/EC represents the legal basis for the performance of the analytical methods and gives technical specifications for chemical monitoring. Based on the requirements of this directive, the application of internal and external quality control measures, such as the use of blanks, standards, (certified) reference materials or regular participation in laboratory inter-comparison, is strongly recommended.

Look in:
Commission Directive 2009/90/EC

Article 1

Subject matter

This Directive lays down technical specifications for chemical analysis and monitoring of water status in accordance with Article 8(3) of Directive 2000/60/EC. It establishes minimum performance criteria for methods of analysis to be applied by Member States when monitoring water status, sediment and biota, as well as rules for demonstrating the quality of analytical results.

Article 3

Methods of analysis

Member States shall ensure that all methods of analysis, including laboratory, field and on-line methods, used for the purposes of chemical monitoring programmes carried out under Directive 2000/60/EC are validated and documented in accordance with EN ISO/IEC-17025 standard or other equivalent standards accepted at international level.

Article 4

Minimum performance criteria for methods of analysis

1. Member States shall ensure that the minimum performance criteria for all methods of analysis applied are based on an uncertainty of measurement of 50 % or below (k = 2) estimated at the level of relevant environmental quality standards and a limit of quantification equal or below a value of 30 % of the relevant environmental quality standards.

5. MONITORING OF CHEMICAL SUBSTANCES IN SEDIMENT

5.1. Sampling strategy for chemical monitoring in sediment

General criteria and good practices for sediment sampling strategy are already reported in CIS Guidance Document No. 19 [EC, 2009].

Sampling strategies for sediment monitoring may have two major approaches: a probabilistic design, where sampling points are randomly selected within the sampling site, and a targeted design, where sampling points are selected on the basis of an analysis of pressures and pre-existing knowledge of point sources.

Probabilistic design is more appropriate for diffuse source characterisation, whereas targeted design is better suited for the implementation of the WFD at surveillance, operational and investigative monitoring sites.

In targeted designs, sampling points are selected on the basis of prior knowledge of other factors such as water depth, bottom topography, nature of the sediment (clay, sand, pebbles, peaty), contaminant loading and accessibility.

In general, targeted sampling is appropriate for situations in which:

- the site boundaries are well defined;

- the objective of the investigation is to screen an area for the presence or absence of contamination. In CIS Guidance No. 19 [EC, 2009], section 4.3, it is further stated that "...*areas can be cost-efficiently scanned using sediments and biota to compare contaminant levels in different areas and to identify possible sources of contaminants to the area*". And "*In using sediments and biota as a first level screening for certain chemicals in the monitoring programme, water measurements may be downscaled. The initial screening will help to identify areas of concern and where to direct effort, such as follow up with water samples and direct measurements*.";

- information is desired for a particular condition (e.g., “worst case”) or site;

- schedule or budget limitations preclude the possibility of implementing a statistical design.

For trend analyses, the sampling strategies and the procedures of examination and analyses of sediments should ensure that continuity with pre-existing monitoring programmes is maintained. Any changes should only be made if comparability with long-term data is guaranteed. This also includes continuing to use suspended particulate matter (SPM) or freshly deposited sediments collected by sediment traps or sedimentation boxes as an alternative to sediments for monitoring contaminants in large lowland rivers.

5.1.1. Selection of sediment sampling stations

General criteria for the selection of monitoring sites in WFD monitoring programmes are discussed in CIS Guidance documents No. 7 [EC, 2003] and No. 19 [EC, 2009].

Whatever the water body, sediments should be sampled at sites that are representative of the water body or cluster of water bodies. This requires understanding of the hydrological and geo-morphological characteristics and the pollution sources. This information can be derived from earlier studies, current monitoring programmes or a dedicated preliminary survey.

Sediments are much less temporally variable, but inherently much more heterogeneous than waters. The homogeneity of a sampling area may be checked in a pilot phase by defining one or more transects (according to the area extent), where five sampling points for each transect are selected. In each sampling point, five or more independent surface sediment samples have to be collected. An aliquot for each sample should be analysed after homogenisation and sieving (see Section 5.2.6). The homogeneity can be checked for the between-sample (between sampling points in the transect) and the within-sample (within sampling points) variance, using an Anova/F-test. If the within-sample variance is of the same order as, or even exceeds, the between-sample variance, the whole transect should be considered as a single sampling site.

The areas where homogeneity has thus been checked will serve for the identification of the sampling sites and the number of replicates. Owing to the physical heterogeneity of the sediment, statistical analyses should be carried out on data normalised with respect to the fine fraction (see 5.1.5).

There is no need for even distribution of sampling sites in a water body. In a homogeneous water body, such as a pristine lake, the number of sampling sites may be relatively low. But if gradients are to be expected as a result of changing morphological and/or input conditions, or of areas that are of concern ('hot spots'), a higher number of sampling sites should be defined.

Known point sources, e.g. from present or past industries, need special attention, as they are not representative and may bias the overall evaluation of a given water body. Tributaries often have different water and thus also different suspended matter/sediment characteristics from the receiving river or lake. Receptor water bodies should be sampled downstream of the discharges or the tributary confluence, at a point where complete mixing has been established. According to Art. 4 of Directive 2008/105/EC, mixing zones should be designated by Member States. The Technical Guidance document for the identification of mixing zones under Article 4(4) of the EQS Directive is currently under development.

Net deposition areas with soft sediments characterised by a relatively high amount of fine fraction (the fraction <63 m, consisting of silt and clay) are preferred as sampling sites, whereas areas where sediments contain peat, pebbles or rocks, compacted sediments, or coarse sand should be discouraged. As a rule of thumb, sediments should contain at least 5% fine fraction (<63 µm), information which may have to be obtained from preliminary trial surveys.

Alternatively, especially in the cases of rivers without sediments or with perturbed sediments, SPM and freshly deposited sediment can be used to collect the desired fine fraction. Knowing that deposition of suspended particles from the water column is favoured in areas with relatively low energy in the water (waves, currents), the following general criteria can be provided for the selection of the sampling sites:

- in rivers and transitional waters (estuaries), the currents are highest in the central channel or river bed, in which means that a relatively low amount of fines deposited on the bottom. Higher concentrations of fine-grained deposits are found in areas where the water flow is lower, such as near the side of the river (in concave stretches of the river) and in accumulation areas within estuaries;

- in natural estuaries with complex suspended solids dynamics (i.e. estuaries with settling and erosion zones, tidal flats, etc.), representative sampling is possible only upstream of the tidal limit. In such cases, the sampling site should be located in the non-tidal zone of unidirectional flow (e.g. upstream of a weir);

- in lakes and reservoirs the highest energy dissipation occurs near the inlet of rivers, and on the shores (wave action). The highest concentration of fines may therefore be found away from these sites;

- in coastal waters, areas with high tidal currents must be avoided. Sedimentation areas, such as embayments or areas of relatively deep water, are preferred.

When the final objective is the assessment of a temporal trend in chemicals contamination, a representative number of sites should be selected, giving preference to sites used for surveillance monitoring. The same sampling sites should be used over the years. This requires continued accessibility, and also that the sampling site, and the related sampling points, are well defined by exact geographic coordinates, with the datum point of the reference system also being given. Finally, the site should be large enough to supply multiple samplings if sediment cores are taken.

5.1.2. Number of replicate samples per station

Multiple samples have to be collected at each sampling site in order to estimate factors contributing to the overall variance in the analytical data. It is recommended that three to five samples (independent replicates) are selected at each site.

QA/QC procedures should also cover the sampling phase, as it is part of the overall measurement process. The sampling procedures adopted in routine monitoring of sediments quality should be validated and sampling quality control performed. Validation allows the evaluation of the sampling quality under stated (routine) conditions and provides an estimation of the contribution of sampling to the measurement uncertainty (including the analysis). It can be performed by taking replicate (duplicate) samples (6–10 in the pilot phase) at the same point, differing as little as possible one from the other in terms of space and time. In general, only the random component of uncertainty (repeatability) arising from sampling may be assessed. Replicating the analyses on each duplicate also enables the contribution due to the analytical phase to be evaluated. Pooling of individual samples into one composite sample is not recommended in the pilot phase as this prevents the estimation of field variability, which is an essential parameter for power analysis and trend tests.

Since the potential range of substances to be analysed is wide, the sampling quality performances may be reasonably assessed only for a selected measurand (e.g. metals).

Whatever the sampling quality requirements, the sampling procedure performance may be kept under control during routine sampling activity by applying the same, previously validated, sampling procedure at the same sampling point. Quality control may be performed through the collection of replicate samples, as in the validation, and setting up a quality control chart. Frequency of sampling quality control depends on the extent of the sampling locations and of the planned sampling frequency.

5.1.3. Sediment sampling frequency

As a result of a usually limited sedimentation rate (usually in the range 1–10 mm/y, but larger values occur) and the physical and biological mixing of surface sediments, the composition of sediments generally is usually rather stable in comparison to the concentrations of contaminants in the water column, except for rivers characterised by turbulent flow. As a consequence, sampling of sediments generally requires i a lower frequency than sampling of e.g. surface waters.

Directive 2008/105/EC states that monitoring should be performed at a minimum frequency of once every year for compliance with EQS, and once every three years for temporal trend analysis, unless technical knowledge and expert judgement justify another interval.

Sediment samples should be collected at an appropriate frequency that matches the expected changes in the sediment, taking into account the hydrological regime and the sedimentation rate of the water body studied. Estuaries, rivers and reservoirs, and sometimes lakes, may show large differences in hydrodynamic characteristics over the year. The higher the expected/observed changes, the higher the frequency.

In highly dynamic water bodies such as estuaries, sampling several times per year may be required. However, the application of normalisation techniques (see Sections 5.1.5 and 5.4, below) can greatly reduce the variability arising from changes in the bulk properties of sediment (e.g. changes in particle size distribution arising from changes in water flow regimes).

It is recommended that sampling be undertaken during a period with low current velocities, and the preferred period corresponds to the time of lowest water discharge rate (flow). Moreover, bioturbation is lowest in the winter period. It is recommended to plan the sampling campaigns in the same time window every year, preferably under similar flow conditions.

Special attention should be given to sites significantly affected by changing sediment input, in which water flow and therefore accumulation rates may change seasonally, following, for example, flood events or ice cover. Sampling during or shortly after a flood should be avoided.

If high fluctuation in the concentration of contaminants during the year is measured or expected at selected hot spots, higher frequencies should be adopted.

It might be helpful to distinguish between variations in physics (e.g. high and low run-off periods) which lead to changes in bulk sediment composition (% sand, % mud etc.) and thereby lead to changes in the concentrations of contaminants when looking at the whole sediment, and processes such as seasonality in use of herbicides that lead to changes in pollutants load in sediment. The former should be addressed through normalisation methods, while the latter should be addressed by increasing sampling frequency.

Sediment sampling frequency could be reduced when parameters are demonstrated, by monitoring data and the analysis of pressures, to be significantly below the quality targets or when no significant trend can be observed or expected.

When monitoring for temporal trends, sound statistical analysis will require several data points in time. Notwithstanding that the WFD reporting cycle is six years, a recommended approach might be to sample annually for the first WFD cycle in order to allow a trend analysis with better statistical confidence for that cycle, and then reduce the frequency thereafter if considered appropriate. Trend analyses after 12 or 18 years would continue to make use of the assessed data from the first six years.

Sampling of suspended solids for trend analysis should be carried out at least 4 times a year, although monthly sampling should be the goal. The median of a year should be used to observe the trend, as it is less sensitive to the outliers (this eliminates, for example, findings made at times of high water, which are less representative for trend observation).

5.1.4. Sediment sampling depth

Sediment monitoring generally addresses the top layer of the sediment because this layer indicates the actual deposited material and the actual status of pollution. Furthermore, the top layers of the sediment form the habitat of benthic organisms, and the protection of ecosystems is the main aim of WFD. These top layers are the net result of deposition of particulate matter from the water column (sedimentation) and physical (e.g. by currents, waves) and biological mixing (bioturbation), which is restricted in most areas to the top 5–10 cm. Sediments and SPM are sources of food and are subject to dynamic interactions with the water column due to resuspension.

The main criterion for choosing the correct sediment sampling depth (the thickness of the sediment layer sampled) in a water body is knowledge of the deposition rate of the sampling site. In theory, the lower the deposition rate, the thinner the layer that one may want to sample. In situations with steady sedimentation and undisturbed sediments, such as some oligotrophic lakes, the very top layer of the sediment will contain the most recent information and thinner top layers may be sampled (from 0.5 to 1 cm depth).

In practice, apart from this kind of specialised environment where bioturbation and physical disturbance of sediment are negligible and undisturbed surface sediments can be sampled, it is recommended to sample the top layer of the sediment, from 1 to 5 cm depth, depending on the deposition rate. The sampling depth should be defined for each sampling site. In the case of highly perturbed sediment or in large fast flowing rivers, the sediment sampling depth could be more than 5 cm. For comparison reasons, sampling depths should be maintained over the years for the respective sites.

Different intervals may be appropriate for the sampling of sediment core profiles.

5.1.5. Sediment fraction to be analysed

Sediments consist of a large range of particles, ranging from the very fine clays (<2   m) to coarse pebbles and stones of several mm in size. Their surface is often coated by organic matter, which acts as a binding site for many pollutants and other compounds. The smaller the particle, the larger the relative surface area, that means that the greater part of many hazardous substances is contained in the finer sediment fractions, which are also the primary food source for biota.

Fine material (inorganic and organic) and associated contaminants are preferentially deposited in areas of low hydrodynamic energy, while in areas of higher energy, fine particulate matter is mixed with coarser sediment particles, which generally have a much smaller capacity to bind contaminants. This dilution effect arising from the presence of coarser material will cause lower and variable contaminant concentrations in the resulting whole sediment. Obviously, grain size is one of the most important factors controlling the distribution of natural and anthropogenic components in sediments, along with organic matter content. It is, therefore, essential to normalise for the effects of grain size in order to provide a basis for meaningful comparisons of the occurrence of substances in sediments of variable grain size distribution and texture within individual areas, between areas or over time.

When analysing whole sediment (i.e. <2 mm fraction) for spatial distribution surveys, the resulting maps may give a direct reflection of pollutant distribution only if the sediments have homogeneous bulk composition (e.g. are all mud, or are all sand) throughout the whole surveyed area. In areas with varying grain size distributions, however a map of contaminant concentrations will be closely related to the distribution of fine-grained sediments, and any effects of other sources of contaminants, for example anthropogenic sources, will be at least partly obscured by grain size effects. If samples used for a spatial survey consist predominantly of fine material (>80% fines), the influence of grain size distribution is of minor importance and may be ignored avoiding the need for sieving procedures.

In temporal trend monitoring, too, differences in grain size distribution can obscure trends.

Selection of the grain size fraction considered as the ‘fine fraction’ used for the analysis depends on the general aim of the sediment analysis; it should reflect the distribution of the particular analyte as a function of the sediment particle size.

Sieving to collect the <20 µm fraction is an effective way to reduce variability. In most areas, however, the portion of 20–63 µm is rather small compared to the fraction <20 µm fraction. For pragmatic reasons (labour-intensive sieving process to collect very fine fractions) analysis of the grain-size <63 µm fraction, representing the clay-silt fraction, is widespread in many current monitoring programmes. Consequently the recommended procedure for the correction for grain size effects in sediments is the collection of the <63 µm sediment fraction. This recommendation is made recognising the effort required to undertake the sieving process and the added risk of contamination.

In some water bodies, such as estuaries of large mainland rivers, the 20–63 µm fraction is not negligible. In these cases, even when sieving at <63 µm, co-factors (see Section 5.4) still need to be determined.

An alternative procedure, based on the normalisation to the <63 µm fraction, can be recommended in order to avoid the sieving process and the associated risk of contamination. As concentrations of contaminants in sandy sediments are usually negligible, chemical substances (both organic and inorganic compounds) may be analysed in the <2 mm fraction and subsequently normalised to a sample consisting of 100% of the <63 µm fraction. In order to get reliable normalised results, the amount of fines should be at least 10%. Moreover, with this alternative procedure it is mandatory to measure the actual granulometry of the analysed sediment sample.

SPM or freshly deposited sediment in rivers can be used as a source of <63 µm material, except in particular hydrological situations, such as floods, when large particles can be moved and redeposited.

5.2. Technical aspects of sediment sampling

Of the ISO 5667 series of standards providing guidance on sampling techniques; the followings should be taken into account for sediment sampling:

- Design of sampling programmes [ISO, 2006];
- Preservation and handling of samples [ISO, 2003];
- Sampling of rivers and streams [ISO, 2005];
- Sampling from lakes [ISO, 1987];
- Sampling of bottom sediments [ISO, 1995];
- Guidance on preservation and handling of sludge and sediment samples [ISO, 1999];
- Sampling of marine sediments [ISO, 2004].

Notwithstanding the importance of the general principle presented in the standards, which should be known by the staff carrying out the sampling, the exact procedure/equipment will always be dependent on the conditions at the actual sampling site. As sampling sites may be rather different, the staff should be sufficiently experienced to decide on the appropriate procedure/equipment. In general, the technical aspects of sampling do not depend on the water body concerned, but on the logistic requirements. Shallow waters may be present in any water body, deep waters are present in many lakes and coastal environments. The sampling operation is technically driven more by water depth than by the type of water body.

Even before sampling starts, it is important to check whether the sampling site is disturbed by unexpected events (tourism, boating, debris, etc). Samples should be collected from physically undisturbed sediments. For example, in manual sampling near the shoreline, the person taking the sample should avoid sampling in his footprints.

It is good practice to complete a sampling report, which may include a general description of collected samples including colour, homogeneity (presence or absence of stratification), presence or absence of animals (indication of bioturbation), surface structures, odour and any visible contamination (e.g., oil sheen).

Furthermore, contamination during sampling, sample pre-treatment (sieving, homogenising, freeze drying) and storage of samples has to be avoided. Other sources of contaminant degradation (oxidation, photodegradation) should be minimised.

Many further manuals, which describe technical procedures for sediment sampling, are available [see e.g. U.S. EPA, 2001; Kramer et al., 1994; Mudroch and Azcue, 1995; UNEP/MAP, 2007].

5.2.1. Sample volume

Sample volume is dependent on:

- The (expected) concentration of the hazardous substances (for organic micro-pollutants the sample volume should be larger than for trace elements);

- The percentage of the fine fractions which accumulate contaminants;

- The number of analyses that need to be carried out on the sample (nutrients, trace metals, organic micro-pollutants, radio-tracers, co-factors, etc.);

- The number of replicates for each analysis.

Obviously, for surface sediment samples, replicates may provide a larger sample volume, but for vertical profiles the volume of slices of sediment will remain limited. Samples obtained by corer are usually rather limited in volume (for a top 5 cm sample, an 8 cm Ø corer gives a sample of about 250 ml). In general it is recommended to obtain the following sample volumes (Table 2):

Table 2 Recommended sediment sample volumes

Type of analysis	Volume
Trace elements	50 ml
Organic micro-pollutants	200 ml

These are obviously only indicative values for operators because the sediment porosity should also be taken into account. If sandy sediments are sampled, the sample volume may need to be much larger in order to obtain sufficient amounts of fine material for subsequent analyses.

5.2.2. Sediment samplers

Either a grab sampler or a corer may be used to sample the top layer of the sediment, while in smaller and shallow rivers, scoops can also be employed. Grabs or corers are designed to penetrate the substrate as a result of their own mass or leverage. They come in a multitude of types and designs, often tuned to use in specific conditions. In general, their practical use depends on several factors such as water depth, sample volume, sediment type, construction material, ease of handling, and whether a surface sample or a vertical profile has to be collected. Table 3 provides a recommendation for the use of sampling equipment for surface sediment sampling according to water depth and sample volume. Small grabs and corers collect a sample of approximately 250 ml.

Table 3 Recommendation for use of sampler for the collection of the top layer of sediments (# = usable; - = not usable)

	Grab sampler	Hand corer	Gravity corer	Box corer
Water depth				
0–3 m	#	#	-	-
3–25 m	#	-	#	#
> 25 m	#	-	#	#
Sample volume				
<1–2 dm^3	#	#	#	#
>2 dm^3	#	-	-	#

It must be underlined that only the use of a large diameter or box corer enables reliable, undisturbed collection of the top surface layer for analyses. When using corers, about 20 cm sediment should be collected, and the top layer (from 1 to 5 cm depth, depending on the deposition rate) retained.

The choice of sampler type will be determined in part by the type of sediment. For the purpose of WFD monitoring, the following options are recommended [Slobodnik et al., 2004]:

- sand: both grab and corer systems can be used;
- clay: it may be necessary to use a corer because a grab system may not penetrate easily into the clay;
- consolidated bottom sediment: both grab and corer systems can be used;
- unconsolidated (very soft) bottom sediment: grab systems are not suitable, as they are prone to sink through the top layer. Corer systems perform better.

Analyses of depth profiles can be used to get additional information on the history of contamination and to reconstruct the past trend. This approach is best applied in sediments where the sediment accumulation rate is high and the rate of disturbance (physical or bioturbation) is sufficiently low so as to cause negligible disturbance to the contaminant profiles. Sediment profile samples are collected exclusively by corers.

5.2.3. Grab samplers

Grab samplers are normally mounted on a winch and attached to a rope or pole. The limited weight of small grab samplers allows operation by hand, which could prove convenient in the field. The sampler is locked in the open position and lowered to some distance above the bottom sediment. It is important to reduce the lowering speed when approaching the bottom as a bow wave may flush away the fine sediment before the sampler reaches the bottom. When the sampler touches the surface sediment, a latch is released allowing the 'jaws' to close when the cable/pole is pulled up, thus collecting a surface sediment sample. The grab sampler should be retrieved slowly to ensure that the jaws dig into the sediment and to avoid loss of the surface layer.

After retrieval, the sampler is lowered into a clear tray. Before opening the jaws, the water contained above the sediment is gently siphoned away, taking care not to wash away fine sediments at the same time. After discarding the water, the grab sampler is opened and emptied in the tray.

Problems in sampler operation include their sinking too deeply into very soft sediments, mixing of the target surface sediment layer, not collecting sufficient sediment in hard substrates, or stones between the jaws preventing their closure.

To minimise contamination, sediment that has been in contact with the sampler is to be avoided, and surface samples are collected from the central part of the sample. Stainless steel versions minimise contamination of the sample (beware of contamination of Ni and Cr). Other materials for grab samplers include coated steel samplers, but they may contaminate samples for trace element analysis (rust, paint). Alternatives are aluminium samplers.

5.2.4. Corers

Core samplers are used when information concerning the vertical profile of the sediment is of interest, or when grab samplers cannot be used because of, for example, the sediment type.

Corer tubes are usually made of PVC or Perspex, the latter offering an immediate view of the sample collected. A polyethylene inner sleeve may be used to protect the sample from contamination by the corer wall. For the determination of trace organic pollutants, other materials such as stainless steel could be chosen to minimise contamination.

Hand-operated corers can conveniently be used to collect surface sediments: they may be a short plastic tube of 8 cm Ø and are manually pushed into the undisturbed sediment for about 30 cm. If necessary, the air on top is replaced by ambient water, a rubber stopper is inserted and the sampler is retrieved. A cap is placed immediately at the bottom end. Then the water is siphoned off, and the top 5 cm of sediment is collected; a piston may help to push out the sediment. A hand operated corer with an extension tube or rod can be used to water depths up to about 3 m, depending on the currents. The core length obtained is limited by the diameter of the tube and the friction of the tube wall: maximum core length (tube diameter)^2. Hand corers have limited use for collecting profiles.

Gravity corers in principle act in a similar way to hand-operated corers, but in deeper water. The attached weight pushes the corer tube into the sediment. Often a valve is placed in the top section, preventing spillage of the sample during retrieval. Because of their weight, gravity corers are not easy to operate manually, and a winch is usually required. Core length is limited for the same reasons as for hand-operated corers, and they are of limited use for profile samples.

Box corers are very heavy, specialised equipment that collect large diameter undisturbed cores, from which replicate sub-samples may be collected (e.g. by hand-operated corer). As they are usually operated from research ships, they can be used in water depths >3 m. Usually the core length is maximum 1 m, and consequently they are of limited use for the collection of long profile samples. Operation requires specialised staff.

Usually one core is collected per sampling point. Within one core there is a chronology between different sediment layers. A replicate core, even collected nearby, may have a different sedimentation history and corresponding sediment depths may be different. Unless samples are collected by multi-corer, where the tubes are mounted in parallel and the distance between the cores is minimal, pooling of replicate samples is not recommended.

The distribution of sub-samples should be concentrated near the surface. The top of the sediment would be sliced to e.g. 3–6 slices (1–3 cm thick) and the lower part of the sample would be collected for reference.

5.2.5. Collecting of SPM and freshly deposited sediments

The following techniques are primarily used to collect suspended solid samples: centrifuge pumps and stationary or mobile settling basins or suitable traps/collection crates. In addition, samples of suspended solids can be collected through filtration. With filtration, however, the sample quantity is generally small and therefore barely sufficient for an analysis, especially of the organic substances.

Sampling with centrifuge pumps usually takes several hours and is more akin to taking individual samples while settling basins generally collect monthly composite samples. In fact, sedimentation traps or boxes may be exposed to the water for two to four weeks, to sample suspended sediments carrying the present contaminants. This sampling technique has the advantage that samples represent the very last deposited layers, especially in slow-flowing continental mainland rivers, which can be also used for trend analysis.

Settling basins do not allow for quantitative separation of the suspended solids from the water phase, and fine grains in particular are not collected in full. In contrast, centrifuge pumps almost completely separate suspended solids from the water, but they could influence the particle size distributions. These characteristics should be taken into account when the sampling methodology is chosen.

5.2.6. Transport and sieving

All samples must be sieved over 2 mm mesh as soon as possible after collection to remove large detritus and benthic organisms. Otherwise, during subsequent sample handling and processing, such as storage, freezing or ultrasonic treatment, biotic material will deteriorate and become part of the sediment sample. In order to minimise the potential for disturbance of the sediment/water equilibrium wet sieving is best performed at the sampling point with ambient water. The same water should be reused to prevent changing the equilibrium If field sieving is not possible, sieving should take place in the laboratory under controlled conditions.

Samples (sieved or not) are transferred preferably into wide-mouth, pre-cleaned bottles of amber glass (or aluminium, or other non-contaminating material) for organic analysis or into plastic bags or bottles for trace element analysis. Alternatively, amber glass jars can be used for all kinds of contaminants. Sampling containers should be filled to the top (minimal headspace) to reduce the likelihood of oxidation and loss of acid volatile sulphide (AVS) during transport. It is preferable to store samples under refrigeration (about 4°C) and transport them as soon as possible to the laboratory. Refrigeration is easily accomplished with cooling boxes and cooling inserts.

Transport of cores is critical as the integrity of the core has to be maintained. Samples near the sediment/water interface will be disturbed and will mix when transported in a horizontal position, thus losing their profile characteristics. In addition, even when transported in the vertical position, vibration will tend to compact the sediment. If possible, cores should be sub-sampled and sieved directly in the field.

Until the final sieving procedure that isolates the fines for subsequent analyses (see Section 5.1.5), which is normally carried out in the laboratory, the sample can be stored at 4°C for about a week and up to 3 months when frozen at -20°C, unless otherwise specified in the analytical methods for specific degradable compounds. Whenever possible, freezing should be avoided because it can change the grain size distribution of the sediment.

In the case of the AVS measurement, sediment should be preferably kept at 4°C, although freezing has negligible effects on AVS levels. If stored at 4°C, the period between sampling and AVS analysis should be no longer than two weeks.

If provided by the sampling strategy (see Section 5.1.5), the silt+clay fraction (<63 µm) could be separated by sieving over a 63 m mesh sieve. As clays tend to form lumps of considerably larger diameter, sediments should be sieved wet. A minimal amount of ambient water should be used. It is strongly recommended to avoid sediments becoming dry. If it happens, sediments should be pre-soaked in water for at least 2 hours to break up the lumps.

In the case of saline samples it is particularly important to sieve with water with approximately the same salinity as at the sampling location. If no local water is available, the correct salinity value can be obtained by diluting a stock of seawater collected from the open sea.

Sieving may be carried out by simple means, using a sieve mounted on a funnel filled with water and moving the sieve manually. For the processing of larger numbers of samples, sieves may be placed on vibrator tables. The water can be efficiently separated from the sieved material by centrifugation. Sieving procedures have been described and evaluated in the QUASH project [QUASH, 1999; Smedes et al., 2000].

Sieves are traditionally made of corrosion-resistant brass (rim and mesh). Today, stainless steel is preferred for organics analyses. These must not be used for the analysis of trace metals, however. For trace metals, polymer sieves are recommended (PVC or acrylic rim, with e.g. nylon or polyester mesh).

5.2.7. Preservation and Storage

Storage begins when the samples are taken. All storage methods will affect the sample to some extent, and the choice of preservation technique depends mainly on the objective of the sample collection. Because the first few hours after sampling are the most critical for changes to occur in the sample, preservation steps should be taken, where possible, immediately upon sample collection. No recommendations can be given for a universal preservation or storage technique. A technique for one group of analyses may interfere with other analyses. To overcome this problem, a sufficient sample volume should be collected to allow specific preservation or storage techniques for each specific group of analytes.

Temperature is the most important factor affecting the samples, from the time of sample collection through handling to the final analyses. Another source of contamination is the adsorption of contaminants from laboratory air. Degradation and volatilisation of pollutants could be a source of errors too.

In the laboratory, the sieved sediment samples should be deep-frozen at -20°C and, when frozen, freeze-dried in a freeze-dryer as soon as possible. Check contamination during freeze-drying by placing a glass jar with 2 g C18 bounded silica in the freeze dryer in parallel with the samples.

Air-drying is not appropriate due to high contamination risks. Besides, samples may be difficult to disaggregate and mineral structures may be affected. If a freeze-dryer is not available, in order to limit microbial breakdown, the samples could be air- or oven-dried at 25–30°C till more or less constant weight as soon as possible after sieving. Losses of some determinands (volatile or semi-volatile compounds, such as e.g. 2–3 rings PAHs) can occur during this process, even when the drying is done at cool temperatures (<30 C). Prior to analyses of inorganic constituents (e.g. metals), sediment samples may be dried at 105°C (except for mercury determination, which needs a drying step at <50°C).

Containers for storing lyophilised or dried sediment samples are preferably wide-mouth bottles with a screw cap. Samples taken for the analysis of organic contaminants must be stored in amber glass, polytetrafluoroethylene (PTFE), stainless steel or aluminium containers. Sediments collected for analysis of metals can be stored in closed plastic or glass containers. Since sediment particles have a small surface area which exchanges with the container surface, the contamination risk is limited and it is possible to use a glass jar for all determinations in order to simplify sediment characterisation.

For mercury, samples must be stored in acid-washed borosilicate glass or quartz containers, as mercury can move through the walls of plastic containers. For organotins, storage of samples is preferably done in amber glass bottles, but containers of other materials such as polycarbonate or aluminium are also suitable. Maximum suggested time of storage of freeze dried sediment before analysis is about 180 days (30 days for Hg) if stored in a cool, dark place.

Archiving sediment samples is a must in QA/QC procedures. All samples should be kept for the duration of the monitoring in order to be able to come back to any of them, or to all of them, in case of problems in the analysis or interpretation. In addition, it may be useful to archive part of the original sample in order to be able to re-analyse the material for (other) compounds at a later date. Freeze-dried sediments remaining after analyses are stored in the original sample bottle, closed with an airtight lid to protect against moisture. When stored in a cool, dark place, samples may be archived and stored for 10-15 years, i.e. for the duration of the monitoring programme. For less stable compounds this period may be shorter.

5.3. Analytical methods

Only a few standard methods exist for sediment analysis (for PBDE, Cd, Pb, Ni, pentachlorophenol, tributyl tin compounds) [Lepom and Duffek, 2005]. As regards soil analysis, standard methods are lacking for only 10 substances. However, existing ISO standard methods for soil analysis, summarised in CIS Guidance No. 19 “ANNEX I: List of ISO Standards for soil analysis” [EC, 2009], may be applied to sediments after validation on the appropriate matrix.

JAMP Guidelines for Monitoring Contaminants in Sediments [OSPAR, 2003] currently contain detailed advice on sampling, sample preparation and analytical methods for some contaminants in marine sediment. OSPAR Guidelines currently cover metals, chlorobiphenyls, PAHs, mono-, di- and tributyltin, PBDEs and HBCD; advice on PFOS, alkylated PAHs, co-planar CBs and dioxins in sediment is currently under development.

The analytical methods applied after extraction or digestion of the sediment, are generally the same for water and sediment samples. The principles of available analytical methods for priority substances are reviewed in CIS Guidance No. 19 “ANNEX II: Substance Guidance Sheets” [EC, 2009].

The use of standardised methods is recommended, because these methods have been finally validated in interlaboratory trials. Nevertheless, not all standardised methods meet the minimum performance criteria stated in Directive 2009/90/EC. The use of standardised methods should only be mandatory if the analysis or the quantification contains “method-defined” parts. This is the case for e.g. the selection of congeners of brominated diphenyl ethers, the quantification of alkylphenols, and both the selection and quantification of short chain chlorinated paraffins, if available.

The methods will, to some degree, dictate the amount of sediment sample required for each analysis. *Vice versa* the amount of sample used in an analysis affects the detection limits attainable by a particular method.

5.3.1. Organic compounds

Solvent extraction methods described in standards for soil can also be used for dried sediment. EPA has adopted various extraction procedures, from classical Soxhlet extraction to advanced techniques such as Microwave Assisted Solvent Extraction (MASE) and Pressurised Solvent Extraction (PSE).

Special care should be taken for volatile compounds for which extraction of wet samples, avoiding the freeze-drying step, could be preferable. Extraction of wet sediment samples requires the use of a first extractant that is miscible with water (such as acetone), followed by a less polar extractant such as pentane or hexane. This procedure works well for non-polar priority substances such as organochlorinated pesticides, PAHs, PBDEs and chlorinated benzenes.

Alternative extraction methods for volatile compounds use purge-and-trap or headspace techniques.

The analytical techniques for semi-volatile organic compounds generally involve solvent extraction from the sediment matrix. Extensive cleanup is required if there is a likelihood of (*a*) biological macromolecules, (*b*) sulphur from reduced sediments and (*c*) oil and/or grease in the sediment.

The recommended detection method for analysis of semi-volatile and volatile organic pollutants in sediment is based on the use of capillary-column gas chromatography (GC) with mass spectrometry (MS). For the determination of organohalogenated compounds, GC with Electron Capture Detector (ECD) can also be used. The most selective methods using GC/MS techniques are recommended for most organic compounds, because such analysis can often reduce problems caused by matrix interferences.

Non-volatile organic compounds require HPLC separation with selective detection such as fluorescent and electrochemical detection. Standard methods are under development based on mass spectrometric detection with atmospheric pressure ionisation hyphenated to liquid chromatography systems.

5.3.2. Metals

For the determination of metal concentrations in sediment, samples must be digested with concentrated inorganic acids in a traditional open system or, more commonly, in sealed vessels in a microwave oven and analysed by methods such as inductively coupled plasma-atomic emission spectrometry (ICP-AES) or ICP-MS, graphite furnace atomic absorption spectroscopy (GFAAS) or atomic fluorescence spectrometry.

OSPAR recommends the inclusion of HF in the digesting medium [OSPAR, 2003]. By this approach, the total metal content, including that part which is of geochemical origin, is measured and that procedure allows the application of normalisation co-factors based on Al or Li content (see 5.4). This approach requires knowledge of the distribution of background concentrations of trace metals of geochemical origin.

In surface waters, background concentrations are less assessed and are very variable in a water body. HF digestion could lead to an overestimation of the trace metals content. The use of less aggressive acid mixtures (such as for example concentrated nitric acid + hydrochloric acid, Aqua regia), which are moreover safer substitutes, is therefore recommended, depending also on the final detection technique.

SEM-AVS (Simultaneously Extracted Metals – Acid Volatile Sulphides) analysis should be carried according to the United States Environmental Protection Agency (US-EPA) method [U.S. EPA, 1991] integrated by the Dutch National Institute for Public Health and the Environment (RIVM). Extraction with 6M HCl solution should be carried out on a homogenised wet sample. The formed H_2S gas, collected in a NaOH-solution, is spectrophotometrically determined at 660 nm using dimethyl-p-phenylenediamine hydrochloride as colour reagent. Metals are determined on the filtered supernatans.

5.3.3. Quality Assurance / Quality Control procedures

Proper Quality Assurance/Quality Control procedures include the validation of methods by analytical laboratories, routine internal QC procedures and independent external QC procedures.

The validation of an analytical method, including the determination of measurement reliability, bias, etc., requires the use of certified reference materials. In CIS Guidance No. 19-"ANNEX III: Existing certified reference materials" [EC, 2009], a complete list of sediment certified reference materials (CRM) is reported. CRMs are currently available for the determination of metals, PAH and chlorinated pesticides in sediment. For other organic priority substances, no suitable CRMs have been developed yet.

Internal QC procedures should include the routine monitoring of the performance of analytical methods, for example by the inclusion of duplicate samples or (laboratory) reference materials in analytical batches. The results from these samples should be assessed using standard statistical methods such as Shewhart charts to ensure that the methods remain under statistical control.

It is recommended that laboratories participate in suitable external interlaboratory comparisons. A grouping of Proficiency Testing Laboratories has been established to meet the needs of WFD. This PT–WFD network (http://www.pt-wfd.eu/) is comprised of organisers of proficiency tests which support the implementation of the EU Water Framework Directive. It seeks to ensure that the demands of the EU WFD are met through the organisation of high-quality proficiency tests which are performed in a harmonised and comparable way.

5.4. Normalisation co-factors

Normalisation is defined here as a procedure to correct contaminant concentrations in sediment for the influence of the natural variability in bulk sediment composition (grain size, organic matter and mineralogy).

Isolation of the fine fraction by sieving can be regarded as a physical normalisation to reduce the differences in sediment granulometric composition (*see* Sections 5.1.5 and 5.2.6).

In data reporting, any geochemical-based differences in sediment composition that remains after sieving can be corrected for by the use of co-factors. It is also mandatory to report raw data, expressed as weight pollutant/weight sediment, together with normalising co-factors and/or normalised data.

For the analysis of trace elements in the sieved fine fraction, a common normalisation method involves the use of the aluminium (Al) concentration. Clay minerals are rich in (e.g.) Al or Li, the sands (quartz) are not. Generally, compared to aluminium, more accurate normalised data can be expected using lithium. Total sediments are analysed for the trace element, including the co-factor; the trace metal concentration is normalised with respect to the normaliser content that represents the fine fraction (normaliser content in sample minus the normaliser content in pure sand or in the >63 µm fraction). In this case Al or Li is used as a proxy to fine sediment particles. The aluminium content in the sandy fraction may, however, vary from area to area. Therefore, to use this method, a statistically meaningful relationship between Al and grain size must be established in the sediment of the area prior to the application of the method.

For the analysis of trace organic compounds in sediment, a widely used normalisation method involves normalisation using the total organic carbon (TOC) concentration. Clay and silt minerals are coated with organic matter, while the coarser fractions contain relatively very small amounts of TOC due to their small relative surface area. The ratio of [concentration of the organic compound]/[TOC] is the normalised value. However, care has to be taken, as organic matter in a sample is not always well defined and it can be composed of material with different properties. Furthermore, the nature of the organic matter may show spatial variation. Also, while normalisation using TOC is effective for lipophilic substances such as chlorinated compounds and PAHs, it may not be valid for other classes of compounds which bind to particles and clays with more polar bonds.

Detailed guidance on the use of normalising parameters for sediments is given in Annex 5 of the JAMP Guideline for Monitoring Contaminants in Sediments [OSPAR, 2003; see also OSPAR, 2001].

6. MONITORING OF CHEMICAL SUBSTANCES IN AQUATIC BIOTA

6.1. Introduction

The monitoring of chemical substances in aquatic biota should be performed according to the minimum requirements of Directive 2008/105/EC and according to the recommendations in CIS Guidance No. 19 [EC, 2009] and in the EQS Guidance document in course of publication [EC, 2010].

The objectives of biota monitoring under the WFD are:

- compliance checking against EQS values for the purpose of the classification of chemical (for the 33 priority substances and 8 certain other pollutants) and ecological status (in the case of river basin-specific pollutants) of the waterbodies;

- long-term trend analysis of concentrations of substances that tend to accumulate in biota in the context of surveillance monitoring programmes of WFD.

The substances to be monitored in aquatic biota should be selected on the basis of the recommendations given in Chapter 3.

The monitoring of mercury, hexachlorobenzene (HCB) and hexachlorobutadiene (HCBD), substances for which a European EQS has been derived, should be performed in accordance with the recommendations contained in this chapter.

Biota monitoring programmes under international conventions for inland, transitional, coastal and marine waters already exist: e.g. Helsinki Commission (HELCOM), OSPAR, International Commission for the Protection of the Rhine (ICPR), MEDPOL. In general, species that are already used in existing national or international monitoring programmes should be used for biota monitoring under Directive 2008/105/EC.

The methodology to determine the natural background concentrations of metals in biota is included in the EQS guidance in course of publication.

6.2. Sampling strategy for chemical monitoring in biota

The biota sampling strategy for a given water body should include the choice of the substances to be monitored (see Chapter 3), the selection of the species representative for that specific water body, the selection of the sampling sites, the monitoring frequency and the monitoring techniques.

The natural variability within biota samples should be reduced by an appropriate sampling design, keeping in mind that differences in age, size, sex and sexual maturity status can affect the measured concentrations of contaminants. Sampling strategies should be devised so as to minimise the impact of these factors. Biota sampling should only take place when fish and bivalves are in a stable physiological state, and outside the normal period of spawning. Fishes should be collected from areas characterised by relatively low natural variability.

Moreover, the following general recommendations are given:

- For the selection of species for biota monitoring, Member States should not use species that are endangered or that require special protection in compliance with “Habitat Directive” requirements or any other national or international action plan for nature conservation. Active biomonitoring, such as caging and transplantation procedures must avoid the introduction of allochthonous species to waterbodies. Non-native species should not be used in active biomonitoring.

- Sampling strategies for biota monitoring should seek continuity with pre-existing monitoring programmes when relevant. In some cases and for some species, harmonisation with the biota sampling performed for the purpose of the classification of the ecological status can be useful.

6.2.1. Selection of biota species and link with EQS derivation

In the selection of biota species, consideration should be given to the main purposes of the EQS Directive: trend monitoring and compliance with EQS. Where possible the same species sampled should be used for both purposes.

The species should be selected mainly on the basis of their ability to reflect the quality of the water body that has to be monitored and, in the case of compliance checking, on the basis of the trophic level for which an EQS has been derived.

The WFD requires biota EQSs to protect:

1. humans from adverse effects resulting from consumption of chemical-contaminated food (fish, molluscs, crustaceans, etc.);

2. top predators such as birds and mammals from risks of secondary poisoning brought about by consuming toxic chemicals in their prey;

3. benthic and pelagic predators (e.g. predatory fish) that may also be at risk from secondary poisoning.

The choice of species to be monitored should depend mainly on the identified protection goal (e.g. humans, top predators); where there are a variety of protection objectives, it is preferable to choose a species that can satisfy them all.

According to the EQS guidance in publication, if for a given contaminant it is not possible to monitor the same species (or a trophic level) for which the EQS has been derived, the biota quality standard should be adjusted to the appropriate trophic level of the species actually monitored .

6.2.1.1. Mercury and its compounds, hexachlorobenzene and hexachlorobutadiene

Biota EQS have been derived for mercury and its compounds, for hexachlorobenzene and for hexachlorobutadiene in Directive 2008/105/EC. For these substances specific recommendations for monitoring are therefore given, based on the criteria that have been used for the EQS derivation which are indicated in the datasheets of the priority substances available in the public section of the CIRCA forum:

(http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/i-priority_substances/supporting_background/substance_sheets&vm=detailed&sb=Title).

For the substance class “Mercury and Compounds” the EQS of 20 µg/kg in prey tissue has been derived for methylmercury and the protection objective is the prevention of secondary poisoning of top predators; for this substance the species to be monitored should be a prey (diet) for top predators of the waterbodies to be classified. Prey can be fish or shellfish, depending on the local aquatic trophic chains.

For the substance “Hexachlorobenzene” the EQS of 10 µg/kg has been derived based on the risk for humans consuming seafood. It is therefore recommended that this substance should be monitored in edible parts of fish and shellfish that form part of the human diet.

For the substance “Hexachlorobutadiene” the EQS of 55 µg/kg is based on the protection of top predators from secondary poisoning. It is therefore recommended to monitor this substance in species that represent a prey (diet) for the aquatic top predators of the waterbodies to be classified. Prey can be fish or shellfish, depending on the local aquatic trophic chains.

6.2.2. Recommendations for the selection of biota species

In Europe, because of the varied geography and the wide variety of ecosystems, there is a huge number of aquatic biota species. As indicated earlier, the selection of biota species should be performed in compliance with the general requirements of the WFD and EQS Directive, but the choice of species will be necessarily limited by their availability. It is therefore important to have comprehensive knowledge of the geographical area to be represented by the collected sample.

The selection of the species should be based, if possible, on the following criteria:

- a relationship exists between contaminant concentrations in the species and average concentrations in the surrounding environment;
- the sampled organism is a potential food for predatory organisms or humans;
- the species accumulates the contaminants;
- the species is sedentary (migrating species should be avoided) and thus represents the sampling location, and does not originate e.g. from aquaculture plants;
- the species is widespread and abundant in the study region, to allow comparisons between different areas;
- the species lives long enough so that more than one year-class can be sampled, if desired;
- the species is large enough to yield sufficient tissue for analysis;
- the species is easy to collect and hardy enough to survive unfavourable conditions;
- the species is easy to identify.

When more than one species needs to be monitored in specific environments, organisms belonging to different trophic levels should be selected to evaluate the transfer of pollutants through diet. Top predators do not necessarily reflect site-specific bioavailability of chemicals but are useful for detecting the biomagnification risks.

In the following paragraphs, examples of species that meet the criteria for good monitoring practices are mentioned, but eventually the selection of actual monitoring species will also be governed by local conditions, such as latitude and altitude.

6.2.2.1. Suggested species for lakes

Perch (Perca fluviatilis L.)
Perch can be found in many parts of Europe, from Portugal in the south west, Spain and Italy in the south, Greece in the south east and northwards. It is also used as a matrix for contaminant monitoring in different European countries (e.g. Sweden, Finland, France, and Switzerland) and is

therefore a well characterised species. Perch is the most commonly used species within the national Swedish freshwater monitoring of organic contaminants and metals, but it is also used for coastal monitoring in the Baltic Sea. The fish species integrate the environmental contaminants in a given area and accordingly represent a good marker for environmental quality. Perch is fairly stationary up to a size of approximately 20 cm. The spawning season takes place between February and July and sampling should be avoided during this period.

Bream (Abramis brama)
Bream has a wide distribution within Europe with the exception of the extreme north and south. It is used for contaminant monitoring in e.g. Germany and France. It occurs in both fresh and brackish waters and is among the most frequently found fish species in central Europe. It is therefore available for long-term repeatable sampling.

Bream mainly feed on benthic organisms. Being bottom feeders, they are good indicators of pollution in the sediment, rather than just in the free column water. They are also resistant to a high load of pollutants.

The sampling should take place in August and September, after the spawning period; depending on the atmospheric conditions, it may be possible to conduct the sampling as early as the middle of July or as late as the middle of October.

Experience gained in very different types of waters reveals that eight- to twelve-year-old bream comply best with the criteria set for Environmental Specimen Banking (ESB-Germany), but specimens of other ages can also be chosen.

Arctic char (Salvenius alpinus)
Arctic char is used for contaminant monitoring in the alpine lakes of, for example, Sweden and Switzerland, where other fish species recommended for contaminant monitoring are not present. The sampling should take place outside the spawning season, which in the northern parts of Europe occurs between August and October.

In the parts of Europe where this species is rare, its use for monitoring purposes should be avoided.

European Eel (*Anguilla Anguilla*): Eels are benthic fishes, carnivorous in their feeding behaviour and preying on insect larvae, worms, crustaceans, snails, mussels, and fishes, in particular small bottom-dwelling species, resulting in high bioaccumulation of toxic pollutants. Eels have been demonstrated to be good indicators for a wide variety of chemical compounds (e.g. PCB, heavy metals, organochlorine pesticides). Because of the protected status eels should only be used for existing trend monitoring (to continue old monitoring programmes) and for this species the principle of conservation has to be respected.

6.2.2.2. Suggested species for rivers

Bream (Abramis brama) and chub (Leuciscus cephalus)
The bream and the chub are used as organisms for environmental monitoring because of their size, abundance and widespread presence. Sampling can be confined to bream aged eight to twelve years and takes place in the late summer after the spawning season (ESB-Germany). Specimens from outside this age bracket may also be used.

Brook trout (Salvelinus fontinalis) or Rainbow trout (Oncorhynchus mykiss)
These species are suggested in the mountainous regions (salmonide regions).

Zebra mussel (Dreissena polymorpha)
The zebra mussel is a sedentary inhabitant of slow-flowing and stagnant waters, where it filters vegetable and animal microorganisms. As a consequence, *Dreissena polymorpha* is exposed to hazardous substances, whether in solution or particulate suspension and is therefore useful in active biomonitoring and in toxicity and impact tests (ESB-Germany). The zebra mussel is an alien species and should be not used with caging in rivers where it is not yet known to be present.

Alternatively *Anodonta cygnea* should be used.

Other candidate species for biota monitoring include:

- European Eel (*Anguilla Anguilla*): See under 6.2.2.1.

- The aquatic bryophytes (*e.g.* genera *Fontinalis*) for heavy metals.

- The bivalves *Anodonta cygnea*, *Unio pictorum* and *Corbicula fluminea* which are additional suitable species for rivers, lakes and active monitoring (caging) strategies.

- The macroinvertebrates which can be used with caging : *Gammarus pulex, Chironomus spp*, in particular for metals bioaccumulation.

- Periphyton, which is also useful for a very broad range of contaminants, and is particularly recommended for heavy metals.

- The microinvertebrates *Hydropsychae sp.* and *Erpobdella sp.*

6.2.2.3. Suggested species for transitional, coastal and territorial waters

Molluscs
Bivalve molluscs are among the most widely used bioindicators, owing to the absence of regulatory mechanisms of internal concentrations of many chemicals, and their ability to accumulate trace metals, polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons, halogenated organic compounds, phosphate organic pesticides, etc.. Because of their biological and ecological characteristics, mussels (*Mytilus spp*) have been commonly used in more than 50 nations during the last 40 years, providing a time-integrated picture of local contamination [Cantillo, 1998]. These species are also well characterised for the biological cycle and several sets of data are available on the influence of natural and environmental factors on bioaccumulation.

In this respect mussels (*Mytilus spp.*) should be considered the priority species to investigate, using natural populations or transplanted organisms. Alternative bivalve species which in specific circumstances could be considered (i.e. for their site-specific ecological importance) might include bivalves of the genus *Perna*, oysters (*Crassostrea spp., Ostrea spp.*), clams (i.e. *Donax spp., Chamaelea spp., Tapes spp., Macoma spp.),* and *scallops (Pecten spp., Chlamys spp,)*.

Another bivalve species recommended in the Baltic is *Macoma baltica*.

Species-related differences for concentrations of some trace metals should be considered for comparisons. For example oysters present much higher basal levels of copper and zinc than mussels, and similar species-specific features include elevated levels of copper in *Donax semistriatus*, and of cadmium in digestive tissues of scallops.

Fishes
A number of benthic or demersal fishes can be proposed for monitoring the presence of some chemical pollutants.

The most commonly used Mediterranean species include: the red mullet, *Mullus barbatus* or *M. surmuletus*, the seabass *Dicentrarchus labrax*, the gilthead seabream *Sparus aurata, and* various gobid species, i.e. *Gobius spp.* and *Zosterissessor ophiocephalus*. Suitable fish species for the Atlantic and the North Sea include the dab *Limanda limanda*, the plaice *Pleuronectes platessa*, the flounder *Platichthys flesus,* and the cod *Gadus morhua*. Other species could be considered of particular ecological/biological relevance in specific sites. Eel *Anguilla Anguilla* can be used only as referred in point 6.2.2.1.

Other species in the Baltic area include: eelpout (*Zoarces viviparus*) and herring (*Clupea harengus*).

Among fish species, those at the highest levels of food chains (top predators) are naturally exposed to larger amounts of contaminants accumulated through the diet, and higher basal levels are thus detected for specific chemicals such as mercury, and halogenated and persistent organic pollutants.

Seabird eggs could also represent a good matrix for the assessment of chemical pollution in the higher trophic levels (for example Guillemot, *Uria aalge,* in Sweden).

6.2.3. Selection of sites: general considerations

The geographical representativeness of a sample in lakes varies with, for example, species and size. Small fish (e.g. perch) represent a much smaller part of a lake than larger ones or other big predatory fish species. It is therefore important to register coordinates not only for the lake, but also for the sampling site within the same lake.

The fish should be collected from a sampling site representative of the area. The site should not differ from the general picture of the area of concern such as for example an isolated bay. Differences between a lotic and a lentic environment, high-flow and low-flow rivers, and feeding behaviour of the species should be highlighted.

In rivers the sampling sites have to be representative of the respective ecosystem, and/or of the respective sampling region. This means that they must not be close to local sources of emissions. The minimum distance from such pollution sources depends on the type of emissions and on numerous hydrologic and hydrogeographic factors, e.g. water depth, water width, surface and volume of the water body, degree of mixing, pH-value, oxygen content, water hardness, conductivity, trophic level, flow rate, wind direction, wind strength, character of the riparian zone, exposure, etc. The minimum distance from the nearest source of emission must therefore be ascertained separately for each sampling site.

For active monitoring with zebra mussels, a secure, undisturbed and sheltered position should be chosen.. Natural sources of irritation, e.g. too strong a current or a risk of siltation, need to be avoided, as do possible irritations by river boat traffic. Otherwise, the exposure spots need to be readily accessible, even in bad weather. In the selection and demarcation of sampling sites for the sampling of free-living populations (passive monitoring), the population must be of a sufficient size, density and stability in order to ensure good long-term sampling. Furthermore, long-term use of the sampling sites and access to the exposure spots must be secured by contract as a basic principle. The detailed arrangements will depend on the level of protection and the ownership structure.

In the case of shellfish in marine or estuarine areas, samples should preferably be collected from sub-tidal or inter-tidal regions, otherwise as near to the low water spring tide level as possible. If a specific pollution source is known, they should be collected as far as possible at the same depth and type of exposure (*i.e.* in terms of light and wave action) in order to reduce variability in contaminant uptake. The boundary of the sampling site must be specified. At locations where suitable natural populations are not available, caged mussels or other organisms may be used.

A minimum number of marine coastal stations should be selected in each country for national monitoring programmes. In order to select appropriate stations, knowledge of the ecological dynamics of specific areas and the support of dynamic information derived from remotely sensed satellite data can be useful. Satellite sensors could provide spatial and temporal patterns relevant to some sea surface parameters (such as temperature, chlorophyll-like pigments, suspended matter), or useful to visualise the geographical influence of river inputs, domestic/urban/industrial plant discharge, coastal runoff or general sea dynamics. Where possible, advantage should be taken of existing monitoring programmes, for example those operated by the regional conventions, e.g. OSPAR, HELCOM, MEDPOL etc.

6.2.4. Sampling period

For biota monitoring the sampling period should be selected carefully on the basis of the following criteria.

Concentrations of chemical pollutants in tissues of bioindicator organisms can be influenced by many environmental and biological factors, independent of the variations in anthropogenic inputs. In particular, seasonal fluctuations must be carefully considered for the correct interpretation of the results, and to discriminate natural variability from changes due to human impact.

Among the most relevant of the important environmental factors which modulate bioavailability and the tissue burden of chemicals are fluctuations of temperature, organic matter, presence of nutrients, water fluxes and circulation, up-welling phenomena, freshwater or river inputs, and land runoff. Seasonal changes of tissue concentrations have also been reported during phytoplanktonic blooms, which can modulate the bioavailability of several chemicals.

Other biological variables, including intrinsic species-specific features such as the phase of reproductive cycle, weight fluctuations, changes in relative tissue composition, the massive development of gonadic tissues during gametogenesis and the loss of weight during spawning, have all been demonstrated to be of particular relevance. Depending on the strategy and objectives of the monitoring plan, it can be recommended to select the sampling periods in advance or to consider the most important variables which might influence the results obtained.

When designing large-scale and/or long-term (years to decades) biomonitoring projects to assess temporal trends of contamination, the influence of seasonal variability can be reduced by defining in advance the sampling period(s) which will be kept constant for all subsequent years. Carrying out sampling of biota during a period in the year when contaminant concentrations are not being significantly affected by changes in physiological mechanisms is essential for consistency of sampling. Such periods of minimal change are generally related to periods outside the spawning cycle and when food supply is relatively constant.

In order to avoid such variations it is recommended that sampling take place in the off-spawning period. In order to obtain comparable data from the various sampling stations it is necessary to establish the off-spawning period at all these stations in order to ensure that samples are taken at the correct times.

“Early summer periods” can be suggested for several species, considering the generally favourable weather conditions and in order to avoid the impact due to the increase in tourist activities and the greater human consumption of fish and shellfish. For central Europe, the “Late summer period” can be suggested for cyprinides. Do not simply adopt a particular month used elsewhere without understanding the biological reasoning behind the proposed selections.

Sampling periods, however, often need to be adapted in a site-specific manner, to local characteristics, regional projects and requirements, specific objectives or accidental events. In such conditions, sampling periods cannot be decided in advance or on the basis of some standard formula. Nevertheless, the influence of more common biological and environmental factors can be easily evaluated with simple procedures, thus allowing proper comparisons between data obtained in different periods. The more important environmental factors at sampling time should be reported (i.e. date, seawater temperature, salinity, phytoplankton development): all this information is generally available online from regional or national environmental agencies and it does not represent an additional cost or effort for biomonitoring projects.

The influence of tissue weight, which can be subject to extended seasonal variations mostly related to gonadic development, trophic conditions and energy status, can be accounted for by measuring different types of condition indices (CI). For example, good results have been obtained with the condition index $K_f = 100^* M / L^3$ (M = weight in g, L = length in cm).

For bivalves, the index is calculated as the ratio between tissue weight and shell length (or weight or volume), while for fish the hepato-somatic or gonado-somatic indices reflect the ratio between liver (or gonad) weight and whole body weight. Although such measurements are only indirect estimates, their utility has been largely documented; in addition they are very easy to register (only a calliper and a balance are needed), and no additional costs or technical personnel have to be considered.

In marine areas, recommendations on sampling periods for different species and geographical areas are available from the regional conventions (OSPAR, MEDPOL, HELCOM etc).

6.2.5. Sampling frequency

Directive 2008/105/EC states that, for compliance with EQS, the frequency of biota monitoring should be at least once every year, unless technical knowledge and expert judgement justify another interval. ”*For the purpose of trend monitoring as a guideline a frequency of one every 3 years should be performed; unless technical knowledge and expert judgment justify another interval”.*

Sampling frequency should consider biological half life of contaminants, aim of monitoring, presence of anthropogenic inputs/pressure, and availability and quality of previous results or trends.

There is no ideal sampling frequency appropriate for all environmental conditions and monitoring purposes. More common sampling strategies for evaluating chemical accumulation in biota can be based on weekly frequencies (generally only for very short-term periods) or, more often, monthly, seasonal, six-monthly or at least annual. The choice of the most appropriate sampling frequency should consider and combine at least the following criteria:

- biological half life of investigated contaminants;

- the objective of the monitoring programme;

- the local presence of anthropogenic inputs and/or temporary pressures;

- the availability and quality of previous results or trends for the monitored area.

The biological half-life (or turnover) of contaminants reflects the rapidity with which, once accumulated by the organisms, these compounds can be metabolised and eventually excreted. Some metals (such as cadmium and lead) have a long turnover, in the range of 6 months, indicating that an episodic pollution event could be “registered” by the organisms for this duration.

On the other hand, metals such as copper, or polycyclic aromatic hydrocarbons, have a much faster turnover (in the range of 3–6 weeks), meaning that an episodic event could not be detected after a much longer period. Based on these considerations, a six-months frequency would not allow the detection of temporal fluctuations in bioavailability of PAHs (e.g. in a petrochemical or harbour area), while a monthly frequency would be not cost-effective to monitor lead accumulation in a coastal site.

In general terms, a surveillance programme could be based on a low-frequency (six-months/annual) sampling strategy, especially if the monitored area is not challenged by marked anthropogenic pressures. On the other hand, a higher frequency (monthly to seasonal) should be recommended in areas characterised by the presence of specific impacts and/or specific forms of pollutants (e.g. petrochemical sites, industries, river estuaries, harbours, etc.). This will allow patterns of variation to be understood and more cost-effective monitoring designs to be applied. A specific monitoring project, i.e. to evaluate the impact of a temporary activity (such as dredging) should include sampling periods before, during different phases of and after the end of operations. An "investigative" monitoring programme in an area where the source of pollution is unknown should begin with a high frequency (i.e. 1–2 months) which might be lowered depending on the results obtained and, again, the possible presence of anthropogenic impacts.

It is recommended for the purpose of trend monitoring to start at least with a cycle of one examination every 3 years. After several cycles it may be appropriate to downscale the frequency to one every 6 years.

6.2.6. Trend Analysis

The main characteristics of the data collected for the purpose of temporal trend analyses are the following:

- Collection of biota annually at the same time within each year.
- The time should be principally outside the spawning period.
- The same size range of the target species is sampled each year.
- Sampling guidelines are necessary to provide some control over both between-years biological variation (e.g. mean length, condition, stock composition) and within-year biological variation (e.g. individual fish length).

The presence of suitable biota depends on the respective water body types, and the selection of the biota must be tailored to the conditions found in the water body. The organisms chosen must be typical for the water body type and as far as possible resident species that occur frequently in the water body under investigation. This is to ensure that catching and studying the species can be guaranteed over a long period of time. In coastal waters flounder and blue mussels are suitable organisms while in inland water bodies bream, perch, chub and molluscs such as the zebra mussel can be used. It may be desirable to study two different fish species per monitoring point so that different feeding habits can be taken into account and to ensure that, if a fish species disappears, reference can at least be made to the trend in the other species.

6.3. Technical aspects of biota sampling

6.3.1. General

Either passive biomonitoring (collection of wild population) or active biomonitoring (translocation/caging of organisms) may be used. The advantages of the latter lie in the ability to choose the monitoring station, knowledge of the exposure duration, and the reduction of variability between individuals.

6.3.2. Sampling methods (passive)

6.3.2.1. Fish

Fish may be captured by trawling, netting, creels and other appropriate methods, depending on the species and location.

Electrofishing can be also used for small, shallow rivers (commonly chalk streams), drained canals or full navigational waterways with a maximum depth of 2.5 m.

The method of capture in lakes and rivers will depend on the type of water body. It is therefore not possible to use the same method of capture successfully in all types of water bodies. Anchored gillnets are used in deep, stagnant or slowly running waters; dragnets are particularly well suited for catching bream in shallow stagnant water bodies. In very large bodies of flowing water, bag nets with a fixed mouth can be used.

When fish can be sampled from either research vessels or commercial vessels, the former is the preferred option, since research vessels are likely have better facilities for processing and storing scientific samples. In both cases, the following precautions must be taken when selecting samples from the trawl catch to ensure that contamination is kept to a minimum:

- trained personnel must be present when a trawl comes on board to ensure that the sample can be isolated from possible sources of contamination during the release of fish from the net;
- the trawling time should not exceed one hour and the trawling speed should be as slow as possible to reduce damage and stress to the fish;
- fish which are visibly damaged or in bad condition must not be selected;
- clean containers should be available on deck to hold the samples temporarily before they are taken to the ship's laboratory. Containers used for holding fish collected from the ship's normal trawling operations must not be used;
- personnel must wear clean gloves when the samples are taken from the net. The samples should be transferred to the ship's laboratory as quickly as possible and rinsed with clean sea water to remove any material adhering to the surface;
- equivalent precautions should be taken on modern fisheries research vessels, when the catch is released from the net directly into facilities below deck; only material suitable for the subsequent analyses should be retained (see *Shellfish*).

For all methods of capture it is necessary to transfer the fish immediately after the catch into a net cage, which is floating in habitat water. This cage should be of sufficient size, fabricated without knots and must be freely floating in habitat water. Depending on the size of the fish, no more than 20 individuals at the same time should be kept in conditioning in one cage.

Alternatively, the fish can be kept in the transport containers, where they are provided with fresh air through a ventilation system. The advantage – compared to the net cage – is that the fish can be transported to the mobile laboratory if it has not been possible to set it up directly at the waterside.

The number of organisms sampled can be limited by the efficiency of the capture method. As a general rule, the optimal number of sampled specimens should allow 3–5 replicates for each class of investigated chemicals. Depending on the size of fish and approximate weight of tissues, individual samples or pooled samples can be considered. A single pool of tissue, or a series of pools of tissue, should be created from each sampling station. Each of the pools should be analysed for all contaminants of interest.

6.3.2.2. Shellfish

Bivalves can be sampled by hand, scuba diving, dredging or any other appropriate and convenient method. Individuals that are free of fouling and bored shells should be preferably sampled. When collecting mussels by ship, a commercial mussel dredge can be used. When collecting mussels by hand, personnel should wear gloves. Clean containers made of material suitable for the subsequent analyses should be used for transportation.

The number of sampled organisms should be sufficient for the whole set of chemical analyses and representative of the investigated area. Bivalves (especially mussels and clams) will be grouped in pools (see below) and approximately 5 replicates (each constituted by at least 3–5 specimens) should be considered for each class of chemicals. An appropriate number of specimens to be collected is normally about 100. As regards size, bivalves sampled from wild populations should be approximately 70–90% of the maximum size within the population. Such specimens will be of a similar age and therefore metabolically comparable. Sampling at a uniform size will also ensure comparability between populations.

6.3.3. Caging

The choice of an “active” monitoring strategy based on translocation procedures is a widely used approach where organisms are deployed in appropriate cages and maintained at the investigated sites for 4 weeks. The duration of exposure depends on site/species.

Caged organisms facilitate investigation in areas where native organisms are absent, and they reduce the influence of genetic/population differences, of seasonal variability or adaptive phenomena, all factors which can limit the capability to discriminate between different levels of environmental disturbance.

Analyses of caged organisms provide a time-integrated assessment of environmental quality over the 4-week translocation period, but do not reflect chronic exposures or long-term effects of chemical pollutants. They are therefore of particular importance when monitoring current bioaccumulation or monitoring exposure concentration-dose effects relationships.

Caging procedures are very well established and widely applied with mussels (*Mytilus spp*) and mosses. Generally caging is not suitable for fish because it cannot account for the natural urge to move and will lead to unnatural stress and illness. Furthermore, fewer standardised protocols are available for fish, which are often not tolerant to translocation procedures.

After collection of caged organisms (bivalves), transportation procedures are the same as described for wild specimens.

6.4. Choice of tissue for analyses and tissue preparation

6.4.1. Fish

The choice of appropriate tissues is more critical for fish and can be influenced by the monitoring aims, the classes of investigated chemicals, and the tissue availability. A number of replicates (3–5) should be prepared for analyses of each class of chemicals, pooling tissues of more specimens if necessary. For fish, the analysis of whole tissues is suggested if the objective of protection is the ecosystem. The tissue selected will also be dependent on the type of EQS used for compliance monitoring. If the EQS refers to edible (to humans) tissue, then analyses should be carried out on edible tissue (e.g. muscle tissue) rather than whole organisms.

Muscle tissues can generally provide sufficient amounts for analyses; they reflect the edible portion (by humans, but not by other organisms in higher trophic levels) and typically accumulate lipophilic pollutants such as halogenated compounds and methylmercury, and should be analysed for these pollutants. Accumulation of such compounds in muscle tissues can, however, be a long-term process, mediated by trophic transfer and greatly influenced by biomagnification, thus requiring a careful evaluation of trophic position when different species are compared; muscle concentrations do not reflect actual bioaccumulation and do not reveal recent temporal variations in chemical levels. In addition, these tissues are not a target for chemicals such as aliphatic or polycyclic aromatic hydrocarbons and the majority of trace metals.

The liver is one important target organ for some classes of chemicals, reflecting their current bioaccumulation but, depending on species and size, it may not provide sufficient tissue for analysis, unless pooled samples can be prepared.

Gills can be considered as an alternative to liver, since they are also an important target for some chemicals (not for hydrophobic organic contaminants, which accumulate in lipid-rich tissues) and do not generally represent a problem in terms of the amount of tissue available.

Dissection of fish tissues should be carried out onboard or as soon as possible after sampling in order to obtain reliable results. During dissection, biometric measurements need to be registered (length and weight of whole organisms, weight of whole liver and whole gonads). These parameters will be used to determine hepato- and gonado-somatic indices that reflect the ratio between liver (or gonad) weight and whole body weight that is useful for the choice of sampling period.

6.4.2. Shellfish

For mussels, the whole tissues can be dissected for chemical analyses. Mussels should be opened while still alive and avoiding tissue damage. Water contained within the shell is allowed to drain away. This is especially important for mussels collected in areas with high turbidity or on silt/clay bottoms; in such cases, whole tissues can be rinsed with clean seawater after being dissected.

If it is not possible onboard, organisms will be dissected in the laboratory. Before dissection, bivalve molluscs shall be allowed to depurate in clean seawater for 12–48 hrs before being processed. It should be reported whether or not the samples have been depurated. After collection, mussels will be packed in iced containers, wrapped in clean humid woven fabric (not in water) and transported to the analytical laboratory for dissection preferably within 24 hours of sampling: if longer periods are required to transport samples, organisms should be dissected and properly stored immediately.

For each sampling, 5 replicates, each constituted by the tissues of at least 3–5 specimens, should be prepared for every class of analysed chemicals. Biometric measurement (weight of tissues, weight and length of shell) should be registered for each individual before composite pools are prepared. The condition index is then calculated as the ratio between weight of tissues and weight (or length) of shells.

Samples can be stored at -20°C until processed for analyses. The same number of pools and specimens per pool should be used for comparing different sites and/or different periods.

6.4.3. Pooling of specimens of biota

It may be necessary to pool (bulk) biota tissues, particularly in the case of fish livers and mussel and other shellfish tissues, in order to provide sufficient quantities of material for chemical analysis or to save resources.

Pooling can distort the statistical analysis of log-transformed data by increasing the yearly mean concentration values and decreasing the power of tests to detect trends. It has, however, been shown that in general pooling does not influence trend identification (i.e. differences between years and associated regression coefficients will be unaffected, although trends may be less precisely estimated than from unbulked data), if pooling is consistent between years, i.e. if samples consist of the same number of pools which contain the same number of specimens.

If the sample variance is dominated by small-scale differences in time or space or by genetic and/or physiological differences between individual biological samples rather than of instrumental errors at the chemical analysis stage, it might be an option to use pooled samples. The statistical power of temporal or spatial studies is determined by the random/unexplained sample variation. The relation between the instrumental error and other sources of variation, and the relation between the cost of chemical analysis and collection and preparation of samples, will determine the number of individual samples in each pool and the number of pools that should be analysed to achieve good cost-efficiency.

Keeping the same number of individuals in the pool between years is the most important aspect, i.e. in the pool, for a given length class, the number should be the same each year. It is also important to maintain the same number of pools each year (preferably based on length-stratification of the sample if possible).

However, it has to be emphasised that there are a number of advantages in using individual samples, especially for temporal trend studies: information about sample variance is important in itself; changes in variance are often the first sign of a change in contaminant burden; freedom to choose an appropriate central measure (for right skewed distributions i.e. geometric mean values or medians) whereas pooled samples will represent arithmetic means. Furthermore, individual sampling enables adjustments for confounding factors (e.g. fat content, age, size) and detection of extreme values [Bignert et al., 1993].

6.5. Analytical methods

6.5.1. Organic compounds

Procedures for the analysis of organic contaminants in biota include extraction from wet or freeze-dried samples with organic solvents, removal or destruction of lipids, cleanup, fractionation, high pressure liquid chromatography (HPLC) or gas chromatographic separation and different kinds of detection, e.g. fluorimetric, electron capture or mass-spectrometric.

The total fat weight can be determined and used to normalise analytical results; this procedure should be considered as an alternative to weight normalisation.

The total fat weight should be determined using the method of Bligh and Dyer (1959) or an equivalent method. EU regulations discourage the use of chlorinated solvents and alternative methods, which use cyclohexane and isopropanol, have been developed [Smedes, 1999]. Critical reviews which compare the various available methods for tissue lipid determination can be found in literature [see e.g. Randall et al., 1991; Manirakiza et al., 2001].

The recommended methods for the analysis of semivolatile organic pollutants involve serial extraction of homogenised tissue samples with suitable solvents, followed by alumina and/or gel-permeation column cleanup procedures that remove co-extracted lipids. The extract is concentrated and analysed for semi-volatile organic pollutants using capillary GC.

Chlorinated hydrocarbons (e.g., PCBs and chlorinated pesticides) should be analysed by GC/ECD. The same tissue extract is analysed for other semi-volatile pollutants (e.g., PAHs, phthalate esters, nitrosamines, phenols, etc.) using GC/MS.

Unlike the situation for chlorobiphenyls (CBs), where GC techniques are used exclusively, two major approaches based on GC-MS and HPLC with variable wavelength fluorescence detection (HPLC-FLD) are followed to an equal extent in the analysis of PAHs. Decisions to perform analysis of non-chlorinated hydrocarbons and resulting data interpretation should consider that many of these analytes are readily metabolised by most fish and many invertebrates.

JAMP Guidelines for Monitoring Contaminants in Biota [OSPAR 1999] present the sampling and analysis of contaminants in fish, shellfish and seabird eggs. They are suitable for trace metals, chlorobiphenyls and some other chlorinated organic compounds, (*e.g.* DDT and metabolites, HCH, HCB and dieldrin). Technical details relating to sampling, analysis, QA and reporting are given in Technical Annex 1 (organic contaminants) and Technical Annex 2 (metals).

6.5.1. Metals

Analysis of trace metals in biota generally includes decomposition and dissolution of the sample, matrix separation and detection using element-specific spectrometric instrumental procedures (e.g. AAS, ICP-MS, ICP-OES).

Before the digestion procedure, samples should be oven-dried to constant weight or lyophilised to eliminate the water content; the oven temperature should be kept under 50°C to avoid loss of more volatile elements such as Hg. Wet weight and dry weight must be carefully measured. Analyses may also be performed on wet, homogenised samples, even though some digestion procedures are negatively affected by the presence of water; differences in water content could influence the comparison between different samples.

Digestion for trace metals normally involves a hot nitric acid or nitric acid/perchloric acid digestion and dissolution of the tissue sample. Microwave technology may be used for tissue digestion to reduce contamination and to improve recovery of metals.

A range of instrumental methods is available for the determination of metal concentrations in biota digests. It is important that possible matrix interferences on the quantification of elemental concentrations by element-specific spectrometric instrumental procedures (*e.g.* AAS, ICP-MS, ICP-OES, etc) are investigated. Procedures such as standard additions, or multiple dilutions, can be very useful. The matrix interferences encountered in analysis of metals may require case-specific digestion techniques for overcoming interference problems.

6.6. Preparation of data for analysis

Analytical data on contaminant concentrations in biota can be expressed in a variety of ways. For example, laboratories can express these data on dry weight (dw), wet weight (ww), or lipid weight (lw) bases.

Directive 2008/105/EC states that EQS for mercury, hexachlorobenzene and hexachlorobutadiene are expressed on a wet basis. In order to create comparability between data within and between sampling sites, and in order to allow comparison with assessment criteria such as EQSs, or other environmental assessment criteria, data on chemical concentration in biota should be expressed on a wet basis. In addition (but not as an alternative), other normalisation procedures can be presented, as well as appropriate and reliable conversion factors for dry weights and lipid weights.

A consequence of this approach is that the field data and data assessment criteria (EQSs) need to be expressed on the same basis, i.e. wet weight, dry weight or lipid weight. If an assessment criterion is initially expressed on a different base (unit) to the one used for the analysis of field samples, it is necessary to convert the results, for example from wet weight or lipid weight to dry weight.

Conversions are necessary to ensure that maximum use is made of the field data supplied by monitoring programmes. Conversion of field data should be only done, however, if the contaminant data for the sample are accompanied by the necessary specific conversion information (e.g. a measured value for % dry weight in the same sample).

6.7. Environmental Specimen Banking (ESB)

In the process of developing a monitoring strategy for biota it is crucial to consider the importance of environmental specimen banking. Environmental specimen banking can serve as a complement to environmental monitoring by:

- real-time monitoring, i.e., analyses of specimens for comparison with data from samples to be collected in the future for monitoring long-term trends in pollution at a particular site;

- retrospective monitoring, i.e., monitoring with reference to new and emerging polluting substances and natural substances the presence of which indicate environmental influence. Retrospective studies are also carried out when new, improved methods for analysis are introduced; these studies will also verify earlier results by way of renewed analyses;

- ecotoxicological research, i.e., research concentrating on biological effects in relation to concentrations of toxic substances in individuals and populations of animal species exposed to and influenced by environmental pollution.

7. COMPLEMENTARY METHODS

The application of complementary methods in designing monitoring programmes, in surveillance, and in operative and investigative monitoring under WFD has been briefly reviewed in CIS Guidance No. 19 [EC, 2009]. In that Guidance some complementary methods have been listed which can also be applied in sediment monitoring. This chapter offers some critical remarks on the application of passive sampling and techniques for toxicant identification to sediment and biota monitoring. Technical reports on the use of alternative effect-based (biomarker, bioassays) monitoring tools will be prepared as part of the next WG-E activity.

7.1. Passive sampling techniques

Passive samplers are the tried and tested technology for the determination of dissolved phase concentrations of bioaccumulative organics in the aquatic environment. This sampling technique is based on the deployment *in situ* or use in the laboratory of devices capable of accumulating contaminants dissolved in water or sediment pore water. Such accumulation occurs by diffusion, typically over periods of days to weeks. Contaminants accumulated in the sampler are eluted and their concentration levels measured, allowing the quantification of time-weighted average concentrations in water or equilibrium pore water concentrations in sediment. It enables time-integrated sampling or sampling of truly dissolved concentrations of contaminants in water or aquatic sediments. Even for those chemicals that are present at extremely low concentrations in the dissolved phase and are primarily accumulated in biota via dietary uptake, passive samplers generally extract sufficient amounts of residues for analysis. Passive sampling can also be employed in batch sediment extractions under laboratory conditions to provide estimates of contaminant concentrations in pore water or assessment of bioavailable concentrations of contaminants in sediment [Harmsen, 2007¸ ISO 2008]. A report for the ICES Marine Chemistry Working Group summarised the established or expected/potential performance of various passive samplers of compounds that are listed under WFD and other directives or conventions [Booij , 2009].

7.1.1. Application in sediment monitoring

Until recently sediment monitoring has relied on the determination of total or normalised contaminant concentrations. This approach, however, does not distinguish between freely dissolved and bound molecules and aims to assess the presence of chemicals rather than their chemical activity and availability [Smedes et al., 2007a, 2007b, 2007c]. Since many laboratory and field studies have demonstrated that biological effects in benthic organisms are not generally related to the total concentration of contaminants in sediments, alternative and more representative measures of the bioavailable fraction of contaminants in sediments are required. In addition, it has been shown that traditional empirical models tend to overestimate pore water concentrations.

The application of passive sampling to sediment monitoring can be undertaken *in situ* with buried passive samplers or in batch experiments in the laboratory following grab sampling or coring (and sectioning). Passive samplers can be used to:

- determine freely dissolved contaminant concentrations in pore water;
- estimate sediment-pore water partition coefficients for contaminants of interest;
- measure contaminant desorption rates;

- estimate the entire fraction of contaminants available for desorption within a relatively short time scale or fraction effectively contributing to the partitioning with pore water and/or biota;

- measure surface water/pore water activity ratios to estimate whether sediments act as a source or sink for contamination in the overlying water.

The most commonly used passive sampling approach is based on the principle that the passive sampler is exposed to a sediment sample until a thermodynamic equilibrium between the two phases is established. According to partition theory, which applies to most hydrophobic organic contaminants, the concentration of compound in the sampler is directly proportional (by the equilibrium partitioning coefficient between sampler and water) to the freely dissolved concentration of sampled compounds in pore water. Because this concentration is considered to be the driving force for the uptake of the contaminants by aquatic organisms, the bioavailability of a substance can be directly assessed using passive samplers. However, depending on sampler characteristics (e.g. surface and thickness of the sampler, diffusion coefficient in the sampler material), equilibrium may not be established for the most hydrophobic compounds during exposure and therefore performance reference compounds (such as used for surface water deployments) can be used to quantify sampler-pore water exchange kinetics and dissolved concentrations in such situations.

In all cases it is absolutely crucial to select appropriately the combination of sampler and sediment volumes in order to avoid significant depletion of the sediment and consequently of the pore water phase. The true freely dissolved concentration of contaminant in pore water can be determined when the sampler’s sorption capacity is kept well below that of the sediment sample to avoid depletion during the extraction. When the sorption capacity of sampler to sediment is kept high, samplers can be used to measure the amount of total contaminant in sediment that is available for release to the aqueous phase within a given time. This represents the fraction available to take part in partitioning with sediment organisms. The contaminants remaining in the sediment following such extraction can be considered effectively unavailable. This fraction can also be estimated by repeated/successive extractions of the sediment with an adsorbent phase such as Tenax. Such procedures also enable the quantification of contaminant desorption rates.

The concentration difference between the concentrations in pore water determined from the sediment versus those from the overlying water give direct information on the chemical activity difference between sediment and water, and on the direction of the contaminant diffusion at the sediment−water interface as well. This enables identification of sites where remediation of sediment may be appropriate treatment. Other parameters such as sedimentation rates and the resolution of sediment sampling close to the sediment–water interface are crucial for such measurements.

For metals, the technique of diffusive gradients in thin films (DGT) provides an important contribution to understanding the processes that metals undergo in sediments. DGT provide measurements in sediments that can be reported either as the mean flux of labile metal species to the device during the deployment time, or as the mean interfacial concentration in pore water. For a given device and deployment time, the interfacial concentration can be related directly to the effective concentration of labile metal [Davison et al., 2007]. This concentration represents the supply of metal to any sink, be it DGT or an organism that comes from both diffusion in solution and release from the solid phase. The primary use of DGT in sediments has been to investigate the distribution of solutes (metals) at high spatial resolution and to interpret the dynamics of the pollutant release from sediment. Pore water concentration profiles with a fine resolution can be obtained by deploying DGT probes vertically in sediment and across the sediment–water interface. Modelling of metal accumulation in DGT with increasing exposure time can allow the estimation of sediment–water partition coefficients for metals of interest.

7.1.2. *Application in biomonitoring*

Knowledge of dissolved phase chemical concentrations is a critical part of understanding how aqueous exposure levels relate to the pollutant concentrations measured in organisms at various trophic levels of aquatic ecosystems. The freely dissolved concentrations of pollutants represent the driving force for bioconcentration. Thus, passive samplers enable *in situ* determination of hydrophobic bioaccumulative organic compound exposure to organisms at the lowest trophic level (filter feeders, e.g. mussels) in nearly all food chains [Huckins et al., 2006; Smedes, 2007]. The estimation of bioaccumulation factors (BAFs) in certain species of concern (e.g. mussels) has been demonstrated. Moreover, since contribution of dietary uptake of organic compounds with log K_{ow}s <5.5 is generally very small, organism exposure assessment can be potentially extended to higher trophic levels for less hydrophobic compounds.

Studies have demonstrated that passive samplers are biomimetic when diffusional partitioning processes mediate concentrations in organisms of concern (i.e., when residue accumulation in organism tissues follows equilibrium partitioning theory). But the large number of variables, which potentially affect the accumulation of hydrophobic organic compounds in biota, suggests that it is unrealistic to expect any single passive sampler to be biomimetic of all biomonitoring organisms. Also, it is similarly unrealistic to expect that one or two species of biota mimic bioaccumulation in all organisms of concern.

Variables affecting pollutant accumulation in passive samplers are limited to physicochemical properties of the sampled chemical, exposure site conditions, and exposure scenario factors such as the constancy of chemical concentrations during the exposure period. The ability to generate chemical-specific calibration data and then adjust these values to site-specific conditions (e.g. using so-called performance reference compounds; PRCs) [Huckins et al., 2002] means that analyte concentrations obtained using passive samplers are directly comparable across sample sites.

There are some fundamental similarities in the characteristics and processes affecting the accumulation of hydrophobic organic compounds in biota and passive samplers:

- diffusion of non-polar compounds through non-porous organic polymers used in construction of passive samplers for these substances, such as low density polyethylene and silicone, has been shown to be similar to diffusion across biomembranes;

- the processes of pollutant diffusion across the water boundary layer and the lipid-like membranes of passive samplers and aquatic biota, and the partitioning between the polymers/lipids and the exposure water (according to equilibrium partitioning theory), are important factors in the accumulation of hydrophobic organic compound residues in both matrices;

- The uptake rate, defined in ng/time, is only dependent on the surface and if the volume/surface ratio (=thickness) is high, the time required to get equilibrium is high for both samplers and organisms.

On the other hand, there are some critical aspects that should be taken into account in comparing data obtained from passive samplers and biomonitoring organisms;

- When the accumulation of hydrophobic organic compounds in biota occurs solely by respiration or dermal absorption, there are significant correlations between the uptake rate constants measured in organisms used for biomonitoring and the passive sampler; in passive samplers, concentrations are often higher than those in biomonitoring organisms because there is a larger surface area in contact with the sampled medium;

- Although the relative magnitudes of uptake rate constants of passive samplers and organisms can be similar, the depuration rate constants are usually much greater in biomonitoring organisms than in passive samplers. The associated half-lives of residues in biomonitoring organisms are much shorter than in passive samplers;

- Active physiological processes such as metabolism may play a role in fast clearance from biomonitoring organism tissues. The lower depuration rate constant values in passive samplers compared with biota have a major effect on the retention of contaminants that are absorbed during episodic exposure events;

- Direct comparison of partition coefficients with BAFs can only be made when both passive samplers and biomonitoring organisms have attained equilibrium. Since many passive samplers are designed to remain in the linear uptake mode during typical exposure periods of several weeks, the attainment of equilibrium by passive samplers is an exception rather than a rule;

- If target compounds are environmentally persistent (i.e. not readily biotransformed) and dietary uptake is very limited, an improvement in the comparability between the two sampling matrices (i.e. biota and passive samplers) can be observed;

- When diet plays a major role in the uptake of hydrophobic compounds (e.g. in organisms at higher trophic levels), the patterns of hydrophobic organic compound residues in biomonitoring organism tissues and passive samplers will be different;

- Better correlations can be usually found with caged organisms (active biomonitoring). In an ideal case both methods provide a time-integrated assessment of environmental quality over the same exposure period. Such an approach does not, however, reflect chronic exposures or long-term effects of chemical pollutants (see section 6.3.3);

- In bivalves, BAFs inversely related to exposure concentration were observed in some cases because of the presence of chemical stressors which induced bivalve closure or reduced feeding;

- Unlike biomonitoring organisms, passive samplers accumulate sufficient residue mass for the quantitation of ultra-trace levels of extremely hydrophobic contaminants.

Nevertheless, monitoring by passive samplers has some practical advantages over the use of caged organisms:

- initial concentrations of contaminants in samplers are negligible, whereas it is often difficult to obtain non-contaminated test organisms;

- passive samplers do not metabolise pollutants;

- losses due to mortality are avoided;

- unlike biomonitoring organisms, samplers can be applied in environments with a very broad range of water quality parameters where biomonitoring organisms may not survive;

- the geographical range of available biomonitoring organisms limits their applicability, whereas passive samplers can be deployed in almost any environment;

- the uptake process in samplers is simple (diffusion and sorption) compared with that active in organisms;

- dissolved concentrations of pollutants accumulated by passive samplers are clearly bioavailable, whereas the contribution of non-incorporated residues in the gut complicates the estimation of contaminant bioavailability from chemical body burdens in whole organisms;

- passive samplers better retain contaminants that are absorbed during episodic exposure events (integrative sampling providing time-weighted average concentrations over a long period);

- certain behavioural, physiological and anatomical characteristics of biomonitoring organism species affect bioaccumulation;

- the analytical variability of the analysis of passive samplers is in most cases lower than that associated with matrices such as biota or sediment. This is because the samplers have a constant composition and sorption properties. Moreover, the level of matrix interferences is lower with extracts from passive samplers than with extracts from biota and sediment.

7.2. Sediment ecotoxicity test for the evaluation of ecological status and investigative monitoring

Chemical analysis of pre-selected sets of toxicants (e.g. priority pollutants) is often not able to explain ecotoxicological effects of complex environmental samples. Risk assessment based on concentrations, e.g. of priority pollutants in sediments or water, obviously does not reflect the risk of the actual mixture of contaminants, but only the risk of those pre-selected toxicants.

Bioassays, biomarkers and other ecotoxicological tests are useful tools for the evaluation of the real state of sediment in which both known and unknown contaminants are present at concentrations sufficient to cause toxicity to the test organisms. Effect-based monitoring is also useful for the development of investigative monitoring. Through a field inventory the long-term impact on benthonic fauna can be investigated. Combining the three assessment methods (chemical, bioassay, ecology) can give an answer (called the Triad approach) that cannot be given by any of the individual methods by themselves. The Triad approach has been described in detail by Chapman [1990].

There is a need for new monitoring tools that help to understand the link between chemical and ecological status. Combined biological and chemical–analytical approaches make important progress towards an identification of those toxicants that are relevant for site-specific risks and towards an estimation of the portion of an effect that can be explained by the analysed chemicals.

Toxicity identification evaluation (TIE) and effect-directed analysis (EDA), which both combine biological and chemical analysis with physicochemical manipulation and fractionation techniques, have been shown to allow for toxicant identification in many matrices and for many toxicological endpoints.

TIE on sediment is based on guidance published by the United States Environmental Protection Agency [US EPA, 2007]. The basic concept in TIE is to use physical/chemical manipulation of a sample to isolate or change the potency of different groups of toxicants potentially present in a sample. Rather than using a chemical detector to determine whether a change has occurred, a biological test, in this case a toxicity test, is used as the “indicator” to determine whether the manipulation has changed toxicity. The EPA Guidance document provides guidance for both interstitial water and whole-sediment TIEs and combines our current understanding of TIE methods for both marine and freshwater interstitial waters and whole sediments. This guidance does not include approaches for the implementation of sediment TIE in a regulatory context.

An upcoming alternative technique is Effect Directed Analysis or EDA, which is attracting interest mainly in Europe [Brack et al, 2007 and reference therein]. Based on a biological response, indicating a potential or actual undesirable effect, the responsible compounds may be identified by fractionation procedures and chemical analysis and counter-measures designed. Prerequisites for a successful application of the approach are (*a*) significant concentrations of specifically acting toxicants rather than an even distribution of potential toxicity over high numbers of compounds in very low concentrations, as may be observed in samples taken far from pollution sources and (*b*) the use of a toxicological endpoint that allows the detection of specific effects, rather than only baseline toxicity.

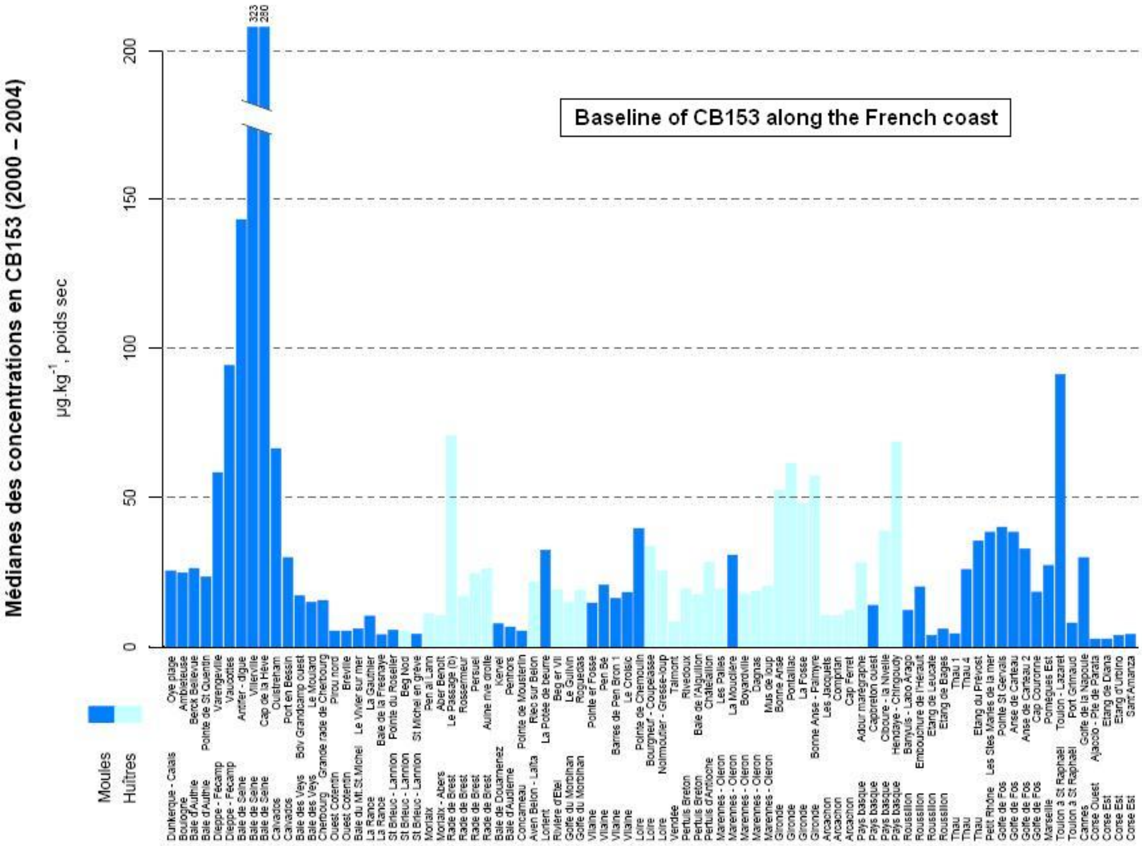
While TIE originates from effluent control in a regulatory context in the US, EDA is a more scientific approach developed by analytical chemists to identify unknown hazardous compounds in various environmental or technical matrices. TIE is based exclusively on *in vivo* testing, while EDA is applied to both *in vitro* and *in vivo* tests in order to detect active fractions and compounds. EDA is not restricted to identifying the cause(s) of acute toxicity; it also aims to identify potentially hazardous compounds in the environment, even if the concentrations present should not cause acute effects. Thus, extraction and pre-concentration procedures as well as the analysis of sensitive sub-lethal biochemical *in vitro* responses are important tools in EDA.

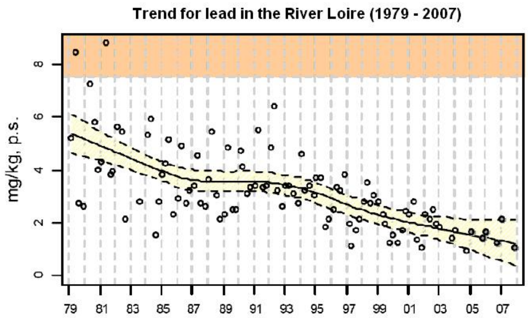
8. CASE STUDIES

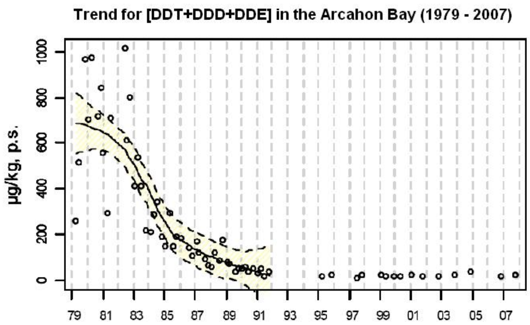
8.1. Case study 1

Background information
Title/Name of case study: RNO (Réseau National d'Observation de la qualité du milieu marin) French National monitoring network from 1974 to 2007. 1974 - 1988 : measurements in water samples (hydrology and some contaminants) **1979 - 2007 : Mussel Watch : contaminants in biota (this case study)** and sediment survey 2008 : Because of the WFD application, end of the Mussel Watch, back to the past (water).
Type of case study : **Spatial and temporal trends monitoring for contaminants in biota.** a 30 years mussel watch type monitoring network in France
Reporting Institution : **IFREMER (Institut Français de Recherche pour l'Exploitation durable de la Mer)** French Institute of research for the sustainable exploitation of the sea
Web-Link: http://www.ifremer.fr http://wwz.ifremer.fr/envlit
Main sources for further information; literature: Contact for the Mussel Watch (coordinator) : Didier.Claisse@ifremer.fr From 1983 to 2006 an annual bulletin presented results of parts of the network. They can be downloaded at http://wwz.ifremer.fr/envlit/documents/bulletins/rno
Objective of case study - Brief background information: The aim of the RNO was to evaluate the levels and trends of the coastal chemical contamination. It was created in 1974 by the Ministry in charge of the Environment and co-ordinated by IFREMER. The biota branch started in 1979 and contaminants in water were no longer measured in water after 1985 as they gave very poor results. This monitoring programme in biota was the main tool providing systematic knowledge of the contamination levels along the French coast. It was also the provider of French data for the international OSPAR convention. It was recently extended to the overseas departments, Martinique, Guadeloupe (Caribbean Sea) and the island of La Réunion (Indian Ocean). From its beginning in 1979, the RNO Mussel Watch collected about 10 000 biota samples, on which 150 000 measurements were made.
Contribution to
Specific contribution linked to WFD monitoring programmes In the frame of WFD, OSPAR and MEDPOL some sampling sites have been kept. Knowledge of contamination helped to design the monitoring programme of WFD.
Description About 80 sampling sites along the French coast were sampled (Mussels and oysters) first quarterly then twice a year (February and November). Samples were homogenized and freeze dried before analysis. Parameters were metals (9), DDT, DDD, DDE, a and g-HCH, PCBs (9 congeners) and PAH (37). All the samples have been archived in a sample bank since 1981.
Experiences gained - Conclusions - Recommendations **Experience gained** (see figures below) **:** National baseline for 9 metals, 14 organochlorines, 37 PAH. Reference sites and hot spots identified Temporal trends for 33 contaminants Knowledge of seasonal variations in biota as the sampling frequency was 4/year from 1979 to

2002.
Monitoring strategies, sampling, and analysis expertise. QA long experience
33 years time series and 30 years sample bank.







Conclusion:
Although it considers only bioaccumulative contaminants, this programme has greatly advanced the knowledge of marine contamination in France. It has also been a vehicle for improvement of analytical techniques in the marine environment.

Recommendations:
Quality has a price. Partners cannot be selected only on money criteria. The success of this program is largely due to the creation of a stable and durable community of partners. A sense of ownership of the project by the participants is essential. An exclusively commercial relationship with laboratories is inadequate.

Outlook - Next steps – Accessibility of results/information

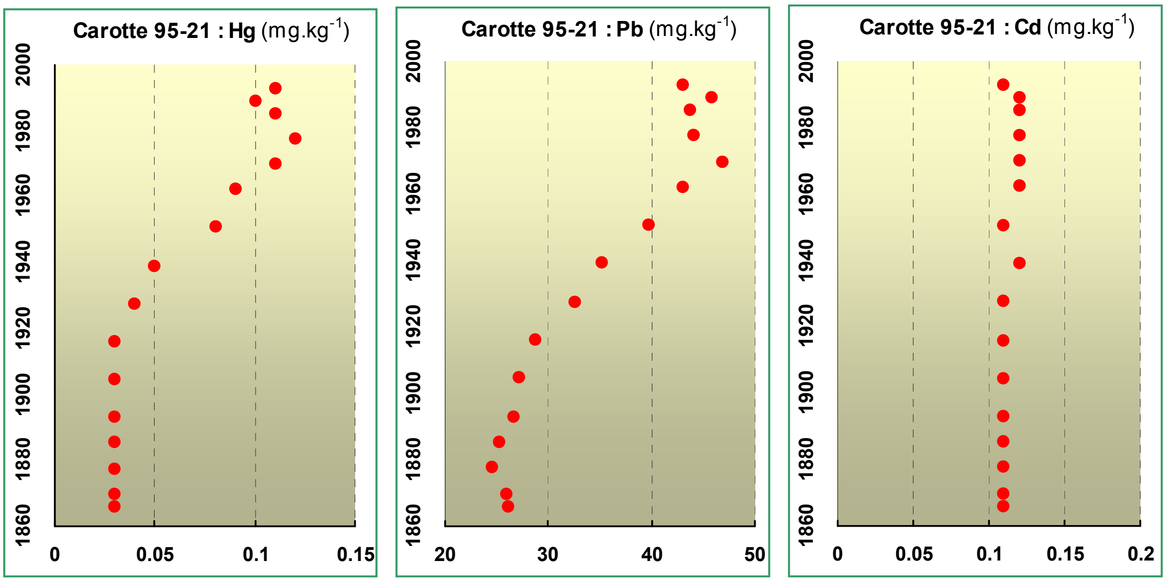
Data are archived with those from other monitoring networks (microbiology, phytoplankton, benthos…) in the database QUADRIGE[2]. Various tools and output software were developed to give public access to the raw data and trend analysis. http://wwz.ifremer.fr/envlit/resultats/surval__1 Then "resultats par paramètre"
Data can also be obtained by request to the coordinator.

8.2. Case study 2

Background information
Title/Name of case study: RNO (Réseau National d'Observation de la qualité du milieu marin) French National monitoring network from 1974 to 2007. 1974 - 1988 : measurements in water samples (hydrology and some contaminants) **1979 - 2007 :** Mussel Watch : contaminants in biota and **sediment survey (this case study)** since 2008 : Because of the WFD application, the program was modified.
Type of case study : **Spatial and temporal trends monitoring for contaminants in sediment.**
Reporting Institution : **IFREMER (Institut Français de Recherche pour l'Exploitation durable de la Mer)** French Institute of research for the sustainable exploitation of the sea
Web-Link: http://www.ifremer.fr http://wwz.ifremer.fr/envlit
Main sources for further information; literature: Contact (coordinator) : Didier.Claisse@ifremer.fr From 1983 to 2006 an annual bulletin presented results of parts of the network. They can be downloaded at http://wwz.ifremer.fr/envlit/documents/bulletins/rno
Objective of case study - Brief background information: The aim of the RNO was to evaluate the levels and trends of coastal chemical contamination. It was created in 1974 by the Ministry in charge of the Environment and co-ordinated by IFREMER. The sediment branch started in 1979 and contaminants in water were no longer measured in water after 1985 as they gave very poor results. This monitoring programme in sediment was conducted sporadically until 1992. From 1993 it has been formalized with a consolidated sampling design. It was intended to give knowledge of contamination levels along the French coast, further offshore than biota, and with an integration over several years rather than months (biota). It was also the provider of French data for the international OSPAR convention.
Contribution to
Specific contribution linked to WFD monitoring programmes In the frame of WFD, OSPAR and MEDPOL the sampling design has been modified (see below).
Description The first centimetre of the sediment can incorporate several years of inputs. Until 2007 the strategy was to cover the entire French coastline every ten years by means of annual sampling campaigns covering a different section of coastline each year. Measured contaminants are the same as in biota, accompanied by descriptive and normalizing parameters such as particle size, organic carbon, carbonates, aluminium, iron, lithium, manganese. On a few selected points, deep cores are taken and cut into many horizons. The analysis and dating of each of them can retrace the history of contamination over several decades (see below). WFD application has changed the frequency of sampling to 6 years instead of 10 and reduced the number of sampling sites for some regions. Cores are taken with a box corer in order not to mix the sediment layers. Samples are freeze dried before analysis. In addition to normalizing parameters, contaminants measured are metals (9), DDT, DDD, DDE, a and g-HCH, PCBs (9 congeners) and PAH (37). Most of the Samples are archived in a sample bank.
Experiences gained - Conclusions - Recommendations **Experience gained** (see figures below) **:** Experience in results normalisation. National baseline for 9 metals, 14 organochlorines, 37 PAH. Reference sites and hot spots identified Historical trends on some sites.

Monitoring strategies, sampling, and analysis expertise. QA long experience.
Sample bank.

Historical trends for Hg, Pb, Cd in a deep core taken in the *Golfe d'Aigues-Mortes* in 1995.



Conclusion:
Although it considers only hydrophobic contaminants, this program has greatly advanced the knowledge of marine contamination in France. It has also been a vehicle for improvement of sampling and analytical techniques in the marine environment.

Recommendations:
Quality has a price. Partners cannot be selected only on money criteria. The success of this program is largely due to the creation of a stable and durable community of partners. A sense of ownership of the project by the participants is essential. An exclusively commercial relationship with laboratories is inadequate.

Outlook - Next steps – Accessibility of results/information

Data are archived with those from other monitoring networks (microbiology, phytoplankton, benthos…) in the database QUADRIGE[2].

Data can be obtained by request to the coordinator.

8.3. Case study 3

Background information
Title/Name of case study: Monitoring of contaminants in sediments and suspended particulate matter.
Type of case study: Routine measurements at sampling sites in the freshwater reach of the river Elbe, and in North Sea estuaries started between 1980 and 1990 for surveying temporal and spatial development of concentrations of particle-bound contaminants.
Reporting Institution for the case study**:** Federal Institute of Hydrology, Koblenz.
Web-Link: Elbe: www.arge-elbe.de/wge/Download/DDaten.php; www.arge-elbe.de/wge/Download/DBerichte.php
Main sources for further information; literature: Heininger, P., J. Pelzer, E. Claus, u. S. Pfitzner: Results of long-term sediment quality studies on the river Elbe. Acta hydrochim. hydrobiol. 31, 2003 (4-5), 356-367; Heininger, P., Schild, R., de Beer, K., Planas, C., Roose, P., Sortkjaer, O: International pilot study fort he determination of riverine inputs of PAHs to the maritime area on the basis of a harmonised methodology. Federal Environmental agency. Research report 299 22 286, UBA-FB 00343e; Ackermann, F., Schubert, B. (2007): Trace metals as indicators for the dynamics of (suspended) particulate matter in the tidal reach of the River Elbe.- In: U. Förstner und B. Westrich (ed.): Sediment Dynamics and Pollutant Mobility in Rivers, Chapter 7.4: S. 296-304. Springer-Verlag Berlin Heidelberg, ISBN-Nr. 978-3-540-34782-8); Schubert, B., Pies, C., Heil, C.: Schadstoffmonitoring von Schwebstoffen und Sedimenten in Ästuaren (Monitoring of contaminants in suspended particulate matter and sediments in estuaries).- In: Aspekte des Schadstoffmonitoring an Schwebstoffen und Sedimenten in der aquatischen Umwelt, 18. Chemisches Kolloquium, 16.-17.06.2009, Koblenz; Guidance document 19: Case study „ Conversion of pollutant concentrations measured in suspended particulate matter (SPM) into total concentrations in the whole water sample; Claus, E.: Empfehlung für Schwebstoffuntersuchungen an Überblicksmessstellen im Elbeeinzugsgebiet; ordered by: Ad-hoc-Arbeitsgruppe der Arbeitsgruppe Oberflächenwasser der Flussgebietsgemeinschaft Elbe, 2010 (Draft).
Objective of case study - background information: In surface waters, some of the priority substances are predominantly adsorbed to solids, i.e. to sediments and SPM. For trend assessment, these contaminants are monitored in sediments and SPM. For trend detection of particle-associated contaminants in solids, samples should represent a defined sedimentation period. For sediments, sampling depth should therefore reflect the period under consideration, i.e. sedimentation rates should be known. However, often these are not known or too small for representing the surface sediment of a defined period of e.g. one year reliably. Sampling periods of SPM, however, are well defined, and SPM can be used as an alternative for sediments for trend monitoring. The objective of the case study is to support the use of SPM for trend monitoring and compliance checking, where appropriate.
Contribution to support trend monitoring of contaminants in sediments and compliance checking with EQS
Specific contribution linked to WFD monitoring programmes Specific monitoring of contaminants adsorbed to suspended particulate matter and sediments. Monitoring results can support trend monitoring of contaminants in sediments and compliance checking with EQS, where these are available for sediments on an EU or national level.

Description At several stations along the freshwater reach of the river Elbe and in the North Sea estuaries, particle bound contaminants are monitored in sediments and SPM. In areas of low hydrodynamic energy with fine-grained sediments and high sedimentation rates, sediments are mainly sampled with grab samplers or a corer. Particularly, if areas of low energy are lacking, SPM is sampled by sedimentation traps over a period of usually 4 weeks or by flow-through centrifuges over periods of several hours. Frequency of sediment sampling varies from 1 – 2 samples/a to 12 samples/a. SPM is generally sampled 12 times/a. Sampling frequency depends on the hydromorphological regime and sedimentation rates. As contaminants strongly tend to accumulate in fine-grained particles and organic matter, a correction for differences in grain size distribution is carried out (normalisation), unless samples show similar composition. Assessment of contaminant concentrations takes into consideration river discharge. Especially in estuaries, concentrations are strongly influenced by the freshwater discharge.
Experiences gained - Conclusions – Recommendations **Experience gained:** Monitoring programmes have been operated by the Working Committee for the Protection of the River Elbe (ARGE Elbe) and the Federal Institute of Hydrology for more than 10 – 20 years. A reliable trend assessment requires long term measurements. Comparative measurements revealed, that contaminant concentrations resulting from monitoring in sediments and in SPM at the same or a nearby stations are approximately equivalent, provided potential differences in sample composition are corrected for and sediment samples reflect a similar sedimentation period as SPM. **Conclusion**: Sampling of surface sediments requires less time, effort and cost than sampling of SPM and easily yields sufficient sample mass for analyses . Usually, grain-size correction is required for sediments, unless samples are predominantly fine-grained. Also contaminant concentrations in SPM sampled with sedimentation traps have to be normalised, as fines may not be separated completely. If a centrifuge is used for sampling SPM, no further grain-size correction is required. Usually, sediments do not reflect a defined period, unless high sedimentation rates prevail. In contrast, SPM can be sampled over a defined period. SPM sampling can be applied, if SPM concentrations are >10 mg/l. **Recommendations**: - Sediment samples and SPM sampled with sedimentation traps should be normalised, e.g. by analysing a fine fraction. - The frequency of sampling has to take into account hydrodaynamics and sedimentation rates prevailing at sampling sites. - Especially, when using SPM, the assessment has to take into consideration river discharge. Also in estuaries, freshwater discharge should be considered in the assessment. - For a reliable trend assessment, time series should be longer than 10 years.
Outlook - Next steps – Accessibility of results/information

8.4. Case study 4

Background information

Title/Name of case study:

Sediment cores for retrospective monitoring of contaminants in lakes.

Type of case study:

Sediment stratigraphy (core) studies to reveal recent history of contaminants to be strongly restricted or phased out (e.g. Priority Hazardous Substances).

Reporting Institution:

Finnish Environment Institute.

Web-Link: http://www.ymparisto.fi

Main sources for further information; literature:

Munthe, J., Wängberg, I., Rognerud, S., Fjeld, E., Verta, M., Porvari, P. and Meili, M. 2007. Mercury in Nordic ecosystems. *IVL Report* B1761, 43pp.

Mannio, J. 2001. Responses of headwater lakes to air pollution changes in Finland. *Monographs of the Boreal Environment Research* 18, 48pp.

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see also: Usenko S, Landers DH, Appleby PG & Simonich S. 2007. Current and Historical Deposition of PBDEs, Pesticides, PCBs, and PAHs to Rocky Mountain National Park. *Environ. Sci. Technol.* 2007, 41, 7235-7241

Objective of case study - background information:
To monitor the progressive reduction in the contamination of priority substances (PS) and phasing out of Priority Hazardous Substances (PHS).
To assess compliance with the no deterioration objective (concentrations of substances are below detection limits, declining or stable and there is no obvious risk of increase) of the WFD.
To assess long-term changes in natural conditions and to assess the long term changes resulting from widespread anthropogenic activity.

Contribution to:

Specific contribution linked to WFD monitoring programmes
Cost-effective method to check the recent history of substances with high affinity to particle phase. The concept is based on short sediment core sampling (ca. 10 to 30 cm), checking the recent history of priority hazardous substances such as HCHs, HCB, HCBD, Hg, PAHs and TBT. This is useful information for the assessment purposes in the first phase of WFD (before 2015). The method is readily applicable to many candidate substances such as PCB, PCDD/F and PFOS.

Description
Short core sediment monitoring/survey to look at the recent history (<30-40 yrs) of contaminants. The top of the sediment is sliced to e.g. 3-6 slices (a´ 0.5-3 cm) and one reference slice from deeper sediment layers (> 20cm) depending on the sedimentation rate.

There is good knowledge of the typical sedimentation rate in Nordic lakes from tens-hundreds of lakes, sampled e.g. for Hg surveys. The sedimentation rate in these lakes can be from 0.5-2.0 mm/yr to more than 10 mm/yr. Sedimentation is not, however, several centimetres per year. Note that these lakes represent a very significant portion of the whole lake population in Europe.

In comparison to a grab or single sample of sediment surface, slicing the sediment reveals the relative timescale of the subsequent samples. Analysing only one top layer does not reveal any timeframe, only the present status of the sediment, at least on the first sampling occasion.

After analysing this "trend" of ca. 5 slices (with 2-3 replicates and perhaps pooling), one can shift to biota (fish) monitoring to follow the future changes (yearly) of the same contaminants. In Finland, this strategy/method will be applied to surveillance, impact and investigative monitoring in all River Basin Management Areas. Sediment cores have been analyzed for 5-10 locations (depending on the substances) and will be studied consequently ca. 5-10 locations per year.
Experiences gained - Conclusions - Recommendations **Experience gained and conclusion:** In the past, many of the polluted lakes were dated using radiochronology. Sediment dating is very much site (and core) specific, but the general picture is possible to reveal for substances with little degradation/diagenesis in the sediment and long history in use/emissions and later in regulation (PAHs, most OCPs, metals, TBT, PBDE). This has been demonstrated widely for e.g. Pb, Hg, PCB and PCDD/F in similar studies in Boreal and Alpine European lakes as well as in North America and Arctic regions (see literature above). The accumulation conditions in (well selected) lakes are not as difficult to interpret as in marine systems. **Recommendations**: The concept works only for certain types of environments such as lake sites with relatively well known sedimentation rates and little influence of water currents. The technique is also applicable to sheltered coastal conditions, at least in the Baltic Sea.
Outlook - Next steps – Accessibility of results/information Short core sediments can provide some information, which it is not possible to gain with other WFD matrices. Retrospective analysis of cores is invaluable information on the effectiveness of the past control policies for Priority Hazardous Substances and other strongly controlled PBT/vPvB substances. Regionally coherent sediment data can be compiled for larger geographical assessments and status reports. Results will be made available in data bank of SYKE, utilised in WFD status reporting and in scientific reports and publications.

8.5. Case study 5

Background information
Title/Name of case study: PCDDs, PCDFs, DL-PCBs, NDL-PCBs, and PBDEs in fishes collected from the urban tract of the River Tiber
Type of case study: A preliminary monitoring activity was undertaken to individuate the priorities in terms of POPs contamination for the development of a research project in the area of urban ecology in the City of Rome and for the evaluation of fish species as indicators of water quality contamination.
Reporting Institution: Italian National Institute of Health
Web-Link: http://www.iss.it/
Main sources for further information; literature: Miniero R, Guandalini E, Brambilla GF, Dellatte E, Iacovella N, Abate V, De Luca S, Iamiceli A, di Domenico A (2010). PCDDs, PCDFs, DL-PCBs, NDL-PCBs, and PBDEs in fish collected from the urban tract of the river Tiber. *Monitoring and Assessment*, Submitted for publication
Objective of case study - background information: The main objectives of this preliminary monitoring programme were: the individuation of relative performance of the chub (*Leuciscus cephalus*) in the assessment of chemical contamination, individuation of priorities of specific tracts of River Tiber within the urban environment, prioritization of chemical contaminants among the ones taken into consideration.
Contribution to :
Specific contribution linked to WFD monitoring programmes Assessment of the chemical contamination of a freshwater system in an urban context
Description Substances monitored: Dioxins (PCDDs), furans (PCDFs), dioxin-like action polychlorobiphenils (DL-PCBs), non dioxin-like action polychlorobphenils (NDL-PCBs), and polybromodiphenylethers (PBDEs) *Sampling area:* The sampling sites are located at three sites along the river Tiber in Rome, all of them lying in the urban area. Collected specimens: the European chub was chosen as a representative of species living in the water column for the purposes of the study. Number of samples and frequency: At each site 1 pool of 10 individuals was analysed. From each specimen, the skin was removed and only the fillets were taken into consideration for the POPs determination.
Experience gained: The eel is going to be abandoned as a popular bioaccumulation indicator, because is in decline and a suitable substitute needs to be found On this issue, the chub shows some interesting characteristics, but its role in term of bioaccumulation indicator needs to be further clarified. This species is common in freshwater basins and relatively easy to collect. **Conclusion**: Among the three sectors of the river Tiber investigated, some contamination differences were found in the fish sampled. On the whole, these differences appear to be of minor importance, indeed, in analysis of the chemical-specific contamination profiles, the chub samples show an

inter-site consistency. This appears particularly evident for PCDD and PCDF. **Recommendations**: The chub's capability as an indicator of chemical pollution needs to be further explored. In particular in terms of site-specific detection of contamination profile. To this end, it is also recommended that parameters about its biology need to be taken into account to define its role as a bioaccumulation indicator.
Outlook - Next steps – Accessibility of results/information This preliminary study constitutes a basis for developing a research project in the field of urban ecology related to a river basin. The Department of Environment and Primary Prevention (*Ambiente e Connessa Prevenzione Primaria*) of the Italian National Institute of Health is an important Italian institution involved in developing projects at national and international level on POPs human and environmental risk assessment. Info about this issue can be found via the following website (in Italian and in English): http://www.iss.it/

8.6. Case study 6

Background information
Title/Name of case study: National Swedish Contaminant Monitoring Programme in Marine Biota
Type of case study : **Spatial and temporal trends monitoring for contaminants in biota.** Monitoring activities within the Swedish national contaminant programme in marine biota
Reporting Institution : Environmental Protection Agency (Sweden)
Web-Link: www.naturvardsverket.se
Main sources for further information; literature: *Bignert, A., Nyberg E., Asplund L., Eriksson U., Wilander A., Haglund P. 2007. Comments Concerning the National Swedish Contaminant Monitoring Programme in Marine Biota. Report to the Swedish Environmental Protection Agency, 2007-03-31. 128 pp.* Bignert A., Göthberg A., Jensen S., Litzén K., Odsjö T., Olsson M. and Reutergårdh L. 1993. The need for adequate biological sampling in ecotoxicological investigations: a retrospective study of twenty years pollution monitoring. The Science of the Total Environment, 128 (1993) 121-139. Green N.W. and Rönningen. 1994. Contaminants in shellfish and fish 1981-92. Joint Monitoring Programme (JMP) Norwegian biota data. NIVA 1995, report no. 585/94
Objective of case study - Brief background information: The main objectives of the monitoring programme in marine biota could be summarised as follows: to estimate the levels and the normal variation of various contaminants in marine biota from several representative sites, uninfluenced by local sources, along the Swedish coasts. The goal is to describe the general contaminant status and to serve as reference values for regional and local monitoring programmes to monitor long term time trends and to estimate the rate of found changes – to assess compliance with the no deterioration objective. to estimate the response in marine biota of measures taken to reduce the discharges of various contaminants to detect incidents of regional influence or widespread incidents of 'Chernobyl'- character and to act as watchdog monitoring to detect renewed usage of banned contaminants. to indicate large scale spatial differences to explore the development and regional differences of the composition and pattern of e.g. PCB's, HCH's, DDT's and PCDD/PCDF as well as the ratios between various contaminants.
Contribution to:
Specific contribution linked to WFD monitoring programmes Surveillance monitoring design and operational monitoring design for biota
Description Substances monitored: Metals, for example Hg, Cd, Pb and Cu and organic substances, for example PCB, DDT, Lindane, brominated flameretardants, dioxins, PFCs and PAHs. *Sampling area:* The sampling sites are located in areas regarded as locally uncontaminated and, as much as possible, uninfluenced by major river outlets or ferry routes and not too close to heavily

populated areas.

Collected specimens: For many species adult specimens are less stationary than sub-adults. To increase comparability between years, young specimens are generally collected. Only healthy looking specimens with undamaged skin are selected.

Number of samples and frequency: At the new Baltic and west coast sites in general 2 pools of 12 individuals are analysed from each site/species (herring and perch). 10-12 individual specimens from the old Baltic sites (reported to HELCOM) and Swedish west coast sites (reported to OSPARCOM) are analysed annually from each site/species. For guillemot eggs and perch (old sites), 10 individual specimens are analysed. Organochlorines in blue mussels are analysed in pooled samples containing 10-20 individual specimens in each pool.

Experiences gained - Conclusions - Recommendations
Continuous development of design for both a spatial and temporal monitoring programme and also increased knowledge of choice of matrix. The importance of quantifying objectives.

Conclusion:
Herring is the most commonly used indicator species for monitoring contaminants in biota within the monitoring programme (COMBINE) in the HELCOM convention area and is sampled by Finland, Estonia, Poland and Sweden. Herring muscle tissue is fat and thus very appropriate for analysis of fatsoluble contaminants i.e. hydrocarbons.

Cod is among the ‘first choice species’ recommended within the OSPAR Joint Assessment and Monitoring Programme (JAMP) and HELCOM COMBINE. The cod liver is fat and organic contaminants are often found in relatively high concentrations. For that reason, it is also a very appropriate matrix for screening for ‘new’ contaminants.

Mussels are one of the most common used organisms for monitoring contaminants in biota. Adult mussels are sessile and hence it is easier to define the area the samples represent, compared to fish. Blue mussel is among the ‘first choice species’ recommended within the OSPAR JAMP.

Recommendations:
It is very important that the objectives of the monitoring are quantified before designing a monitoring programme. When the objectives are defined the choice of sampling location, matrix, sampling method and analytical procedure could cause problems if the proper guidelines are not followed.

Outlook - Next steps – Accessibility of results/information

The programme on marine biota is a long term programme with continuous development and possible addition of new substances in the future.

IVL Swedish Environmental Research Institute is national data host for the programme. Results and data can be found via the following website (in Swedish only):
http://www.ivl.se/vanstermeny/miljodatadatavardskap/datavardskapbiota/biotadatabas.4.360a0d56117c51a2d30800064287.html

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COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

Guidance document No. 26

GUIDANCE ON RISK ASSESSMENT AND THE USE OF CONCEPTUAL MODELS FOR GROUNDWATER

EUROPEAN COMMISSION

environment

COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

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GUIDANCE ON RISK ASSESSMENT AND THE USE OF CONCEPTUAL MODELS FOR GROUNDWATER

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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FOREWORD

The Water Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC, "establishing a framework for Community action in the field of water policy" (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In particular, one of the objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, several guidance documents directly relevant to groundwater have been developed and endorsed by the Water Directors. They provide Member States with guidance on e.g. the identification of water bodies (CIS Guidance No. 2), the analysis of pressures and impacts (CIS Guidance No. 3), monitoring (CIS Guidance No. 7) etc. in the broad context of the development of integrated river basin management plans as required by the WFD.

As a follow-up, and in the context of the new Groundwater Directive (2006/118/EC) developed under Article 17 of the Water Framework Directive, Member States have expressed the need to clarify a range of issues, which resulted in the development of new guidance documents complementing the existing series, focusing on aspects covered by both the WFD and the Groundwater Directive, namely Groundwater Monitoring (CIS Guidance No. 15), Groundwater in Drinking Water Protected Areas (CIS Guidance no. 16), Prevention of Direct and Indirect Inputs of Pollutants (CIS Guidance no. 17) and Groundwater Status and Trend Assessment (CIS Guidance No. 18).

To complement these guidance documents and in order to support the ongoing implementation process of the WFD, it was decided to set up recommendations about the generic elements of risk assessment, the use of conceptual models and their specific implementation for groundwater under the WFD building upon the experience and knowledge gained within the RISKBASE project funded under the 6th Framework Programme. For this purpose, an informal drafting group has been established under the umbrella of the CIS Working Group on Groundwater (WG C). This drafting group has been coordinated by Austria (RISKBASE), DECHEMA, and Arcadis (NICOLE), and involved a range of experts from other Member States and from stakeholder organisations.

The present Guidance Document is the outcome of this drafting group. It contains the synthesis of the output of discussions that have taken place since 2007. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the procedure of Guidance development through meetings, workshops, conferences and electronic media, without binding them in any way to this content.

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LIST OF CONTENT

ANNEXES

LIST OF USED ABBREVIATIONS

DWPA – Drinking Water Protected Area
GWD – Groundwater Directive (2006/118/EC)
RBMP – River Basin Management Plan
TV – Threshold Value
WFD – Water Framework Directive (2000/60/EC)

1. INTRODUCTION

Under Article 5 of the Water Framework Directive (WFD), in 2005 Member States developed and reported on the first risk assessment for groundwater bodies and the likelihood of meeting or failing the WFD's environmental objectives, including good status (see WFD Art. 4b) by 2015. As a further preparation for the first cycle of River Basin Management Plans (RBMP), which were due to be published in December 2009, monitoring programs and threshold values have been established. Within this first management plan period (2009–2015) a review of risk assessments is due to be performed by December 2013 and thereby prepare for the second river basin management plan starting in December 2015, as noted in Figure 1. The relationship between the Article 5 risk assessment and the status assessment is noted in Chapter 2.4 and Figure 4.

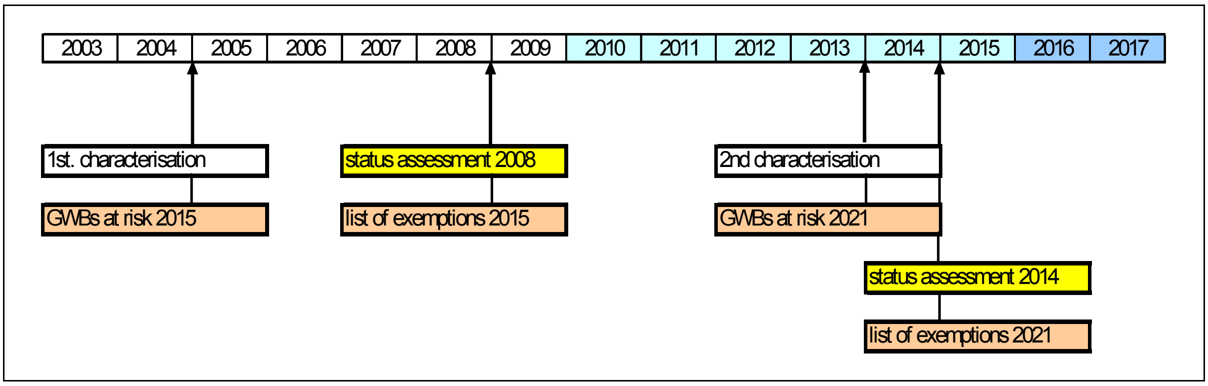

Figure 1: Implementation of the WFD – Timetable 1st and 2nd cycles.

This guidance document describes the generic elements of risk assessment, the use of conceptual models and their specific implementation for groundwater under the WFD. Emphasis is given to the broader notion that characterisation and risk assessment concern five objectives defined within Article 4 (see Chapter 3). Accordingly the document on hand provides insight in risk assessment and the use of conceptual modelling in a holistic manner. Aiming to reframe the context it does not describe a restricted procedure or a step-by-step recipe.

Risk assessment tries to draw a causal chain linking the origin of a hazard or pressure (e.g. an identified or estimated loading of a polluting substance) along an environmental pathway to consequences for human health or the environment (using concepts such as vulnerability, exposure and impact assessment). It should also provide some assessment of the probability of, and confidence in, such a forecast. Scientifically this is generally known as the 'source-pathway-receptor' paradigm (SPR). Risk assessment procedures in practice have to address a variety of topics and scales. Therefore the applied procedures vary and need to be suitable for purpose.

The procedures recommended in this guidance are based on experience and lessons learnt since the first WFD Article 5 reports (e.g. as discussed at the WG C Workshop in January 2004). Such procedures need also to take into account and refer to the first results of the monitoring programs implemented under the WFD.

The main focus of this document is to describe a coherent approach on how to assess risks caused by different pressures (such as diffuse and point source pollution with respect to groundwater quality and abstraction with respect to groundwater quantity) at different scales ranging from site scale (local) up the scale of a groundwater body. Therefore the document is complementary to Guidance Documents Nos. 15 (Monitoring), 16 (Groundwater in Drinking Water Protected Areas), 17 (Direct and Indirect Inputs) and 18 (Groundwater Status and Trend Assessment).

During the process of assessing SPR relationships a conceptual understanding and/or a series of hypotheses will be built up based on the available evidence. This conceptual model may be tested and progressively refined as new data are obtained. The use of conceptual models as an essential tool in groundwater risk and status assessment is recognized by the new Groundwater Directive (GWD, 2006/118/EC) and is discussed in Chapter 3 of this guidance.

It is important to recognize the role of risk assessment in groundwater management, including the preparation of information and data to enable the planning of monitoring systems and the development of remedial measures. A prerequisite to groundwater risk assessment is a sound understanding of groundwater systems, which is supported by Conceptual Models and needs to be developed and adapted to the cycles of groundwater management.

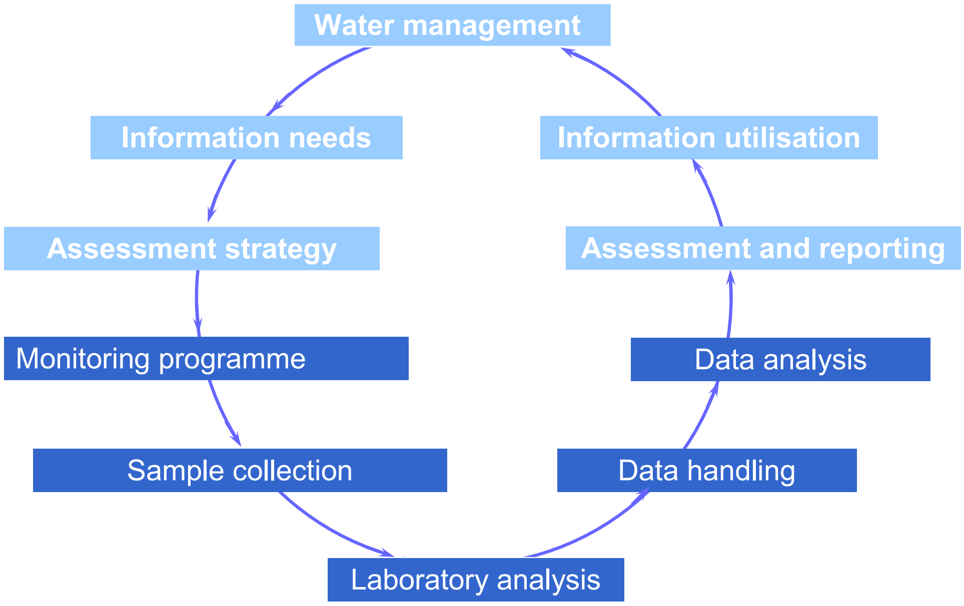

Figure 2: The water management cycle (Ref 9)

2. RISK ASSESSMENT OVERVIEW

2.1 Scope

This guidance document is concerned with the use of 'risk' and 'risk assessment' in the WFD and GWD as noted in Annex I. Thus, in the context of this guidance document, risk needs to be understood specifically as risks not to achieve the environmental objectives of the WFD (see 2.3 and 3) and not in its classic perspective of possible risks for human health and the environment. The first cycle of river basin planning under the WFD started in December 2003 when the WFD had to be implemented into national law. The first River Basin Management Plan for the period of 2009–2015 (RBMPs) had to be published in December 2009. The preparation of the next RBMP cycle starts very soon as at least three years before the beginning of the period to which the plan refers (by 2012), Member States have to publish a timetable and work programme for the production of the plan. The review of the risk assessment according to Article 5 WFD is due in 2013. Further risk characterisation for groundwater during the next planning cycles will also consider monitoring data and the status assessment procedures (including the use of threshold values set by Member States).

2.2 Towards risk-based management - integrating assessments and management

Drawing on an analysis of established approaches to risk management, the International Risk Governance Council (IRGC) has developed a Risk Governance Framework whose purpose is to help policy makers, regulators and risk managers both understand the concept of risk governance and apply it to their handling of risks. A detailed description of the framework was published in IRGC's White Paper "Risk Governance – Towards an Integrative Framework" in 2005[1]. An introduction to the framework is available on the IRGC website[2].

In its 2005 White Paper on Risk Governance, the IRGC has put forward a model of inclusive Risk Governance (see Figure 3), which offers a structure for an integrative process regarding assessing and managing risks. The framework comprises four phases: Pre-Assessment, Risk Appraisal, Characterisation and Evaluation, and finally Management (informed decisions and implementation). A fifth, Risk Communication, runs parallel to these phases.

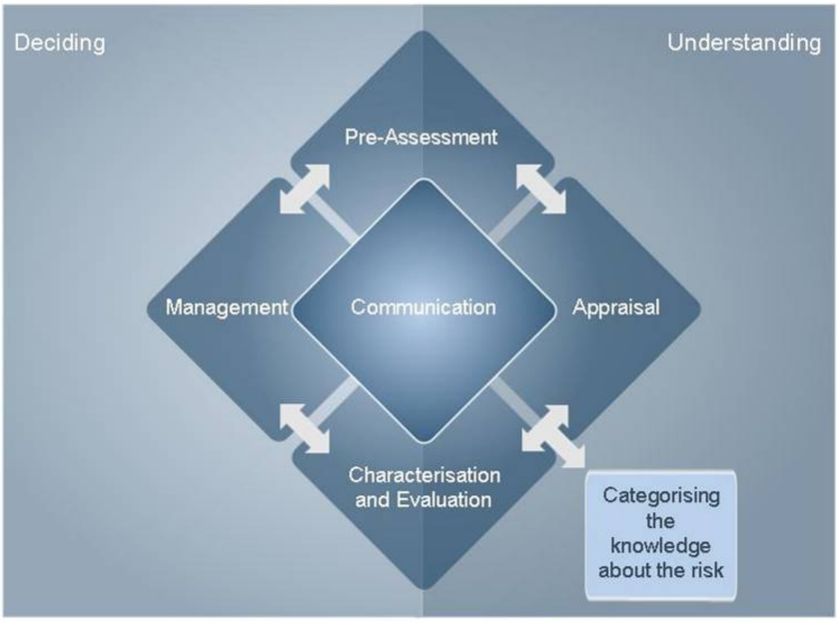

Figure 3: Basic Model of Risk Governance (IRGC 2007a)

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1 IRGC White Paper No1 "Risk Governance – Towards an Integrative Approach", IRGC, Geneva, 2005. The full text of this document can be downloaded from www.irgc.org

2 http://www.irgc.org/IMG/pdf/An_introduction_to_the_IRGC_Risk_Governance_Framework.pdf

In terms of the IRGC framework groundwater risk assessment within the implementation of the WFD can be understood as representing the pre-assessment phase, which is a prerequisite to establish an integrated and coherent information and data collection process for ending up with a sound understanding at the characterisation and evaluation phase (phase 3). This phase can be understood as being equal to the status assessment. Importantly it is to recognize that the evaluation according to the IRGC framework puts emphasis on having an acceptability and tolerability judgement.

RISKBASE[3], a Coordination Action on Risk Based Management of River Basins, understands the WFD as being risk-based, ecologically centred and recognizing the need to balance improvements to water and ecosystems quality with economic benefits (Brils J. and Harris B, Eds. 2009). Asking for well-designed, coordinated and monitored 'learning catchments' to transform the general framing and develop best practice the risk governance framework described by the International Risk Governance Council is recommended as a source of inspiration to integrate assessments and management.

2.3 Objectives defined by the WFD

Underlying the many references to risk within the WFD (see Annex 1) is the concept that we are assessing the impact of human activity on the environment and specifically those impacts that threaten our ability to meet the objectives of the WFD (as set out in Article 4[4]).

Article 4 contains five objectives for groundwater:

1. Prevent or limit the input of pollutants;
2. Prevent the deterioration of status of groundwater bodies;
3. Achieve good groundwater status (both chemical and quantitative);
4. Implement measures to reverse any significant and sustained upward trend;
5. Meet the requirements of protected areas.

WFD objectives apply at different scales and so the Source-Pathway-Receptor (SPR) model for each of these objectives will also be scale dependent. This will have a direct effect on the scope and scale of the conceptual models that are an essential part of describing and assessing risks.

For groundwater quantity, risk assessment is focused on objectives 2, 3 and 5 and in particular quantitative status as defined in Annex V, 2.1.2 of the WFD. Taking account of all the elements of this definition requires assessment of risks at scales varying from local (impacts on individual dependent surface waters or terrestrial ecosystems) to groundwater body scale (available resource balanced against the recharge and abstraction).

Taking in account the description of good qualitative status in WFD Annex V all the objectives of Article 4 apply for groundwater quality. The relationships between these objectives are more complex and interdependent, as described below and in CIS Guidance Documents nos. 17 and 18 (Refs 1, 2). Risks need to be assessed for a wide range of SPR relationships at scales from the very local (for example, consideration of whether engineering design and operational controls applied to storage of hazardous substances in a tank are sufficient to prevent their release from the storage system and entry into groundwater) through to medium scale (for example, impacts on individual abstraction boreholes or terrestrial ecosystems) and finally to whole groundwater bodies (whether a body achieves good status).

2.4 Temporal scale of groundwater risk assessment

We also need to consider the time horizons over which risks need to be assessed. In order to manage risks on a day to day basis the primary focus for the prevent or limit objective is the immediate impact

3 Integrated risk-based Management of the water-sediment-soil system at river basin scale; funded under the EC 6th RTD Framework Programme (FP6), reference GOCE 036938

4 In the case of Groundwater Chemical status this includes meeting the requirements of Article 7 (Drinking Water Protected Area objective; CIS Guidance Document no. 16).

of an activity on groundwater with a view to maintaining existing good controls, improving management where necessary, restricting or prohibiting that activity as most appropriate. In contrast, the ability to achieve good groundwater status has to be evaluated taking into account the typically long time-scales associated with hydrogeological processes at the groundwater body scale. Risk management measures may take many years (or even decades) to have a significant impact on status.

Status assessment (the classification of water bodies) is formally undertaken and reported once every six years and is based on monitoring data collected over the previous river basin planning cycle. The current status of the water body reflects any effects resulting from measures that have been undertaken in previous plan periods. In contrast, the risk assessments for all the Article 4 objectives (considering both chemical and quantitative status), as described in Article 5 of the WFD (obligation to submit a report according to Article 15 of the WFD) and noted in Figure 4, looks forward a couple of years and attempts to predict what the condition of the groundwater body will be at the end of the next river basin management plan period. Based on this assessment and the procedures noted in Articles 4 and 11 of the WFD, measures may be put in place. These measures, which should reflect the risks identified in the Article 5 report, may comprise strategic planning, remediation schemes, abstraction controls and “prevent or limit” measures mentioned above.

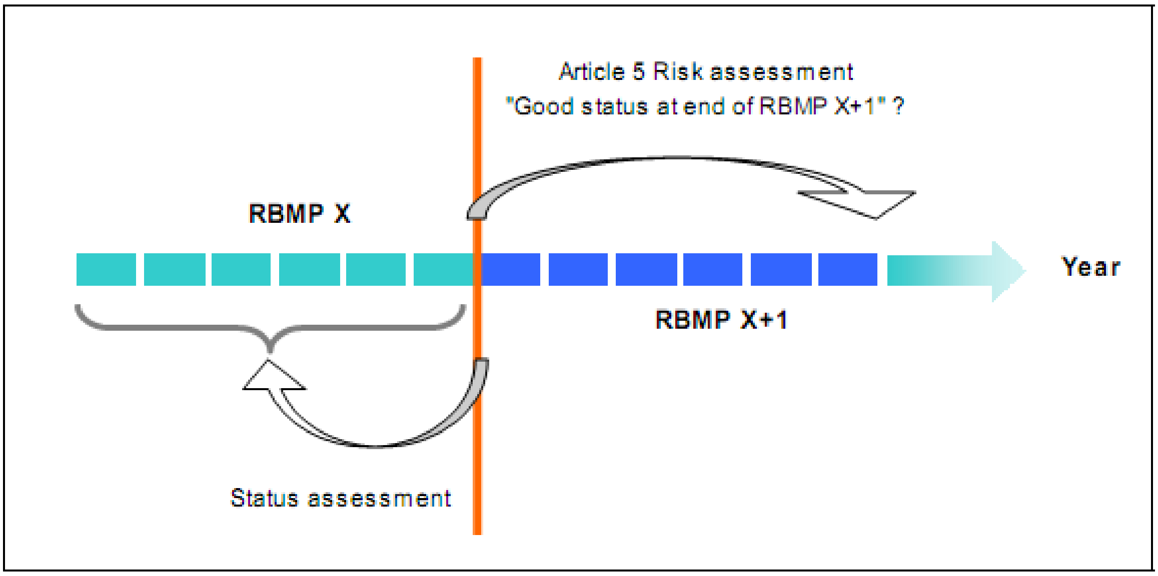

Figure 4: Risk assessment regarding the status objective looks into the future whereas status assessment looks back on the performance (from CIS Guidance document No.18)

2.5 Considering uncertainty

Uncertainty affects all stages of the risk assessment and management processes. Analysing the sources and magnitudes of uncertainties can help to identify knowledge gaps and inform decision makers on the most appropriate risk management measures, including whether or not precautionary action is necessary. When making decisions on risk management options it is important to understand how different sources of uncertainty (in data, from sampling, environmental variability, lack of knowledge and in models) contribute to the variation in the final risk estimates. Sensitivity analysis (varying parameter values in the risk model to examine the variation in outcomes) is very useful in this respect.

Compared with most environmental media, the groundwater environment is rather inaccessible, highly heterogeneous and difficult to observe/monitor. The movement of pollutants in three spatial dimensions and over the long timescales that are typical of many groundwater environments make predictions difficult. As a consequence a large degree of uncertainty is inherent in many hydrogeological assessments, particularly with respect to pathways. For example, movement through and attenuation in the unsaturated zone is a key factor in determining the risk to groundwater quality from an activity on the land surface. Yet this pathway by its nature is one of the most difficult to monitor.

Risk assessment and uncertainty analysis are of wide application in groundwater protection. They can act as a counterbalance to the costs and practical difficulties in directly observing pollutant linkages. For many subsurface processes a statistical or deterministic approach to risk assessment may not be necessary or feasible and a “weight of evidence”[5] approach may either be sufficient or the best we can achieve. In both circumstances conceptual models (see chapter 3 and Annex II) are an essential supporting tool to risk assessments in these circumstances.

2.6 Tiered risk assessment

Rarely in groundwater assessments do we have sufficient data to make reliable predictions in outcomes. Tiered risk assessment combined with a simple assessment of confidence can assist in focusing resources on those areas of highest uncertainty and of utmost relevance to risk management decisions.

A typical example of tiered assessment is given in Figure 5. Here the risk assessment aims to divide a group of groundwater bodies into those that are “at risk” or “not at risk” failing to meet good status. Risk screening is used to pragmatically divide the groundwater bodies in an efficient course of action into those where there is high confidence that the body is “not at risk” or is “at risk” failing to meet the status objective (based on monitoring and hazard data and clear environmental standards). What remains in the centre of the figure is a group of bodies where there is relatively low confidence (substantial uncertainty) in the assessment. Qualitative assessments as well as semi-quantitative assessments are pressure and parameter-specific (e.g. evidence for parameter A, uncertainty and further investigation necessary for parameter B) and prepare the final classification.

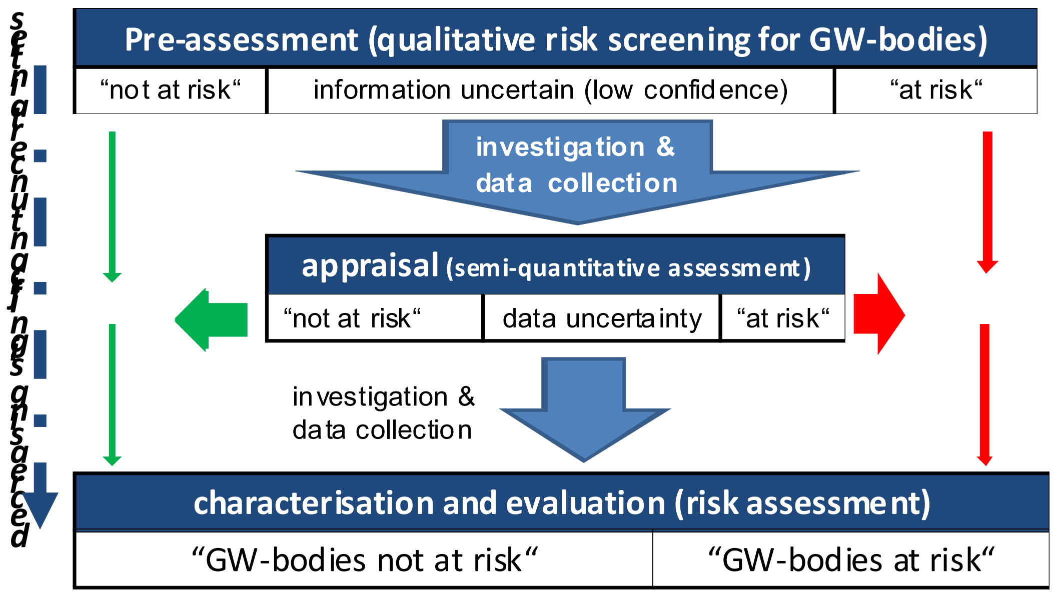

Figure 5: Tiered approach for risk assessment (from Technical Report on Groundwater Risk Assessment – adapted)

At the next level of assessment (appraisal often termed as semi-quantitative assessment) further data collection and analysis are focused on the remaining bodies. These are then further divided into “not at risk”/”at risk” bodies where there is now sufficient confidence in the assessment, leaving a further tranche of bodies where there is still significant uncertainty. The process is then repeated until all bodies can be assessed with an acceptable degree of uncertainty. It follows that additional investigation and monitoring should be focused on those areas where there is most uncertainty rather

5 The use of whatever data are available to make an assessment of the most likely outcome or the ‘direction of travel’ in the assessment.

than those areas where there is confidence that groundwater is in a good or poor condition in relation to the “at risk” assessment. If significant data uncertainties remain the characterization and evaluation needs to follow a transparent ‘weight of evidence’-approach to classify a groundwater body as being “at risk” or not.

Tiered assessment is implicit in the overall WFD river basin planning process. The initial characterization is often based on little data but is conservative. Where risks are identified further characterisation is required to identify the likely pressures and impacts and areas of uncertainty. From the second cycle onwards uncertainty should diminish because monitoring data, from the WFD monitoring programme will be available. These data in turn can be used to improve the risk assessment. Figure 2 shows that the monitoring strategy, measures and status assessment (including the setting of threshold values) take place after risk assessment. So for the planning cycle (n+1), the knowledge gathered during the previous planning cycle (n), should be used to review monitoring strategy, measures and threshold values.

2.7 Risk Assessment and the precautionary principle

The approach taken by the European Commission in applying the precautionary principle is elaborated in a communication document from 2000[6]. In the Rio Declaration[7] the precautionary principle was interpreted as follows:

“Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”

Following this principle it is not acceptable to delay taking action because of uncertainty where there is a risk of serious harm. The use of risk assessment can sometimes seem to be in conflict with this principle. In reality risk assessment can be employed to clarify issues and identify impacts that are serious enough to warrant precautionary action.

The use of the precautionary principle presupposes a scientific evaluation of the risks which, because of the insufficiency of the data, their inconclusive or imprecise nature, makes it impossible to determine with sufficient certainty the risk in question[8].

Conversely risk assessment can also identify where impacts are unlikely to occur and/or be serious. If further investigation would significantly improve our knowledge and confidence and provide better focus for risk management measures, action may be delayed, providing no serious or irreversible harm would result.

The principle should be considered within a structured approach to analysis of risk which comprises three elements: risk assessment, risk management and risk communication. Where action is deemed necessary, measures based in the precautionary principle should be, inter alia:

- subject to review, in the light of new scientific data, and
- capable of assigning responsibility for producing the scientific evidence

necessary for a more comprehensive risk assessment.

The prevention of the input of hazardous substances to groundwater is an example of where a precautionary approach has been adopted. Substances are classified as hazardous based on their inherent toxicity, persistence and bioaccumulative properties. Despite this fact, there are circumstances where evidence of hazardous substances in groundwater does not contradict the precautionary principle. Given a risk assessment (supported by monitoring data) can demonstrate that such inputs are environmentally negligible and all necessary and reasonable measures to prevent have been taken, they are tolerable under the GWD and in accordance with the precautionary principle.

6 “Communication from the Commission on the precautionary principle”, COM(2000) 1

7 United Nations Conference on Environment and Development, 1992

8 COM (2000) 1 final, p. 14

2.8 Improved risk assessment through the river basin planning cycles

The first Article 5 reports submitted by Member States (in accordance with Article 15) had to make predictions based on relatively sparse data and often with only a broad knowledge of the operational requirements of the WFD Article 4 objectives. For example, at the time the first Article 5 reports were compiled the detailed requirements for groundwater quality (and in particular groundwater chemical status) were unknown as these were subject of the GWD and CIS guidance (Ref 2). The first risk assessments will therefore be associated with substantial uncertainties.

Member States now have the benefit of both clarity on objectives and operational requirements, with several years of monitoring data and the first status assessments (classifications). Conceptual models can now be used to assimilate and focus new risk assessments on areas of greatest uncertainty. By this process we can build on the work of the previous river basin planning cycle and improve our future risk assessments.

Through time, the scope and scale of risk assessments (and associated uncertainties) should decrease, reflecting better data and the impact of measures, unless new threats to the environment appear. A minimum level of risk assessment will always be necessary as the WFD will continue to require forward predictions of complex environmental conditions and processes.

3. CONCEPTUAL MODEL OVERVIEW

3.1 What are conceptual models and what are they used for?

A conceptual model is the basis for reliable decisions in groundwater risk assessment and management. The aim is to have an instrument for:

- Experts discussing, developing and complementing their understanding of the groundwater system
- Communication with the public and decision makers: making non-experts understand how an aquifer system is working;
- Understanding and visualization of both simple and complex groundwater bodies, depending on the purpose;
- Assessing risks related to groundwater;
- Visualisation of how, where and when risks may impact groundwater;
- Planning of monitoring systems and measures to protect or remediate groundwater;
- Prediction of the effects of measures;
- Providing a reliable basis for simulating and predicting processes in groundwater with mathematical or numerical (computer) models;
- To help an assessor identify whether a groundwater body achieves its Article 4 objectives;
- To identify the reasons why a groundwater body fails any status objectives;
- To allow short-listing of the potential measures that are most likely to remedy the situation in an effective and sustainable manner;
- Justifying exemptions/alternative objectives where there is a risk of failing to achieve good groundwater status.

In the new Groundwater Directive as well as in several of the CIS Guidance Documents the use of ‘conceptual models’ is mandatory or recommended (see chapter 3.3). The term ‘conceptual model’ is not defined in the Groundwater Directive, nor is there a common definition by the Guidance Documents that recommend its use (different definitions see Table 2). The circumstances under which conceptual models can be applied may vary widely, from detailed assessments by hydrogeologists to a simplified picture of interacting processes for communication purposes with stakeholders. The fact that the use of conceptual models is recommended in several Guidance Documents, emphasises that conceptual models are *important* tools in groundwater management.

First experiences with the characterisation reports and status assessments indicate that Member States use very different approaches. *Working Group C has initiated this Guidance with the aim of creating a common understanding of conceptual models and risk assessment and the use of conceptual models within groundwater management*. The term conceptual models have been introduced in several Guidance documents before, to support different purposes. This Guidance intends to complement these earlier documents and gives an overview of available knowledge on this subject, relating it to the different steps of groundwater management.

It is also not the intention to choose a ‘correct’ definition of the term ‘conceptual model’ but rather to discuss how models, including conceptual ones, can assist in groundwater management. The philosophy behind the WFD is to start thinking about (ground)water management with all available knowledge (no matter how little), then focus on what are or may be environmental or human risks and then collect information where needed to improve understanding. In this process, one may start with a schematic description, then point out possible risks, start monitoring and use the monitoring results to improve the understanding of the system and the effectiveness of measures. If necessary for a better understanding, or for a selection of the most appropriate measures, the conceptual models may evolve into (complex) numerical models. The starting schematic model can definitely be called a *conceptual* model. A complex numerical model is definitely *not* a *conceptual* model anymore. For the purpose of groundwater management it doesn't really matter to what extent models are still called *conceptual models*. What counts is that simple models are sufficient for the initial phase of groundwater management, and that more complex models need to be used only if and when appropriate within the management process.

Definition of conceptual model

In the context of this guidance, a conceptual model is a means of describing and optionally quantifying systems, processes and their interactions. A hydrogeological conceptual model describes and quantifies the relevant geological characteristics, flow conditions, hydrogeochemical and hydrobiological processes, anthropogenic activities and their interactions. The degree of detail is based on the given problems and questions. It is one of the basic steps for the management of groundwater bodies.

Conceptual models are needed to describe groundwater quantity (linked to quantitative status) as well as chemical composition (chemical status) of groundwater, as referred to in the WFD.

Conceptual models can be developed to different degrees of complexity, from simple qualitative descriptions of the geology to complex combinations of qualitative and quantitative descriptions of the hydrogeological processes and the impacts. To cover the different needs for management of groundwater bodies, spatial investigation scales vary from small (10-100's m^2) to large (km^2) and time resolution from hours/days to month/years. It depends on specific tasks and problems (e.g. groundwater quantity, chemical composition, point source pollution, diffuse pollution, interaction with surface waters, land use). For transboundary groundwater bodies it is highly recommended that jointly agreed conceptual models are developed.

Annex II describes a way of setting up a conceptual model. Depending on the special requirements of the different WFD activities described above, a basic three step procedure is suggested, with differing data requirements, scales and complexity.

3.2 Role of conceptual models within groundwater management

The management of groundwater systems consists of steps in a continuous cycle as described in the Introduction (see Figure 2). Within the cycle of groundwater management conceptual models can be used in different phases with a different purpose, such as risk assessment, monitoring strategy and status assessment (see Figure 6).

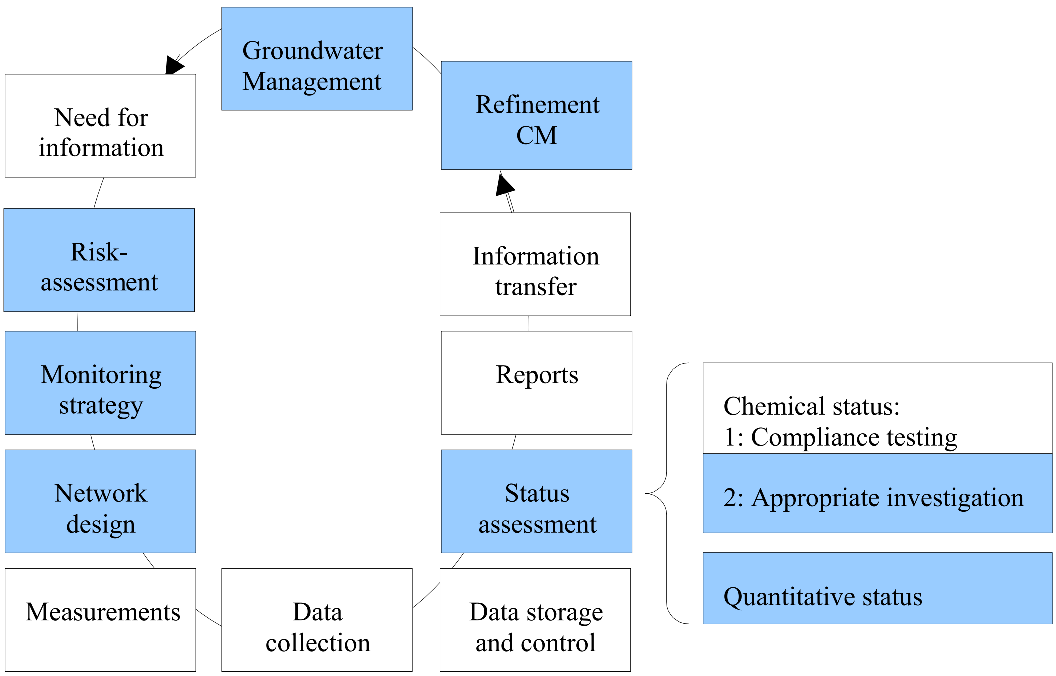

Figure 6: Role of conceptual models in groundwater management in blue the steps where conceptual models can be useful or may be even essential)

In the *first phase* of the implementation of the WFD, groundwater bodies had to be delineated and characterised (Groundwater Body System). The main emphasis was on the general description of the hydrogeological system, including the chemical and quantitative conditions in the groundwater body. This system could mostly be understood and made transparent to the public with the help of basic (simple) conceptual hydrogeological models:

- These models should roughly describe groundwater flow directions in relation to the main watercourses and the position of important terrestrial and aquatic ecosystems within the groundwater body, as well as the distribution of relevant land uses.
- It is a good starting point for planning a monitoring strategy and developing a representative monitoring network - by comparing the number and distribution of existing monitoring stations with hydrogeological and hydrochemical data, the distribution of (potential) inputs and the receptors that could be affected.
- Existing conceptual models may be refined and the need for more detailed (hydro)geological data at a more local scale can be assessed. New hydrogeological data and the results of monitoring may lead to more complex conceptual hydrogeological models at more detailed scales if necessary.

In the *second phase*, during the first status assessment in 2009 additional data (hydrochemical monitoring data, groundwater level data, recharge and abstraction rates) were collected:

- Additional data can now be integrated into the existing conceptual models.
- Based on the results of the first status assessment and a refined conceptual model, the future development of groundwater status (quantitative and chemical) can be assessed.

In the *third phase*, the assessment of the future development of groundwater status leads to a prediction of whether the good quantitative and chemical status of groundwater can be achieved by the end of the (next) plan period. If not, (additional) measures have to be undertaken by a Member State:

- In predicting the effectiveness of measures in time and space, sometimes more specific data are needed. In particular, the behaviour of seepage water in the unsaturated zone and groundwater flow times can be added to a conceptual model and may lead to incorporation of a more sophisticated mathematical model.

3.3 Use of conceptual models and references in CIS guidance documents

3.3.1 Use of conceptual models within the WFD

The WFD does not contain the term 'conceptual model', but implicitly requires the set-up of conceptual models, by requesting Member States to characterise all water bodies. For each water body it has to be determined whether there is a risk of failing to meet the objectives at the end of the plan period. A conceptual model is indispensable for this purpose. The most important parameters to be taken into account in characterisation are listed in WFD Annex II, paragraphs 2.1 and 2.2 (see Look-Out-Box below) and discussed in Chapter 5 of this guidance.

LOOK OUT!

Annex II of the Water Framework Directive

2. GROUNDWATERS

2.1. Initial characterisation

Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:

- the location and boundaries of the groundwater body or bodies,
- the pressures to which the groundwater body or bodies are liable to be subject including:
  - diffuse sources of pollution
  - point sources of pollution
  - abstraction
  - artificial recharge,
- the general character of the overlying strata in the catchment area from which the groundwater body receives its recharge,
- those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.

2.2. Further characterisation

Following this initial characterisation, Member States shall carry out further characterisation of those groundwater bodies or groups of bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identification of any measures to be required under Article 11. Accordingly, this characterisation shall include relevant information on the impact of human activity and, where relevant, information on:

- geological characteristics of the groundwater body including the extent and type of geological units,
- hydrogeological characteristics of the groundwater body including hydraulic conductivity, porosity and confinement,
- characteristics of the superficial deposits and soils in the catchment from which the groundwater body receives its recharge, including the thickness, porosity, hydraulic conductivity, and absorptive properties of the deposits and soils,
- stratification characteristics of the groundwater within the groundwater body,
- an inventory of associated surface systems, including terrestrial ecosystems and bodies of surface water, with which the groundwater body is dynamically linked,
- estimates of the directions and rates of exchange of water between the groundwater body and associated surface systems,
- sufficient data to calculate the long term annual average rate of overall recharge,
- characterisation of the chemical composition of the groundwater, including specification of the contributions from human activity. Member States may use typologies for groundwater characterisation when establishing natural background levels for these bodies of groundwater.

The initial characterisation had to be carried out for all water bodies. Therefore the data listed according to WFD, Annex II, paragraph 2.1, should be available for all groundwater bodies. Many of the data required for developing conceptual models can be derived from the initial characterisation. Often this will be sufficient for at least basic conceptual models. Further characterisation (see Look-Out-Box and WFD Annex II, paragraph 2.2) only needs to be conducted for groundwater bodies that are considered to be ‘at risk’ of failing the WFD’s environmental objectives following the initial characterisation. (Note that, as explained in chapter 2, in case of doubt a groundwater body should be declared ‘at risk’.)

One aim of using conceptual models is to *describe the relation* between groundwater quality/resources, the local (geogenic) conditions and anthropogenic inputs/impacts *in an understandable way*. In the case of no or only little groundwater (monitoring) data the conceptual model contains basic information, e.g. on land use distribution within the area of the groundwater body, a rough estimation on depth to groundwater, characteristics and thickness of the overlaying soil and groundwater flow direction. Nevertheless with this more generic information it is already possible to give a first rough estimation on what kind of impacts (pollution, damage caused by abstraction) could be expected in which region of the groundwater body. At this stage the role of the conceptual model is to provide the basis for a reasonable set-up and extension of a monitoring network.

Subsequently, monitoring data is used to check the assumptions made for the first conceptual model. This improvement of the conceptual model is an important element in the groundwater management process in order to increase system understanding and to develop effective planning and control measures. This check and (re)balance may have various outcomes:

- In the case of a good correlation between the conceptual model assumptions and the measured data (especially when no risk of deterioration of good status can be observed[9]), usually there is no further need to refine the conceptual model or collect additional data.
- Where there is significant divergence, this has to be explained. This requires the collection of more data (e.g. extension of monitoring network, increased monitoring frequency) or additional data (e.g. input of substances, degradation/retention capacities, flow/spreading velocities in groundwater/leachate). This process may need to continue until the improved conceptual model can describe the measured data in a consistent way, with sufficient certainty.
- To find impartial criteria with sufficient certainty is difficult (see also section 3.6). Resolving the uncertainty sufficiently may be difficult, but it is better to invest in a good conceptualisation than to base measures on a weak conceptual model, with the risk that those measures may be ineffective in meeting WFD objectives or are simply unnecessary.

3.3.2 'Conceptual models' in guidance documents

Conceptual models are mentioned in several previously published guidance documents as listed in Table 1. In some of these documents, a definition is given (see table 2). Several of the documents stress the iterative process of developing conceptual models and refining them where necessary. They note that conceptual models are useful in:

- understanding the significance of pressures;
- design of a monitoring network;
- interpreting monitoring data;
- evaluating the monitoring network;
- establishing threshold values;
- status assessment;
- trend assessment.

[9] Note that, according to Article 5.2 of the Water Framework Directive, the characterisation "shall be reviewed, and if necessary updated". That implies that a complete re-characterisation is not always needed.

Table 1: Overview of EU guidance documents relevant for groundwater. Indicated is whether the document holds definitions and/or recommendations for conceptual models. Taken from Spijker et al., 2009.

CIS Guidance document	Definition	Recommendation
No 3, Pressures and Impacts	-	+
No 7, Monitoring	+	+
No 12, The role of Wetlands	-	-
No 15, Groundwater Monitoring	+	+
No 16, Drinking Water Protected Areas	-	-
No 17, Guidance on Preventing or Limiting Direct and Indirect Inputs	+	+
No 18, Guidance on Groundwater Status and Trend Assessment	+	+

Table 2: Definitions of conceptual models given in four guidance documents.

Guidance document on Monitoring:
'A conceptual model is a simplified representation, or working description, of how the real hydrogeological system is believed to behave. It describes how hydrogeologists believe a groundwater system behaves'

Guidance document on Groundwater Monitoring:
'Conceptual models are simplified representations, or working descriptions, of the hydrogeological system being investigated'

Guidance document on Preventing or Limiting Direct and Indirect Inputs:
'A conceptual hydrogeological model is the schematization of the key hydraulic, hydro-chemical and biological processes active in a groundwater body'

Guidance document on Groundwater Status and Trend Assessment:

'Conceptual models are (...) a working understanding of the geological and hydrogeological system being studied'

This guidance document deals with risk assessment, one of the areas for which conceptual models can be applied. Therefore the remaining part of this chapter as well as Annex II, focus on the use of conceptual models in risk assessment.

3.4 Properties of conceptual models

3.4.1 Spatial and temporal scale

Before developing a conceptual model, it is important to determine its areal extent and its boundaries. A conceptual model for a groundwater body looks different than a model for a catchment area of one abstraction site. In both cases however, it is important to realise that an effect which is observed at one point, can be caused by a pressure at some distance. Therefore the spatial boundaries of the model should be chosen carefully and in 3 dimensions. In case of doubt, it is better to choose the boundaries well beyond the area of interest albeit they may subsequently be reduced as hydrogeological/physical information allows the zone of potential influence to be delineated (e.g. as groundwater flow direction or the geological boundaries of an aquifer system are established); the iterative process described before will lead to a better understanding of the relevant area. Similarly, it is important to consider the temporal scale relevant for the model.

Annex II describes this in more detail.

3.4.2 Main points during set-up of a conceptual model

Four aspects are important during set-up of a conceptual model.

1. Main characteristics:
    a. Scope and questions to be answered - to determine the degree of detail and complexity of the conceptual model.
    b. Determination of the relevant area.
    c. Definition of vertical and horizontal structuring units (hydrogeological units).
    d. Land use distribution
2. Parameterisation/quantification:
    a. Description and quantification of important hydraulic, geochemical and hydrochemical parameters introduced *where possible and necessary*.
    b. Consideration of processes with slow kinetics (e.g. solution processes, unsaturated zone flow, changes in surface conditions, climate variations).
    c. Description of the most important climatic and unsaturated zone parameters.
    d. Identification of emerging issues that could pose a potential risk.
3. Dealing with uncertainties: we need to assess potential uncertainties, variability, and whether data are representative.
4. Evaluation of a conceptual model: it is advisable to start with a simple model, then analyse its performance and, by stepwise improvements, make a more complex model if the simpler model is not sufficient. It might be necessary to return to a previous step if it turns out that the conceptual model is not consistent with actual data.

Corresponding to these systematic issues it is important to recognise that establishing and refining a conceptual model is an iterative process and all relevant parties should be involved this process.

3.5 Look out for visualisation

It is important to document all steps of the conceptual model. The complexity of the visualisation is dependent on the scoping questions and the potential audience. It can extend from simple 2D maps to more elaborated cross sections and 3D pictures. Annex II gives a more detailed description of the procedure, with proposals for an appropriate level of visualisation.

An example of visualisation is taken from www.wfdvisual.com (see Figure 7) and completed with labels describing the most relevant information. A three-dimensional basic picture like this without exact scale can be used for information of politicians, stakeholders and the interested public to help visualise the hydrogeological situation and the data needed. This picture shows the spatial distribution of an aquifer and the overlying unsaturated zone, the flow and direction of groundwater and surface water and hydrogeological features of the aquifer, such as aquifer type (fissured), lithology (sandstone), permeability etc. By combining the hydrological components - precipitation, groundwater recharge, surface water and groundwater - in one picture, the (conceptual) relationships can be shown. Also shown are the pressures (both for chemical quality and quantitative status) as well as the relevant receptors.

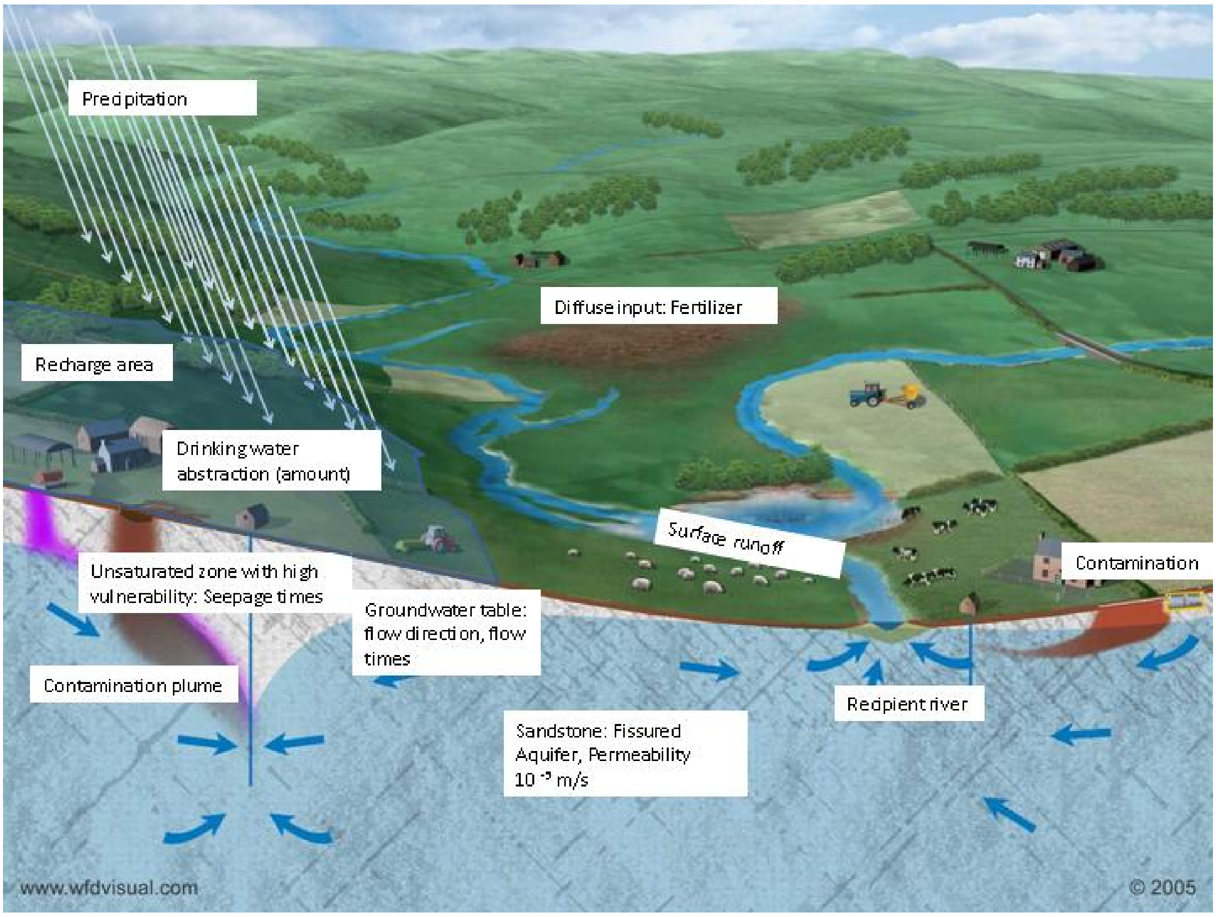

Figure 7: Visualisation example for a conceptual model. Reproduced with permission from WFDVisual.com (www.wfdvisual.com).

3.6 Validation and quality assurance of conceptual models

A conceptual model is dynamic, evolving with time as new data are obtained and as the model is tested. Its development and refinement should adopt an iterative approach. Before re-characterisation takes place, the conceptual model should be evaluated, refined and validated. All data concerning the nature of the groundwater body collected during the characterisation process should be tested against the conceptual model, both to refine the model and to check for data errors. In doing so, the distance to target should be kept in mind: the closer a groundwater body gets towards poor status the more accurate the conceptual model should be in order to carry out a correct compliance test.

Wherever possible, validation of a conceptual model should be based on sufficient monitoring data. Where this is not possible, an analysis of the characteristics of the pressures and receptors combined with monitoring data can be a suitable validation method. Following the approach applied to the selection of relevant substances (CIS Guidance Document No. 3), one can analyse the pressures on a groundwater body (top-down), analyse the observed effects on receptors (bottom-up), and compare these, taking into account travel times within the environment. This comparison offers insight in the validity of the conceptual model. Overall, the weight of evidence should support the conceptual model.

In general it is important to plan and log the validation steps that will be carried out, taking into consideration aspects such as availability of data and the distance to the final objective.

4. WFD OBJECTIVES AND RISK ASSESSMENT

This chapter discusses the use of risk assessment with respect to the five objectives of Article 4 (see Chapter 2.3). For the objectives prevent or limit (1), good groundwater status (3) and protected areas (5), a lot of information is already available. Especially relevant are the following:

- CIS Guidance Document No.3 'Analysis of Pressures and impacts' (2003):
  - (page 25–50) chapter 3 describes a 'general approach for the analysis of pressures and impacts'
  - (page 63–65) section 4.5.3 deals with tools to assist the analysis of pressures and impacts, especially for groundwater
  - (page 70–76) sections 5.2 and 5.3 deal with 'information needs and data sources' when analysing pressures and impacts.
- Technical Report on Groundwater body characterisation (2004):
  - (page 6 and 7) extracts about initial and further characterisation are especially useful for *how* risk assessment can be performed. These deal with chemical and quantitative status as well as with inputs.
- Technical Report on Groundwater Risk assessment (2004):
  - (page 13 and 14) extracts about initial and further characterisation (sections 2.4.1 and 2.4.2)
  - (page 14–18) chapter 3, 'specific guidance', sections 3.1, 3.2 and 3.3. Deals with:
    - identifying driving forces and pressures;
    - identifying significant pressures;
    - assessing the impacts of pressures
  - (page 19) evaluating the risk of failing the objectives
- CIS Guidance Document No.16 'Guidance on Groundwater in Drinking Water Protected Areas' (2007)
- CIS Guidance Document No.17 'Guidance on preventing or limiting direct and indirect inputs' (2007)

The above documents are not legally binding, but they are a result of discussions between many practitioners involved in implementing the groundwater aspects of the WFD and therefore represent a common understanding.

4.1 Prevent or limit the input of pollutants

This objective can apply at all scales from local (for point sources) to groundwater body (mostly for diffuse sources) and is described in detail in Guidance Document 17 (Ref 1). "Prevent or limit" measures are the first line of defence and are the most effective mechanism for protecting groundwater quality. If we correctly assess risks to meeting the 'prevent or limit' (P/L) objective and then implement appropriate risk management measures, in time all the other WFD groundwater quality objectives will be met.

The risk assessments for inputs of hazardous substances (which we must prevent) and non-hazardous substances (which we must limit to avoid pollution) are distinct.

For hazardous substances the risk assessment is curtailed in the sense that it has previously been determined (by the WFD and GWD) that, subject to the exemptions in Article 6 of the GWD, any entry into groundwater is undesirable and should be prevented[10]. In effect all sources (hazardous substances) are assumed to have similar characteristics and the target or receptor in all cases is the water table. SPR characterisation therefore is confined to the source (volume and physico-chemical properties) and the pathway linkages, in particular the ability of unsaturated zone (where this is present) to attenuate the inputs.

For non-hazardous substances a full SPR characterisation is needed as the sources may vary in terms of inherent hazard and the target may be groundwater in the vicinity of the input (in the case of a sensitive and valuable groundwater resource) or a receptor some distance down-gradient of the input, such as an abstraction or dependent aquatic or terrestrial ecosystem. What constitutes harm at the

[10] Guidance Note No.17 describes what prevent means in the context of this objective.

targets (receptors) will vary according to the nature of the pollutant as well as to uses and the sensitivity of the receptor. The procedure for making this assessment is outlined in CIS guidance (Ref 1).

In terms of conceptual modelling only a relatively simple, site specific model may be sufficient to understand a local groundwater system and to assist the assessment of the risk of point source inputs to the P/L objective. The wider scale of diffuse inputs may require a more complex model to support the risk assessment.

Due to the very wide range of potential hazards and the multiple points of compliance, it is difficult to map the risks to the P/L objective for the purposes of the WFD Article 5 reports. Maps of potential sources of contamination can only give an initial hazard assessment at a large scale. Effective systems of permits or other controls may be in place. In this way risks are being managed to meet the P/L objective and it would be misleading to indicate that there is a risk of not meeting that objective. It is suggested that Article 5 P/L "at risk" maps should focus primarily on releases (point sources or delineated diffuse sources) that may not be under sufficient control to meet WFD objectives. There would then be a more direct relationship between the risk maps and the need to implement additional measures during river basin management planning.

4.2 Prevent the deterioration of chemical status of groundwater bodies

The risks of not meeting this objective comprise two elements:

- Those risks associated with a failure to have sufficient P/L measures (for both diffuse and point sources) in place – in other words, are all existing activities (potential hazards) under control?
- Risks arising from sources of contamination in the ground, where the original activity has ceased or is now under control but there is residual contamination that could impact in time on the status of water bodies.

The latter risk is particularly common in hydrogeological situations where flow is slow in the unsaturated zone or in the groundwater body, in deep aquifers and where recharge is low. It is particularly important in these cases to have a conceptual model that looks at historic as well as current activities and examines different time lines/temporal scales.

Because of the time lags (delays) between inputs at the land surface and impacts on the groundwater environment it is possible that some groundwater bodies may deteriorate from good to poor chemical status even when all necessary and reasonable measures to prevent or limit further inputs have been taken. Modelling may be necessary to make a full appraisal of the risks in such cases and these models will need to be supported by a validated conceptual model.

4.3 Achieving good groundwater status

CIS Guidance Document 18 describes the requirements for meeting good status. A number of tests or elements apply to both chemical and quantitative status as noted in Figure 1 of that document.

In order to undertake the "at risk" assessment for the next planning cycle, an assessment of the risks of not meeting good status for each test will be necessary. Initially the baseline conditions from which this assessment can take place must be defined. This will consist of an assessment (based on monitoring data) of both the current condition within the groundwater body and any significant trends in quality and/or level/flow conditions. This will then need to be combined with data on current and predicted land and water uses and inputs to groundwater (source characterisation).

A significant risk to any one of the elements of status will cause the groundwater body to be at risk of failing either groundwater quantitative or chemical status. This system is simple but a resulting map of risk for all the tests combined may not present a clear view of actual risks. It is recommended that risk maps for each element or test for good status are presented so that these can be directly compared to the status (classification) maps. The greater the number of pressures the more detailed the supporting conceptual model will need to be.

For some tests an assessment of deterioration is part of the test for good status (Drinking Water Protected Area and Saline intrusion tests), so there can be overlaps with the risk assessments for deterioration in status and the trend assessment.

Where there is a risk of failing to achieve good groundwater status, the conceptual model and risk assessments will play an integral part in justifying exemptions/alternative objectives.

4.4 Implement measures to reverse any significant and sustained upward trend

The risk assessment for this objective will be closely linked to the assessment of deterioration noted above – in many cases the monitoring data that will assess compliance will come from the same monitoring network. The main difference will be that in order to assess risks of not meeting this objective, we need to not only assess deterioration in quality but also when this deterioration will cease and when the trend will be reversed. Predictions will be over long time scales (probably several river basin management plan periods) and will be inherently uncertain.

A key part of the risk assessment will be consideration of not only the impact of past and current land use activities but what are also the likely future land uses that may have an impact on the predicted trends. Planned measures will need to be factored in to the assessment. Climate change could be a significant factor that may influence such long term trends. For example, changes in recharge or farming practices could reverse (or assist) the measures already taken to reverse upward trends. A series of future land use scenarios may need to be considered using the conceptual model of the groundwater body to assess in principle the potential impacts. This may extend to quantitative modelling to assess the effectiveness of any remedial measures under these different scenarios.

4.5 Meeting the requirements of protected areas

For both chemical and quantitative status, protected areas in practice come within the status objective via the requirement to assess the risks to dependent ecosystems. In addition, compliance with Article 7.3 (Drinking Water Protected Area objective) is one of the elements of meeting good groundwater chemical status.

In order to carry out a risk assessment for drinking water abstraction sites all information within the catchment area on inputs, groundwater characteristics (geohydrology and -chemistry) should be analysed in connection with each other. An initiative such as a Drinking Water Protection File can be a suitable platform for this (Wuijts et al., 2007; see Annex III). This approach can be applied to the analysis of dependent ecosystems as well.

5. ELEMENTS TO CONSIDER DURING THE 2ND PLANNING CYCLE

5.1 How to consider information and data of the previous planning cycle

5.1.1 Key issues

As noted in the introduction to this guidance, planning for the second cycle of WFD RBMPs starts soon after the delivery of the first RBMPs. The preparation period is significantly reduced from the 9 years of the first cycle (2000–2009) to 6 years (2010–2015), with the first key deliverable, the next Article 5 characterisation report, due in December 2013. Whilst Member States can (and must) build on the work undertaken during the first cycle it will be a significant challenge to undertake second cycle planning whilst simultaneously implementing first cycle measures.

The key elements of second cycle characterisation and risk assessment will be:

- Refinement of water body delineation, where necessary;
- Review of pressures and risks to identify changes and new pressures;
- Factoring in climate change;
- Refinement of characterisation procedures to ensure consistency of approach with classification (status assessment).

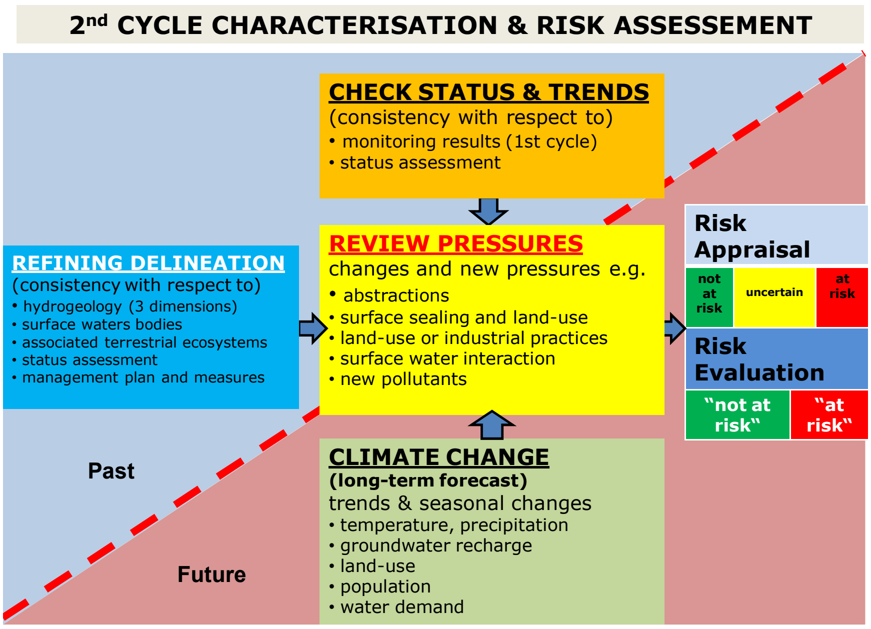

Figure 8: Key elements to consider during the 2nd planning cycle

5.1.2 Water body delineation

The delineation of water bodies, although subject to CIS guidance is not prescribed in detail in the WFD and therefore many different approaches have been adopted by Member States. Water bodies are management units and therefore their delineation should reflect management issues at the river basin district level.

With the benefit of experience from the first planning cycle, Member States may wish to change water body boundaries. However, in doing so, they should consider the consequent changes in status assessment/classification that may then follow. Radical changes in boundaries may affect the ability to provide a stable baseline against which the effectiveness of measures and progress in meeting WFD status objectives can be assessed – it will be difficult to assess compliance between RBMP cycles.

All groundwater bodies need to be associated with dependent surface water bodies - groundwater status is in part determined by the condition of these dependent water bodies. Therefore, changes in the delineation of both groundwater and surface water bodies must be taken into consideration. Potentially changes in status (both deterioration and improvement) could occur simply by changes in boundaries, whereas in practice there may be no environmental changes.

As a general guide it is advisable not to make whole scale changes in groundwater body boundaries from one river basin management plan to another unless this is essential to manage these water bodies and meet WFD objectives.

The WFD only requires the reporting of groundwater body boundaries in two dimensions and in some cases Member States may not have defined the third (depth) dimension for their groundwater bodies. However, it is advisable that the full spatial extent of groundwater bodies is defined and incorporated in conceptual models for the second river basin planning cycle, even if this is not formally reported.

The maximum depth of the groundwater body may be governed by purely hydrogeological factors or a consideration of whether there are any resource issues within a deep aquifer. As they are management units, it is not necessary to define groundwater bodies in deep aquifers that are not exploited by man and have limited connection to dependent ecosystems. Status assessments may serve no purpose in such circumstances but there is still a requirement to protect groundwater quality under the ‘prevent or limit’ objective.

5.1.3 Characterisation of groundwater bodies

The characterisation within the second planning cycle has to take into account all the information gathered during the initial and further characterisation exercises in the first planning cycle. In addition all the data and information obtained from monitoring and other investigatory activities should be integrated in the new assessment.

First of all it has to be checked whether the delineation of groundwater bodies and dependent surface water bodies has changed. Then initial characterization (see Look-Out-Box chapter 3.3), should be conducted for any newly defined groundwater bodies or simply updated for existing groundwater bodies. These data are then used to assess whether a groundwater body is “at risk” of failing WFD objectives (including good status) at the end of the second management plan period (see chapter 4).

For groundwater bodies previously assessed as not being “at risk” checks must be made as to whether there are existing or planned changes in land use, abstraction or other factors causing a risk for the groundwater body itself, or for risks to directly dependent surface water ecosystems or terrestrial ecosystems or the risk of impairment of human and other legitimate uses that could prevent the achievement of WFD objectives.

Further characterisation must be carried out for all “at risk” groundwater bodies (see Look-Out-Box, chapter 3.3).

5.1.4 Monitoring data

In the first planning cycle some Member States may have had little or no monitoring data on some of the significant pressures and impacts. With the implementation of WFD monitoring requirements all Member States should now have improved data which can be used to assess the accuracy of the first cycle risk assessments and to update the conceptual model of the groundwater body and/or the risk assessment. Based on any additional data gained to support the second cycle of characterisation, monitoring strategies and networks should be reviewed and if necessary revised. However, in refining monitoring networks checks must be made to ensure that monitoring to assess the effectiveness of measures and long term compliance with WFD objectives is not disrupted and the necessary consistency and comparability of data with previous cycles is maintained.

5.2 How to consider changes

5.2.1 Changes in land use

The first cycle of initial and further characterisation should have set a baseline against which the measured and predicted future effects of new developments on groundwater quality and quantity can be assessed. If this baseline is incomplete, it should be further developed during the second cycle characterisation and risk assessment.

A key focus should be changes in agriculture and its water demand, due to e.g. future increasing production of biofuel or increasing monocultures for the production of fast growing firewood. Also important is the prediction of changes in population and future land use (e.g. growing towns, decreasing population in the countryside, changes in transport infrastructure, industrial activities, connectivity and interaction to surface water).

Groundwater quantity is often influenced by changes in land use. The sealing of the soil by building new traffic infrastructure and new settlement areas can have significant consequences for groundwater recharge. In addition to this, there can be an increase of water abstractions in the vicinity of settlements due to higher drinking water demand for population and industry. Changes in agriculture can cause a higher groundwater abstraction due to higher needs of irrigation.

Changes in land use also affect groundwater quality: ploughing up grassland mobilises the store of nitrogen. Higher needs in irrigation could be responsible for an increased leaching of nutrients from the soil. Growing new sorts of crop can cause a higher demand on fertilizers and pesticides. In this case it is very important to estimate the protection properties of the soil and the unsaturated zone and to avoid the cultivation of crops with high fertilizer or pesticide demand on high vulnerability soils and aquifers.

5.2.2 Climate change

Groundwater resources and their long-term replenishment are controlled by long-term climate conditions. Climate change will therefore have a great impact on groundwater resources during the next decades. Although time scales of climate change and river basin planning cycles are different it is of importance to describe expected changes systematically already now.

Climate change can cause very different impacts on groundwater systems, from droughts and water scarcity in the Mediterranean region to increases in recharge in the mid-European countries. In humid regions, more frequent and intense precipitation incidents and longer dry periods may occur.

Groundwater will be less directly and more slowly impacted by climate change as compared to e.g. rivers. This is because rivers get replenished on a shorter time scale, and drought and floods are quickly reflected in river water levels. Groundwater, on the other hand, will be affected more slowly and sometimes by different patterns of precipitation. Only after prolonged droughts (particularly with reduced winter rainfall) groundwater levels will show declining trends.

Seasonal changes in precipitation are one important effect of climate change. Predictive models (e.g. Germany) forecast an increase of precipitation in the winter months and a decrease in the summer months. For agriculture, this has an effect on the irrigation demand in the summer months. Even if there is a higher groundwater recharge for the whole year, the increasing of groundwater abstraction in summer due to irrigation and a higher demand of public water supply may locally cause a long term trend of declining groundwater levels with all its consequences e.g. risks for terrestrial ecosystems and influences on the chemical quality of groundwater. Also irrigation itself can have impacts on groundwater quality, as more nutrients can be washed out of the soil.

Increased variability in rainfall may also decrease groundwater recharge in humid areas because more frequent heavy rain will result in the infiltration capacity of the soil being exceeded, thereby increasing surface runoff. In semi-arid and arid areas, however, increased rainfall variability may also increase groundwater recharge, because only high-intensity rainfalls are able to infiltrate fast enough before evaporating, and alluvial aquifers are recharged mainly by inundations during floods. (Groundwater and Climate Change: Challenges and Possibilities, BGR and GEUS, 2008).

For the second cycle of WFD Article 5 risk assessment, a consideration of the predicted changes in precipitation and groundwater recharge and the influence of its consequences (higher drinking water consumption in summer, rise in irrigation measures, surface runoff) is considered essential. The data of the dynamic regional climate modelling CLM / REMO could be used to estimate the effects of climate change in Europe. Climatic water balances using forecasted precipitation and temperature data can provide regional groundwater recharge data for the future. In connection with predictions of the development of population, water demand and changes in land use, the impact on quantity and quality of the GWB should be evaluated for the coming periods of the RBMP.

5.3 Risk assessment, Status and the use of threshold values.

5.3.1 Alignment of characterisation and status assessment methods

The characterisation exercise for the first planning cycle was carried out before the requirements of the new Groundwater Directive (2006/118/EC) and therefore the detailed requirements for groundwater chemical status assessment were known. The use of threshold values in status assessment is a further key development, as noted below.

We also now have supporting guidance (e.g. CIS Guidance Document No 18). As a result there may be wide divergence between the first cycle characterisation and classification assessment methods - the Article 5 reporting of pressures and impacts may not necessarily align with the elements or tests of good status. It is recommended that the future risk assessments undertaken as part of characterisation should take into consideration the status elements defined in the new Groundwater Directive and its associated guidance.

5.3.2 The Groundwater Directive

The Groundwater Directive in its preamble point 7 states that '(..) threshold values should be established, (..) , in order to provide criteria for the assessment of the chemical status of bodies of groundwater.' The chemical status is defined in the Water Framework Directive, Annex V, Table 2.3.2. Good groundwater status, according to that definition, refers to a situation where:

- no saline or other intrusions take place;
- quality standards are not exceeded (the Groundwater Directive set standards for nitrate and pesticides);
- the quality of groundwater does not lead to failure to achieve the environmental objectives for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies;
- the quality of groundwater does not lead to significant damage to terrestrial ecosystems which depend directly on the groundwater body;
- changes in conductivity do not point to intrusions.

According to Article 3.7 of the GWD, the European Commission has to prepare a report on the establishment of these threshold values within Europe. This report was published in March 2010 (Ref 8) which is a first important step of the implementation of the Directive.

The Groundwater Directive also specifies how threshold values should be used in determining the groundwater chemical status (Article 4.2). Basically, if groundwater quality standards or threshold values are not exceeded anywhere in the groundwater body by (time-averaged at each sampling site) the measurements, the body is in good status. In all other cases, the groundwater body does not immediately get assigned as "poor status", but Member States shall carry out an 'appropriate investigation'. In that investigation, Member States shall determine whether:

- the exceedance represents a 'significant environmental risk';
- the conditions for good chemical status of table 2.3.2 of the WFD are met;
- (for groundwater bodies from which water is abstracted for human consumption) the requirements of Article 7.3 of the WFD are met (avoiding deterioration in order to reduce the level of treatment required);

- the ability of the groundwater body to support human uses has not been significantly impaired by pollution.

In addition to the definition of the good chemical status from the WFD, the GWD explicitly mentions 'significant environmental risk', the requirements of Article 7.3 and the human use of groundwater in the context of good chemical status.

5.3.3 Guidance document on groundwater status and trend assessment

Referring to the Groundwater Directives, CIS Guidance Document 18 (Groundwater status and trend assessment) further elaborates the assessment of status, including the 'appropriate investigation'. The guidance document also deals with confidence in the status assessment and suggests the introduction of a surface criterion of 20% to quantify the 'significance of an environmental risk'. This would mean that, provided the other tests have been met, an exceedance of less than 20% of the area does not lead to a poor status of the groundwater body. Nevertheless it needs to be recognized that besides this generic recommendation, specific considerations on pressures (e.g. land-use), the characteristics of groundwater bodies and possible receptors (e.g. surface water) are the necessary assumptions to derive a surface criterion more specifically.

5.3.4 Implications for risk assessment

Although there is a framework for the use of threshold values in CIS Guidance Document No.18, the selection and precise use of threshold values (TVs) is determined by Member States and must be reported in their RBMPs. Threshold values should be derived for those pollutants responsible for the 'at risk' declaration of a groundwater body and must be set at a level whereby if no threshold value is exceeded, this means that there is no significant impact on the receptors noted in the definition of good chemical status. This in effect sets a potential upper limit to a threshold value. In contrast, there is little constraint on the lower limit to which a threshold value is set within the Directive itself. This is down to a variety of practical considerations and the level of precaution that the responsible body within the Member State wishes to adopt. In effect this means that, in terms of risk assessment, threshold values may be set at any level from a risk screening level (no risk to the receptor) through to a risk management level (higher values would result in damage to the receptor).

For the above reasons great care has to be exercised in applying threshold values to the risk assessments undertaken during characterisation – their application must take into account the status assessment method within which they have been used by the Member State. A further consideration is that whilst Member States may have reported (minimum) overall TVs for a groundwater body, they may have used different values in the assessment of each of the component elements of status. Environmental standards will vary between receptors and any risk assessment undertaken during characterisation needs to take account of such variations.

It is also important to note that initial characterisation is conducted to determine whether the groundwater body is "at risk" of failing any of the WFD's environmental objectives, of which status is only a part. In the context of the WFD this is a precautionary risk screening exercise, which is quite distinct from the need to assess whether there is actual damage to a groundwater body from human activity (i.e. poor status) and therefore whether remedial action (measures) should be taken.

What does this all mean for the use of TVs in risk assessment? If TVs have been set at the risk screening level, then they can be used as such during characterisation to identify those groundwater bodies that are definitely not at risk, as far as the status and trend objectives are concerned. However, in many cases this will not be the case and risk screening values for the "at risk" assessment may have to be set a lower level than the reported TVs for groundwater bodies.

Whilst TVs may be a useful indicator for the risk assessment they should not be used in isolation. New substances may need attention, changes in land use may lead to new risks (or earlier risks may have been reduced), recent monitoring data may shed a new light on risks known before, and so on. The pressures and impact analysis from the previous planning cycle must be fully updated.

Special attention should be paid to the way Article 7 is included in the risk assessment. Since the Groundwater Directive also sets objectives for the human uses of a groundwater body, this should be part of the risk assessment. For abstractions within a groundwater body the groundwater quality in the abstraction wells should be evaluated in relation to the standards of the Drinking Water Directive and the risk of deterioration, by trend assessment (Article 7.3) (ref. to Guidance on DWPAs).

5.4 Risk assessment, measures and exemptions

It is important to highlight that this chapter is focused on the relation of the RA and exemptions for 2021 and not for the 2015 period.

The 1st risk assessment (2004) based on Pressures and Impacts Analysis was prepared principally without benefit of a status assessment and with little knowledge of limits and methods of groundwater body's classification. Status assessment, the derivation of TVs and trend assessment was conducted in the second half of 2008. The forecast of exemptions in 2015 (groundwater bodies failing the environmental objectives in spite of planned measures) was also needed. The time period between characterisation and the publication of the River Basin Management Plan (RBMP) was long enough to enable the collection of more data and the development or refinement of the assessment methods including exemptions.

Risk assessment for the 2nd RBMP should not be the same as for the first RBMP (2004). We have better knowledge, new methods and more data. The role of risk assessment is also different.

The same steps are required by the WFD in the 2nd river basin planning cycle but the time available for assessment is shorter: the results of river basin characterisation should be available by the end of 2013 and the status assessment and list of exemptions in 2021 must be prepared by the end of 2014 (see figure 1). GWBs which will not reach their environmental objectives by 2021 must be listed even where measures have been applied. The justification of proposed exemptions is an obligatory part of the RBMP according to the WFD requirements.

The time schedule has not been the only reason for paying more attention on role of RA in further exemptions assessment. The main characteristic of the risk assessment is the forecast of the groundwater status at the end of the management plan period. This is also the basis of the exemptions assessment. In 1st RBMP 4 years between the risk assessment (2004) and the status assessment (2008) allowed time to get both more quantitative and qualitative data. In the 2nd RBMP only 1 year is available for the same exercise.

Another main difference between the initial risk assessment and the list of exemptions in the next planning cycles is probably the uncertainty of status assessment results and planned measures. The low degree of the reliability and high level of uncertainty in the impact of planned measures in 1st Planning cycle are the most important gaps. Data from monitoring, using new approaches and methodology from the start of the second planning cycle can reduce such gaps.

Risk assessment in the 2nd planning cycle can, as a part of characterisation, reflect status assessment results from 2008-2009 but clearly cannot use the results from the second status assessment (due in 2015). On the other hand water bodies identified as being at risk (2nd cycle) are all the bodies where environmental objectives will not be met in 2021 without measures. Exemption assessment will be focused on water bodies in poor status (or with significant upward trend etc.) where we have to evaluate whether or not the planned measures will be effective. For this purpose, information about status assessment or other environmental objectives from 2014–2015 and the list of planned measures will be available. This means the same tool (or approach) can be used for risk assessment as for exemption assessment. Figure 9 presents the relation between the RA, exemptions and programmes of measures. The planning process should be made in an integral manner, since each part of the cycle influences other parts. Programmes of measures should be based on the risk assessment results, while using the conceptual models and other relevant tools increases the reliability in predicted outcomes.

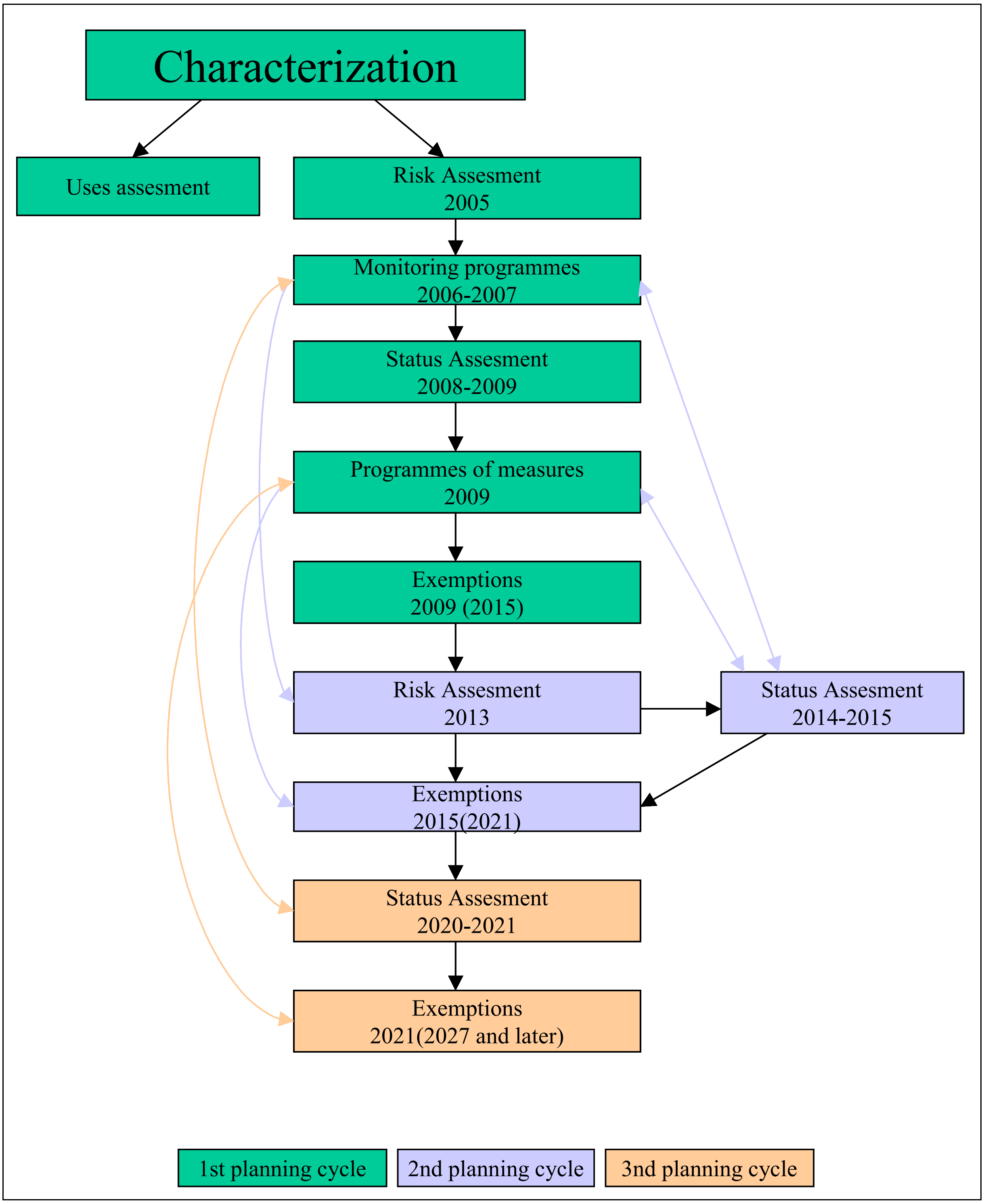

Figure 9: Relation between the RA, exemptions and programmes of measures

The RA is indirectly mentioned in the Guidance on exemptions (No. 20, 2009). The separate approach has been described in the text as well as in figures (e.g. figures 10). The figures also take into account the link between the measures and different types of exemptions. The list of exemptions should be reviewed every 6 years in the RBMP.

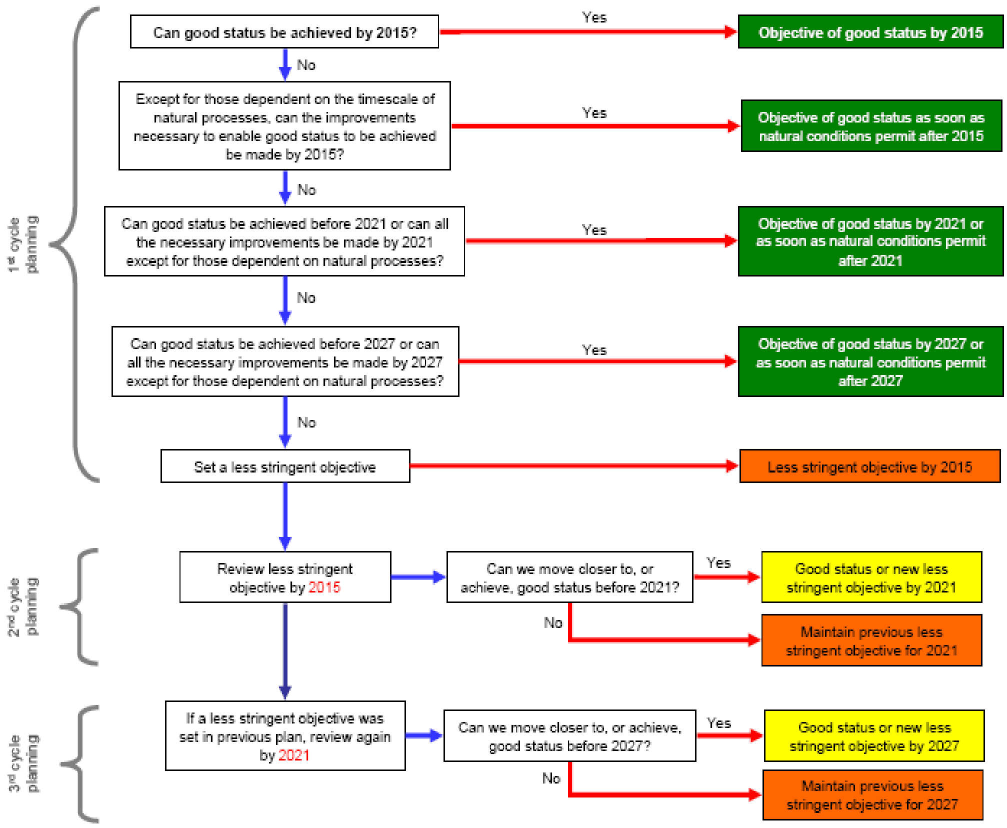

Figure 1: Stepwise thinking process for the considerations of exemptions from good status. The orange boxes refer to Art 4.5, the green except the first box to Art 4.4. For water bodies designated as heavily modified or artificial, references in the Figure to 'good status' should be taken to mean 'good ecological potential and good surface water chemical status*[16]*. Note, if the objective of "good status" is aimed for (green boxes), the achievement of "good status" needs to be confirmed by monitoring data.

Figure 10: Scheme of the exemptions requirements and requirements of current RA (Link between measures and exemptions) (Guidance Document No. 20)

6 References

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8. C(2010) 1096 final, 2010: Report from the Commission in accordance with Article 3.7 of the Groundwater Directive 2006/118/EC on the establishment of groundwater threshold values. http://ec.europa.eu/environment/water/water-framework/groundwater/policy/current_framework/implementation_policy_en.htm
9. European Commission, 2008: Groundwater Protection in Europe.

ANNEX I

SUMMARY OF QUOTATIONS RELATED TO "RISK" IN THE WATER FRAMEWORK DIRECTIVE

WFD	Quotation	Related topic	Related documents
Recital (44)	In identifying priority hazardous substances, account should be taken of the precautionary principle, relying in particular on the determination of any potentially adverse effects of the product and on a scientific assessment of the risk.	Prevent and limit	Guidance Document No 17 - Direct and indirect inputs
Article 11 l)	any measures required to prevent significant losses of pollutants from technical installations, and to prevent and/or to reduce the impact of accidental pollution incidents for example as a result of floods, including through systems to detect or give warning of such events including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems.	Prevent and limit	Guidance Document No 17 - Direct and indirect inputs
Article 16.1	The European Parliament and the Council shall adopt specific measures against pollution of water by individual pollutants or groups of pollutants presenting a significant risk to or via the aquatic environment, including such risks to waters used for the abstraction of drinking water. For those pollutants measures shall be aimed at the progressive reduction and, for priority hazardous substances, as defined in Article 2(30), at the cessation or phasing-out of discharges, emissions and losses. Such measures shall be adopted acting on the proposals presented by the Commission in accordance with the procedures laid down in the Treaty.	Prevent and limit Priority substances	Guidance Document No 17 - Direct and indirect inputs
Article 16.2	The Commission shall submit a proposal setting out a list of priority substances selected amongst those which present a significant risk to or via the aquatic environment. Substances shall be prioritised for action on the basis of risk to or via the aquatic environment, identified by	Priority substances Non-specific for groundwaters	
Article 16.2 a)	risk assessment carried out under Council Regulation (EEC) No 793/93 (1), Council Directive 91/414/EEC (2), and Directive 98/8/EC of the European	Priority substances	Council Regulation (EEC) No 793/93 (1), Council Directive

WFD	Quotation	Related topic	Related documents
	Parliament and of the Council (3)	Non-specific for groundwaters	91/414/EEC (2), and Directive 98/8/EC of the European Parliament and of the Council (3)
Article 16.2 b)	targeted risk-based assessment (following the methodology of Regulation (EEC) No 793/93) focusing solely on aquatic ecotoxicity and on human toxicity via the aquatic environment.	Priority substances Non-specific for groundwaters	Regulation (EEC) No 793/93)
Article 16.2	When necessary in order to meet the timetable laid down in paragraph 4, substances shall be prioritised for action on the basis of risk to, or via the aquatic environment, identified by a simplified risk-based assessment procedure based on scientific principles taking particular account of	Priority substances Non-specific for groundwaters	
Annex II 2.1	Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:	Risk assessment	Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003
Annex II 2.2	Following this initial characterisation, Member States shall carry out further characterisation of those groundwater bodies or groups of bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identification of any measures to be required under Article 11. Accordingly, this characterisation shall include relevant information on the impact of human activity and, where relevant, information on:	Risk assessment	Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003
Annex II 2.3	For those bodies of groundwater which cross the boundary between two or more Member States or are identified following the initial characterisation undertaken in accordance with paragraph 2.1 as being at risk of failing to meet the objectives set for each body under Article 4, the following information shall, where relevant, be collected and maintained for each groundwater body:	Risk assessment	Technical report on groundwater risk assessment issues as discussed at the workshop of 28th January 2004

WFD	Quotation	Related topic	Related documents
Annex V 2.2.2	for groundwater bodies identified as being at risk of failing to achieve environmental objectives under Article 4, ensure sufficient density of monitoring points to assess the impact of abstractions and discharges on the groundwater level,	Quantitative status assessment	Guidance Document N°15_Groundwater Monitoring Guidance
Annex V 2.2.3	for groundwater bodies identified as being at risk of failing to achieve environmental objectives under Article 4, ensure sufficient frequency of measurement to assess the impact of abstractions and discharges on the groundwater level,	Quantitative status assessment	Guidance Document N°15_Groundwater Monitoring Guidance
Annex V 2.4.2	bodies identified as being at risk following the characterisation exercise undertaken in accordance with Annex II, Bodies which are identified in accordance with Annex II as being at significant risk of failing to achieve good status shall also be monitored for those parameters which are indicative of the impact of these pressures	Chemical status	Guidance Document N°15_Groundwater Monitoring Guidance Guidance Document No 18 - Groundwater Status and Trend Assessment
Annex V 2.4.3	establish the chemical status of all groundwater bodies or groups of bodies determined as being at risk Operational monitoring shall be carried out for all those groundwater bodies or groups of bodies which on the basis of both the impact assessment carried out in accordance with Annex II and surveillance monitoring are identified as being at risk of failing to meet objectives under Article 4. The selection of monitoring sites shall also reflect an assessment of how representative monitoring data from that site is of the quality of the relevant groundwater body or bodies.	Chemical status Chemical status	Guidance Document N°15_Groundwater Monitoring Guidance Guidance Document No 18 - Groundwater Status and Trend Assessment

SUMMARY OF QUOTATIONS RELATED TO "RISK" IN THE GROUNDWATER DIRECTIVE

GWD	Quotation	Related topic	Related documents
Recital (4)	Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme (5) includes the objective to achieve water quality levels that do not give rise to significant impacts on, and risks to, human health and the environment.	General	
Recital (14)	It is necessary to distinguish between hazardous substances, inputs of which should be prevented, and other pollutants, inputs of which should be limited. Annex VIII to Directive 2000/60/EC, listing the main pollutants relevant for the water environment, should be used to identify hazardous and non-hazardous substances which present an existing or potential risk of pollution.	Prevent and Limit	Guidance Document No 17 - Direct and indirect inputs
Article 3 b	threshold values to be established by Member States in accordance with the procedure set out in Part A of Annex II for the pollutants, groups of pollutants and indicators of pollution which, within the territory of a Member State, have been identified as contributing to the characterisation of bodies or groups of bodies of groundwater as being at risk, taking into account at least the list contained in Part B of Annex II.	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment
Article 3.6	Threshold values can be removed from the list when the body of groundwater concerned is no longer at risk from the corresponding pollutants, groups of pollutants, or indicators of pollution.	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment
Article 4 2 c i)	on the basis of the assessment referred to in paragraph 3 of Annex III, the concentrations of pollutants exceeding the groundwater quality standards or threshold values are not considered to present a significant environmental risk, taking into account, where appropriate, the extent of the body of groundwater which is affected;	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment
Article 5.1	Member States shall identify any significant and sustained upward trend in concentrations of pollutants, groups of pollutants or indicators of pollution found in bodies or groups of bodies of groundwater identified as being at risk and define the starting point for reversing that trend, in accordance with Annex IV.	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment

GWD	Quotation	Related topic	Related documents
Article 5.2	Member States shall, in accordance with Part B of Annex IV, reverse trends which present a significant risk of harm to the quality of aquatic ecosystems or terrestrial ecosystems, to human health, or to actual or potential legitimate uses of the water environment, through the programme of measures referred to in Article 11 of Directive 2000/60/EC, in order progressively to reduce pollution and prevent deterioration of groundwater	General	
Article 5.3	Member States shall define the starting point for trend reversal as a percentage of the level of the groundwater quality standards set out in Annex I and of the threshold values established pursuant to Article 3, on the basis of the identified trend and the environmental risk associated therewith, in accordance with Part B, point 1 of Annex IV.	Environmental risk	
Article 5.5	Where necessary to assess the impact of existing plumes of pollution in bodies of groundwater that may threaten the achievement of the objectives in Article 4 of Directive 2000/60/ EC, and in particular, those plumes resulting from point sources and contaminated land, Member States shall carry out additional trend assessments for identified pollutants in order to verify that plumes from contaminated sites do not expand, do not deteriorate the chemical status of the body or group of bodies of groundwater, and do not present a risk for human health and the environment	Prevent and limit	Guidance Document No 17 - Direct and indirect inputs
Article 6.1.b	for pollutants listed in Annex VIII to Directive 2000/60/EC which are not considered hazardous, and any other non hazardous pollutants not listed in that Annex considered by Member States to present an existing or potential risk of pollution, all measures necessary to limit inputs into groundwater so as to ensure that such inputs do not cause deterioration or significant and sustained upward trends in the concentrations of pollutants in groundwater. Such measures shall take account, at least, of established best practice, including the Best Environmental Practice and Best Available Techniques specified in the relevant Community legislation.	Prevent and limit	Guidance Document No 17 - Direct and indirect inputs
Article 6.3.e i)	measures that would increase risks to human health or to the quality of the environment as a whole; or	General	

GWD	Quotation	Related topic	Related documents
Article 10	Without prejudice to Article 8, the Commission shall review Annexes I and II to this Directive by 16 January 2013, and thereafter every six years. Based on the review, it shall, if appropriate, come forward with legislative proposals, in accordance with the procedure laid down in Article 251 of the Treaty, to amend Annexes I and/or II. In its review and in preparing any proposal, the Commission shall take account of all relevant information, which might include the results of the monitoring programmes implemented under Article 8 of Directive 2000/60/EC, of Community research programmes, and/or of recommendations from the Scientific Committee on Health and Environmental Risks, Member States, the European Parliament, the European Environment Agency, European business organisations and European environmental organisations.	General	
Annex I.2	The results of the application of the quality standards for pesticides in the manner specified for the purposes of this Directive will be without prejudice to the results of the risk assessment procedures required by Directive 91/414/EEC or Directive 98/8/EC.	Risk assessment	Directive 91/414/EEC and Directive 98/8/EC
Annex II A	Member States will establish threshold values for all pollutants and indicators of pollution which, pursuant to the characterisation performed in accordance with Article 5 of Directive 2000/60/EC, characterise bodies or groups of bodies of groundwater as being at risk of failing to achieve good groundwater chemical status. Threshold values will be established in such a way that, should the monitoring results at a representative monitoring point exceed the thresholds, this will indicate a risk that one or more of the conditions for good groundwater chemical status referred to in Article 4(2)(c)(ii), (iii) and (iv) are not being met. all pollutants which characterise bodies of groundwater as being at risk, taking into account the minimum list set out in part B;	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment
Annex II C	information on the number of bodies or groups of bodies of groundwater	Chemical status	Guidance Document No 18 -

GWD	Quotation	Related topic	Related documents
	characterised as being at risk and on the pollutants and indicators of pollution which contribute to this classification, including the observed concentrations/ values; information on each of the bodies of groundwater characterised as being at risk, in particular the size of the bodies, the relationship between the bodies of groundwater and the associated surface waters and directly dependent terrestrial ecosystems, and, in the case of naturally-occurring substances, the natural background levels in the bodies of groundwater;		Groundwater Status and Trend Assessment
Annex III	The assessment procedure for determining the chemical status of a body or a group of bodies of groundwater will be carried out in relation to all bodies or groups of bodies of groundwater characterised as being at risk and in relation to each of the pollutants which contribute to the body or group of bodies of groundwater being so characterised	Chemical status	Guidance Document No 18 - Groundwater Status and Trend Assessment
Annex III 4 e)	The risk from pollutants in the body of groundwater to the quality of water abstracted, or intended to be abstracted, from the body of groundwater for human consumption	DWPAs	Guidance No 16 - Groundwater in DWPAs
Annex IV A	Member States will identify significant and sustained upward trends in all bodies or groups of bodies of groundwater that are characterised as being at risk in accordance with Annex II to Directive 2000/60/EC, taking into account the following requirements:	Trend assessment	Guidance Document No 18 - Groundwater Status and Trend Assessment
Annex IV B 2	once a starting point has been established for a body of groundwater characterised as being at risk in accordance with Section 2.4.4 of Annex V to Directive 2000/60/EC and pursuant to point 1 above, it will not be changed during the six-year cycle of the river basin management plan required in accordance with Article 13 of Directive 2000/60/EC;	Trend assessment	Guidance Document No 18 - Groundwater Status and Trend Assessment

ANNEX II

Setting up Conceptual Models for Groundwater Systems

1. INTRODUCTION TO THE CM ANNEX

In the new Groundwater Directive as well as in several Guidance Documents, the use of 'conceptual models' is mandatory or recommended, for various purposes. The term 'conceptual model' is not defined in the Groundwater Directive.

In this Annex an approach to set up conceptual models for purposes related to the WFD and GWD and assist in groundwater management is described.

Definition of conceptual model

In the context of this guidance, a conceptual model is a means of describing and optionally quantifying systems, processes and their interactions. A hydrogeological conceptual model describes and quantifies the relevant geological characteristics, flow conditions, hydrogeochemical and hydrobiological processes, anthropogenic activities and their interactions. The degree of detail is based on the given problems and questions. It is one of the basic steps for the management of groundwater bodies.

Depending on the specific problems/questions to be addressed for groundwater, a conceptual model (I) is an evolving system that is starting simple and may grow in complexity and (II) starts with a basic descriptive approach of structures and processes and may reach up to their parameterization. The CM is a knowledge based approach that is evolving during development and use.

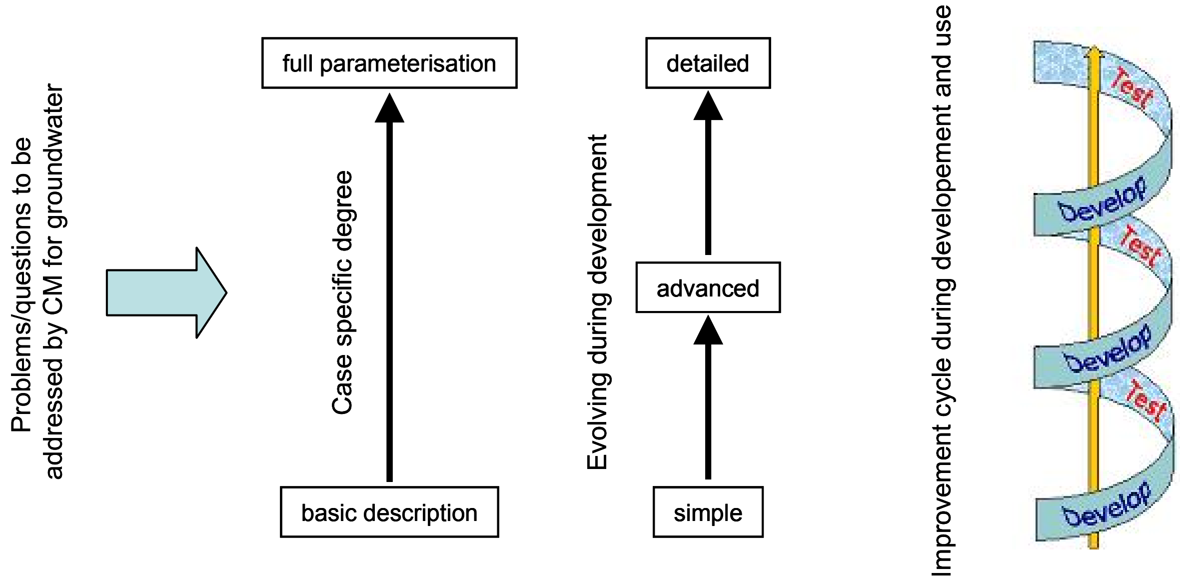


Figure 1: The application requirements determine the CM's degree of parameterization and complexity.

It can be concluded that the use of conceptual models is recommended for various purposes. Its cyclic nature (stepwise approach) is emphasized: start simple, refine later if necessary.

2. BASIC PROCEDURE

For many purposes CM in different degrees of elaboration and complexity are already existing. Mostly, they are a good basis to build on. Nevertheless, the complete procedure of setting up a CM is described here.

To address the different aims for Conceptual Models a stepwise approach is suggested. Within the steps there is a follow up of a qualitative description (e.g. what structures, processes are there) and a quantitative description of parameters (e.g. flow rates, concentrations):

Step 1, basic CM for the groundwater body

- Step 1a, qualitative CM
- Step 1b, Quantification of parameters in the CM

Step 2, to include risk assessment aspects into the CM[11]

- Step 2a, qualitative description of impacts (anthropogenic)
- Step 2b, quantitative description of impacts

Step 3, to include risk management aspects into the CM

- Step 3a, description of effects of existing measures
- Step 3b, prediction of effects of existing and future measures

Dependent on the aims a consequent follow up of these steps is not mandatory.

[11] Step 2, especially the quantitative consideration is quite similar to the assessment of groundwater bodies

3. INITIAL CONSIDERATIONS FOR SETTING UP A CONCEPTUAL MODEL

3.1 Scope and questions to be answered by a CM

The management of groundwater systems holds by its nature various steps in a continuous cycle (see figure 6 chapter 3.2 in the main document). Within the cycle of groundwater management conceptual models can be used in different phases with a different purpose. Each step gives rise to different questions to be answered. For instance:

- *Information and communication*: To allow an integration of and communication to no expert stakeholders
- *Status assessment*:
    - What is the interaction between groundwater and ecosystems?
    - How can MS inform risks and the effect of action plans to the public?
    - Do the groundwater bodies meet the environmental objectives of the WFD (Article 4)?
- *Monitoring*: What is the best design of a monitoring network within the frame of the WFD?
- *Risk assessment*: What is the risk of not meeting the environmental objectives of the WFD (Article 4)?
- *Risk management*: Where to initiate which measures and what are their effects in time and space.

Depending on the questions to be addressed different degrees of detail and complexity are required in the development of a CM (see figure 1).

The questions to be answered by a conceptual model also set demands upon the scale in time and space to be considered. For instance when evaluating the effect of inputs on abstractions, one typically studies a local scale, while for the design of monitoring network a regional scale is in place. It should be kept in mind that independent from the scale of interest, in all considerations for a conceptual model, hydrogeological boundaries determine the extension of the areas to be considered. For instance, for studying again the effect of inputs on abstractions, the catchment area should be taken into account when setting up the conceptual model.

3.2 Spatial scale

The whole system of aquifers, aquicludes, unsaturated zone, etc. is under consideration in this guidance. This approach covers e.g. the surface water interaction and unsaturated zone interaction.

For the delineation of a conceptual model it is obligatory to move from an overview scale like groundwater bodies to a detailed scale considering several aspects, e.g. the recharge area of a sampling site: In the first case, the groundwater body as a whole is the area of the conceptual model. In many cases only parts of a groundwater body are the origin of poor status (depending on e.g. high abstraction areas, land use). It is helpful to define the water balance for the area covered by the conceptual model. If parts of the groundwater bodies are negatively influenced e.g. by point sources, only those areas that might be affected have to be considered in the CM more detailed. The smallest scale of CM is the catchment area of a sampling point.

In general this means that different scales have to be considered when setting up a CM. A varying depth of data is needed, from only basic data in the overview scale to more specific data in the detailed scale where the CM should provide a reliable basis for description, risk-assessment and -management. This allows to reduce data needs in areas that are not affected.

3.3 Temporal scale

Temporal scale is very important in the CM elaboration, because it touches e.g. basic information on groundwater dynamics (like infiltration rates, geogenic changes of physical/chemical groundwater properties).

Temporal aspects can be distinguished into natural variations (e.g. seasonal effects) and anthropogenic influences like rising concentrations, decreasing groundwater levels).

3.4 Main points during CM set-up

Based on the previous considerations in chapter 2 and 3 the following main points can be summarized:

Basic delineation

- Scope and questions to be answered determine the degree of details and complexity of the CM (chapter 3.1).
- Definition of the investigation area based on the regional hydrogeological situation including relevant geological and tectonic structures, characterisation of main groundwater and surface water catchment areas (chapter 3.2)
- Definition of the balance and target area, based on sufficient geohydraulic boundary conditions (chapter 3.2)
- Vertical and horizontal structuring units (hydrogeological units) have to be defined. Formations with comparable hydrogeological characteristics (see chapter 5.1) have to be combined and important heterogeneous areas have to be kept.

Description, parameterisation and quantification

- Description and Quantification of important hydraulic, geochemical and hydrochemical parameters where possible and necessary. They have to be transferred from point to areas of parameter zones, without misrepresenting driving processes and interactions.
- Consideration of processes with slow kinetics (e.g. solution processes, unsaturated zone flow, changes in surface conditions, climate variations…)
- Description of the most important climatic and unsaturated zone parameters
- Delineation of land use distribution
- Identification of emerging areas that could pose a potential risk (chapter 5.2)
- Evaluation and assessment of potential uncertainties, variability, and representatives in data and structures (chapter 5.2).

Cyclic approach

- The setting up of a CM is not a static process, it requires several iteration steps during development (e.g. by aligning it with new field data), application (e.g. a numerical model serves to verify whether complex interacting processes are appropriately described), and maintenance (see Figure 2).
- Be aware that it might be necessary in one of the CM development steps, e.g. step 2b (chapter 5.2) to get back in one of the previous steps in case it turns out that actual data show that the CM is no longer consistent or shows new gaps.

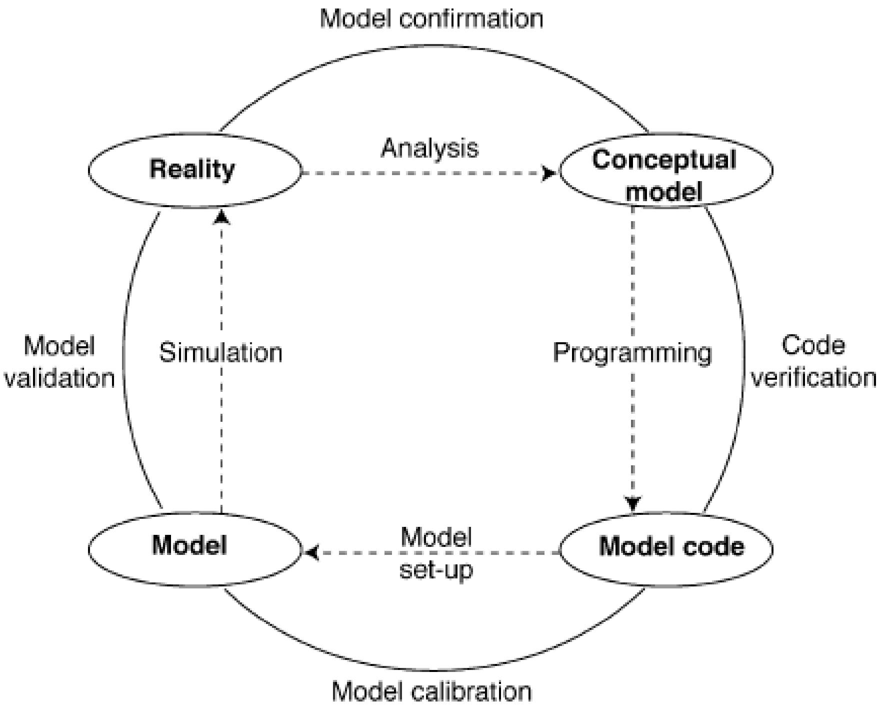


Figure 2: Cyclic approach for developing a conceptual model[12]

[12] Refsgaard, J. C., Henriksen, H. J. r. (2004). Modeling guidelines - terminology and guiding principles. Advances in Water Resources, vol. 27, no. 1, pp. 71-82.

4. DATA

During setting up a CM the requirements defined in chapter 3 determine the need for screening existing data from various sources or to collect new data.

It is important to be aware that, in addition to the WFD and GWD, groundwater monitoring data are collected for the purposes of other European and national programmes or Directives. These data can be used within the CM. They can be very valuable, as they provide quite often long lasting existing data sets and as future data out of these programmes can be integrated in the CM as well. Their use also avoids an unnecessary collection of new data. Thus a wide range review of existing data and data collection activities is very important.

Setting these data in the context of a CM gives an added value to them.

4.1 Data check list

The data checklist provides a comprehensive overview of information that might be needed. In practice, depending on the questions to be answered (chapter 3.1), only a limited selection of these data is needed. Tables with examples (without claiming completeness) for the data needed are given below.

Step 1, basic CM for the groundwater body

Step 1a Qualitative CM:

Step 1a is to give an overview on the aquifer geometry and basic characteristics. It has to consider topographic information, geology and hydrogeology in a qualitative, descriptive way.

Step 1b Quantification of parameters

Step 1b quantifies the elements described in step 1a. It considers e.g hydraulic, geochemical hydrochemical and soil data and values. It may occur that for this quantification step further detailed data of step 1a are useful.

Table 1: Conceptual Model – qualitative description (step 1a)

Topography • Morphology • Surface waters (stream flows, lakes, springs) • Surface water catchment areas	**Geology** • Lithology • Tectonics • Stratigraphy
	Hydrogeology • Groundwater catchment area • Aquifer geometry • Hydrogeological units Aquifer type (porous, fissured, karst etc.) Geochemical type (silicious, calcareous etc.) Permeability (rough estimation high, medium low) Confined/unconfined Consolidated/unconsolidated rock • Groundwater (chemical) typology • Single/multi-aquifer system • Unsaturated zone • Estimation of flow directions • Local uses of groundwater

Table 2: Conceptual Model – quantification of parameters (step 1b)

Geochemical data • Clay content • Organic carbon content (in soil/aquifer matrix) • Mineralogical composition of soil/aquifer matrix	**Hydraulic data** • Hydraulic conductivity • Porosity (total/effective) • Groundwater levels • Hydraulic gradients • Direct recharge (rainfall) • Indirect recharge/discharge (interaction with surface waters, drainage and sewers)
Basic hydrochemical data • Temperature • pH • Conductivity • Redox potential • Alkalinity • Dissolved oxygen • Dissolved organic carbon • Mineral content (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}, HCO_3^{-}, Cl^{-}, SO_4^{2-}, NO_3^{-})	**Specific hydrochemical data** • Compounds related to age determination (e.g. ^{3}H) • Trace compounds
Soil (pedology) • Soil type distribution • Depth of development	

Step 2, to include risk assessment aspects into the CM[13]

Step 2a Qualitative description of impacts (anthropogenic)

Step 2a is to delineate different types of land use, receptors and potential impacts/risks.

Table 3: Conceptual Model – qualitative description of impacts (step 2a)

Land use and potential stress factors and risks[14], e.g. • Agriculture • Industry • Infrastructure • Abstraction and infiltration points • Heat storage or extraction points	**Receptors e.g.** • Protective zones (e.g. water supply facilities, wetlands, ecotopes)

[13] Step 2, especially the quantitative consideration is quite similar to the assessment of groundwater bodies

[14] For an overview on land use distribution maps based on CORINE land use data, NATURA 2000, etc. can be used

Step 2b Quantitative description of impacts

Step 2b is to quantify emission, immissions and uses.

Table 4: Conceptual Model – quantitative description of impacts (step 2b)

Emission of anthropogenic sources	**Inputs to groundwater by anthropogenic sources**
• Agriculture (e.g. N surplus) • Industry • Infrastructure • Mining (including mines, tailing dams and spoil heaps) • Waste management activities • Diffuse soil contamination (e.g. caused by atmospheric deposition)	• Case-specific pollutants (e.g. CHC, TPH, BTEX, oxygenates, HM, PAHs, pesticides, creosotes, nitrate, sulphate, ammonia) • Corresponding degradation products • Additional potential electron acceptors and nutrients ($Mn^{2+/4+}$, $Fe^{2+/3+}$, P) • Indicators of biodegradation (Mn^{2+}, Fe^{2+}, CH_4) • metals
Groundwater use • Abstraction or infiltration rates • Heat storage or extraction	

Step 3, to include risk management aspects into the CM

Step 3a Description of effects of existing measures

In step 3a existing data of groundwater quality and quantity are used to derive information on parameters (e.g. travel times) that impact the effects of existing measures. This might be information that results out of the interpretation of time dependent data (e.g. nitrate travel times calculated out of concentration peaks in two monitoring wells). For measures related to groundwater quantity effects on groundwater level and groundwater related ecosystems due to changes in an abstraction regime can be calculated.

Table 5: Conceptual Model – description of existing measures and effects (step 3a)

Measures for groundwater quality	**Measures for groundwater quantity**
• existing concentration data rows for calculation (in relation to river basin management plan) of travel times in unsaturated/saturated zone • temporal and spatial development of anthropogenic input (e.g. fertilizer) • results of tracer tests • calculated/measured degradation/reaction rates	• existing data on groundwater/surface water levels • existing data on groundwater abstraction • results of tracer tests

Step 3b Prediction of effects in future of existing and future measures

Step 3b has to provide data that allow the prediction of effects of existing and future measures. These data are based on the data collected for step 3a and also includes data collected in steps 1 and 2, especially the quantifying data. Thus step 3b marks the transition from the conceptual model to the mathematical and numerical model.

Table 6: Conceptual Model – forecast on effects due to measures (step 3b)

Future effects of measures for groundwater quality	**Future effects of measures for groundwater quantity**
• calculated (in relation to river basin management plan) travel times in unsaturated/saturated zone • calculated degradation/reaction rates • scenarios of climate development • scenarios of future developments in land use, population and water demand	• calculated effects to groundwater level and groundwater related ecosystems by changes in abstraction regime • scenarios of climate development • scenarios of future developments in land use, population and water demand

4.2 Data review

By implementing or following several national and European programs and guidelines related to groundwater, soil, surface water and related fields a large data base is available that should be considered carefully before initiating new data collection activities.

When comparing or combining data out of different sources a quality check e.g. in terms of collection method, scale and temporal aspects should be made.

4.3 Data collection/acquisition

New data should only be collected, if, after careful consideration, existing data turned out not to be sufficient related to the target group to be addressed and the questions to be answered. (See also Chapter 3 of main document)

5. CONCEPTUAL MODEL DEVELOPMENT

5.1 Basic CM for the groundwater body, step 1 qualitative and quantitative CM

Description of Step1a. qualitative parameters in the CM

The task is to define a first understanding of the spatial scale to be considered (chapter 3.2) based on topographical data and definition of surface water catchment area. This is followed by the development of a hydrogeological understanding out of geological data.

The main knowledge increase of this step is:

⇨ Definition of hydrogeological properties

⇨ Derivation of hydrogeological units.

These outcomes allow a refinement of the investigation area and a first estimation of the groundwater balance area as interface to step 1b.

At the end of step 1a a first overview on the hydrogeological system should already be possible (principle maps/sketches)

The results of this step can be shown as e.g. cross sections, maps, block diagrams, providing:

- Spatial distribution/delineation of hydrogeological units in the area delineated for the CM
- Description of monitoring network (see Monitoring guidance)
- Integrate information on groundwater flow (directions)

Description of Step1b, Quantification of parameters in the CM

Hydraulics:

The hydraulic characteristics are described by integrating measured soil (pedological) and hydraulic data (e.g. groundwater levels, gradients, permeabilities, recharge, discharge, level of drainage)

The main knowledge increase of this step is:

⇨ Groundwater balance for draft balance area

⇨ Adjustment of balance area related to groundwater balance

⇨ A first estimation if the existing monitoring network is sufficient

The results of this step can be shown as e.g. cross sections, maps, block diagrams, providing:

- Quantified Water balance, split to different components of discharge and recharge
- GW flow directions
- Depth to GW table
- Travel times of seepage and groundwater
- Other refined products of step 1a.

Hydrochemistry:

The aim is to elaborate a spatial and temporal distribution of basic and, specific (where necessary) hydrochemical data (natural groundwater composition).

The main knowledge increase of this step is:

⇨ understanding and quantification of natural hydrochemical processes

⇨ e.g. allows to identify natural background level (according to Guidance on Groundwater Status and Trend Assessment)

⇨ further confirmation of balance area

⇨ further confirmation of flow regime

The results of this step can be shown as e.g. maps, diagrams, providing:

- Groundwater chemistry characterisation in time and space
- Natural background levels
- Refined products of step 1a and 1b hydraulics.

5.2 Risk based requirements – step 2, including risk assessment aspects

Description of Step 2a, qualitative description of impacts (anthropogenic)

In this step, different types of land use and receptors are delineated (according to Guidance on Groundwater Status and Trend Assessment and Guidance on the application of the term 'direct and indirect inputs' in the context of the Groundwater Directive 2006/118/EC).

Also, a delineation of risks is done by identifying specific points or areas that could pose a risk and the identification of types of actual or potential inputs (direct/indirect, point/diffuse, actual/historical, permanent/periodic) has to be done in this step.

The main knowledge increase of this step is:

⇨ Identification of the location of anthropogenic inputs (hazards)

⇨ Identification of the location of (potential) receptors

⇨ Identification of plausible pathways between hazards and receptors

⇨ Identification of actual risks (magnitude and probability of unacceptable impacts at receptors)

The results of this step can be shown as e.g. maps, providing:

- Distribution of different types land use
- Distribution of different anthropogenic impacts
- Distribution of different receptors

Description of Step2b, quantitative description of impacts

Emissions, immissions and uses are described in this step. Aims are the definition of monitoring data requirements, (type of parameter characterising the impacts, where to measure, frequency of measurements) and the temporal and spatial distribution of substances measured in the groundwater caused by anthropogenic impacts (e.g. landfill contamination plume). For groundwater quantity, temporal and spatial variations of anthropogenic influences on the hydraulic system (e.g. drinking water abstraction) are to be considered.

The main knowledge increase of this step is:

⇨ the spatial delineation of concentrations and fluxes

⇨ the variability of concentrations and fluxes in time

⇨ identification (quantification?) of mobility relevant processes (attenuation, dilution, see Guidance on Groundwater Status and Trend Assessment)

The results of this step can be shown as e.g. maps and diagrams, providing:

⇨ the delineation of areas and receptors affected

⇨ the reconstruction of the impacts from past events until today

⇨ first predictions of the future development of the impacts

5.3 Risk management based requirements (step 3)

In step 3, the CM development process is directly linked to the program of measures of the WFD. It is necessary to distinguish measures regarding groundwater quality and quantity.

Description of Step3a, description of effects of existing measures

Measures for GW quality:

With the help of time series analysis, the effects of existing measures can be described by estimations of travel times in the unsaturated and saturated zone and by delineating the impact on the kinetics of degradation and attenuation processes. The impact of measures addressing temporal and spatial development of past anthropogenic inputs can be described.

This is the basic instrument for the understanding of the processes described in step 2 and the knowledge base to provide a basis for the prediction of future processes in step 3b.

Measures for GW quantity:

Here, a description of past and ongoing measures (e.g. changes in abstraction regime) and their effects to groundwater level and groundwater related ecosystems is made.

The main knowledge increase of this step is:

- an understanding of the effects of measures on groundwater quantity and quality.
- a knowledge base to decide, if a good status can be achieved in principle?

The results of this step can be shown as:

- maps of the spatial and timely development in impact areas, where measures have been taken already
- diagrams of the development of risk related parameters due to existing measures.

Description of Step3b, description of effects of existing measures

Based on the information in Step 3a, step 3b provides data sets for future scenarios that can feed into mathematical or numerical models.

Measures for GW quality:

With the help of calculations of travel times in the unsaturated and saturated zone it is possible to compare the effects of measures in time and space to deadlines defined in river basin management plans. In this step, also scenarios considering the future climate and land use development, population and water demand can be elaborated.

Measures for GW quantity:

Mainly, the effects to groundwater level and groundwater related ecosystems by different scenarios of measures focusing on the abstraction/infiltration regime is calculated. Like for groundwater quality, scenarios considering the future climate and land use development, population and water demand can/should be elaborated.

The main knowledge increase of this step is:

- if proposed/planed measures in principle are sufficient to reach the RBMP goals
- the time of reaching a trend reversal
- the time of reaching a good status/natural background level
- advise, if there is a need for prolongation of deadlines or less stringent environmental objectives

The results of this step can be shown as diagrams and maps together with a text description.

5.4 Documentation/Visualisation

It is important to have aggregated documentation of all steps of a CM. It should be clearly shown, where improvement loops are situated. The complexity of the visualisation is dependent on the scoping questions and the people addressed. Data sources used have to be documented.

Appropriate media for publishing are e.g. pictures, diagrams, maps, block diagrams, cross sections, text, Slide shows, Web Map Services, viewer.

6. VALIDATION OF CM, QUALITY ASSURANCE

6.1 Introduction

A conceptual model is dynamic, evolving with time as new data are obtained and as the model is tested. Its development and refinement should adopt an iterative approach. Before the conceptual model can be used, it has to be calibrated. Before re-characterisation takes place, the conceptual model should be evaluated, refined and validated. All data concerning the nature of the groundwater body collected during the characterisation process should be tested against the conceptual model, both to refine the model and to check for data errors. In doing so, the distance to target should be kept in mind: the closer a groundwater body gets toward a good status the more accurate the conceptual model should be in order to carry out a correct compliance test. If there is uncertainty about the reliability of the results, the groundwater body is at-risk beforehand.

Four types of data will have to be included in the calibration and validation process:

1. process data: e.g. groundwater to surface water interactions, steady state or transient state
2. structure : e.g. geological structure, boundary conditions
3. inputs: e.g. rainfall, groundwater recharge, evapotranspiration
4. parameters: e.g. permeability, storage coefficient

The main difference between calibration and validation is the timing when those processes take place:

- Calibration is executed before the conceptual model can be considered finished : it is the process where the values of all the parameters that can vary have been chosen in such a way that the calculated groundwater levels, velocities, concentrations,… are as close as possible to the real ones;
- Validation is executed after the conceptual model is finalised an when a significant set of new data is obtained; in this stage one can check if the new data are well predicted; if not one should restart the calibration process.

The validation of a conceptual model can be based on monitoring data if there is sufficient data available. Quite often this is not the case. Then an analysis of the characteristics of the pressures and receptors combined with monitoring data can be a suitable validation method. Following the approach applied to the selection of relevant substances (Guidance no. 3, 2003), one can analyse the pressures on a groundwater body (top-down), analyse the observed effects on receptors (bottom-up), and compare these, certainly taking into account a travel time distribution. This comparison offers insight in the validity of the conceptual model.

In general it is important to plan and log the validation steps that will be carried out, taking into consideration aspects such as availability of data and the distance to the target.

6.2 Validation of conceptual models

Within CM setup the first step in validation is to put existing data consistently together to a conceptual model. As CM is not a static image, new information that can feed into the CM appears over time (e.g. monitoring data, information construction measures…) when these new information can be constantly put into your CM this validates that the actual design of the CM is right. In case of conflicts, both the conceptual model design and the quality of the new information have to be reviewed, to come up with a consistent solution. The validation by monitoring data and new information is the most common way.

Besides this validation by monitoring data, it is also possible to make use of mathematical models (usually computer based) for validation. A first way is, if the existing conceptual model can be reproduced by a mathematical model (e.g. reproduction of measured groundwater levels or hydrographic curves). A second but more time consuming way is to compare the forecasting of CM based mathematical models with later monitoring data of the groundwater body.

6.3 Quality assurance

Errors in the development of a CM will be perpetuated throughout the other steps of setting up the CM and are likely to result in developing a sampling and analysis plan that may not achieve the data required to address the relevant issues. It is important to identify theories and assumptions underlying the CM to ensure adequate transparency. If the problem is complex, it may be considered breaking it into more manageable pieces, which might be addressed by separate studies. Priorities may be assigned to individual segments of the problem and the relationship between the segments examined.

There are two primary types of intended uses of the data: data for *decision making* and data necessary for *making estimations.* Models can be used to generalise point information to information for areas.

Decision problems

- Does the concentration of contaminants in groundwater exceed acceptable levels?
- Does the pollutant concentration exceed a standard?
- Does a contaminant pose a human health or ecological risk?
- Is the contaminant concentration significantly above background levels?
- Etc.

Estimation problems

- What is the average rate of groundwater flow in the aquifer?
- What is the distribution of pollutant groundwater concentrations over space and time?
- What are the sizes of endangered species populations within the habitat of concern?
- How do the background contaminant concentrations vary over space and time?
- Etc.

In order to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels *performance or acceptance* criteria should be derived that the collected data will need to achieve. *Performance* criteria, together with the appropriate level of common Quality Assurance practices, will guide the design of new data collection efforts, while *acceptance* criteria will guide the design of procedures to acquire and evaluate existing data relative to the intended use. Therefore, the method to use and the type of criteria to be set will, in part, be determined based on the intended use of your data.

The Data Quality Objective Process (Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4, February 2006) can be used to develop *performance* and *acceptance* criteria (or data quality objectives) and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to set up a conceptual model.

The DQO Process is a series of logical steps that gives guidance to a plan for the resource-effective acquisition of environmental data. It is both flexible and iterative, and applies to both decision-making (e.g., compliance/non-compliance with a standard) and estimation (e.g., ascertaining the mean concentration level of a contaminant). The DQO Process is used to establish *performance* and *acceptance* criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO Process leads to efficient and effective expenditure of resources; consensus on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

In general, *performance* criteria represent the full set of specifications that are needed to design a data or information collection effort such that, when implemented, generate newly-collected data that are of sufficient quality and quantity to address the project's goals. *Acceptance* criteria are specifications intended to evaluate the adequacy of one or more existing sources of information or data as being acceptable to support the project's intended use.

When evaluating scientific and technical information, the EPA recommends using the five General Assessment Factors (GAFs) documented in Table 7.

Table 7: EPA General Assessment Factors

Soundness: The extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application.
Applicability and Utility: The extent to which the information is relevant for its intended use.
Clarity and Completeness: The degree of clarity and completeness with which the data, assumptions, methods, quality assurance and analyses employed to generate the information are documented.
Uncertainty and Variability: The extent to which the variability and uncertainty (quantitative and qualitative) in the information or the procedures, measures, methods or models are evaluated and characterized.
Evaluation and Review: The extent of independent verification, validation, and peer review of the information or of the procedures, measures, methods or models.

These general assessment factors can be used to describe the Quality Assurance of the conceptual model.

7. GLOSSARY

A comprehensive glossary of terms on Groundwater can be found on the webpages of “The Groundwater Foundation”:

http://www.groundwater.org/gi/gwglossary.html

8. LITERATURE

J. Spijker, R. Lieste, M. Zijp, T. de Nijs, 2009. Conceptual Models for the Ground Water Directive. See www.rivm.nl/bibliotheek/rapporten/607300010.html) .

EU (1980). Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances. Official Journal of the European Union, L 20.

EU (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Union, L 327/1.

EU (2006). Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. Official Journal of the European Union, L 372/19.

ANNEX III - Examples

A CONCEPTUAL MODEL TO CHARACTERISE A GROUNDWATER BODY

GWB Leibnitzer Feld - Location and boundaries

The groundwater body "Leibnitzer Feld" is situated in the Austrian province of Styria to the south of Graz in southeast Austria. It is a single groundwater body in a porous medium, extending in a north-south direction and covering 103 km^2 at altitudes ranging between 157 and 340 m a.s.l. (above Adriatic Sea level).

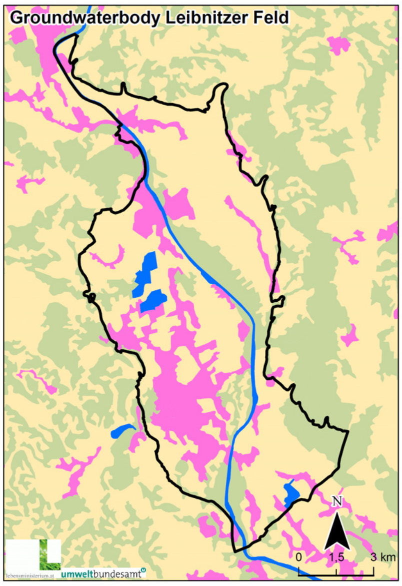
Morphologically, the groundwater body is clearly delineated by mountains to the north, east and west. To the south, the river "Mur" marks the delineation.

Land use and pressures

On the basis of evaluations of CORINE Landcover 2000 data (CORINE, 2000), the following distribution of land usage across the groundwater body Leibnitzer Feld was obtained, as shown in Table 1 (in % of total area). Main pressures are due to water abstraction, agriculture, industrial sites and contaminated sites (see also anthropogenic impact).

Table 1: Leibnitzer Feld - land use according to CORINE Landcover (2000).

Land use	***%***
Artificial surfaces	19.4
Agriculture	61.3
Forests and semi-natural areas	14.8
Surface waters	4.5



LEGEND:

Pink: artificial surfaces

Yellow: agricultural areas

Green: forests and semi-natural areas

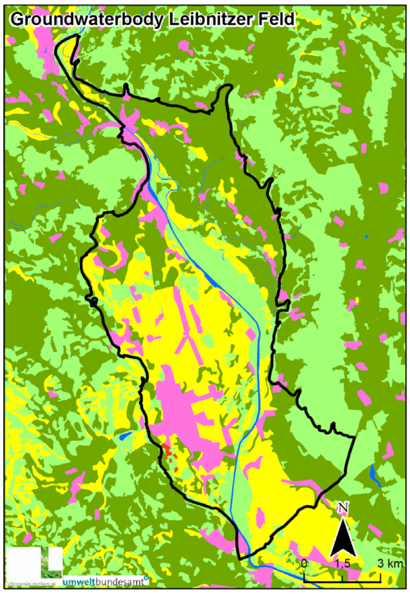
Light blue: wetlands

Blue: surface water

Figure 1: Land use according to CORINE (2000) in the groundwater body Leibnitzer Feld (Data source: Water Quality Monitoring Ordinance, Federal Legal Gazette No. 479/2006 as amended; Federal Ministry of Agriculture, Forestry, Environment and Water Management, Department VII/Unit 1 National Water Management; Offices of the Provincial Governments, Umweltbundesamt GmbH)

Overlying strata

Confining layer and depth to groundwater table: More than 75% of the groundwater body is covered with confining layers, mostly clays of varying thickness. The thickness of the overlying strata varies in dependence of the surface morphology, ranging from less than 2 m in the valley floodplains to more than 8 m on the upper terraces in the northeast. In the west of the Leibnitzer Feld the thickness of the overlying strata varies between 4 and 7 m at mean groundwater levels. The confining layers in the Mur area are characterised by low nitrate retention (see figure 2), as are large parts in the south and southwest of the groundwater body.



LEGEND:

Red: Very low nitrate retention capabilities (i.e. highest risk for groundwater)

Yellow: Low nitrate retention capabilities

Green: Medium to high nitrate retention capabilities

Blue; surface waters

Lime: Forest; partly-forest

Pink: Settlement

Figure 2: Nitrate retention capabilities of the confining layers in the Leibnitzer Feld (Data source: Water Quality Monitoring Ordinance, Federal Legal Gazette No. 479/2006 as amended; Federal Ministry of Agriculture, Forestry, Environment and Water Management, Department VII/Unit 1 National Water Management; Offices of the Provincial Governments – Nitrate retention: Institute for Land and Water Management Research, Petzenkirchen (IKT)).

Characteristics of soils

Table 1: Soil types in the Leibnitzer Feld according to FAO Soil Type Units classification (H2O-Fachdatenbank [H2O database], 2009).

FAO - Soil Type Units	%
Be - Eutric Cambisol	77.6
Je - Eutric Fluvisol	5.8
Wd - Dystric Planosol	9.2
We - Eutric Planosol	7.4

Geological characteristics

Water level of the aquifer: unconfined.

Petrography of the aquifer: The average thickness of the Quaternary gravel terraces (sandy gravel with fractured rock) is 6-10 m. Most of the lower terrace is composed of slightly silty, sandy gravel and fractured rock. The Mur floodplains are also composed of slightly silty and sandy gravel, which is – in contrast to the lower terrace – overlain by an alluvial clay layer with a thickness of 1.5 to 3 m. The thickness of the sediments of the floodplain layer ranges mostly between 4 and 6 m. Small channels, filled with fine sediment, are a common characteristic of the areas near the Mur.

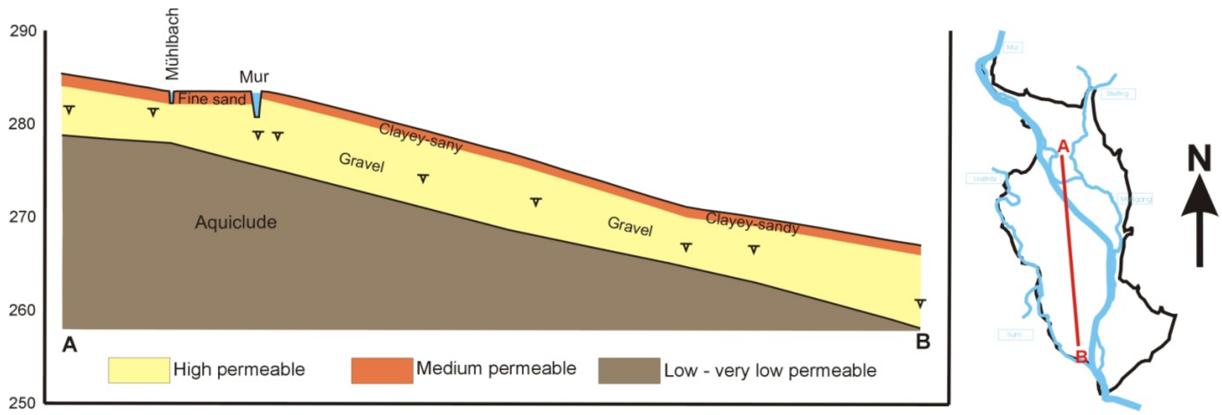


Figure 3: Schematic cross-section through the groundwater body Leibnitzer Feld

Thickness of the groundwater body: At mean groundwater levels, the thickness of the shallow Quaternary groundwater body varies between less than 2 m in boundary areas near bedrock and more than 8 m in small-scale areas near the Mur (see figure 3). A groundwater thickness of more than 4 m is only reached in the northeast of the Leibnitzer Feld and in the west of the Leibnitzer Feld (H20-Fachdatenbank, 2009).

Aquiclude: The configuration of the relief underlying the Quaternary bedrock valley sediments is relatively consistent, and the gradient corresponds more or less to today's course of the river Mur. The flat undulating bedrock relief with zones of consistently shallow and wide depressions shows only a few signs of hollows consistent with the character of deep chutes. The pre-Quaternary underground is mostly composed of silty-sandy rocks or clayey rocks dating from the Neogene. In the northeast of the Leibnitzer Feld Leitha limestone below the Quaternary gravel were detected.

Hydrogeological characteristics

Groundwater flow directions: The northeast part of the Leibnitzer Feld is characterised by groundwater flow in the southeast direction (parallel to the Mur). At the eastern boundary of the Leibnitzer Feld groundwater flowing down from surrounding slopes gains more and more importance. The flow direction in this area is from northeast to southwest, coinciding with the groundwater flow parallel to the Mur river. The flow direction in the western part of the Leibnitzer Becken is, in general, from northwest to southeast. In some of the westernmost parts the Lassnitz and Sulm rivers become the receiving waters for the groundwater.

Hydraulic conductivity – flow velocities: Overall, differences in hydraulic conductivity tend to be small in the groundwater body, ranging mainly between 2E-3 and 7E-3 m/s except in some local zones, with generally higher permeability in the valley floodplains of the Mur and Sulm. The usable porosity of the terraces varies between 6 and 9%, and between 9 and 18% in the floodplains (*H2O-Fachdatenbank*, 2009). Flow velocity ranges between 0.4 and 8.5 m/d.

Groundwater balance: At mean groundwater level, the groundwater flux at the level of the town of Leibnitz (in the southwest) is 125 l/s (Fank, 1998).

Precipitation: Total long-term annual mean precipitation in the Leibnitzer Feld is 902 mm, ranging between 848 and 939 mm. The proportion of winter precipitation is low (*H20-Fachdatenbank*, 2009).

Surface water interaction and recharge

Interaction between surface waters and groundwater: There are strong interactions between different rivers, streams and the groundwater. In many parts of the floodplains, surface waters drain the shallow groundwater. Some surface waters are of vital importance for groundwater recharge in the northeast of the Leibnitzer Feld, with groundwater alimentation strongly depending on the flow conditions in the surface waters. Bank filtrate of the Mur is considerably alimenting groundwater.

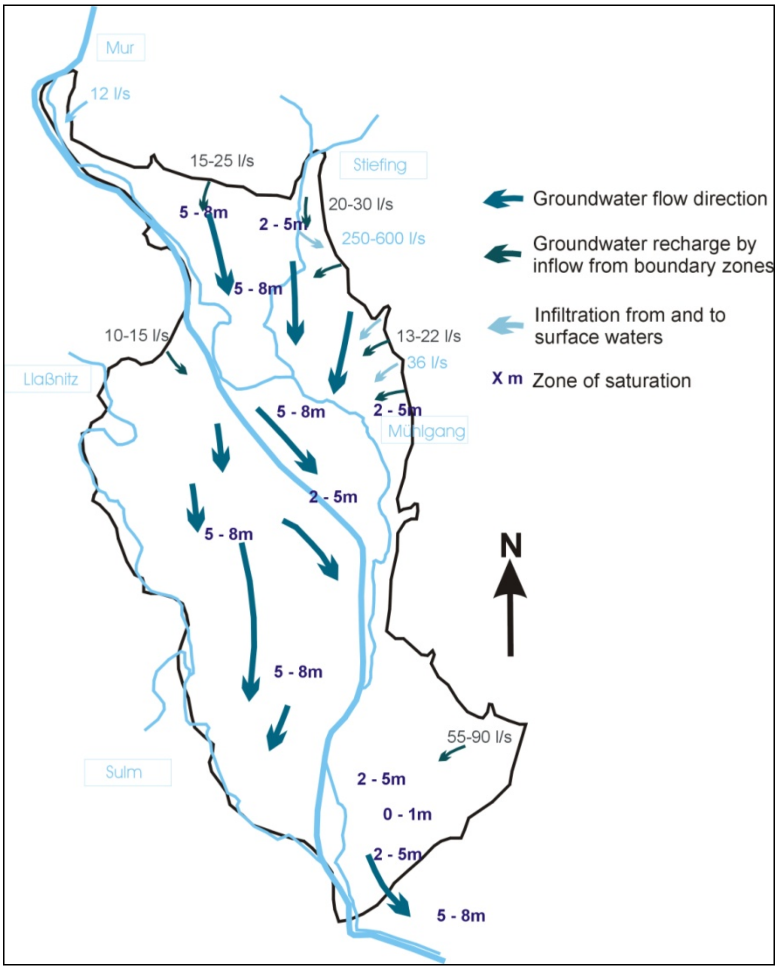


Figure 5: Groundwater body Leibnitzer Feld - Schematic illustration of hydrogeological characteristics, surface water interaction and recharge.

Groundwater recharge: According to the groundwater model “Leibnitzer Feld” (simulation period 1987), recharge from percolating precipitation (340 mm/a, average value for the years 1971-1990) amounts to about 28 million m3 (71%), followed by infiltration from surface waters (18%) and inflow (groundwater) from boundary zones with 4.4 million m3 (11%).

With a total area of 103 km2, an assumed mean groundwater thickness of 4 m and a storage coefficient of about 13%, the groundwater volume is about 54.6 million m3. The average volumetric discharge of flow through groundwater recharge within the Leibnitzer Feld is 10 l/s km2 (*H2O-Fachdatenbank*, 2009).

Groundwater chemistry and anthropogenic impacts

Groundwater chemistry: Geochemistry in the groundwater body is silicate/carbonate dominated (*H2O-Fachdatenbank*, 2009).

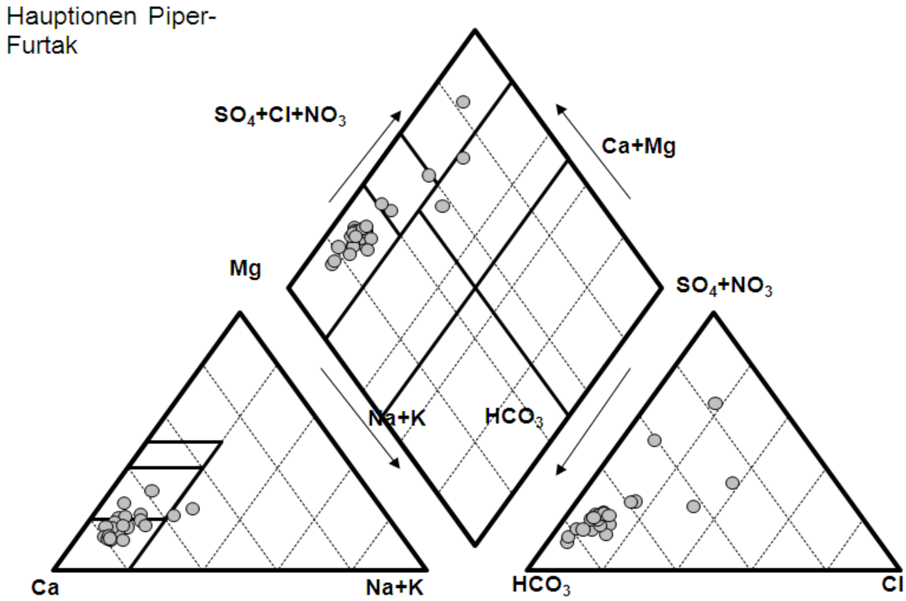


Figure 4: Major ions illustrated in a Piper-Furtak diagram.

Anthropogenic impacts: Anthropogenic impacts on groundwater include water abstraction, constructions, industrial sites and designated contaminated sites, as well as tourism, agriculture and forestry (H2O-*Fachdatenbank*, 2009). Groundwater is used on a large scale for drinking water and also for commercial purposes. Major interference with the former flow regime along the Mur due to power stations is evident.

Due to a number of drinking water and other uses particular efforts to protect groundwater resources are necessary and established.

Literature

Fank J. et al., 1993: Hydrogeology und groundwater model Leibnitzer Feldes (only available in German)

H2O-database, 2009 (H2O-Fachdatenbank, 2009)

B Drinking Water Protection File: an approach for risk assessment on a local scale

Introduction

The Water Framework Directive sets, among others, objectives for water intended for human consumption (Article 7). These objectives hold both preserving the current status of the resource quality as well as an aimed improvement of quality in time, all in relation to the quality standards of the Drinking Water Directive (98/83/EC). The characterization of water bodies therefore holds an assessment of the risk of failing to meet the drinking water objectives. The Netherlands developed an instrument named the Drinking Water Protection File with the aim to carry out such a risk assessment for an abstraction site on a local scale. This instrument was developed two years ago and has since then been tested for several sites. The experiences with the instrument have led to the intention to implement it on a nationwide scale. The results should contribute to the program of measures of the second implementation cycle of the WFD (2015-2021).

Description of a DWPF

In a Drinking Water Protection File (DWPF) all information is collected that is relevant for the water quality at the abstraction site now and in the future. Based on this information measures can be developed that are effective with respect to water quality and costs of measures. The DWPF complements the existing protection policy and offers an instrument to implement Article 7 of the WFD. Decisions upon the measures to be carried out will be taken by the competent authorities, laid down in their plans and consequently summarized in the river basin management plans. In the preparation of a DWPF the relevant stakeholders are involved, such as water managers (provinces and water boards), water companies, and municipalities. The provinces are leading this process. The number of parties involved depends upon the type of abstraction (surface water or groundwater) and the location and size of the catchment area.

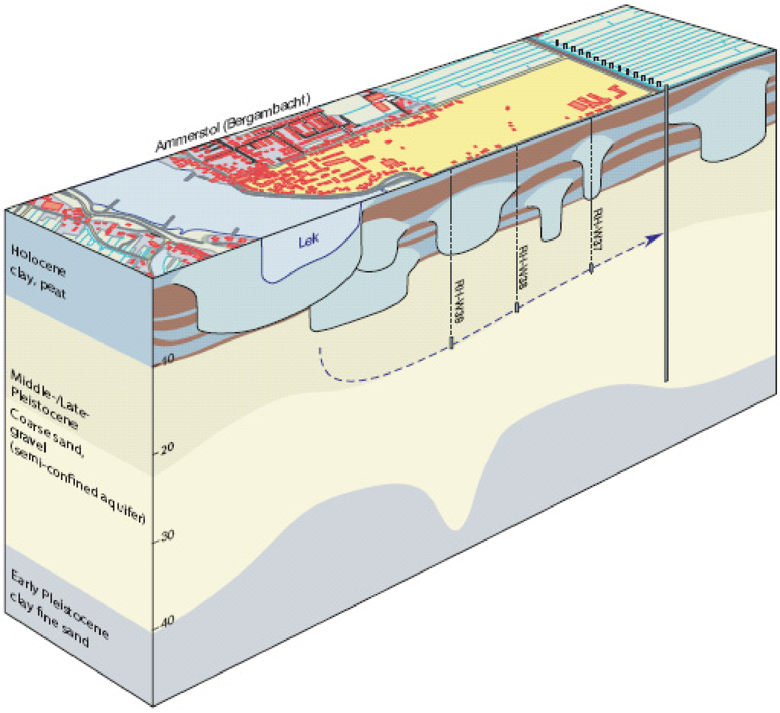
A Drinking Water Protection File holds at least the following elements:

- Information on the abstraction itself and the water system (quality and quantity);
- Information on activities that influence water quality (pressures);
- Identification of relevant substances. What are possible pollution sources?
- Current protection policies and practices. Where are the bottlenecks?
- What are the most (cost) effective measures for dealing with relevant substances?

Example

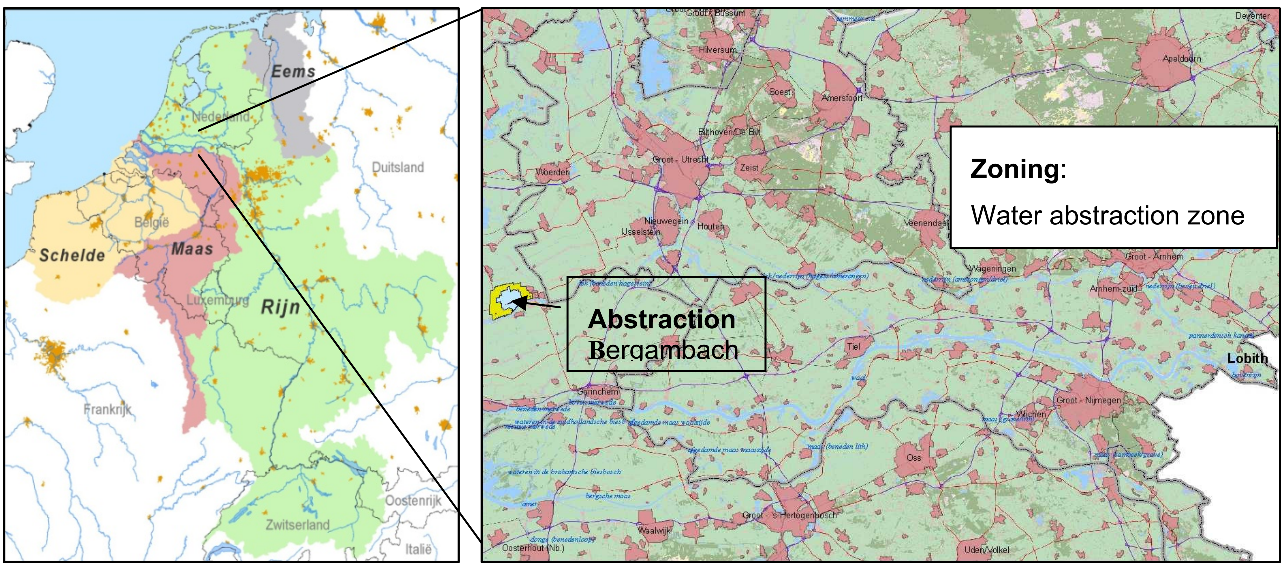
The DWPF-instrument has been tested for several abstraction sites. In this case we present an overview of the DWPF for the Bergambacht abstraction site. The Bergambacht site supplies drinking water to 280,000 consumers in the Netherlands. Surface water from the Lek river (a Rhine branch) infiltrates to the groundwater and is abstracted at 500-1000 m from the river bank. The soil passage ensures attenuation and dilution of substances present in the subsurface water. The quality of the abstracted water is primarily determined by the quality of the infiltrated river water (80-90%) and for the remaining 10-20% by the groundwater quality of the surrounding polder (Bergambacht). For groundwater intended for human consumption no specific standards are in place. In the DWPF the abstracted water is therefore compared to the drinking water standards. This does not mean that groundwater abstracted for human consumption has to comply to the drinking water standards. In the Netherlands all water companies have a facility in place to treat the water up to the drinking water standards.

In the current situation the car fuel additive MTBE, the solvent diglyme and volatile chlorinated hydrocarbons, are found in the abstracted groundwater in concentrations exceeding Dutch standards for drinking water. In order to meet the standards, the water company applies water treatment by activated carbon filtration.



In addition, concentrations of other substances, such as several pharmaceuticals and pesticides, appear to be rising, although not yet exceeding drinking water quality standards. Water quality data from local surface water, the river Lek and the upstream Rhine indicate that the pollutants originate from industrial and sewage effluent, storm water overflow spills and agriculture in both the Netherlands and upstream countries. The DWPF demonstrates that it is important to discuss these substances on a river basin level, but that there are possibilities for improvement within the Rhine Delta as well. Possible measures are more stringent regulation with respect to pesticides, reduction of spills of untreated sewage water, adjustment of effluent discharge permits and high-performance sewage water treatment.

With the in-depth analysis provided by a DWPF, a common understanding is created of the risks at drinking water abstraction sites. From there, actions supported by the relevant parties can be formulated.



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Common Implementation Strategy
for the Water Framework Directive (2000/60/EC)

Guidance Document No. 27

Technical Guidance For Deriving Environmental Quality Standards

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Common Implementation Strategy
for the Water Framework Directive (2000/60/EC)

Guidance Document No. 27

Technical Guidance For Deriving Environmental Quality Standards

FOREWORD

The EU Member States, Norway, and the European Commission in 2000 have jointly developed a common strategy for implementing Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive. In particular, one of the objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

Under the WFD Common Implementation Strategy, an Expert-Group (EG) on Environmental Quality Standards (EQS) was initiated in 2007 to produce guidance on establishment of the EQSs in the field of water policy. This activity was led by UK and the Joint Research Centre and supported by the Working Group E (WG-E). The Working Group E is chaired by the Commission and consists of experts from Member States, EFTA countries, candidate countries and more than 25 European umbrella organisations representing a wide range of interests (industry, agriculture, water, environment, etc.).

The enclosed Technical Guidance has been developed to support the derivation of EQSs for priority substances and for river-basin-specific pollutants that need to be regulated by Member States according to the provisions of the WFD. The Commission intends to use the Technical Guidance to derive the EQSs for newly identified priority substances and to review the EQSs for existing substances.

Article 16 of the Water Framework Directive (WFD, 2000/60/EC) requires the Commission to identify priority substances among those presenting significant risk to or via the aquatic environment, and to set EU Environmental Quality Standards (EQSs) for those substances in water, sediment and/or biota. In 2001 a first list of 33 priority substances was adopted (Decision 2455/2001) and in 2008 the EQSs for those substances were established (Directive 2008/105/EC or EQS Directive, EQSD). The WFD Article 16 requires the Commission to review periodically the list of priority substances. Article 8 of the EQSD requires the Commission to finalise its next review by 2011, accompanying its conclusion, where appropriate, with proposals to identify new priority substances and to set EQSs for them in water, sediment and/or biota.

The Scientific Committee on Health and Environmental Risks (SCHER) adopted its opinion on Technical Guidance for Deriving Environmental Quality Standards in October 2010[1]. The Water Directors endorsed the Guidance during their informal meeting under the Hungarian Presidency in Budapest (26-27 May 2011).

This Guidance Document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. The Water Directors agreed to make publicly available the Guidance in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

The Water Directors would like to thank the leaders of the activity and the members of the Working Group E for preparing this high quality document. The Water Directors also commit themselves to assess and decide upon the necessity for reviewing this document in the light of scientific and technical progress and experiences gained in implementing the Water Framework Directive and Environmental Quality Standards Directive.

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1 http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_127.pdf

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1 Environmental Quality Standards (EQSs) under the Water Framework Directive

Article 16 of the Water Framework Directive (WFD) (EC 2000) sets out the strategy against chemical pollution of surface waterbodies. The chemical status assessment is used alongside the ecological status assessment to determine the overall quality of a waterbody. Environmental Quality Standards (EQSs) are tools used for assessing the chemical status of waterbodies. The EQS Directive (EC 2008a) establishes the maximum acceptable concentration and/or annual average concentration for 33 priority substances and 8 other pollutants which, if met, allows the chemical status of the waterbody to be described as 'good'.

EQSs for the 33 substances identified by the EU as Priority Substances (PSs) and Priority Hazardous Substances (PHSs) are derived at a European level and apply to all Member States. They are also referred to as Annex X substances of the WFD.

In addition, the WFD (Annex V, section 1.2.6) establishes the principles to be applied by the Member States to develop EQSs for Specific Pollutants that are 'discharged in significant quantities'. These are also known as Annex VIII substances of WFD. Compliance with EQSs for Specific Pollutants forms part of the assessment of ecological status (Figure 1-1). EQSs are therefore key tools in assessing and classifying chemical status and can therefore affect the overall classification of a waterbody under the WFD (Figure 1.1). In addition, EQSs will be used to set discharge permits to waterbodies, so that chemical emissions do not lead to EQS exceedance within the receiving water.

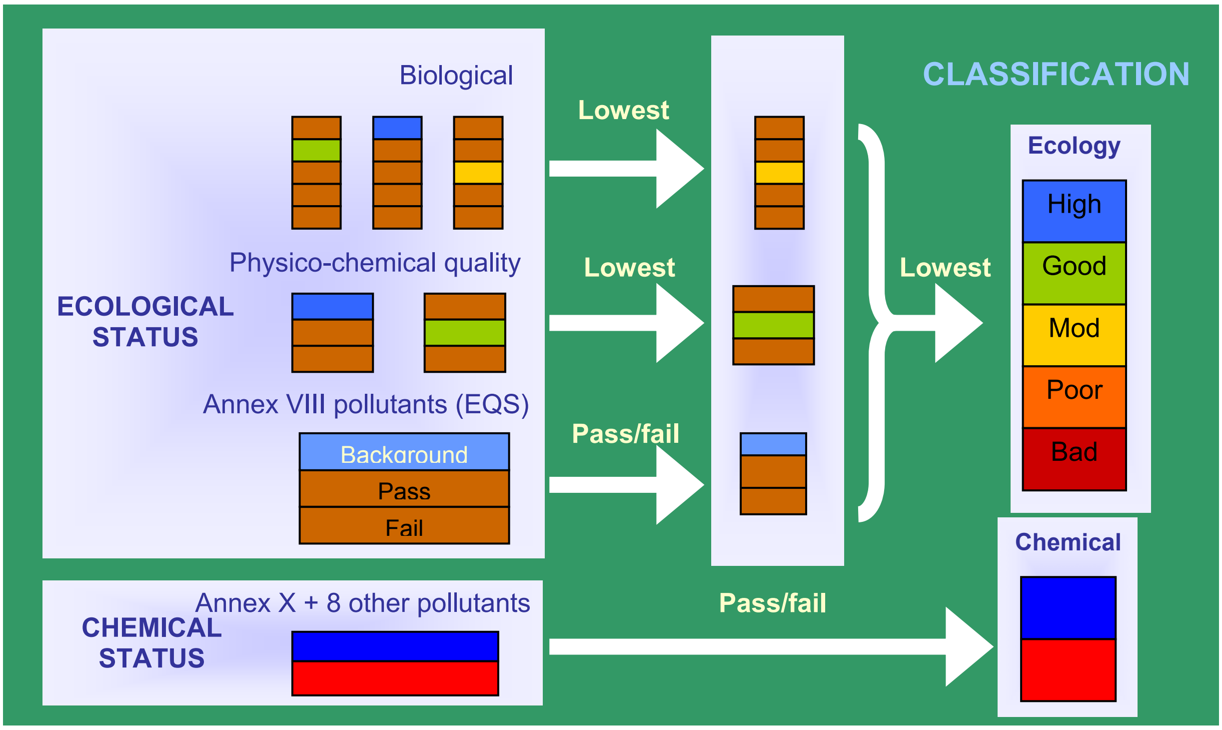


Figure 1.1 Role of EQSs in waterbody classification

Whilst establishing the principles of EQS derivation, Annex V, Section 1.2.6 of the Water Framework Directive does not provide the necessary detail for practitioners to develop EQSs in a consistent manner, or cover all the scientific issues that may be encountered.

In 2005, a technical guidance document was prepared (Lepper, 2005) for the purpose of EQS derivation. This covered many of the key technical issues involved in deriving EQSs however the science has since moved on requiring the need for an update of the guidance.

The risk assessment paradigm on which the technical guidance for EQS derivation is based (ECHA, 2008) relies on worst-case assumptions. Whilst this is entirely legitimate within a tiered assessment framework, to ensure environmental protection, when this paradigm is applied to EQS derivation it can lead to unworkable and/or unrealistically low EQS values (CSTEE[2], 2004; Lepper 2005). One of the factors leading to unmanageable water column standards is the very low concentrations that arise for some substances with low water solubility, or a tendency to bioaccumulate through the food web. If these substances pose a significant risk through indirect toxicity (i.e. secondary poisoning resulting from food chain transfer), and their analysis is more feasible in other environmental matrices, such as biota and/or sediments, then a biota standard or sediment standard may be required alongside, or instead of, the water column EQS, as referred to in the EQS Directive 2008/105/EC (Art 3, para 2). For this reason, guidance on the derivation of biota and sediment EQSs is required. There is also a need for further guidance on setting EQSs for metals in ways that allow speciation and bioavailability to be accounted for. Furthermore, we are now in a position to refine the guidance for the derivation of water column standards in the light of technical advances and experience of EQS setting gained in recent years. These issues are amongst those covered in this new guidance.

1.2 Scope of the guidance

This guidance document addresses the derivation of environmental quality standards for water, sediment and biota. It addresses the need for further guidance highlighted above and responds to comments made by the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE, 2004) and by the Scientific Committee on Health and Environmental Risks (SCHER) in 2010. It also takes account of the principles highlighted in a SETAC (Society for Environmental Toxicology and Chemistry) workshop on environmental standards that took place in 2006 (SETAC, 2009) so that the latest scientific thinking on setting and implementing environmental standards is reflected.

This guidance applies to the derivation of EQSs for PSs, PHSs and Specific Pollutants. The guidance focuses on the steps required to derive EQSs that comply with the requirements of Annex V of the WFD. It assumes that the chemicals for which EQSs are required have been identified, i.e. the guidance does not cover chemical prioritisation. However, it does address some aspects of the way an EQS is implemented, where this has a direct bearing on the way an EQS is derived and expressed, e.g. assessing compliance with an EQS. The guidance does not cover issues relating to sampling and chemical analysis: these are covered by separate guidance on monitoring (EC, 2010).

The quantity of data available for deriving an EQS can vary. Where an EQS can be derived on the basis of a large dataset there may be only small uncertainties in the final outcome. If, however, only a very small dataset is available, the residual uncertainties can be large. Uncertainty is accounted for by the use of assessment factors (AFs) but, clearly, there is a considerable difference in the robustness and reliability of such EQSs compared to those

[2] Scientific Committee on Toxicity, Ecotoxicity and the Environment

based on extensive data sets, and it may even be inadvisable to implement such EQSs**.** This technical guidance does not recommend when uncertainties are so large that an EQS should not be implemented, or used in only an advisory capacity. That decision is for policymakers but this could come under review as we gain more experience in setting and using environmental standards for the WFD. However, **the scientist has an important role in advising the policymaker about the major uncertainties and key assumptions involved in deriving an EQS. This is particularly important for EQSs which are to be applied across Europe (e.g. for Priority Substances or Priority Hazardous Substances)**. It is also important to highlight to the policymaker the practical steps which might be taken to reduce uncertainty (e.g. generation of additional ecotoxicity data) and the benefits these would have e.g. reducing the size of AFs. The scientist should also advise policymakers when uncertainties are small and the resulting EQS is correspondingly robust. With this in mind, a proforma technical report is appended (Appendix 2) to prompt the assessor for the information that should be reported, including advice to policymakers.

A further point to add is that confidence about regulatory decisions involving EQSs can also be affected by the way in which an EQS is implemented, eg how compliance is assessed. Although detailed monitoring guidance lies outside the scope of this guidance, it is useful to consider implementation issues during EQS setting. Although the final decision about EQS values should reflect the scientific risk, those responsible for EQS derivation are encouraged to discuss implications for water management practices with policy makers and those responsible for implementing an EQS. These might include, for instance, implications for permitting and emission controls, sampling (e.g. whole water vs filtered samples), statistical aspects of compliance assessment, availability of suitable analytical methods, the impact of residual uncertainty in the EQS and a threshold for the relevance of a specific pollutant for which an EQS is needed (e.g. exceedance of 50% of the EQS).

This guidance is intended for use by environmental scientists with an understanding of the principles of risk assessment. A detailed appreciation of the principles and practice of environmental chemistry and ecotoxicology is also recommended. Much of this guidance will be familiar to those used to dealing with effects assessments under REACH (Registration, Evaluation and Authorisation of Chemicals) (Regulation (EC) 1907/2006).

1.3 Links to chemical risk assessment

It is important to highlight some conceptual differences between EQS derivation and the estimation of a PNEC (Predicted No Effect Concentration) from chemical risk assessment or TER (Toxicity Exposure Ratio) for a pesticide. For example:

- the concept of an overall threshold (Sections 2.3 and 2.4) that protects all receptors and routes is a feature of EQS derivation that does not normally apply in chemical risk assessment

- whereas there are opportunities to refine a risk assessment in the light of new data, this is often not the case in EQS derivation; although additional data may sometimes be voluntarily provided, we cannot usually demand the commissioning of new studies so have to utilise what is available to us

- an exceedance of the EQS will not normally trigger a refinement of the standard

- an underlying requirement of the WFD is to protect the most sensitive waters in Europe. For metal EQSs, where bioavailability is to be accounted for (Section 2.10) there is therefore a requirement to protect a higher proportion of waterbodies than for PNECs estimated as part of a risk assessment

- in EQS derivation, field and mesocosm data have an important role as lines of evidence in helping define the standard (through helping reduce uncertainty) but would not be regarded as 'higher tier' data that would replace laboratory-based ecotoxicity data as done in the assessment of the impact of pesticides.

A PNEC derived as part of a risk assessment will provide a key step in the derivation of an EQS and, in some cases, the PNEC from a risk assessment will be identical to the EQS. However, for the reasons outlined above, it will not be sufficient to simply adopt the PNEC as the EQS as a matter of course. Nevertheless, the process of deriving environmental standards is similar to that used in the effects (i.e. hazard) assessment that is required for a risk assessment for chemicals. For the purposes of the WFD, short and long-term effects are of concern, though greater emphasis is placed on risks from long-term or continuous exposure. Authoritative guidance on effects assessment for chemicals has been developed, notably the technical guidance developed for industrial chemicals (now under REACH (ECHA, 2008)) and pesticides under Directive 91/414/EEC. Annex V of the WFD refers directly to the methodology described for the Existing Substances Regulation (ESR) (now under REACH). Furthermore, the guidance for undertaking risk assessment of pesticides allows for short term impacts and recovery. As far as possible, the technical guidance for EQSs described here is consistent with the guidance for effects assessments performed for chemical risk assessment under REACH.

1.4 Structure of guidance

Generic issues and principles that apply to the derivation of EQSs across all media and receptors are outlined in Section 2. The guidance is separated into sections dealing with different environmental media, ie derivation of EQSs for the water column are considered in Section 3, those for biota in Section 4 and those for sediment in Section 5. Risks from metals pose particular challenges and the guidance reflects the latest scientific developments for taking account of speciation and bioavailability in deriving thresholds and assessing compliance with these EQSs. Detailed guidance for deriving EQSs for metals in water, biota and sediment is given in the respective Sections. Recognising the growing importance of computational and non-testing methods in the estimation of environmental hazard, guidance on the use of such methods when deriving EQSs is given in Section 6. Finally, Section 7 outlines how to estimate EQSs for mixtures.

At various points in the guidance, we refer to Appendices and scientific background documents to accompany the guidance. These are intended to provide more detailed explanations for the technical advice given here.

2. GENERIC ISSUES

2.1 Use of EQSs in waterbody classification

The WFD establishes a framework for protection of all surface waters and groundwaters, with an obligation to prevent any deterioration of status, and to achieve good status, as a rule by 2015. The overall good status is reached for a certain waterbody if both ecological and chemical status are classified as good.

EQSs established at EU level by the EQS Directive (2008/105/EC) for the 33 priority substances and 8 other pollutants are used within the WFD to assess the chemical status of a waterbody. Good chemical status is achieved where a surface waterbody complies with all the environmental quality standards listed in Part A of Annex I of EQS Directive and applied according with the requirements set in Part B of Annex I of the same directive. If not, the waterbody shall be recorded as failing to achieve good chemical status.

For Annex VIII substances (Specific Pollutants), each Member State shall establish their EQSs according to Annex V, Section 1.2.6 of WFD. Specific Pollutants are supporting parameters for biological quality elements, thus they contribute among other parameters to the ecological status classification. If the EQSs for these substances are not met, the waterbody can not be classified as either 'Good' or 'High'status, even if the biological quality is 'Good' or 'High' (Figure 1.1).

2.2 Overview of the steps involved in deriving an EQS

Figure 2.1 illustrates the key steps that are involved in deriving an EQS, irrespective of the compartment or receptor at risk. The key steps are broadly consistent across all media/receptors. However, the detail within each step can differ markedly between compartments and receptors.

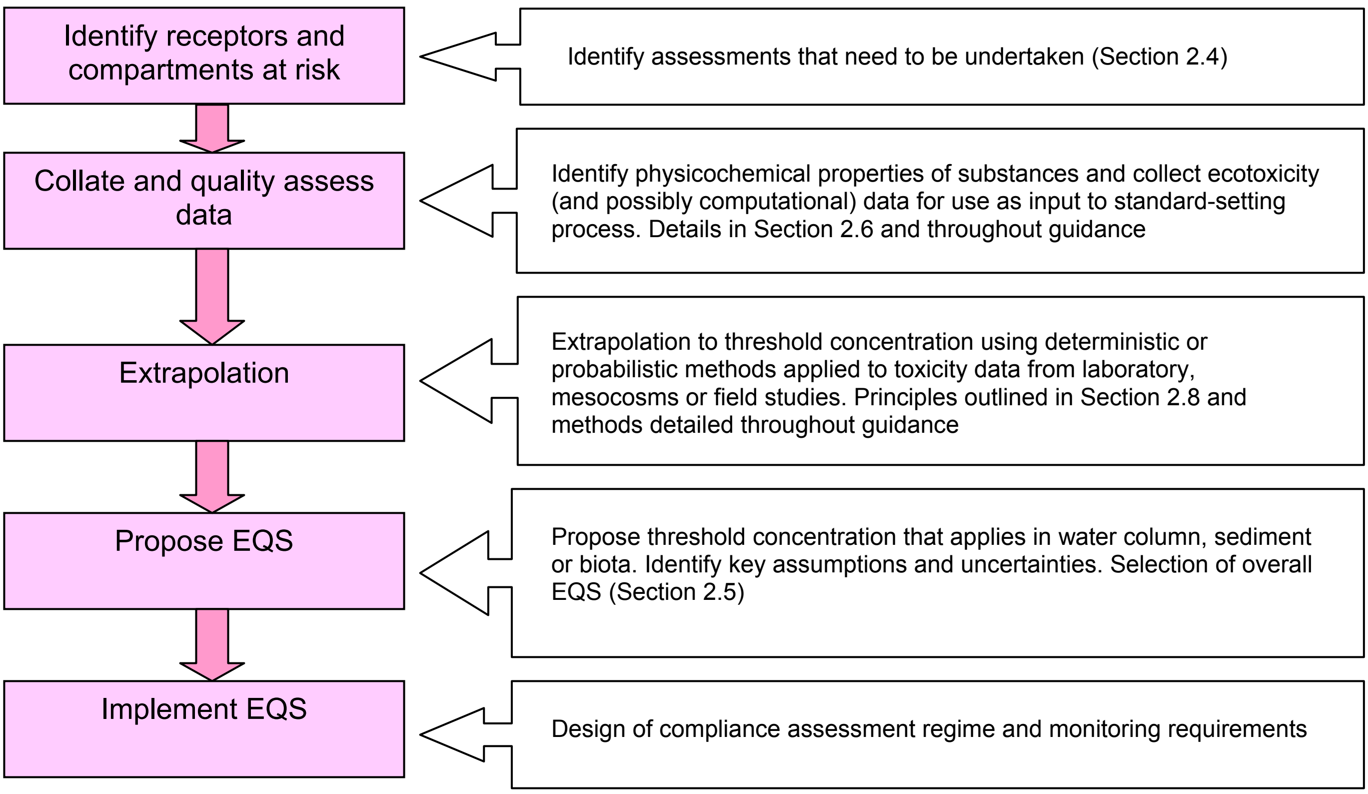


Figure 2.1 Key steps involved in deriving an EQS

2.3 Receptors and compartments at risk

EQSs should protect freshwater and marine ecosystems from possible adverse effects of chemicals as well as human health via drinking water or ingestion of food originating from aquatic environments. Several different types of receptor therefore need to be considered, i.e. the pelagic and benthic communities in freshwater, brackish or saltwater ecosystems, the top predators of these ecosystems and human health.

The receptors and media of concern to EQS setting covered in this guidance are illustrated in Figure 2.2.

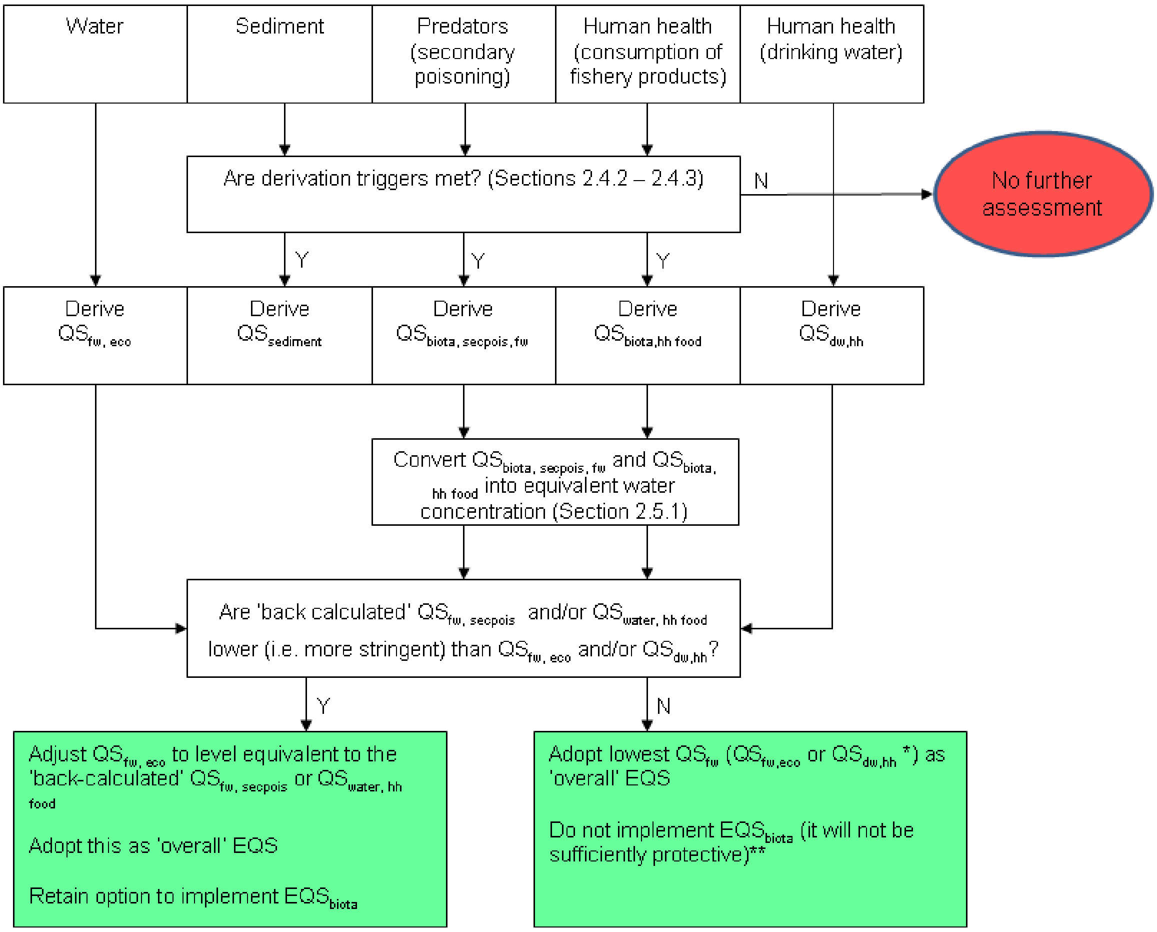
		Environmental compartment		
		Water	**Sediment**	**Biota**
Receptor(s) at risk	**Humans**	**Yes**	**No**	**Yes (consumption of fish products)**
	Sediment dwelling biota	**No**	**Yes**	**No**
	Pelagic biota	**Yes**	**No**	**Yes (secondary poisoning)**
	Top predators (birds, mammals)	**Yes**	**No**	**Yes (secondary poisoning)**

Figure 2.2 Receptors for which an assessment may be required

Yes = potential risks to receptor need to be considered in EQS derivation
No = risks do not need to be addressed in EQS derivation

Not all receptors need to be considered for every substance. This depends on the environmental fate and behaviour of the substance i.e. if a substance does not bioaccumulate (or doesn't have high intrinsic toxicity), there is no risk of secondary poisoning and so a biota standard is not required. However, where a possible risk is identified, quality standards should be derived for that receptor (Figure 2.3). Criteria to help identify which of the assessments are needed for a particular substance are given in Section 2.4. Where several assessments are performed, the lowest (most stringent) of the thresholds will be selected as an 'overall' EQS as illustrated in Figure 2.3 and detailed in Section 2.5.

In this way, all relevant protection objectives should be taken into account. Moreover, all direct and indirect exposure routes in aquatic systems i.e. exposure in the waterbody via water and sediment or via bioaccumulation, as well as possible exposure via drinking water uptake, are accounted for. Figure 2.3 presents the routes taken into account for the freshwater compartment, similar routes are considered for the saltwater compartment, but indicated with different subscripts (fw is replaced by sw in the figure below) See appendix 6 for clarification of the temporary standards used during EQS derivation.



* $QS_{dw,hh}$ can only be adopted as the lowest QS_{water} for waters intended for drinking water use

** unless monitoring in biota is strongly preferred. Under these circumstances, calculate QS_{biota} that is equivalent to lowest (i.e. most protective) QS_{water} and select this value as EQS_{biota}

Figure 2.3 Overview of assessments needed and selection of an 'overall' EQS

The mode of toxic action for a chemical is not always known but, when carrying out an assessment, all relevant modes of toxicity need to be considered. No plausible toxicological hazard should be excluded from consideration. Stressors for which an EQS could be derived, but do not act by chemical toxicity (e.g. temperature, pH) may require a different approach than that described here. Such physical stressors lie outside the scope of this guidance.

2.4 Identifying the assessments to be performed (receptors at risk)

According to Article 3 of the EQS Directive, quality standards shall apply to contaminant concentrations in water, sediments and/or biota. As illustrated in Figure 2-3, **an assessment for several compartments is needed when a substance could pose a risk through direct toxicity in the water column, to predators through the food chain, or to benthic (sediment-dwelling) biota.** On the other hand, **a QS is not required if a substance will not pose a risk to a particular compartment**. For instance, a quality standard for sediment is not necessary if the substance is unlikely to partition to, or accumulate in, sediment. Similarly, quality standards for biota are not required if a substance does not bioaccumulate (or doesn't have high intrinsic toxicity), in which case it is reasonable to conclude that there is no risk of secondary poisoning of top predators, or to human health from consumption of fishery products.

The criteria for identifying which assessments are required are outlined below.

2.4.1 Water column

An assessment to protect pelagic (i.e. water column) organisms from direct toxicity to chemicals is always undertaken. A drinking water threshold is also required for waters used for drinking water abstraction. For these waters, existing health-based standards from either the Drinking Water Directive 98/83/EC or World Health Organization (WHO) could be used, if available, as the basis for the QS derivation, as described in Section 3.9. If no existing standards are available, an assessment of risks to human health from drinking water will be required. However, a QS to protect waterbodies designated for drinking water abstraction is required only when it is lower (i.e. more stringent) than the water column QS to protect aquatic life. A derivation is not required if existing drinking water standards are less stringent (i.e. higher) than the water column QS to protect aquatic life.

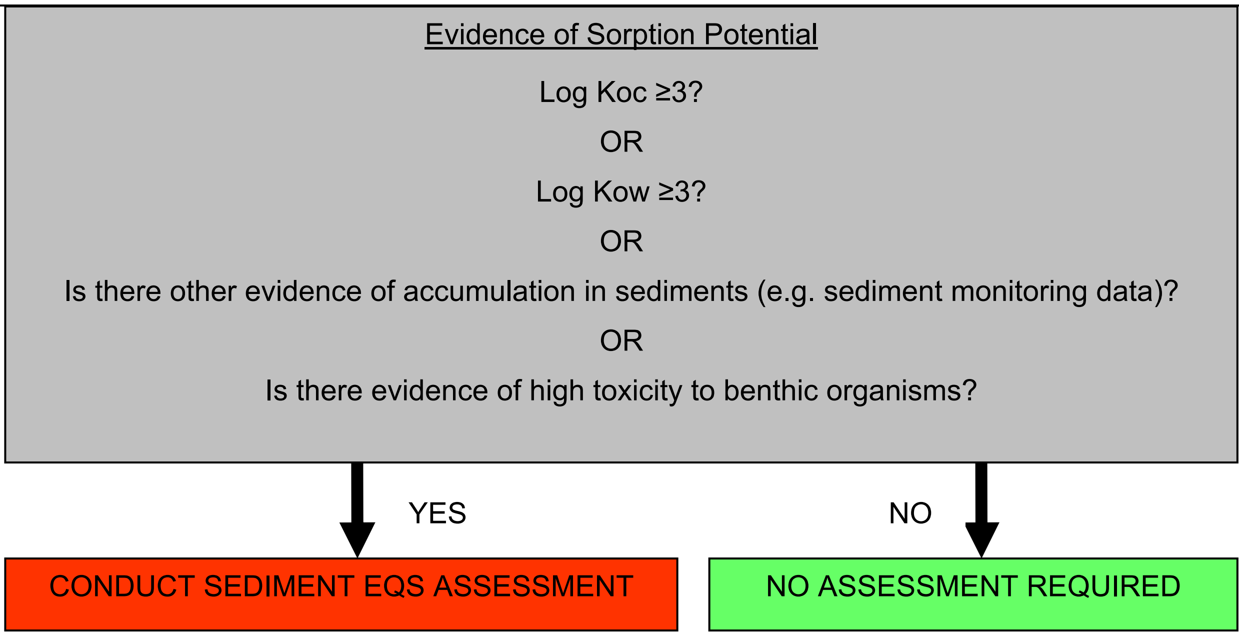
In the derivation of QSs to protect human health two major exposure routes are considered (consumption of fishery products and consumption of drinking water). There may be other routes of exposure, such as exposure during recreation (dermal exposure, ingestion of water). These routes are of minor importance compared to the other routes considered (see for example Albering *et al*, 1999) and are therefore not considered in this guidance.

2.4.1.1 EQSs for transitional waters

Separate EQSs are recommended for freshwaters and saltwaters. However, transitional (e.g. estuarine) waters are intermediate in salinity which can vary on a diurnal cycle. For waters with a low salinity, supporting communities that are closely related to freshwater ecosystems, the freshwater scheme is more appropriate. At salinity levels between 3 and 5‰ there is a minimum number of species present and this can be considered as a switch from communities that are dominated by freshwater species to communities that are dominated by saltwater species. Therefore, EQSs in this document are not reported for 'transitional ánd marine waters', but either for freshwaters or saltwaters. As a default, we recommend a salinity of 5‰ as the cutoff unless other evidence suggests a different cutoff is appropriate for a particular location. For instance, Bothnian Sea (inner BalticSea) is a brackish water body that has a salinity of around 5‰, and has, so far, been treated as a saltwater system.

2.4.2 Sediments

Not all substances require an assessment for a sediment standard. The criteria for triggering an assessment are consistent with those under REACH Regulation (EC) No 1907/2006 (ECHA, 2008, Chapter R.7b). In general, substances with an organic carbon adsorption coefficient (K_{oc}) of <500–1000 $l \cdot kg^{-1}$ are not likely to be sorbed to sediment. Consequently, a log K_{oc} or log K_{ow} of ≥3 is used as a trigger value for sediment effects assessment. Some substances can occur in sediments even though they do not meet these criteria so, in addition, evidence of high toxicity to aquatic organisms or sediment-dwelling organisms or evidence of accumulation in sediments from monitoring, would also trigger derivation of a sediment EQS.



2.4.3 Biota

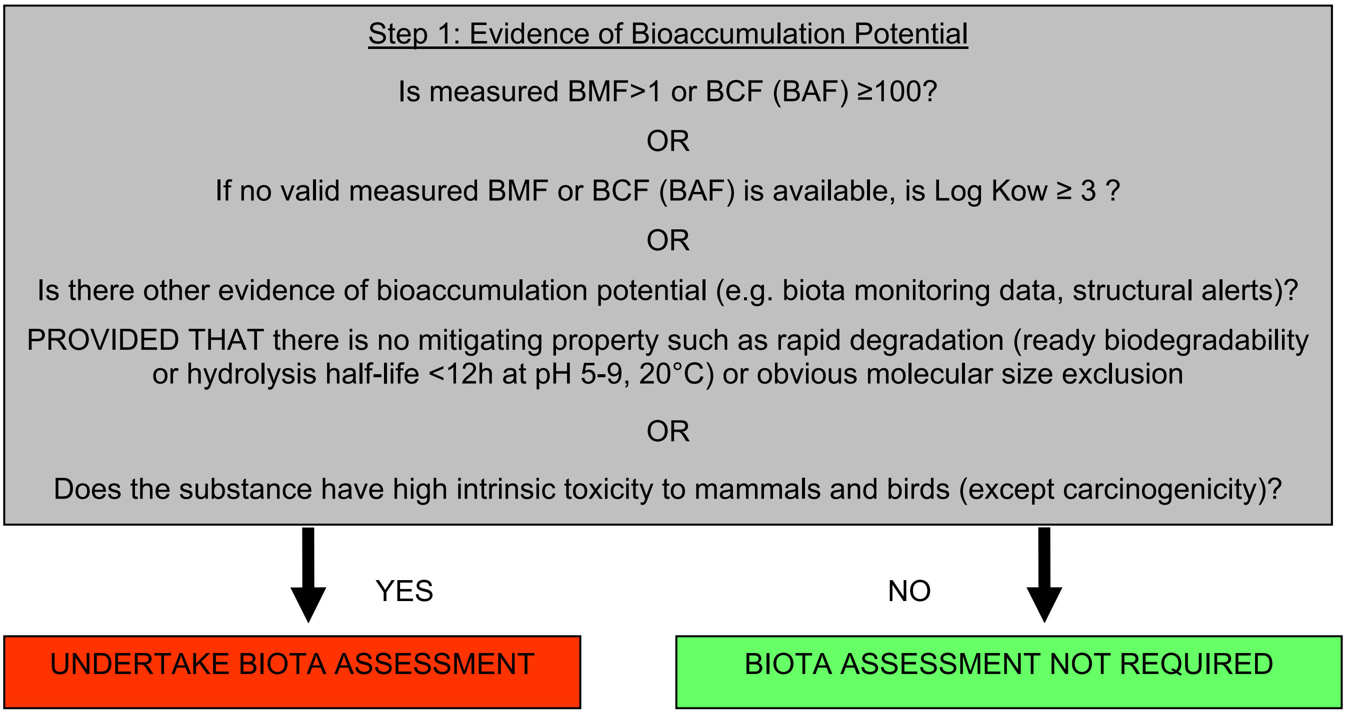
The criteria determining whether or not a biota standard is needed are more complex. A standard would be required if there was a risk of secondary poisoning of predators (e.g. mammals or birds) from eating contaminated prey ($QS_{biota,secpois}$), or a risk to humans from eating fishery products ($QS_{biota,\ hh\ food}$).

The triggers are based on those used to determine whether a secondary poisoning assessment is necessary for a substance under REACH Regulation (EC) No 1907/2006 (ECHA, 2008)[3]. The triggers for derivation of a $QS_{biota,\ hh\ food}$ are dominated by hazard properties whereas a $QS_{biota\ sec\ pois}$ is triggered by the possibility of accumulation in the food chain in conjunction with hazard properties. There are differences between how metals and organic substances are dealt with, and these are highlighted below.

[3] The criteria used to determine whether a substance is Persistent, Bioaccumulative and Toxic (PBT) or very Persistent and very Bioaccumulative (vPvB) under Annex XIII of REACH are more stringent and not suitable for use as a screening decision tree since a substance meeting the PBT/vPvB criteria would require stricter management control than standard setting.

2.4.3.1 *Protection of predators from secondary poisoning*

(1) Organic substances



The assessor should determine whether the substance has the potential to accumulate through food chains and thus expose top predators via their diet. The biomagnification factor (BMF) is the ratio of the concentration of a substance in an organism compared to the concentration in food (prey) items. The bioconcentration factor (BCF) is the ratio of the concentration of a substance in an organism to the concentration in water. A BMF greater than 1 or, in the absence of this information, a BCF greater than or equal to 100 is used as an indication of the potential for bioaccumulation. **When both BMF and BCF data are available, the most reliable should be used, not necessarily the worst case (highest) value**. Usually this will be the BCF data, except for metals, where BCF data can be influenced by the water concentration used in the study (See Section 2.4.3.1 (2)).

If neither BMF or BCF data are available, the octanol–water partition coefficient (K_{ow}), can be used as a surrogate for bioaccumulation potential. A log K_{ow} of ≥3 would be expected to capture substances with a BCF of ≥100. Other evidence of bioaccumulation potential should also be taken into account where available, such as structural features of the molecule or monitoring data from top predators. In addition, factors mitigating bioaccumulation potential should be considered. These include rapid degradation and molecular size. Rapid degradation may lead to relatively low concentrations of a substance in the aquatic environment and thus low concentrations in aquatic organisms. Information on molecular size can be an indicator of limited bioaccumulation potential of a substance as very bulky molecules will pass less easily through cell membranes. Further guidance on molecular size and its impact on bioaccumulation potential is available in the REACH guidance (ECHA, 2008).

(2) Metals

Biomagnification of metals in aquatic organisms is rarely observed and, if it does occur, it usually involves the organo-metallic forms of metals (e.g. methyl mercury) (Brix *et al*., 2000). However, the assessor should examine their potential to biomagnify or cause secondary poisoning in food chains, even for inorganic metal forms. It is especially important to look for evidence of organo-metallic species being formed in some compartments, or if the range over which homeostasis occurs is relatively small (e.g. selenium). Therefore, a useful first step is to review the information available for the metal in question in order to assess whether an in-depth secondary poisoning assessment is needed.

A lack of biomagnification should not be interpreted as lack of exposure or no concern for trophic transfer. Even in the absence of biomagnification, aquatic organisms can bioaccumulate relatively large amounts of metals and this can become a significant source of dietary metal to their predators (U.S. EPA 2007; Reinfelder *et al*. 1998).

For metals, a BCF should not be used. This is because the model of hydrophobic partitioning, giving a more or less constant ratio C_{biota}/C_{water} with varying external concentration, does not apply to metals. For a number of metals an inverse relationship between BCF and external (water-) concentration is observed (McGeer *et al*., 2003). Consequently, BCFs and BAFs are not constant with water concentration. Furthermore, some metals are essential for life and many organisms possess mechanisms for regulating internal concentrations, especially essential metals such as copper and zinc.

Instead, a case-by-case evaluation of the possibility of dietary toxicity is required:

- Information on metal mode of action and homeostatic (internal regulation) controls
- Information on essentiality
- Information on biomagnification (BMF). An example of a study relevant in addressing this question is Ikemoto et al (2008a)
- Information on major toxicities i.e. whether main risks are through direct toxicity to pelagic organisms or secondary poisoning. With regards to the potential for secondary poisoning the assessment of the mode of toxic action in both prey and predator is a key consideration. If there is no evidence of biomagnification (i.e. BMF<1) and no specific toxicity in birds and mammals compared to fish (on a dose based approach), the QSwater, eco should be protective for birds and mammals as well as pelagic organisms.

If the balance of evidence points to a risk of secondary poisoning then an assessment is required.

2.4.3.2 Protection of humans from consuming fishery products

For humans, the derivation of a biota standard is triggered solely on the basis of the hazardous properties of the chemical of interest. The available mammalian and bird toxicity data is used to give an indication of possible risks to top wildlife predators as well as humans since there is usually standard mammalian toxicity data available for well-studied chemicals. Effects on reproduction, fertility and development are of particular concern since these are long-term effects which could impact on populations of organisms.

Specific triggers[4] are as follows:

- a known or suspected carcinogen (Cat. I-II, R-phrases R45 or R40) or
- a known or suspected mutagen (Cat. I-II, R-phrases R46 or R40) or

[4] In accordance with Directive 67/548/EEC.

- a substance known or suspected to affect reproduction (Cat. I-III, R-phrases R60, R61, R62, R63 or R64) or

- possible risk of irreversible effects (R68) or

- the potential to bioaccumulate (see protection of top predators) plus danger of serious damage to health by prolonged exposure (R48) or harmful/toxic/fatal when swallowed (R22/R25/R28).

Note that applicability of these toxicological triggers should follow from R or H phrases, but information obtained from evaluation of toxicological data not necessarily reflected in classification and labelling phrases should not be neglected. It may warrant derivation of a risk limit for human health based on the consumption of fishery products.

The H-statements will soon replace the R-phrases in EU chemicals legislation via the Classification, Labelling and Packaging Regulation (2008) (EC, 2008). The conversion between H and R phrases is provided below. Check the status of the R and H phrases. For those substances where R or H phrases have not been harmonised at the EU-level, consultation with (a) human toxicological expert(s) is needed.

R22 H302: Harmful if swallowed

R25 H301: Toxic if swallowed

R28 H300: Fatal if swallowed

R40 H351: Suspected of causing cancer

R45 H350: May cause cancer

R46 H340: May cause genetic effects

R48 H373: May cause damage to organs through prolonged or repeated exposure

R60 H360: May damage fertility or the unborn child

R61 H360: May damage fertility or the unborn child

R62 H361: Suspected of damaging fertility or the unborn child

R63 H361: Suspected of damaging fertility or the unborn child

R64 H362: May cause harm to breast-fed children

R68 H341: Suspected of causing genetic effects

2.5 Selecting an overall standard

Standards for water, sediment and biota are derived independently and they should all be made available for possible implementation. Where several assessments are performed for the same compartment (e.g. water: protection of pelagic species, protection of human health from drinking water; biota: protection of biota from secondary poisoning, protection of human health from consuming fisheries products), **the lowest standard calculated for the different objectives of protection will normally be adopted as the overall quality standard for that compartment**. An exception will be when the drinking water route results in the lowest (most stringent) QS but a waterbody is not designated as a source of drinking water. It is not sufficient to simply report the 'overall' EQS; the assessor must make available all the relevant QSs and their derivations. Standards for freshwater and saltwaters will be derived independently so the overall $EQS_{saltwater}$ may be different to the overall $EQS_{freshwater}$.

To select an overall EQS, quality standards will need to be expressed in the same units (i.e. mass/volume). This means that biota standards must be 'back-calculated' to the corresponding water concentration. This is referred to in Figure 2-3 and further guidance is given in Section 2.5.1. Finally, sediment QSs are dealt with independently of water column and biota standards. This leads to selection of a separate, overall $EQS_{sediment}$.

2.5.1 Converting biota standards into an equivalent water concentration

Procedures for converting biota standards into water column concentrations are given in Section 4.7.2. It should be noted that the conversion from a biota standard into an equivalent water concentration can introduce uncertainty, especially for (a) highly lipophilic substances and (b) metals.

(a) Where it is necessary to convert a biota QS into an equivalent water column concentration for a highly lipophilic substance, the uncertainties may be taken into account by performing the conversion for extreme BAF values as well as the typical BAF value. If the QS for water lies within the range of possible extrapolated values of the QS for biota, when considering the uncertainties of the extrapolation, it is not possible to determine with high confidence which is the 'critical' QS. These should be reported as key uncertainties, outlining the implications for implementing an EQS.

As explained in Section 2.4.3.1, BCF data for metals may be unreliable. Instead, BAF or BMF data are preferable. To compare a biota standard with water column standards, refer to Section 4.7.1.2.

(b) For an organic substance, if the log $K_{OW} \geq 3$ criterion is met, but no experimental evidence is available on BCF or BMF then the assessor should estimate BCF or BMF from log K_{OW} and translate the biota standard to a water concentration for comparison with water column standards (Section 4.7.1.2). If the estimated QS for biota is the most stringent (i.e. lowest) value, then further investigation to improve BCF and BMF values would be necessary, otherwise there is a risk of developing an unrealistically low QS value for water.

2.6 Data – acquiring, evaluating and selecting data

Comprehensive and quality assessed data are key inputs to QS derivation. Indeed most of the resource required for QS derivation is expended on collecting and assessing data. Appendix 1 provides detailed guidance on how to locate relevant data, evaluate the data to assess their suitability for QS derivation, and select data that will be used to determine a QS.

A brief summary of the main types of data required for deriving QSs is provided below (Section 2.6.1), along with details of the quality assessment of data (Section 2.6.2), and the identification of 'critical' and 'supporting' data (Section 2.6.3).

2.6.1 Types of data required for deriving QSs

2.6.1.1 <u>Data on physical and chemical properties</u>

Properties which can be very important when interpreting laboratory and field ecotoxicity are water solubility, vapour pressure, photolytic and hydrolytic stability, and molecular weight (when assessing risks of bioaccumulation). Such data will make it clear when steps to control exposure concentrations in ecotoxicity experiments are particularly important. This, in turn, helps assess how reliable a toxicity study is (Section 2.6.2). In addition, partition coefficients are needed when deriving a sediment QS when derived using EqP, to conduct transformation calculations (e.g. from mass/volume [mg/L] to mass/mass [mg/kg]). These coefficients (K) include, for example: Koctanol-water (K_{ow}), K suspended particulate matter – water ($K_{susp-water}$), K sediment – water ($K_{sed-water}$), K organic carbon (K_{oc}).

2.6.1.2 Ecotoxicological data

According to Annex V of the WFD, the base set of taxa that should be used in setting quality standards for water are algae and/or macrophytes, *Daphnia* (or representative invertebrate organisms for saline waters), and fish in relation to water column standards. For sediment QSs, the range of species should be expanded to include benthic species (Section 5). However, for the purpose of quality standard setting, the data should not be restricted to this base set. **All available data for any taxonomic group or species should be considered, provided the data meet quality requirements for relevance and reliability** (Section 2.6.2). This may include data for alien species and even exotic species[5], although care should be taken with data generated from experiments using species from extreme environments (e.g. thermophiles, halophytes).

If there are indications of endocrine activity (e.g. bioassays), but not studies are available that allow assessment of adverse effects through this mechanism, this should be highlighted as an uncertainty in the technical report.

Often, multiple data are available for the same species and endpoint (e.g. several studies assessing acute toxicity to *Daphnia*). Unless there is a clear reason for differences between toxicity (e.g. different test conditions, different exposure periods, different life stages or forms of the substance tested, like different metal species), any variation in toxicity may simply reflect random error and the valid data may be aggregated into a single value for each species and endpoint. Detailed guidance on data aggregation is given in Appendix 1

Finally, using ecotoxicological data to derive QSs for metals requires additional considerations. These are dealt with in detail in the relevant sections.

2.6.1.3 Mammalian toxicity data

QSs to protect human health utilise information about effects on mammals from oral exposure, repeated dose toxicity, carcinogenicity, mutagenicity and effects on reproduction, typically No Observable Adverse Effect Level (NOAEL), Acceptable Daily Intake (ADI) and Tolerable Daily Intake (TDI) values identified in the human health section of risk assessments performed under the REACH regime. Oral Reference Doses (RfD), ADI or TDI values adopted by national or international bodies such as the World Health Organization may also be used. For some substances, a threshold level cannot be established (e.g. some genotoxic carcinogens). For these, risk values corresponding to an additional risk of, e.g., cancer over the whole life of 10^{-6} (one additional cancer incident in 10^6 persons taking up the substance concerned for 70 years) may be used, if available.

To assess the risk of secondary poisoning of predators, bird and mammal toxicity data are also used. Further details are to be found in Appendix 1.

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[5] This is because test species not only represent species that occur in European waterbodies but to ensure a range of sensitivities is represented in the dataset with the result that any resulting QS is more likely to protect the range of species sensitivities found in nature.

2.6.1.4 Data on bioaccumulation

Data on bioaccumulation (bioconcentration, biomagnification and/or the octanol-water partition coefficient (K_{ow})) are required if a substance has a potential to bioaccumulate (i.e. it exceeds the trigger-values given in Section 2.4.4). Where data are available that give different indications of bioaccumulation potential, preference should be given to field observations on bioaccumulation and biomagnification factors (BAFs, BMFs) or experimentally derived BCFs and BMFs (and TMFs – Trophic Magnification Factor), if available.

Further details on how to obtain and evaluate data on bioaccumulation can be found in Appendix 1.

2.6.2 Quality assessment of data

A rigorous assessment of the data is needed to ensure that data are **reliable** and **relevant**. This will normally entail a review of the original study report, especially for critical data that are likely to have a major impact on the QS (Section 2.6.3).

Reliability refers to the inherent quality of the method used to conduct the test. A reliable study requires all relevant details about the test to be described. **Relevance** means the extent to which a test provides useful information about the hazardous properties of a chemical. **Only reliable, relevant data should be considered valid for use in setting a quality standard.**

2.6.2.1 Reliability

Guidance on the principles of data validation and the aspects to be considered is given in Appendix 1, based on REACH guidance. Data are assigned a score according to the reliability of the study.

Further assessment of data generated or assessed under Community legislation such as Regulations (EC) 793/93 and 1488/94 (existing chemicals) or Directives 91/414/EC (plant protection products) or 98/8/EC (biocides) is required unless the data published in the risk assessment reports under these legal frameworks have already been subjected to data quality assurance controls and peer-review. The same applies to peer-reviewed data or guidance values (e.g. Tolerable Daily Intakes or Drinking Water values) published by (inter)national organisations such as the World Health Organization (WHO), the United Nations Food and Agriculture Organization (FAO), the Organisation for Economic Development (OECD) or the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic;

Studies on pesticides may be performed on technical material or formulated product. Preference is given to data using technical material because toxicity of the active ingredient is less prone to modification by other formulation ingredients, but specific guidance on treatment of ecotoxicological data for pesticides when formulations have been tested is given in Appendix 1. Not all studies on plant protection properties are suitable for EQS derivation because the exposure regimes are sometimes very short to simulate specific exposure scenarios (mesocosm studies for example).

Studies that have been performed to 'Good Laboratory Practice' (GLP), to international (e.g. OECD) test guidelines and submitted under a regulatory regime may be taken at 'face value' without further review. This is because they have already been reviewed by a competent authority and there is a precedent for their acceptability. An exception to this would be if ecotoxicity studies submitted as part of a regulatory dossier have been performed in such a way that they might not be relevant to QS derivation e.g. unusual exposure regimes or very short test durations.

Detailed guidance for the selection of data to be used for standard setting is provided in Appendix 1, but the following principles are highlighted here:

1. Only data that can be considered as valid may be used, irrespective of the source of the data. **Admissible data are not confined to GLP studies**.

2. Data should be collated in a database with quality scores clearly assigned to each datum. **Only those considered as valid (see Appendix 1, section "Toxicity data") should be used as 'critical' data (Section 2.6.3) in deriving an EQS**.

3. If a QS for a particular receptor cannot be derived because the required data are lacking, this should be flagged.

Again, metals data require additional considerations and these are covered in Section 2.10.

2.6.2.2 Relevance

A study can be well conducted and fully reported but the test endpoint may have little ecological significance. Studies used for EQS derivation should be those where the test endpoint can be related to ecologically significant hazards. For practical purposes, this means effects that can be linked to population sustainability and particularly:

a. survivorship of adults

b. time taken to develop (particularly to reach reproductive age)

c. reproductive output

Most standard test methods include one or more of these endpoints. However, the assessor may be faced with data from studies describing endpoints that do not include direct measurements of survival, development or reproduction but, rather, describe e.g. behavioural effects, anatomical differences between control and treatment groups, effects at the tissue or sub-cellular level, such as changes in enzyme induction or gene expression. Generally these are unsuitable as the basis for EQS derivation. However, some other endpoints are relevant. For example, anatomical changes to gonad development that would prevent successful reproduction, or changes in behaviour if the effect described would impair competitive fitness may be relevant. Avoidance reactions may also be relevant if populations are likely to avoid a contaminated habitat where they would normally be present. Further examples are given in Appendix 1 .

2.6.3 'Critical' and 'supporting' data

Not all data have an equal influence on QS derivation. **Critical data** are ecotoxicity data (typically NOECs/EC10s or LC/EC50) for sensitive species and endpoints that are used as the basis for extrapolation and hence determine – or strongly influence - the value of the QS. Section 3 details the various approaches for extrapolation in particular deterministic and probabilistic methods. Critical data play a key role where a deterministic approach to extrapolation is used (i.e. an AF is applied) because the AF is applied to the lowest credible NOEC/EC10 or LC/EC50 (the critical datum). If a species sensitivity modelling approach is adopted, a distinction between critical and supporting data does not apply. This is because all the data are used in the model extrapolation and so, all the data can be regarded as critical (as long as they are reliable and relevant).

Supporting data are those data that are not described as critical data. They include data that are not among the most sensitive species/endpoints, studies that have estimated a non-standard summary statistic e.g. a LOEC is reported but no NOEC, field or mesocosm experiments that are difficult to interpret, or where a study might be sound but is not fully reported. Supporting data are not used directly for QS derivation when using the deterministic approach but can help inform the derivation of the QS by, for example, identifying sensitive taxa, determining if freshwater and saltwater datasets can be combined for QS derivation, averaging or aggregating the data in order to identify the critical data, and selecting an appropriate AF. All reliable and relevant data are used when deriving a QS using the probabilistic approach, ie SSDs. **Experiments that are clearly flawed should not be used in any way, even as supporting data.**

It is essential that all available toxicity data, both critical and supporting , are subject to rigorous quality assessment and are comprehensively reported as all data may be used, eg in the derivation of an SSD, for aggregation of data for the same species and end point and for comparison of fresh and saltwater data. Further guidance can be found in Appendix 1.

2.6.4 Data gaps - non testing methods

A lack of experimental data can lead to high uncertainty in the derivation process, possibly resulting in over-precautionary QSs. Whilst the generation of well-targeted experimental data can be critical in helping reduce uncertainty, it can be expensive and time-consuming. Under these circumstances there is a useful role for computational methods to fill data gaps, including quantitative structure–activity relationships (QSARs) for predicting toxicity and quantitative structure-property relationships (QSPRs) for estimating physicochemical properties. 'Read across' approaches can also be useful to infer the properties of chemicals for which data are absent, based on the properties of closely related analogues. Such approaches are now recommended in chemical risk assessment (ECHA 2008). Chemical regulation activity and the effort to reduce animal testing under REACH may lead to an increased regulatory acceptance of this type of information and new tools for deriving non-test data. The use of QSARs to predict toxicity has been examined in the following European research projects:

DEMETRA (Emilio Benfenati: Quantitative Structure-Activity Relationships (QSAR) for Pestide Regulatory Purposes; Elsevier 2007, ISBN: 978-0-444-52710-3): Prediction of five eco-toxicological endpoints: Acute toxicity trout, daphnia, quail (oral and dietary exposure), and bee

- CAESAR http://www.caesar-project.eu/: Prediction of five toxicological endpoints: Bioconcentration factor, skin sensitisation, carcinogenicity, mutagenicity, developmental toxicity

Detailed guidance on non-testing approaches is given in Section 6 but possible applications are briefly summarised below.

2.6.4.1 *Predictive models (QSARs, QSPRs)*

The most likely application for computational methods is to fill non-critical data gaps (Section 2.6.3) in the dataset for acute aquatic toxicity, especially when a deterministic assessment is to be followed. It is vital that computational methods are used within their legitimate operating domains; further guidance on QSARs and their use is given in Section 6.

2.6.4.2 *Analogue approaches*

Further non-testing methods include 'read across' and 'category' approaches. The most likely application of read-across is to fill data gaps, when the setting of a QS for mixtures, eg polyaromatic hydrocarbons (PAHs) is preferred compared to the QS for individual substances (Section 2.6.5).

Section 6 outlines another approach for inferring the properties, including ecotoxicological properties, of substances for which data are lacking. Essentially, it uses a category building approach in which chemical analogues are arranged by some physicochemical property (e.g. log Kow) and data from close neighbours are used to fill data gaps by interpolation. The approach can have value in demonstrating that additional AFs are not justified when using data for one substance to derive a QS for another closely related one. However, the following criteria must be met:

- There is a consistent and reliable trend within a category that is relevant to the endpoint of interest (e.g. log K_{ow} increases as ecotoxicity increases)

- If toxicity is the endpoint of interest, reliable measured toxicity is needed to identify the most sensitive trophic group

- Reliable measured data for the endpoint of interest, allowing interpolation to a value for the substance of interest (i.e. where there is a data gap)

- QSARs may be used to support read across but cannot be used to replace measured values

Predictive and analogue methods may be used for generating supporting data but are not suitable for predicting toxicity to be used as critical data. Furthermore, the range of substances to which these models can be applied is limited to chemicals with certain physicochemical and mode of action properties and are not suitable for all substances.

2.7 Calculation of QSs for substances occurring in mixtures

Some mixtures are intentionally emitted with a known and largely constant composition, but change after entry into environment, for example pesticide and biocide preparations. Other mixtures are released with a partly unknown, reasonably constant composition, but change after entry into the environment. In such circumstances an EQS for mixtures of substances may be preferable to deriving EQSs for the individual constituent substances. Section 7 provides guidance on the approaches that can be adopted if a mixture based approach is preferred.

2.8 Using existing risk assessments

In the interests of economy and consistency, it is sensible to utilise existing assessments, or at least the data on which they are based. As noted in section 1, the effects assessments conducted for chemical and pesticide risk assessments share many of the same principles and practices as those used to estimate an QS. Sections 2.8.1 and 2.8.2 provide guidance on the use of such assessments as a basis for deriving QSs, when they are available.

2.8.1 Risk assessments under Existing Substances Regulations (ESR)

For some industrial chemicals, detailed evaluations and risk assessments will already have been prepared under Regulation (EC) No. 793/93 or Directives 98/8/EC, and published in Risk Assessment Reports (RARs). We recommend that the Predicted No Effect Concentrations (PNECs) derived from this process are normally adopted as QSs because the assessments and associated data will have undergone thorough peer review. This also promotes consistency between chemical assessment and control regimes.

However, there are some circumstances that could prompt a review of the RAR PNEC, including:

- If new, potentially critical, ecotoxicity data (i.e. sensitive species or endpoints) has become available since the publication of the RAR.

- If there is new evidence for a mode of toxic action that was not considered in the RAR e.g. new evidence of endocrine disrupting properties.

- Where species sensitivity distribution modelling has been used for extrapolation, there can sometimes be finely balanced arguments about the size of the AF applied to the HC5 to account for uncertainty. For example, where the PNEC for a metal is close to background levels, this would encourage a review of uncertainties and how best to account for them so that a compliance assessment regime for the EQS can be practically implemented.

2.8.2 Pesticide risk assessments under 91/414/EEC

Many pesticides currently on the EU market have been reviewed under the Plant Protection Products Directive (91/414/EEC) which includes an assessment of freshwater ecotoxicity data. The data are peer-reviewed by a competent authority, they usually follow standard (OECD) test methods, and are performed to GLP so the studies are fully auditable. Non-regulatory data, ie data that do not conform to GLP and were not covered by the dossier submitted to the regulatory body may also be included in the review. However, some aspects of risk assessment under 91/414/EEC are different to the approaches taken under REACH to derive PNECs and on which the derivation of EQSs is based. For example:

- The 91/414/EEC assessment is based on a field margin ditch scenario close to the point of application, which would not normally apply under the WFD: the WFD seeks to provide protection to all waterbodies, including lakes, rivers, transitional and coastal waters.
- The 91/414/EEC assessment makes an allowance for recovery from impacts. This does not feature at all in the Annex V methodology under WFD
- Under 91/414/EEC the risk is expressed as a Toxicity Exposure Ratio (TER), based on a direct comparison of toxicity values (without assessment factors) to predictions of concentrations in the environment (PEC). Hence risk assessment under 91/414/EEC does not use AFs applied to the toxicity side of the risk equation, but to the risk quotient, yielding a TER.
- Algal toxicity data are dealt with differently under REACH and 91/414/EEC. This can lead to different outcomes when algae are the critical data determining the threshold (Lepper, 2005).
- Under 91/414/EEC, acute toxicity data are never used to extrapolate to chronic toxicity values; risk assessment for chronic exposure is carried out using only chronic toxicity data because this is a minimum requirement for registration.

Although a risk assessment under 91/414/EEC should not be used directly to set a QS, the list of endpoints produced for the review process and published on the internet by the Commission, provides a valuable data set. These data must, however, be supplemented with other ecotoxicity data where they are available, and also meet quality criteria.

2.9 Extrapolation

Derivation of all QSs requires some form of extrapolation from the available data to estimate a threshold that takes account of uncertainties such as inter- and intra-species variation and laboratory to field extrapolation.

Two main approaches are possible, the deterministic and probabilistic methods. Essentially the deterministic approach takes the lowest credible toxicity datum and applies an AF (which may be as low as 1 or has high as 10000) to extrapolate to a QS, the AF allowing for the uncertainties in the available data. Probabilistic methods adopt species sensitivity distribution (SSD) modelling in which all reliable toxicity (usually NOEC) data are ranked and a model fitted. From this, the concentration protection a certain proportion of species (typically 95%) can be estimated (the HC5).

Laboratory and (where available mesocosm) data are used to derive QSs that account for direct toxicity of chemicals to pelagic and sediment-dwelling organisms. Where there are insufficient data for a probabilistic approach, a deterministic approach is adopted (Section 3). Where there are sufficient data, both deterministic and probabilistic approaches to extrapolation will normally be performed (Section 3). Species sensitivity distribution models explicitly account for differences in sensitivity between species but, as Section 3 explains, a further AF is applied to the HC5 arising from model extrapolation to account for 'residual' uncertainties that are not accounted for by the SSD model. In a deterministic approach, larger AFs are typical, depending on the quantity and type of data available.

The purpose of these AFs is to account for the uncertainty that is not accounted for already in the experimental toxicity data or modelling (in the case of a probabilistic assessment). A basic principle of extrapolation is that, where uncertainty is high, larger AFs are necessary. Guidance on the size of these AFs is given in Section 3. The REACH guidance makes clear the possibility of flexibility in the size of the AF but any change from the 'default' AF (either to increase it, making the QS more stringent or to decrease it, making the QS less stringent) should be justified.

Useful lines of evidence that may be used to inform the extrapolation (and possibly influence the size of AF applied) include mode of action data, effects data from the field, and background concentration data for naturally occurring substances as outlined below.

2.9.1 Mode of action

If there are indications of adverse effects via endocrine activity (e.g. bioassays) or other specific effects that have not been adequately reflected in bird or mammals studies used to derive the NOAELoral (e.g. only 28day studies are available), an additional assessment factor may be considered to cover the anticipated effects.

On the other hand, uncertainty is reduced when there are relevant test endpoints from ecotoxicity studies that are highly relevant to a substance's mode of toxic action. An example would be fish life cycle studies for a chemical that is known to affect the reproductive physiology of vertebrates. Similarly, if a substance has a specific mode of toxic action, and reliable data for taxa that would be expected to be particularly sensitive are available (e.g. data for a range of insects for an insecticide that acts by inhibiting acetyl cholinesterase activity, or data for blue-green algae when dealing with chemicals that have bactericidal properties) then, again, an important aspect of uncertainty is reduced. Under these conditions, a smaller AF than the default value may be justified.

It follows that uncertainty may be increased if data for sensitive taxa are missing when dealing with substances with a specific mode of action like insecticides, herbicides or antibiotics.

2.9.2 Field and mesocosm data

Annex V of the WFD states that:

> *"…the standard thus derived should be compared with any evidence from field studies. Where anomalies appear, the derivation shall be reviewed to allow a more precise safety factor to be calculated."*

Field data, whilst rarely being suitable as the critical data for deriving a QS, can be used to corroborate (or challenge) the choice of AF. Crane et al. (2007), describe techniques for estimating a field threshold based on chemical exposure and biological data from matched locations and sampling occasions in the field. Field data also have a key role in deriving sediment standards (Section 5.2.1.3). In principle, where there is evidence of a mismatch, this would prompt consideration of the reasons why there is a discrepancy between the QS derived using laboratory data and experience in the field. Given the variability in field data (and indeed in laboratory ecotoxicity data), small differences between a laboratory-based QS and field data should not be given undue weight. We suggest that differences larger than an order of magnitude would, however, warrant further investigation and, if justified, a revision of the AF.

Mesocosm studies usually employ only a single contaminant stressor but biological impacts seen in the field may be attributable to several stressors, including non-chemical stressors. This can impair interpretation of matched chemical and biological data. However, if a 'one-sided' analysis is undertaken, i.e. calculate the maximum concentration that still permits good biological quality, the resulting threshold will be a conservative estimate. Analysis of mesocosm or field data may suggest the laboratory-based QS is over-protective (the QS based on laboratory data is lower than the field threshold). However, if the laboratory data do not include species that are known to be sensitive to the contaminant, a reduction of the AF cannot be justified.

2.9.3 Background concentrations

Another line of evidence that could affect the final QS is information about background levels for naturally occurring substances e.g. metals and some organics which occur widely in nature e.g. polycyclic hydrocarbons and some cyanides. The size of the AF should not normally result in a QS that is below the natural background level unless an 'added risk' approach to compliance assessment is to be adopted (Section 3.5). However, if uncertainties in the extrapolation are largely responsible for the QS being below the background level (e.g. an AF > 50 is required), this must be highlighted in the datasheet as a key uncertainty for the policymaker.

2.10 Dealing with metals

2.10.1 Why metals are different

Unlike most organic substances, metals are neither created nor destroyed by biological or chemical processes. Rather, they are transformed from one chemical form to another. Because metals are naturally occurring, many organisms have evolved mechanisms to regulate their accumulation and storage. Moreover some metals are essential nutrients so, when they are not present in sufficient concentrations, can limit growth, survival and reproduction of the organisms. Excess amounts of certain metals, on the other hand, are potentially toxic. Table 2-1 summarises the essentiality status for some environmentally relevant metals.

These features, along with the fact that metals naturally occur as inorganic forms in environmental compartments (e.g. sediments) and are cycled through the biotic components of an ecosystem, complicate the evaluation of toxicity data for inorganic metal substances and have a major influence on the way we derive QSs for metals.

Table 2.1 Essentiality of metals and metalloids to living organisms

Essential	Non-essential
Cr, Co, Cu, Fe, Mn, Mo, Ni, Se, Zn	As, Sb, Cd, Pb, Hg, Tl, Ag, Sn

When evaluating toxicity data to derive quality standards for metals, total metal concentrations are not usually directly related to ecotoxicological effects because many abiotic and biotic processes can modify the *availability* of metals, even rendering them unavailable for uptake. This means that the fraction available for uptake and toxicity may be a very small part of the total metal present. Due to several physicochemical processes, metals exist in different chemical forms which might differ in (bio)availability. Thus, the (bio)availability of metals in both laboratory tests and in the 'real" environment may be affected by several physicochemical parameters such as the pH, hardness of water and the dissolved organic carbon (DOC). Organic carbon (OC) and sulphides levels are key influencing factors for the sediment compartment. As geographically distinct watersheds show distinct geochemical characteristics, the degree to which different aquatic systems can safely accommodate metal loadings will vary. For this reason, ecotoxicity data, derived for the same species and same endpoint may vary widely when artificial/natural waters or sediments are used as test media.

The Water Framework Directive explicitly acknowledges the issues of (bio)availability and naturally occurring concentrations for metals. The Daughter Directive to the WFD on EQSs (2008/105/EC) (EC, 2008) states in Annex I, part B.3:

Member States may, when assessing the monitoring results against the EQS, take into account:

> *(a) natural background concentrations for metals and their compounds, if they prevent compliance with the EQS value; and*
>
> *(b) hardness, pH or other water quality parameters that affect the bioavailability of metals.*

Ideally, the derivation of QSs for metals requires an explicit consideration of (bio)availability using speciation models or, failing that, to utilise dissolved concentrations instead of total concentrations. Background concentrations may also need to be taken into account. Guidance on both bioavailability and backgrounds is provided in more detail in the Sections dealing with specific media (See Section 3.5, 4.7 and 5.2).

Guidance on deriving EQSs for metals is provided in Section 3.5.

2.11 Expression and implementation of EQSs

2.11.1 Accounting for exposure duration

Depending on the release pattern of a chemical and its environmental fate, chemical exposure may occur over long periods - or even continuously - in biota, in sediments, and even in the water column. In the water column, exposure may also occur intermittently for short periods e.g. coinciding with storm events or short periods of chemical use.

In order to cover both long- and short-term effects resulting from exposure, two water column EQSs will normally be required:

(i) a long-term standard, expressed as an annual[6] average concentration (AA-EQS) and normally based on chronic toxicity data

and

(ii) a short-term standard, referred to as a <u>m</u>aximum <u>a</u>cceptable <u>c</u>oncentration EQS (MAC-EQS) which is based on acute toxicity data.

Where EQSs are derived for biota and sediment, they are always expressed as a long-term standard. **It is not appropriate to derive a short-term standard for these compartments because exposure will typically be over long periods of time.**

2.11.2 Including aspects of water management and monitoring into the final decision about EQSs

Although uncertainty is taken into account during extrapolation through the use of modelling and/or AFs applied to critical data, small datasets invariably lead to greater uncertainty in the EQS. Under

[6] When the exposure pattern for a substance is known to be episodic e.g. many pesticides, the averaging period may be a shorter period than a year. This is case-specific but is determined by the expected exposure pattern, not toxicology (EC 2000/60/EC)

some circumstances, the policymaker responsible for implementing a standard may decide that a standard is too uncertain to be used in a statutory context, i.e. the policymaker may decide the risks of implementing an imprecise standard outweigh any benefits, or that it is only appropriate to use the EQS in an advisory context. As explained earlier, the role of the scientist deriving an EQS is to advise the policymaker on the nature and importance of unresolved uncertainties, and the steps that could be taken to resolve them (e.g. conducting further ecotoxicity tests), so that decisions about how to implement the standard can be made in an informed way.

2.11.3 Expression of EQSs for water

The overall EQS for water that is derived as described above is expressed as a dissolved concentration. Water column EQSs may also be expressed as a total (dissolved + particulate) concentration or concentration associated with SPM. In most cases the dissolved concentration will be preferred. However, for substances that are highly adsorbed to suspended matter the EQS might be based on suspended matter concentrations, which can be more appropriate for calculating substance fluxes in river systems. For such substances, this may be preferable to expressing the EQS as a total water concentration because this is dependent on the highly variable suspended matter concentration in water (which is a function of seasonality, turbidity and so on) and so may be highly uncertain. Emission controls are usually based on total concentrations in discharges too. When faced with such situations, the assessor should agree thepreferred method of EQS expression/compliance assessment with policy makers or river basin managers.

3 STANDARDS TO PROTECT WATER QUALITY

3.1 General approach

QSs for the protection of **pelagic communities** (organisms inhabiting the water column) are required for all substances. This Section covers the protection of freshwater and saltwater pelagic communities from both long-term and short-term exposure, as well as those in transitional waters. In addition, this Section also covers the assessment of **risks to human health from drinking water**.

For the water column, four different QS values can be derived:

- A QS based on direct ecotoxicity ($QS_{fw, eco}$ or $QS_{sw, eco}$ (Section 3.2),
- A QS based on secondary poisoning of predators ($QS_{biota\ sec\ pois\ fw}$ or $QS_{biota\ sec\ pois\ fw}$)[7] (Section 4.4),
- A QS based on human consumption of fishery products ($QS_{biota,\ hh\ food}$)[7] (Section 4.5)

and

- A QS for human consumption of drinking water ($QS_{dh,hh}$) (Section 3.9)

As explained in Section 2.4.3, the $QS_{biota,\ sec\ pois}$ and $QS_{biota,\ hh}$ only need to be derived if specific trigger values are met. The lowest of these values is set as the overall EQS, although the drinking water standard is only adopted as an overall standard for waters intended for drinking water abstraction.

As explained in Section 2.5.1, in order to select an overall EQS, it will be necessary to translate biota and human health standards (ie biota, hh) into an equivalent water concentration, so they can be compared directly with other water column QSs. Some jurisdictions may also prefer to assess compliance with these standards by sampling the water column rather than biota. The conversion of biota QSs into their equivalent water column concentrations is covered in Section 4.7.2.

The particular requirements for deriving water column standards for metals are dealt with in Section 3.5.

3.2 Derivation of QSs for protecting pelagic species

3.2.1 Relationship between water column QS and MAC-QS

As explained in Section 2.11, two QSs are required for the water compartment to cover both long-term and short-term exposure to a chemical:

(i) an annual average concentration (QS) to protect against the occurrence of prolonged exposure, and

(ii) a maximum acceptable concentration (MAC-QS) to protect against possible effects from short term concentration peaks. The temporary standard during derivation is termed MAC-QS to distinguish this value from the QS mentioned in (i)

[7] The QS $_{biota,\ sec\ pois}$ and QS $_{biota,\ hh\ food}$ are based on biota standards and are unlikely to be implemented as annual average concentrations in practice. They may be converted to equivalent water concentrations e.g. to set an overall EQS or to enable compliance assessment using water samples instead of biota sampling.

Whilst derivation of the QS typically employs chronic toxicity data, the MAC-QS always relies on acute data. When data are sparse or the ratio between acute effects and chronic no-effects is narrow, the estimated MAC-QS can sometimes be more stringent than the QS. It is also possible that the effects observed in chronic studies are due to the initial contact with the test substance, rather than to prolonged exposure. In that case it is also reasonable that the MAC-QS and QS are similar. When the MAC-QS is lower than the QS, a further analysis should be presented in which the possible causes are discussed. When acute and chronic critical data for the QS derivation relate to the same species, and the acute L/EC50 is lower (more stringent) than the chronic NOEC, the data should be re-evaluated and justified, and/or an EC10 should be derived instead of a NOEC to derive the QS if the statistical analysis to derive the NOEC has insufficient discriminating power. Since effects of chronic exposure normally occur at lower concentrations than those of acute exposure, MAC-QS values below the QS make little toxicological sense.**Therefore, where the derivation of the MAC-QS leads to a lower value than the QS, the MAC-QS is set equal to the QS for direct ecotoxicity**. This is summarised below in Table 3.1.

Table 3.1 Summary of MAC-QS recommendation based on relationship with QS for direct ecotoxicity

Relationship between estimated AA and MAC	Recommendation
MAC-QS < QS	Set MAC-QS equal to AA-QS
MAC-QS > AA-QS	Derive MAC-QS.

3.2.2 Preparing aquatic toxicity data

Aquatic toxicity data are the key inputs to the derivation of water column standards for direct ecotoxicity. Before the assessor can derive QSs the available data must be properly assessed for reliability and relevance. This is because all data contribute to the final outcome, especially when a probabilistic analysis (SSD) is performed. Guidance on data quality assessment is detailed in Appendix 1.

Before starting the extrapolation steps, the following steps are also taken:

- Data are aggregated when there are multiple data for the same species and endpoint (Section 2.6.1.2);
- Analyses are performed to see whether freshwater and saltwater data can legitimately be combined. This is covered in detail in Section 3.2.3.

As an aid to properly understanding the available data, the assessor should plot all the data graphically so that he/she can develop (and communicate) an appreciation of the quantity of data and spread of species and effects over a range of concentrations. A convenient way to do this is to separate acute and chronic data for freshwater and saltwater species, rank effect concentrations or NOECs, and simply plot the cumulative ranks against concentration. This can be achieved simply in Excel (or using the ETX programme (Van Vlaardingen *et al.*, 2004)), ideally identifying the different taxonomic groups by different symbols so any particularly sensitive or tolerant taxa become immediately obvious. This presentation helps inform an understanding of acute: chronic ratios. It also identifies outliers and different sensitive groups, especially if groups are given different symbols.

3.2.3 Combining data for freshwater and saltwater QS derivation

3.2.3.1 Organic compounds

In principle, ecotoxicity data for freshwater and saltwater organisms should be pooled for organic compounds, if certain criteria are met. **Where the criteria for combining data are met (see below), the pooled datasets are then used to derive both freshwater and saltwater QSs, but with different assessment factors (see Sections 3.3.1 and 3.3.2).**

The presumption that for organic compounds saltwater and freshwater data may be pooled must be tested, except where a lack of data makes a statistical analysis unworkable. In those cases where there are too few data (either freshwater or saltwater) to perform a meaningful statistical comparison and there are no further indications (spread of the data, read-across, expert judgement[8]) of a difference in sensitivity between freshwater vs saltwater organisms, the data sets may be combined for QS derivation.

To enable a robust comparison, it is important that a comprehensive set of data is included. For compounds with a specific mode of action, this should include particularly sensitive taxonomic group(s). This reinforces the need for a search strategy for ecotoxicological data that is as wide as possible.

Where there are sufficient toxicity data in both the freshwater and saltwater datasets to enable a statistical comparison, the following procedure should be followed. The null hypothesis is that freshwater and saltwater organisms do not differ in their sensitivity to the compound of interest; *i.e.* they belong to the same statistical population:

1. All freshwater data are collected and tabulated (note: this data set contains one toxicity value per species). Next, a logarithmic transformation of each of these toxicity values is performed.
2. All saltwater data are collected and tabulated (note: this data set contains one toxicity value per species). Next, a logarithmic transformation of each of these toxicity values is performed.
3. Using an F-test, determine whether the two log-transformed data sets have equal or unequal variances. Perform the test at a significance level (α) of 0.05.
4. A test for differences between the data sets e.g. a two tailed t-test where the data are normally distributed (with or without correction for unequal variances, depending on the results of step 3), is performed. Perform the test at a significance level (α) of 0.05[9].
5. Especially for compounds with a specific mode of action, it is important to identify particularly sensitive taxonomic groups and perform a separate statistical analysis for this specific group. If enough data are available to make a comparison for individual or related taxonomic groups (e.g., insects, crustaceans, arthropods, fish, vertebrates), this may help to determine if there are differences between saltwater and freshwater species.

8 Information on a closely related compound(s) may be used (‘read across’) (See Section 6). The toxicity data of the related compound should not be used, but toxicological information or knowledge may be used to underpin conclusions. Any use of information from related compounds should be well documented. This can be especially useful when differences are expected for a compound but the dataset is too small to to perform a meaningful statistical comparison.

9 Beware of confounding factors. For example: (i) a specific group of organisms might be more sensitive than other organisms, (ii) over representation of results from one study or species from a specific taxonomic group in one of the two data sets might cause bias in the results. Results of statistical tests become increasingly meaningful with increasing sample size.

When a significant difference in sensitivity cannot be shown, the two data sets remain combined for QS derivation and the $QS_{fw, eco}$ and the $QS_{sw, eco}$ are derived using the same data set. However, different extrapolations should be used for the two compartments (detailed in Sections 3.3 and 3.4).

When a difference in sensitivity is demonstrated based on toxicity, the freshwater and saltwater data sets should not be pooled and QSs for both compartments should be derived using the respective data sets separately and the appropriate extrapolation method.

3.2.3.2 Metals

Freshwater and saltwater toxicity data for metals should be separated *a priori*. This is because differences in toxicity between freshwater and saltwater species are likely because of differences in metal speciation and bioavailability as well as (osmo)regulation. Datasets should only be combined when there is no demonstrable difference in sensitivity. If metals effects data are expressed as dissolved metal concentrations, freshwater and saltwater sensitivities can be compared to assess whether they can be combined, as described for organic substances (Section 3.2.3.1).

However, when metal bioavailability correction is being considered for the freshwater QS, such correction can not be extrapolated to the marine environment and therefore freshwater and marine NOECs can not be combined.

3.3 Deriving a $QS_{fw, eco}$

3.3.1 Derivation of a QS for the freshwater community ($QS_{fw, eco}$)

For the derivation of the $QS_{fw, eco}$ combined toxicity data sets (with one toxicity value per species) of freshwater and saltwater species may be used (see Section 3.2.3), if after evaluation of the freshwater and saltwater toxicity data it appears that the data can be pooled. Where data permit, the $QS_{fw, eco}$ is derived in three ways:

1. deterministic approach: assessment factor applied to the lowest credible datum ('AF method', Section 3.3.1.1)

2. probabilistic approach using species sensitivity distribution modeling ('SSD method', Section 3.3.1.2),

and

3. using results from model ecosystem and field studies (Section 3.3.1.3).

The methodology is consistent with the REACH provisions for effects assessment for substances that are released continuously. **If the conditions to use the SSD-method for the derivation of quality standards are met, it should always be used. However, a QS should also be derived using the AF method, and, where valid data exist, also using model ecosystems**. In all three methods, remaining uncertainty is taken into account by applying an assessment factor. This implicitly means that the resulting QS, whether it is derived using the AF method, the SSD method, or using model ecosystem studies, are all considered reliable. It is possible, however, that the results differ. These should be covered in the report on the derivation of the QS, with an explanation of possible discrepancies in the results and the reason for choosing the final method. If all methods can be performed, the final $QS_{fw, eco}$ should preferably be based on the results from the SSD method or the model ecosystem-studies, since these entail a more robust approach towards assessing ecosystem effects. It cannot be stated beforehand which method is preferred, the selection of the final $QS_{fw, eco}$ remains subject to expert judgement. The SSD gives a robust estimate of the range of sensitivities to be encountered in an ecosystem, but it is still based on single species data, and species-interactions at the ecosystem level are not covered. In the case of mesocosm studies, it is often not possible to disentangle the exact cause-effect relationships, but

they may point to long-term effects on the ecosystem that cannot be shown in single-species laboratory studies (*i.e.* indirect effects, predator-prey interactions). The relevance of the ecosystem structures of the available model ecosystem studies is an important consideration. In any case, both the SSD and mesocosm should include species that are likely to be sensitive. If sensitive species are not available, nor represented in the mesocosm studies, the deterministic approach may still be preferred, because it makes greater allowance for uncertainty.
Rarely, there may not be appropriate data for the water column available but there are suitable tests with benthic studies (e.g. only sediment tests with chironomids for an insecticide). In such a case it might be considered to apply the equilibrium partitioning method (section 5.2.1.2) in a reversed way from how it is usually applied. However, in such a case it must be considered whether exposure to the substance is primarily through the aqueous phase. This means that for highly hydrophobic substances, where food ingestion contributes significantly to the exposure, this approach could not be applied.

3.3.1.1 Extrapolation using assessment factor method

For substances with small datasets, the deterministic approach or assessment factor method (AF method) is the only realistic option because the data requirements of the SSD method (Section 3.3.1.2) are too demanding. The quantity and types of data available determines the assessment factors used (Table 3.2). The procedures for estimating an $AA\text{-}QS_{fw,\ eco}$ are the same as the aquatic effects assessment and the calculation of the PNEC (≈ $AA\text{-}QS_{water}$) described in the guidance prepared for REACH (ECHA, 2008).

If an assessment factor equal to or higher than 100 is used, this implies a high level of uncertainty and it should always be highlighted in a 'residual uncertainty' paragraph in the technical report describing the derivation of the $AA\text{-}QS_{freshwater,\ eco}$, together with possible ways to reduce this uncertainty (e.g. perform an additional toxicity test for a specific species).

When only short term toxicity data are available an assessment factor of 1000 will be applied to the lowest L(E)C50 of the relevant available toxicity data, irrespective of whether or not the species tested is a standard test organism (see notes to Table 3.2). A lower assessment factor will be applied to the lowest NOEC derived in long term tests with a relevant test organism.

The algal growth inhibition test of the base set is, in principle, a multigeneration test. However, for the purposes of applying the appropriate assessment factors, the EC50 is treated as a short term toxicity value. The NOEC from this test may be used as an additional NOEC when other long-term data are available. In general an algal NOEC should not be used unsupported by long term NOECs of species of other trophic levels. However if the short term algal toxicity test is the most sensitive of the short term tests, the NOEC from this test should be supported by the result of a test on a second species of algae. The investigations with bacteria (eg growth tests) are regarded as short term tests. Additionally, blue-green algae should be counted among the primary producers due to their autotrophic nutrition i.e. they assume the same status as green algae.

The assessment factors presented in Table 3.2 should be considered as general factors that under certain circumstances may be changed. In general, justification for changing the assessment factor could include one or more of the following:

- evidence from structurally similar compounds (Evidence from a closely related compound may demonstrate that a higher or lower factor may be appropriate);
- knowledge of the mode of action (some substances, by virtue of their structure, may be known to act in a non-specific manner);
- the availability of test data from a wide selection of species covering additional taxonomic groups other than those represented by the base-set species;
- the availability of test data from a variety of species covering the taxonomic groups of the base-set species across at least three trophic levels. In such a case the assessment factors

may only be lowered if these multiple data points are available for the most sensitive taxonomic group.

Specific comments on the use of assessment factors in relation to the available data set are given in the notes below Table 3.2.

Table 3.2 Assessment factors to be applied to aquatic toxicity data for deriving a $QS_{fw, eco}$

Available data	Assessment factor
At least one short-term L(E)C50 from each of three trophic levels (fish, invertebrates (preferred *Daphnia*) and algae) (i.e. base set)	1000 [a)]
One long-term EC10 or NOEC (either fish or *Daphnia*)	100 [b)]
Two long-term results (e.g. EC10 or NOECs) from species representing two trophic levels (fish and/or *Daphnia* and/or algae)	50 [c)]
Long-term results (e.g. EC10 or NOECs) from at least three species (normally fish, *Daphnia* and algae) representing three trophic levels	10 [d)]
Species sensitivity distribution (SSD) method	5-1 (to be fully justified case by case) [e)]
Field data or model ecosystems	Reviewed on a case by case basis [f)]

a) The use of a factor of 1000 on short-term toxicity data is a conservative and protective factor and is designed to ensure that substances with the potential to cause adverse effects are identified. It assumes that the uncertainties identified above make a significant contribution to the overall uncertainty. For any given substance there may be evidence that this is not so, or that one particular component of the uncertainty is more important than any other. In these circumstances it may be necessary to vary this factor. This variation may lead to a raised or lowered assessment factor depending on the available evidence. A factor lower than 100 should not be used in deriving an $QS_{fw, eco}$ from short-term toxicity data.
Variation from a factor of 1000 should not be regarded as normal and should be fully supported by accompanying evidence.

b) An assessment factor of 100 is applied to a single long-term result (e.g. EC10 or NOECs) (fish or Daphnia) if this result was generated for the trophic level showing the lowest L(E)C50 in the short-term tests.

If the only available long-term result (e.g. EC10 or NOECs) is from a species (standard or non-standard organism) which does not have the lowest L(E)C50 from the short-term tests, applying an assessment factor of 100 is not regarded as protective of other more sensitive species.. Thus the hazard assessment is based on the short-term data and an assessment factor of 1000 applied. However, the resulting QS based on short-term data may not be higher than the QS based on the long-term result available.
An assessment factor of 100 can also be applied to the lowest of two long-term results (e.g. EC10 or NOECs) covering two trophic levels when such results have not been generated from that showing the lowest L(E)C50 of the short-term tests. This should, however, not apply in cases where the acutely most sensitive species has an L(E)C50 value lower than the lowest long term result (e.g. EC10 or NOECs) value. In such cases the QS might be derived by using an assessment factor of 100 to the lowest L(E)C50 of the short-term tests
.

c) An assessment factor of 50 applies to the lowest of two long term results (e.g. EC10 or NOECs) covering two trophic levels when such results have been generated covering that level showing the lowest L(E)C50 in the short-term tests. It also applies to the lowest of three long term results (e.g. EC10 or NOECs) covering three trophic levels when such results have not been generated from that trophic level showing the lowest L(E)C50 in the short-term tests. This should however not apply in cases where the acutely most sensitive species has an L(E)C50 value lower than the lowest long term result (e.g. EC10 or NOECs) value. In such cases the QS might be derived by using an assessment factor of 100 to the lowest L(E)C50 of the short-term tests.

d) An assessment factor of 10 will normally only be applied when long-term toxicity results (e.g. EC10 or NOECs) are available from at least three species across three trophic levels (e.g. fish, Daphnia, and algae or a non-standard organism instead of a standard organism). When examining the results of long-term toxicity studies, the $QS_{fw,\ eco}$ should be calculated from the lowest available long term result. Extrapolation to the ecosystem can be made with much greater confidence, and thus a reduction of the assessment factor to 10 is possible. This is only sufficient, however, if the species tested can be considered to represent one of the more sensitive groups. This would normally only be possible to determine if data were available on at least three species across three trophic levels. It may sometimes be possible to determine with high probability that the most sensitive species has been examined, i.e. that a further long-term result (e.g. EC10 or NOECs) from a different taxonomic group would not be lower than the data already available. In those circumstances, a factor of 10 applied to the lowest long term result (e.g. EC10 or NOECs) from only two species would also be appropriate. This is particularly important if the substance does not have a potential to bioaccumulate. If it is not possible to make this judgment, then an assessment factor of 50 should be applied to take into account any interspecies variation in sensitivity. A factor of 10 cannot be decreased on the basis of laboratory studies.[10]

e) Basic considerations and minimum requirements as outlined in Section 2.6.1.2.

f) The assessment factor to be used on mesocosm studies or (semi-) field data will need to be reviewed on a case-by-case basis (see Section 3.3.1.3 for further guidance).

Not all circumstances can be dealt with in these footnotes and specific cases may require specific considerations with respect to the choice of the AF. Any deviation from the scheme should be explained. To help with some questions that might arise, further guidance is offered below:

1. *The base set (acute data for fish,* Daphnia, *algae*) *is complete, but chronic data are only available for one trophic level of the base set*: This relates to footnotes a and b because we have to decide whether to use an AF of 100 applied to chronic data or 1000 applied to acute data. An AF of 100 is applied to the lowest chronic NOEC or EC10 but (a) it has to be either *Daphnia* or fish and (b) the NOEC or EC10 should be from the same trophic level as that of the lowest acute L(E)C50. If (a) and (b) are not the case, an AF of 1000 is applied to the lowest L(E)C50 and the two results are compared: lowest L(E)C50/1000 versus NOEC (or EC10)/100; the lowest value is selected as $QS_{fw,\ eco}$.

2. *The base set is complete, but chronic data are only available for two trophic levels from the base set*: This relates to footnotes b and c. An assessment factor of 50 is applied to the lowest chronic NOEC or EC10, if such chronic data are available from two trophic levels from the base set. The trophic levels of the NOECs and/or EC10s should include the trophic level of the lowest acute L(E)C50. If the trophic level for the lowest acute L(E)C50 is not included in the chronic data (NOECs and/or EC10s) then:
   - an assessment factor of 100 is applied to the lowest NOEC or EC10 if the lowest L(E)C50 is higher than the lowest NOEC or EC10;
   - an assessment factor of 100 is applied to the lowest L(E)C50 if the lowest L(E)C50 is lower than the lowest NOEC or EC10.

3. *The base set is complete and chronic data for each of the trophic levels of the base set are available*:
   This relates to footnote c and d. An assessment factor of 10 is applied to the lowest chronic NOEC or EC10 if chronic data are available from all three trophic levels of the base set. The trophic levels

[10] However, this only refers to the deterministic approach. If the SSD approach is used, which is also based on laboratory data, a lower assessment factor than 10 can be used (1-5).

of NOECs and/or EC10s should include the trophic level of the lowest acute L(E)C50. If acute toxicity data are available for trophic levels not covered in the chronic toxicity data, and the trophic level of the lowest L(E)C50 is not included in that of the NOECs and/or EC10s then:

- an assessment factor of 50 is applied to the lowest NOEC or EC10 if the lowest L(E)C50 is higher than the lowest NOEC or EC10;
- an assessment factor of 100 is applied to the lowest L(E)C50 if the lowest L(E)C50 is lower than the lowest NOEC or EC10.

4. *The base set is not complete, because data are missing*
   Although the table refers specifically to *Daphnia*, any reliable data for small crustaceans would be acceptable. In practice, Daphnia data will be the most readily available, but other species such as *Ceriodaphnia*, *Gammarus*, or *Acartia*, the latter in the case of the marine environment, can be considered to fill the gap when data for *Daphnia* are missing. A similar approach can be followed when data for algae or cyanophytes are missing, but macrophyte data are present. If there is evidence that the missing trophic level would not be the potentially most sensitive species (*e.g. Daphnia* in case of a herbicide) or when it can be assumed that the available species are potentially sensitive (*i.e.* insect and *Daphnia* data in case of an insecticide, where algae are missing), the assessment scheme can be followed as if the base set were complete.

5. *Insect growth regulators*
   For this specific type of pesticides, *Daphnia* may not be the most sensitive species. Within the context of pesticide authorisation, it is advised that insects should be tested when for an insecticide the toxicity to *Daphnia* is low (i.e. 48 h EC50 > 1 mg/L, 21 d NOEC > 0.1 mg/L; EC, 2002). This means that where the presence of acute and chronic data for algae, *Daphnia* and fish normally allows for an AF of 10, in this case additional information from insects is considered necessary.

In line with the REACH guidance (ECHA, 2008), data for bacteria representing a further taxonomic group may only be used if non-adapted pure cultures were tested. Studies with bacteria (e.g. growth tests) are regarded as short-term tests. **Consequently, NOECs or EC10 values derived from bacterial studies may not be used in the derivation of the $QS_{fw,\ eco}$ using assessment factors. EC50 values from bacterial tests may be used but they cannot substitute any of the other trophic levels (acute data on algae, *Daphnia*, fish) for completion of the base set**. The same principle applies to toxicity data using protozoans. Nevertheless, NOECs or EC10 values from bacterial studies are valuable and should be tabulated amongst the toxicity data because they are relevant as inputs in an SSD.

Blue-green algae should be counted among the primary producers due to their autotrophic nutrition (ECHA, 2008). Thus, cyanobacteria (blue-green algae or Cyanophyta) belong to the trophic level of primary producers. **This means that data from (both chronic and acute) tests with cyanobacteria are considered as additional algal data and are treated in the same way (*i.e.* if they represent the lowest endpoint, the AF will be based on cyanobacteria, even when data for green algae are present). They can also be used to complete the base set where there are no algal data**.

When there are indications that a substance may cause adverse effects via disruption of the endocrine system of mammals, birds, aquatic or other wildlife species, the assessor should consider whether the assessment factor would be sufficient to protect against effects caused by such a mode of action, or whether a larger AF is needed (Section 2.9.1).

Use of non-testing methods to reduce uncertainty

Emphasis is placed on experimental toxicity data for deriving an EQS. However, non-testing methods (e.g. QSARs, read-across methods) are also available which can be used to predict toxicity of certain organic chemicals and endpoints. They should not be used to generate critical data to derive an EQS, but predicted data can play a role in reducing uncertainty and thereby influence the size of AF chosen for extrapolation. Detailed guidance on the use of non-testing methods is given in Section 6.

3.3.1.2 Extrapolation using SSDs

Statistical extrapolation in line with the provisions of the REACH guidance (ECHA, 2008), namely the species sensitivity distribution method (SSD), can be used for the derivation of EQSs for water. Extensive information on the backgrounds and use of SSDs is given in Posthuma *et al.* (2002).

To construct an SSD, toxicity data are log-transformed and fitted to a distribution function from which a percentile (normally the 5th percentile; often referred to as the HC5) of that distribution is used as the basis for an EQS. Several distribution functions have been proposed. The US EPA (1985) assumes a log-triangular function, Kooijman (1987) and Van Straalen and Denneman (1989) a log-logistic function, and Wagner and Løkke (1991) a log-normal function. Aldenberg and Slob (1993) and Aldenbeg and Jaworska (2000) further refined the way to estimate the uncertainty of the 95th percentile by introducing confidence levels. The log-normal distribution is a pragmatic choice from the possible range of distributions because its mathematical properties are well-described (methods exist that allow for most in depth analyses of various uncertainties) although others are permissible

Data requirements

For estimating a $QS_{fw,\ eco}$ the input data to the SSD should be quality-assessed chronic NOEC or EC10 data according to the criteria recommended in Section 2.6.2. As for deterministic extrapolation, data should first be aggregated to one toxicity value per species, and statistical comparisons undertaken to decide if freshwater and saltwater data can be pooled. In practice, the same dataset is used for both the deterministic and probabilistic methods.

Ideally the dataset for an SSD should be statistically and ecologically representative of the community of interest (Posthuma *et al*., 2002). An EQS should be protective for the wide range of surface waters and communities that can occur within Europe. Given this broad scope of protection of the WFD, the requirements of the REACH guidance with respect to the number of taxa and species to be included in the dataset (ECHA, 2008) are followed, ie the output from an SSD-based QS is considered reliable if the database contains preferably more than 15, but at least 10 NOECs/EC10s, from different species covering at least 8 taxonomic groups. For estimating a $QS_{fw,\ eco}$, the following taxa would normally need to be represented:

- Fish (species frequently tested include salmonids, minnows, bluegill sunfish, channel catfish, etc.)
- A second family in the phylum Chordata (e.g. fish, amphibian, etc.)
- A crustacean (e.g. cladoceran, copepod, ostracod, isopod, amphipod, crayfish etc.)
- An insect (e.g. mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
- A family in a phylum other than Arthropoda or Chordata (e.g. Rotifera, Annelida, Mollusca, etc.)
- A family in any order of insect or any phylum not already represented
- Algae
- Higher plants

SSDs for substances with a specific mode of action

For a substance exerting a specific mode of action, SSDs should be constructed using

(a) the entire dataset (i.e. all taxa, so that the relative sensitivities of taxa can be examined) and

(b) only those taxa that are expected to be particularly sensitive (e.g. for a herbicide acting by photosynthetic inhibition, this would be data for higher plants and algae).

In other words, the minimum requirements to perform an SSD should be also be met for a compound with a specific mode of action, in order to be able to demonstrate deviations from the expected distribution. If there is clear evidence of a 'break' in the distribution between the sensitive and other species, or poor model fit, the HC5 should be estimated using only data from the most sensitive group, provided that the minimum number of 10 datapoints is present. If other evidence is available that indicates there might be a specific sensitive group of species, for example, 'read-across' data from a structurally similar substance, this could also be used.

Testing goodness of fit

Different parametric distributions e.g. log-logistic, log-normal or others may be used. For example, the Anderson–Darling goodness of fit test can be used in addition to the Kolmogorov-Smirnov-test, to help choose a parametric distribution for comprehensive data sets, because it gives more weight to the tails of the distribution. Further details are given in REACH guidance (ECHA, 2008). The following guidance is offered:

Whatever the model fitted to a distribution, results should be discussed with regards to the graphical representation of the species distribution and the different p-values (~probability value: the likelihood of wrongly rejecting a statistical hypothesis when it is true) obtained with each test. ($p < 0.05$ means a probability of < 5%).

The choice of a distribution function other than the log-normal or log-logistic distribution should be clearly explained.

If the data do not fit any distribution, the left tail of the distribution (the lowest effect concentrations) should be analysed more carefully. If a subgroup of species is particularly sensitive and, if there are sufficient data, an SSD may be constructed using only this subgroup. However, this should be underpinned if possible by some mechanistic explanation e.g. high sensitivity of certain species to this particular chemical.

The SSD method should not be used in cases where there is a poor data fit to all available distributions.

Calculating the HC5

The method of Aldenberg and Jaworska (2000) is considered most appropriate because it enables the calculation of a confidence interval (normally the 90% interval) for the HC5. This method is used in the ETX-computer program (Van Vlaardingen *et al*., 2004).
The HC5 according to Aldenberg and Jaworska is calculated as follows:

$$\text{Log HC5} = Xm - k*s$$

Where:

Xm = mean of log-transformed NOEC and EC10 data

k= extrapolation constant depending on protection level and sample size (according to Aldenberg and Jaworska, 2000)

s=standard deviation of log-transformed data

The extrapolation constant k is taken from Aldenberg and Jaworska (2000). Three values are given for k. The 5%ile cu-off value (HC5) is calculated with the median estimate for k and, in addition, the confidence limits are calculated using the upper and lower estimates of k.

The median estimate of the HC5 (sometimes denoted as HC5-50) is used as the basis of the QS. SSD modelling deals explicitly with differences in sensitivity between species. According to the requirements set out above, an SSD can only be constructed when data are plentiful but there may still be some residual uncertainty that needs to be accounted for in the final QS. For this reason, the HC5 is divided by an additional AF:

QS = HC5 / AF

Choice of AF applied to HC5

An AF of 5 is used by default but may be reduced where evidence removes residual uncertainty. The exact value of the AF depends on an evaluation of the uncertainties around the derivation of the HC5. As a minimum, the following points have to be considered when determining the size of the assessment factor (ECHA, 2008):

- the overall quality of the database and the endpoints covered, e.g., if all the data are generated from “true” chronic studies (e.g., covering all sensitive life stages);
- the diversity and representativity of the taxonomic groups covered by the database, and the extent to which differences in the life forms, feeding strategies and trophic levels of the organisms are represented;
- knowledge on presumed mode of action of the chemical (covering also long-term exposure). Details on justification could be referenced from structurally similar substances with established mode of action;
- statistical uncertainties around the HC5 estimate, e.g., reflected in the goodness of fit or the size of confidence interval around the 5th percentile, and consideration of different levels of confidence (e.g. by a comparison between the median estimate of the HC5 with the lower estimate (90% confidence interval) of the HC5);
- comparisons between field and mesocosm studies, where available, and the HC5 and mesocosm/field studies to evaluate the level of agreement between laboratory and field evidence.

3.3.1.3 Use of field and mesocosm studies for derivation of the $QS_{fw,\ eco}$

Field studies and simulated ecosystem studies such as microcosm and mesocosm experiments (e.g. ponds and streams) are frequently used to assess the environmental risks posed by pesticides. They can be a valuable tool to assess the impact of a chemical on populations or communities of aquatic ecosystems under more realistic environmental conditions than is achievable with standard single-species laboratory studies. If such studies are available, and they fulfil the criteria regarding reliability and relevance as defined below, they may be used either as the basis of $QS_{fw,\ eco}$ derivation or, when an SSD is used, to help select the size of AF applied to the HC5. This section specifically deals with the use of mesocosm studies for derivation of the $QS_{fw,\ eco}$. The use of mesocosm data for derivation of the MAC-QS is addressed in Section 3.4.1.3.

Mesocosms

For more detailed guidance on the conduct and evaluation of micro- or mesocosm studies see e.g. Hill *et al*. (1994), Giddings *et al*. (2002) and De Jong *et al*. (2008). The following criteria should be addressed when assessing mesocosm data:

- Adequate and unambiguous experimental set-up
- Realistic community
- Adequate description of exposure patterns, especially in the compartment of interest e.g. water column
- Sound statistical evaluation

- Sensitive endpoints that are in accordance with the mode of action of the chemical

Irrespective of the framework under which the studies were originally conducted, these basic principles apply to all simulated ecosystem studies. However, there may be some features that are of particular importance to QS derivation since the objectives of risk assessment under Council Directive 91/414/EEC and QSs under the WFD are not entirely compatible. The following points are particularly important:

1. For $QS_{fw,\ eco}$ derivation, exposure in the test system must be properly characterised. Therefore a prerequisite for using a field or mesocosm study is that the concentration of the substance is measured over the course of the experiment so that time-weighted average concentrations (TWA) within a well-defined time window can be calculated for persistent active ingredients.

2. All effects observed (and all NOECs derived), must be related to the respective TWA concentration. It is not acceptable to use the initial concentration as the basis for assessment unless there is evidence that this level of exposure has been maintained.

3. This means that, for $QS_{fw,\ eco}$ derivation, mesocosm studies with rapidly dissipating compounds (with half-lives of hours) cannot be used unless steps have been taken to replenish the test substance at intervals consistent with the substance's half-life in the environment. For experiments with a repeated pulse application it should be evaluated on a case-by-case basis whether long-term exposure can be considered to be maintained.

4. In risk assessment of plant protection products, the potential for recovery following removal of the chemical stressor is normally taken into account. This principle does not apply in QS derivation i.e. a temporary impact is not normally tolerated, especially when deriving a $QS_{fw,\ eco}$ which is intended to protect against long-term exposure when recovery conditions might never actually occur.

5. The scope of protection of an EQS under the WFD is broader than that of the "acceptable concentration" in the risk assessment of pesticides. The EQS must be protective for all types of surface waters and communities, not just the type covered by a particular mesocosm or field study. We therefore need to assess whether the test system can be considered as representative for the full range of waterbodies that might be subject to pesticide exposure. Higher tier (e.g. mesocosm) studies in the context of the pesticide risk assessment are normally focused on shallow, eutrophic, waterbodies occurring in the immediate vicinity of agricultural areas. An EQS under the WFD, however, must also assure protection for waterbodies that differ significantly from this paradigm, for instance those with a wide range of flow regimes, subject to point source inputs of plant protection products (e.g. formulation plants), occurring in different climatic zones, or with different trophic status. Preferably, the available (semi-)field data should cover this wide range of water types, but in reality this is not the case and therefore the guidance presented here should be considered when deciding on the choice of the AF (see below).

6. In general, the more similar the test system is to the field situation, the higher its relevance for risk assessment and EQS setting. Differences between experimental mesocosms and the field can result in either an over- or underestimation of the response of the field ecosystem.

   - Species composition: more relevant NOECs are likely to arise when the species composition in a mesocosm is representative of that found in the field. This does not mean that the species composition in a micro- or mesocosm experiment should be exactly the same as that in the field; it is more important that a sufficient number of representatives of sensitive taxonomic groups are present, especially taxa that are expected to be sensitive given the substance's mode of action (e.g. insect larvae in a study with an insecticide that acts by disrupting moulting). Maltby *et al*. (2005) showed that taxonomy plays a more important role than habitat and geographical region in predicting the sensitivity of water organisms to pesticides with a specific toxic mode of action. Furthermore, the representativeness of the biological traits of the tested species is important. In general, vertebrates are not incorporated in mesocosm studies. If laboratory data suggest vertebrates belong to the most sensitive group, little weight should be given to a mesocosm study without vertebrates.

- Avoidance and drift: examples are known from the literature (for example, *Gammarus pulex*; see Schulz and Liess, 1999) of organisms that detect and avoid toxic substances by moving to areas with lower concentrations. Sessile organisms cannot avoid exposure. Although avoidance and drift are relevant endpoints, in general, laboratory and mesocosm studies do not accommodate avoidance reactions.

<u>Selecting an AF to apply to a mesocosm NOEC</u>

According to the REACH guidance, the AF applied to mesocosm studies or (semi-) field data will need to be reviewed on a case-by-case basis (footnote 'f' to Table 3.2), but no guidance is given with respect to the *range* of AFs to be applied. Brock et al. (2008) compared micro/mesocosm experiments for several chemicals in which long-term exposure was simulated. They estimated a geographical extrapolation factor based on the ratio of the upper and lower limit of the 95% confidence interval of NOECs for toxic effects. These factors ranged between 1.4 and 5.4. This suggests that, where there is (a) only a single model ecosystem study, and (b) sensitive taxa are included in the study of a compound with a specific mode of action, an assessment factor of 5 would account for variation in the NOECs. When additional, confirmative mesocosm studies are available, the AF may be lowered. Further discussion around the selection of AFs on mesocosm studies is to be found in Giddings et al (2002).

In determining the size of AF to be applied, the following should be considered:

- What is the overall quality of the micro- or mesocosm study/studies from which the NOEC has been derived?
- What is the relationship between the mode of action of the investigated substance and the species represented in the available micro- or mesocosm studies? Are sensitive species represented?
- Do the available micro- or mesocosm studies include vulnerable species or representatives of taxonomic groups (e.g. families, orders) of vulnerable species that are part of the aquatic ecosystems to be protected?
- Do the available micro- or mesocosm studies represent the range of flow regimes that should be protected by the EQS? Consider specific populations of species inhabiting the lotic and lentic water types to be protected.
- How representative are the mesocosm studies: do they represent the range of trophic statuses of waterbodies that should be protected by the EQS?

3.3.2 Derivation of a QS for the saltwater pelagic community ($QS_{sw,\ eco}$)

The $QS_{sw,\ eco}$ protects the saltwater ecosystem from potential chronic toxic effects. For the derivation of the $QS_{sw,\ eco}$ combined toxicity data sets (with one toxicity value per species) of marine and freshwater species may be used when the provisions for pooling data are met (see Section 3.2.3). As with estimation of the $QS_{FW,\ ECO}$, the $QS_{SW,\ ECO}$ may be derived by several different approaches:

- a deterministic approach using assessment factors applied to a critical datum,
- a probabilistic approach using SSD modelling, and

- using mesocosm data (although field and mesocosm studies are rarely available for saltwater)

3.3.2.1 Extrapolation using the AF method

The procedures for the marine effects assessment as described in the REACH guidance (ECHA, 2008) are adopted here, i.e. specific AFs for marine effects assessment (Table 3.3) are applied to the lowest credible data (critical data) to derive the $QS_{sw,\ eco}$. The AFs (Table 3.3) for deriving the $QS_{sw,\ eco}$ are higher than those used for freshwater. This is justified by the need to account for the additional uncertainties associated with extrapolation for the marine ecosystem, especially the general under-representation in the experimental dataset of specific marine key taxa and possibly a greater species diversity. As a result, the $QS_{,\ eco}$ is often more stringent than the corresponding standard derived for the freshwater environment.

Even when based on the same set of data, the $QS_{sw,\ eco}$ may differ therefore from the $QS_{fw,\ eco}$. Where data are available for additional marine taxonomic groups, the uncertainties are reduced and so the magnitude of the AF applied to a data set can be lowered (Table 3.3).

Data from studies with marine test organisms other than algae, crustaceans and fish, and/or having a life form or feeding strategy differing from that of algae, crustaceans or fish can be accepted as additional marine taxonomic groups and will allow a reduction in the AF applied (provided that the toxicity data are reliable and relevant). Marine species from taxa other than algae, crustaceans and fish include:

- Macrophyta. e.g. Sea grass (Zosteraceae)
- Mollusca. e.g. *Mytilus edulis*, *Mytulis galloprovincialis*.
- Rotifers. e.g. *Brachyonus plicatilis*.
- Hydroids (e.g. hydroids: *Cordylophora caspia*, *Eirene viridula*);
- Annelida. e.g. *Neanthes arenaceodentata*.
- Echinoderms (e.g. sea urchins: *Arbacia punctulata*, *Strongylocentrotus purpuratus*, *Strongylocentrotus droebachiensis*, *Echinocardium cordatum*, *Paracentrotus lividus, Psammechinus miliaris*, or asteroids: *Asterias rubens*).

In addition, marine organisms that belong to the taxa algae, crustaceans or fish but have a different life form or feeding strategy than the representatives in the freshwater toxicity dataset can be considered additional marine taxonomic groups and may also allow a reduction in the size of the AF:

- Macro-algae. e.g. *Enteromorpha* sp., *Fucus* sp and *Champia* sp.
- Crustaceans (including crabs) are found in both freshwater and marine water. However, crabs, for example, have a life form and feeding strategy very much different from *Daphnia* sp., which is the test organism which is nearly always present in the freshwater toxicity data set, or other common freshwater crustaceans. Thus, such species can be used to reduce the AF where other crustaceans may not. Examples of crabs used in toxicity tests include *Cancer magister*, *Cancer pagurus*, *Carcinus maenas* and *Cancer anthonyi*.

Table 3.3 Assessment factors to be applied to aquatic toxicity data for deriving a $QS_{sw, eco}$

Data set	Assessment factor
Lowest short-term L(E)C50 from freshwater or saltwater representatives of three taxonomic groups (algae, crustaceans and fish i.e. base set) of three trophic levels	10,000 [a)]
Lowest short-term L(E)C50 from freshwater or saltwater representatives of three taxonomic groups (algae, crustaceans and fish) of three trophic levels, plus two additional marine taxonomic groups (e.g. echinoderms, molluscs)	1000 [b)]
One long-term result (e.g. EC10 or NOEC) (from freshwater or saltwater crustacean reproduction or fish growth studies)	1000 [b)]
Two long-term results (e.g. EC10 or NOEC) from freshwater or saltwater species representing two trophic levels (algae and/or crustaceans and/or fish)	500 [c)]
Lowest long-term results (e.g. EC10 or NOEC) from three freshwater or saltwater species (normally algae and/or crustaceans and/or fish) representing three trophic levels	100 [d)]
Two long-term results (e.g. EC10 or NOEC) from freshwater or saltwater species representing two trophic levels (algae and/or crustaceans and/or fish) plus one long-term result from an additional marine taxonomic group (e.g. echinoderms, molluscs)	50
Lowest long-term results (e.g. EC10 or NOEC) from three freshwater or saltwater species (normally algae and/or crustaceans and/or fish) representing three trophic levels + two long-term results from additional marine taxonomic groups (e.g. echinoderms, molluscs)	10 [e)]

Notes:

General note:

Evidence for varying the assessment factor should in general include a consideration of the availability of data from a wider selection of species covering additional feeding strategies/ life forms/ taxonomic groups other than those represented by the algal, crustacean and fish species (such as echinoderms or molluscs). This is especially the case, where data are available for additional taxonomic groups representative of marine species. More specific recommendations with regard to issues to consider in relation to the data available and the size and variation of the assessment factor are indicated below.

When there are indications that a substance may cause adverse effects via disruption of the endocrine system of mammals, birds, aquatic or other wildlife species, it should be considered whether the assessment factor would also be sufficient to protect against effects caused by such a mode of action, or whether an increase of the factor would be appropriate.

a) The use of a factor of 10,000 on short-term toxicity data is a conservative and protective factor and is designed to ensure that substances with the potential to cause adverse effects are identified. It assumes that uncertainties identified above make a significant contribution to the overall uncertainty. For any given substance there may be evidence that this is not so, or that one particular component of the uncertainty is more important than any other. In these circumstances it may be necessary to vary this factor. This variation may lead to a raised or lowered assessment factor depending on the evidence available. Except for substances with intermittent release, as defined in ECHA (2008), under no circumstances should a factor lower than 1000 be used in deriving a $QS_{sw, eco}$ from short-term toxicity data.

Evidence for varying the assessment factor could include one or more of the following:

- evidence from structurally similar compounds which may demonstrate that a higher or lower factor may be appropriate.
- knowledge of the mode of action as some substances by virtue of their structure may be known to act in a non-specific manner. A lower factor may therefore be considered. Equally a known specific mode of action may lead to a higher factor.
- the availability of data from a variety of species covering the taxonomic groups of species across at least three trophic levels. In such a case the assessment factors may only be lowered if multiple data points are

available for the most sensitive taxonomic group (i.e. the group showing acute toxicity more than 10 times lower than for the other groups).
Variation from an assessment factor of 10,000 should be fully reported with accompanying evidence.

b) An assessment factor of 1000 is applied where data from a wider selection of species are available covering additional taxonomic groups (such as echinoderms or molluscs) other than those represented by algal, crustacean and fish species; if data are at least available for two additional taxonomic groups representative of marine species.
An assessment factor of 1000 is applied to a single long-term result (e.g. EC10 or NOEC) (freshwater or saltwater crustacean or fish) if this result was generated for the taxonomic group showing the lowest L(E)C50 in the short-term algal, crustacean or fish tests.
If the only available long-term result (e.g. EC10 or NOEC) is from a species which does not have the lowest L(E)C50 in the short-term tests, applying an assessment factor of 1000 is not regarded as protective of other more sensitive species.. Thus, the hazard assessment is based on the short-term data with an assessment factor of 10,000 applied. However, normally the lowest $QS_{sw,\ eco}$ should prevail.
An assessment factor of 1000 can also be applied to the lowest of the two long-term results (e.g. EC10 or NOEC) covering two trophic levels (freshwater or saltwater algae and/or crustacean and/or fish) when such results (e.g. EC10 or NOEC) have not been generated for the species showing the lowest L(E)C50 of the short-term tests.
This should not apply in cases where the acutely most sensitive species has an L(E)C50-value lower than the lowest long term value. In such cases the $QS_{sw,\ eco}$ might be derived by applying an assessment factor of 1000 to the lowest L(E)C50 of the short-term tests.

c) An assessment factor of 500 applies to the lowest of two long term results (e.g. EC10 or NOEC) covering two trophic levels (freshwater or saltwater algae and/or crustacean and/or fish) when such results have been generated covering those trophic levels showing the lowest L(E)C50 in the short-term tests with these species. Consideration can be given to lowering this factor in the following circumstances:
- It may sometimes be possible to determine with a high probability that the most sensitive species covering fish, crustacea and algae has been examined, that is that a further longer-term result (e.g. EC10 or NOEC) from a third taxonomic group would not be lower than the data already available. In such circumstances an assessment factor of 100 would be justified;
- a reduced assessment factor (to 100 if only one short-term test, to 50 if two short-term tests on marine species are available) applied to the lowest long term result (e.g. EC10 or NOEC) from only two species may be appropriate where:
- short-term tests for additional species representing marine taxonomic groups (for example echinoderms or molluscs) have been carried out and indicate that these are not the most sensitive group, and;
- it has been determined with a high probability that long-term results (e.g. EC10 or NOEC) generated for these marine groups would not be lower than that already obtained. This is particularly important if the substance does not have the potential to bioaccumulate.
An assessment factor of 500 also applies to the lowest of three long term results (e.g. EC10 or NOEC) covering three trophic levels, when such results have not been generated from the taxonomic group showing the lowest L(E)C50 in short-term tests. This should, however, not apply in the case where the acutely most sensitive species has an L(E)C50 value lower than the lowest long term result (e.g. EC10 or NOEC) value. In such cases the $QS_{sw,\ eco}$ might be derived by applying an assessment factor of 1000 to the lowest L(E)C50 in the short-term tests.

d) An assessment factor of 100 will be applied when longer-term toxicity results (e.g. EC10 or NOEC) are available from three freshwater or saltwater species (algae, crustaceans and fish) across three trophic levels. The assessment factor may be reduced to a minimum of 10 in the following situations:
- where short-term tests for additional species representing marine taxonomic groups (for example echinoderms or molluscs) have been carried out and indicate that these are not the most sensitive group, and it has been determined with a high probability that long-term results (e.g. EC10 or NOEC) generated for these species would not be lower than that already obtained;
- where short-term tests for additional taxonomic groups (for example echinoderms or molluscs) have indicated that one of these is the most sensitive group acutely and a long-term test has been carried out for that species. This will only apply when it has been determined with a high probability that additional long term results (e.g. EC10 or NOEC) generated from other taxa will not be lower than the long term results already available.

e) A factor of 10 cannot be decreased on the basis of laboratory studies only. It may be permitted if justified by mesocosm or field data.

3.3.2.2 Extrapolation using the SSD approach for deriving an $QS_{sw,\ eco}$

In principle, for quality standards referring to saltwater, the same approach as described in Section 3.3.1.2 can be used. **Marine and freshwater toxicity data are combined, unless evaluation of the freshwater and saltwater toxicity data shows that the data can not be pooled. In such a case, the combined data set can be used to establish a common SSD that is relevant for both freshwater and saltwater effects assessment (Section 3.2.3).**

If a combined dataset is used, the AF of 1-5 applied to the HC5 estimated from the SSD should only be applied for coastal and territorial waters if the data set used to establish the SSD comprises long-term NOECs or EC10s for at least 2 additional typically marine taxonomic groups, other than fish, crustaceans and algae. When there are no additional marine taxonomic groups in the dataset, an AF of 10 is applied **in addition to** the AF of 1-5 to deal with residual uncertainty. This is analogous to the additional AF of 10 for $QS_{sw,\ eco}$ derivation in the deterministic method. When only one additional marine taxonomic group (as defined above) is present in the dataset, an AF of 5 is used **in addition to** the AF of 1-5. This is consistent with the provisions of REACH for marine effects assessment where a larger AF is recommended to cover the increased uncertainty resulting from the larger diversity of marine ecosystems and the limited availability of effects data for marine life forms.

When freshwater and saltwater datasets cannot legitimately be combined, constructing an SSD with ecotoxicological data for marine organisms has the same requirements regarding the quantity and quality of input data as described in Section 3.3.1.2. However, taxa that are poorly represented in the marine environment, like insects and higher plants, may be replaced by more typical marine taxa such as, e.g., molluscs, echinoderms, annelids, specific marine species of crustaceans or coelenterata. This means that the additional marine species are automatically present in this non-combined dataset, and no additional AF is needed in addition to the AF of 1-5 applied to the HC5.

3.3.2.3 Use of simulated ecosystem studies for deriving an $QS_{sw,\ eco}$.

Saltwater mesocosm or field studies can be used for $QS_{sw,\ eco}$ derivation and the guidance for the freshwater situation (Section 3.3.1.3) also applies here. Marine mesocosm data often apply solely to small pelagic organisms such as calanoid copepods, and such studies will therefore seriously under-represent many taxa e.g. benthic epifauna. Thus, it should be taken into account how representative the marine mesocosm study is, when determining the assessment factor to be applied and which standard will be selected as final $QS_{sw,\ eco}$ (ie AF method, SSD method or mesocosm).

Freshwater ecosystem studies could be used for marine effects assessment. However, in such a case an extra assessment factor of 10 should be applied to derive the $QS_{sw,\ eco}$ in addition to the factor applied for the derivation of the $QS_{fw,\ eco}$. However, preference may be given to the deterministic or SSD approach, if the laboratory studies do contain additional marine taxonomic groups.

3.4 Deriving a MAC-QS

For deriving a MAC-QS, the REACH guidance for effects assessment of substances with intermittent release is adopted. If enough short-term EC50/LC50 data are available to construct an SSD this extrapolation approach should be used as well as the deterministic approach, as detailed in Section 3.4.1. Relevant mesocosm studies may be available (especially for pesticides) and these can be used to derive the final MAC-EQS, as described in Section 3.4.1.3 Field monitoring data are unlikely to have a useful part to play in informing the estimation of a MAC-QS because they typically describe changes in biology arising from long-term exposure, so they are more relevant to AA derivation. Any discrepancies in the results obtained with the different extrapolation approaches need to be discussed and the decision for the preferred MAC-QS derivation justified.

Predicted data using QSAR models or 'read across' approaches can be used as supporting information but not as a basis for the derivation of a QS.

Under some circumstances, a MAC-QS may not be justified, eg for substances that exert only sub-lethal effects after prolonged exposure. Steroid oestrogens would be one example.

3.4.1 Deriving a MAC-QS for the freshwater pelagic community ($MAC\text{-}QS_{fw,\ eco}$)

3.4.1.1 Extrapolation using the AF method

For exposures of short duration, acute toxicity data are relevant and the AFs to use are given in Table 3.4. Combined acute toxicity data sets for freshwater and saltwater species may be used if the data can be pooled (Section 3.2.3). Where there are at least 3 short term tests using species from three trophic levels (base set), an AF of 100 applied to the lowest L(E)C50 is normally used to derive the $MAC\text{-}QS_{fw,\ eco}$. Under some circumstances an AF less than 100 may be justified, e.g.

For substances which do not have a specific mode of action (e.g. acting by narcosis only), if the available data show that interspecies variations are low (standard deviation of the log transformed L(E)C50 values is < 0.5) an AF<100 may be appropriate.

For substances with a specific mode of action, the most sensitive taxa can be predicted with confidence. Where representatives of the most sensitive taxa are present in the acute dataset, an AF <100 may again be justified.

Where there is a good understanding of the relationship between acute and chronic toxicity (e.g. acute: chronic ratios for a range of species), the AF used to estimate the MAC may be selected to reflect this, or at least to ensure the MAC is not lower than the AA.

In no case should an AF lower than 10 be applied to a short-term L(E)C50 value.

Table 3.4 Assessment factors to derive a $MAC\text{-}QS_{fw,\ eco}$.

Toxicity data	Additional information	Assessment factor
Base set not complete	–	– [a)]
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae)		100
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae)	Acute toxicity data for different species do not have a higher standard deviation than a factor of 3 in both directions[b)] OR known mode of toxic action and representative species for most sensitive taxonomic group included in data set	10[c)]

Notes.

a) When the base set is not complete, a $MAC\text{-}QS_{fw,\ eco}$ cannot be derived. It should be considered if the base set could be completed with non-testing data (See Section 2.6.). Non-testing data should not be used as critical data in the derivation of the $MAC\text{-}QS_{fw,\ eco}$.
b) To assess the span of the acute toxicity data, all reliable acute toxicity data collected are used, with a minimum of three LC50 or EC50 values, for species representing each of the base set

trophic levels (algae, *Daphnia*, fish). If the standard deviation of the log transformed L(E)C50 values is < 0.5, an assessment factor of 10 could be applied, otherwise an assessment factor of 100 should be applied.
c) Lowest assessment factor to be applied.

For the specific group of insect growth regulators, acute data do not give information on delayed effects and cannot be used for derivation of the MAC-QS because the test duration is too short to detect long-term effects of a single peak of exposure. In general, for compounds with a (very) high acute to chronic ratio, the possibility of delayed effects resulting from a single peak should be considered and the chronic data should be consulted.

3.4.1.2 Extrapolation using the SSD approach

The same approach as described in Section 3.3.1.2 can be applied. However, instead of long-term NOECs, acute L(E)C50 data are the appropriate input data. Combined acute toxicity data sets for marine and freshwater species may be used, if, after evaluation of the freshwater and saltwater toxicity data, the data can be pooled (Section 3.2.3).

The resulting HC5 refers to a 50% effect concentration for 5% of the species, not a no-effect concentration for 5% of the species, because the input of the SSD are L(EC)50 values. An AF is therefore needed to extrapolate to the MAC-$QS_{fw,\ eco}$.(to account for the effects to no-effects extrapolation. This AF should normally be 10, unless other lines of evidence (e.g. acute EC50:acute EC10 (or NOEC) ratios are narrow, or criteria presented in Section 2.9) suggest that a higher or lower one is appropriate.

3.4.1.3 Use of simulated ecosystem studies in deriving a MAC-$QS_{fw,\ eco}$

General guidance regarding the derivation of a QS from micro/mesocosm studies is given in Section 2.9.2. For determining the MAC-$QS_{fw,\ eco,}$ experiments simulating short-term exposure are most relevant.

For substances that do not dissipate quickly, the MAC-$QS_{fw,\ eco}$ values should be based on measured time weighted average (TWA) concentrations, and biological effects determined over a time span that is representative for most acute toxicity studies (i.e. 48–96 h). Measurement of exposure concentrations should take account of both spatial and temporal changes within the mesocosm. Furthermore it is important to determine which part of the exposure profile is most relevant. For example, if the peak concentration causes the effect, the actual initial concentration in the cosms is relevant, as well as the concentration at various time intervals (hours in the case of rapidly-dissipating compounds). An understanding of the exposure phase that is most relevant to any toxic effects (the Ecologically Relevant Concentration, ERC) is important because it (a) influences how the assessor interprets the mesocosm data and (b) how the resulting MAC-EQS should be expressed (e.g. a 24h or a 1 month peak). Such properties must be drawn to the attention of policy makers because it will affect how compliance is assessed, or indeed whether a MAC-EQS for compliance monitoring can be feasibly implemented at all. Such an EQS may still have value for planning purposes.

3.4.1.4 Application of an assessment factor to the threshold concentration from a mesocosm to derive a MAC-$QS_{fw,\ eco}$

For substances for which the mode of action and/or the most sensitive taxa are known, an assessment factor ranging from 1-5 is applied to the lowest threshold concentrations from the available mesocosms, with the same considerations as given for the derivation of the $QS_{fw,\ eco}$ (Section 3.3.1.3).

Brock et al. (2006, 2008) compared the outcome of 6 mesocosm studies with the insecticides chlorpyrifos and lambda-cyhalothrin that simulated short-term exposure. They looked at the spread

(= ratio of the upper and lower limit of the 95% confidence interval) of the threshold concentrations for toxic effects. The spreads were 2.9 for chlorpyrifos and 2.6 for lambda cyhalothrin. They concluded that for a substance with a specific mode of toxic action, an AF of 3 can be applied, provided that the study is well-performed. This can be lowered depending on the number of available mesocosms.

3.4.2 Derivation of a MAC-QS for the saltwater pelagic community (MAC-QS$_{sw, eco}$)

The MAC-QS for coastal and territorial waters (MAC-QS$_{sw, eco}$) is intended to protect the saltwater ecosystem from potential acute toxic effects exerted by transient exposure to toxic chemicals. These peak concentrations can, for instance, occur at fish farms, in connection with batch effluent releases on the ebb tide, or when a ship is cleaned. For transitional waters, the guidance in Section 2.4.4.1 is relevant.

To derive a MAC-QS for saltwater, the same approach as described for the QS$_{sw, eco}$ can be applied in principle. However, instead of using long-term NOECs, acute L(E)C50 data will serve as input data. Combined acute toxicity data sets for marine and freshwater species may be used, if analysis shows that the data can be pooled (Section 3.2.3.).

3.4.2.1 Extrapolation using the AF method

As in the derivation of the QS$_{sw, eco}$, when additional information on the sensitivity of specific saltwater taxonomic groups is available, the additional assessment factor of 10 can be lowered to 5 (one additional marine taxonomic group) or 1 (two or more additional marine taxonomic groups), see Section 3.2 for explanation of what is meant by 'additional marine taxonomic groups'. The AFs to be used when deriving a MAC-QS$_{sw, eco}$ are given in Table 3.5.

Table 3.5 Assessment factors to derive a MAC-QS$_{sw, eco}$

Toxicity data	Additional information	Assessment factor
Base set not complete	–	– a)
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae)		1000
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae)	Acute toxicity data for different species do not have a higher standard deviation than a factor of 3 in both directions b) OR known mode of toxic action and representative species for most sensitive taxonomic group included in data set	100
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae) + one short-term L(E)C50 from an additional specific saltwater taxonomic group		500
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae) + one short-term L(E)C50 from an additional specific saltwater taxonomic group	Acute toxicity data for different species do not have a higher standard deviation than a factor of 3 in both directions b) OR known mode of toxic action and representative species for most sensitive taxonomic group	50

	included in data set	
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae) + two or more short-term L(E)C50s from additional specific saltwater taxonomic groups		100
At least one short-term L(E)C50 from each of three trophic levels of the base set (fish, crustaceans and algae) + two or more short-term L(E)C50s from additional specific saltwater taxonomic groups	Acute toxicity data for different species do not have a higher standard deviation than a factor of 3 in both directions[b)] OR known mode of toxic action and representative species for most sensitive taxonomic group included in data set	10[c)]

Notes.

a) When the base set is not complete, a MAC-$QS_{sw,\ eco}$ cannot be derived. It should be considered if the base set could be completed with non-testing data(See Section 6). Non-testing data should not be used as critical data in the derivation of MAC-$QS_{sw,\ eco}$.

b) To assess the span of the acute toxicity data, all reliable acute toxicity data collected are used, with a minimum of three LC50 or EC50 values, for species representing each of the base set trophic levels (algae, *Daphnia*, fish). If the standard deviation of the log transformed L(E)C50 values is < 0.5, an assessment factor of 10 should be applied, otherwise an assessment factor of 100 should be applied.

c) Lowest assessment factor to be applied.

3.4.2.2 *Extrapolation using SSD approach*

The same approach as described in Section 3.3.1.2 can be applied. However, instead of long-term NOECs and EC10s, acute L(E)C50 data (one value per species) are the appropriate input data. Combined acute toxicity data sets for marine and freshwater species may be used, if after evaluation of the freshwater and saltwater toxicity data, the data can be pooled (Section 3.2.3). This would result in the same HC5 for freshwater and saltwater assessments but, given the greater uncertainties in extrapolation for the marine environment, a larger AF is required than that used to deal with residual uncertainty in the freshwater MAC-QS.

For the MAC-$QS_{fw,eco}$, the default AF to be used on the HC5 is 10. However when the datasets for fresh- and saltwater are combined, for a MAC-$QS_{sw,\ eco}$ derivation an additional assessment factor of 10 is used to deal with residual uncertainty, resulting in a total AF of 100. In line with the derivation of the $QS_{sw,\ eco}$, when one typically marine taxonomic group is present in the dataset, an additional AF of 5 is used on top of the default AF of 10 and when two typically marine taxonomic groups are present, no additional assessment factor is necessary. When separate datasets are used to calculate an SSD for MAC-QS derivation, it follows that the necessary amount of data for marine taxa are available to calculate an SSD, and an additional AF on top of the default AF of 10 is no longer necessary.

3.4.2.3 *Use of simulated ecosystem studies in deriving a MAC-$QS_{sw,\ eco}$*

For the derivation of the MAC-$QS_{sw,\ eco}$ the highest initial concentration in a simulated ecosystem study that caused no ecologically relevant effects may be used. Further guidance regarding the derivation of the MAC-QS from micro/mesocosm studies is given in Section 2.9.2. Freshwater mesocosms should not be used in the derivation of an MAC-$QS_{sw,\ eco}$.

3.5 Deriving EQSs for metals

Many of the principles outlined below also apply to all naturally occurring substances, including metalloids.

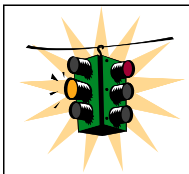
3.5.1 *Metal specific mechanisms of action*

Advances in our understanding of the physiological processes that control the uptake of inorganic metals and toxicity in aquatic systems indicate that for most metals (e.g. Cd, Cu, Zn, Ni, Pb, Ag), the primary target tissues are 'respiratory organs (gills or gill-like structures)' at the interface between the organism and the waterbody. Indeed, *bioavailable* metal species (especially free metal ions) have a high affinity for negative binding sites at gills and gill-like surfaces. Some metals, such as copper and zinc, are taken up and eliminated through the sodium, potassium or calcium channels of the cellular membranes, and are often mediated by specific transport systems (e.g. cation ATPases)[11]. Excessive uptake of metal ions can, thereby, cause impairment of the physiological gill functions; the primary toxicity symptom is often an inhibition of active ion transport (Na^+, K^+, Cl^-) that results in ionic imbalances ultimately leading to toxicity (e.g. ICMM fact sheet No. 7; Pagenkopf, 1983; Playle et al, 1992; Di Toro et al., 2001; Grosell et al., 2002; Landner and Reuther, 2004).

The understanding of the interactions between metal species, water characteristics and ionoregulatory impairment of the respiratory organs, as well as acute and chronic toxicity, has formed the basis for metal bioavailability models. The potential for additional toxicity through dietary intake also has been assessed for a range of metals (Cu, Zn, Ni), and the data from laboratory settings (waterborne versus dietborne toxicity, assessment of potential for secondary posioning), mesocosms contaminated with metals (ECI, 2008) and field exposure assessments (Crane *et al*., 2007; Tipping *et al*., 2007) demonstrated that metal EQSs derived from water-only exposures and the application of metal bioavailability models are, at least for the metals investigated, also protective for dietborne exposures as well as of ecosystem structures and functioning.

Research data on metal speciation, metal bioavailability and metal ecotoxicity have been applied in the EU risk assessments for cadmium, zinc, nickel and copper and in the context of the WFD for cadmium (hardness correction)[12]. The models created through such work have allowed a reduction in the intraspecies variability of several orders of magnitude by the normalisation of acute and chronic toxicity data and they adequately predict metal toxicity within a factor of 2.

3.5.2 *Generic guidance on setting quality standards for metals in water and sediments*



Look Out!

In case of use of bioavailability correction in deriving a QS, the following consideration should be also taken into account:

- Use a QS reference that protects at least 95% of the surface waters instead of 90% in order to follow a precautionary approach.
- Ensure that the use of BLM in upstream parts of a river basin should

[11] Other metals and metalloids may be associated with other uptake mechanisms; for example, arsenic and polonium are often associated with the uptake of phosphorus.

[12] Chronic biotic ligand models (BLMs) have been built and validated in the laboratory and in the field for several metals (Zn, Ni, Cu and to some extent Cd), and the models allow the prediction of chronic metal toxicity in a wide range of waters worldwide. Acute BLMs are available for a much wider range of metals.

	not lead to environmental problems in downstream inland-, transitional- or marine waters, either in the water phase and/or in the sediment and/or in biota due to a changes in bioavailability. • Investigate trend monitoring to evaluate the accumulation of pollutants in sediment. • Ensure that the efforts to reduce emissions (source oriented track) by improving techniques are not diminished. • Reconsider the applicability of bioavailability corrections by evaluating the state of play, for instance every 6 years.

The following generic guidance relates to deriving QSs for metals in water and sediments. For guidance on deriving standards for biota and secondary poisoning, see Section 4.6; for more detailed guidance on sediments, see Section 5.2.2, for an explanation of the specific temporary standards used to derive an EQS see appendix 6

The methods used to incorporate availability/bioavailability corrections will depend on the availability of data and models and metal-specific considerations (e.g. importance of metal–DOC binding in aquatic systems, and availability of a metal-specific biotic ligand model (BLM)).

Figure 3.1 and the text below outline the different steps that allow QSs for metals to be derived for freshwater, marine and benthic compartments in a way that accounts for (bio)availability and background concentrations. The guidance provided is focused on the setting of an AA-EQS, based on chronic ecotoxicity data (NOECs/EC10s) and chronic bioavailability models. A similar approach can nevertheless also be followed when a MAC-EQS is to be derived, based on acute data (EC50s) and acute BLMs.

Because of the differences in iono- and osmoregulatory environments, there may be differences in the toxicity of a substance, and especially of a metal, to freshwater and saltwater species, and it is important to check for such differences. Thus, data should only be pooled if the sensitivity of saltwater species cannot be shown to be significantly different from the sensitivity of freshwater species. Availability corrections for freshwater cannot currently be directly translated to saltwater conditions; therefore, pooling of freshwater and saltwater data should be avoided when availability corrections have been applied.

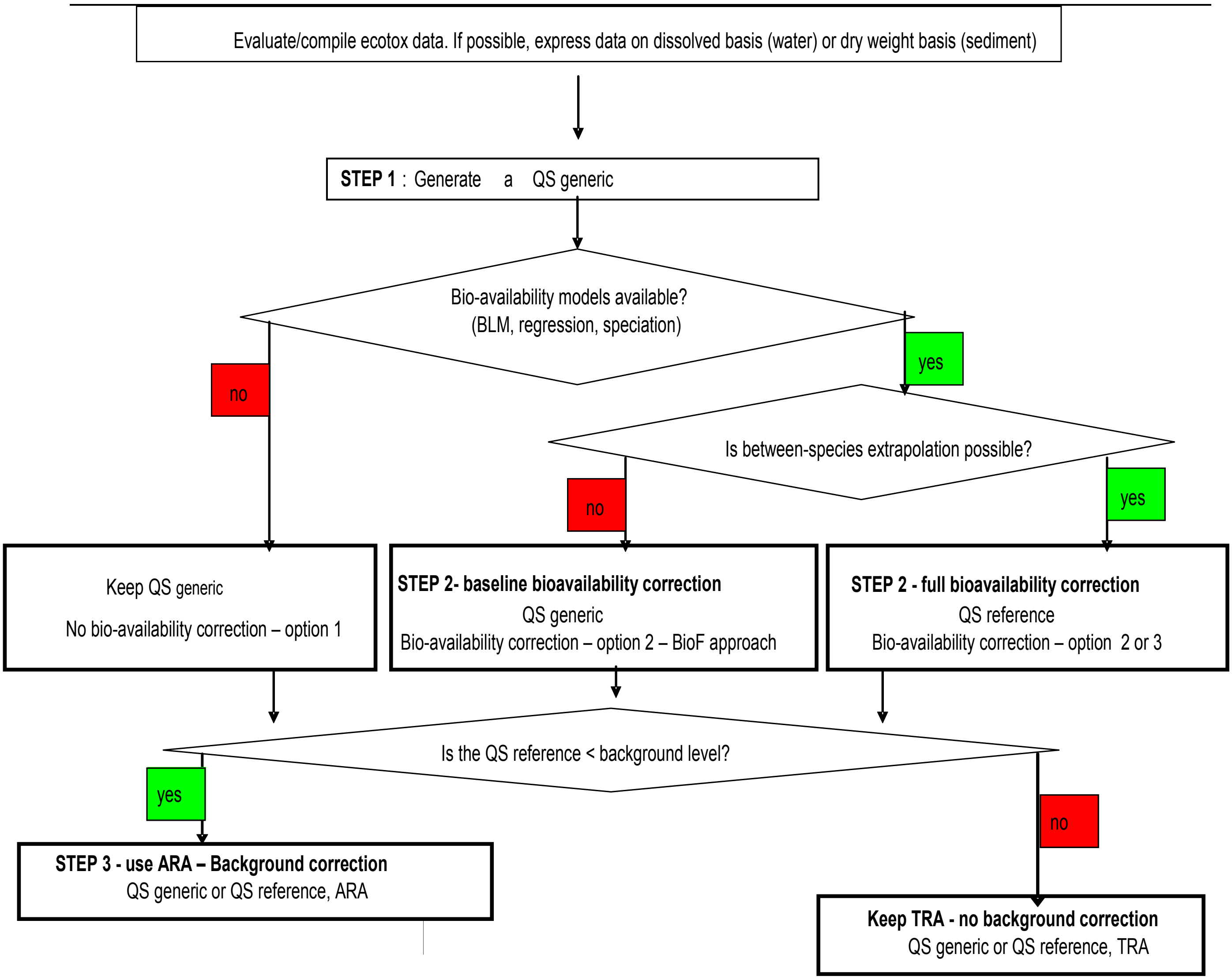


Figure 3.1 Recommended general scheme for deriving QSs and the consideration of bioavailability and background corrections

TRA = total risk approach, ARA = added risk approach (The ARA should not be used in combination with bioavailability correction)

3.5.2.1 Deriving the QS for freshwater

There are three main steps in deriving the QS which are outlined in Figure 3.1. These three steps are the development of a 'generic' QS using ecotoxicity data (Step 1), a QS using bioavailability considerations (Step 2) and a QS accounting for natural backgrounds (Step 3).

The available toxicity data first needs to be compiled and evaluated (See Section 2.6.2.). The quality criteria to be used are the same as those used for organic substances, but some metal-specific issues are to be considered as outlined below.

STEP 1

For the water compartment the first step is simply to express the toxicity data on the basis of the dissolved concentration, after filtration using 0.45-µm filters. Any matrix effects related to the filtration of samples should be assessed[13].

If dissolved concentrations in the test media are not given, the relationship between the total and dissolved metal concentrations in ecotoxicity media should be checked if possible, taking the following into account:

- For some metals and soluble metal salts (e.g. Zn, Cu) tested in artificial media (and especially when tested in semistatic or flow-through systems), no additional conversion into a dissolved fraction has to be applied because there is evidence that all the metal is in solution[14].
- For other less soluble metals, however (e.g. lead), an additional step to convert the total concentration into a dissolved fraction is needed. An analysis of relevant solubility products for the relevant metal salts or the ratio of matched dissolved and total metal monitoring data can inform this estimation of dissolved metal concentrations. Solubility products may be found in, for example, the *Handbook of Chemistry and Physics*, 86th edition, CRC Press.
- If test media are natural waters, total concentrations from individual experiments can be recalculated to dissolved concentrations using partition coefficients (taking binding to DOC into account). It has to be borne in mind, however, that the calculated dissolved concentrations for several metals may be uncertain since the partition coefficient (K_p) has been found to vary by several orders in magnitude.

Once data have been collated derive a $QS_{generic,fw}$ based on extrapolation from ecotoxicity data as described in earlier sections. This should be based on conditions of high bioavailability and on a total risk approach (i.e. backgrounds are not accounted for), thereby adopting a reasonable worst-case approach, as outlined below.

STEP 2 - Bioavailability correction

The influence of the key abiotic factors on metal toxicity needs to be investigated and quantified. The simplest (bio)availability correction is the application of **speciation models**. In cases where speciation models (e.g. WHAM (Tipping *et al*., 1991); MINTEQA2, NICCA (Kinniburgh *et al*., 1999) are available, (bio)availability corrections can be considered[15]. For some metals, models have been developed that go beyond metal speciation and these explain the relationships between abiotic factors and metal bioavailability/toxicity. These are toxicity-based models ranging from

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[13] The handling of the samples should not affect the dissolved metal fraction in any way; contamination during sampling and filtration should be avoided by using ultra-pure equipment. All laboratory equipment, such as glassware, plastics, etc., must be rinsed with a dilute acid (e.g. 1% HNO_3 solution) and demineralised water before use in order to remove all metals adsorbed. Acidification should be done after filtration. Appropriate quality assurance measures (e.g. procedural blanks, assessment of the matrix effect) are recommended.

[14] In most laboratory test systems, the suspended solids are low and the dissolved to total ratio is very high, typically 95% or greater. Organic particles (e.g. from faeces and food) that appears in the test systems throughout the test, do not significantly affect the dissolved metal concentration in the test when semistatic or flow-through systems are used. Solubility products may be found in, for example, the *Handbook of Chemistry and Physics*, 86th edition, CRC press.

[15] Most often this is the free metal ion, but it should be noted that the free ion is not necessarily the best predictor for all metals, and other metal species, such as neutral species (e.g. AgCl, HgS) and anionic species (e.g. SeO^{2-}, AsO_4^{2-}), may contribute to the observed toxicity (Campbell, 1995).

simple **regression models** (e.g. Cd hardness function) to the more-comprehensive **BLMs**[16] for copper (Santore *et al*., 2001; De Schamphelaere and Janssen, 2002 and 2004; De Schamphelaere *et al*., 2002 and 2003b), nickel (Keithly *et al*., 2004; Hoang *et al*., 2004), silver (Paquin *et al*. 1999) and zinc (Heijerick *et al*., 2002a; Heijerick *et al*., 2002b)) as applied in environmental risk assessments. The use of these models could be considered for deriving QSs under the WFD.

Where toxicity in laboratory experiments is expressed in terms of dissolved metal concentrations and **speciation models**, **chronic regression models** (e.g. Cd hardness correction) or **BLMs** have been developed and validated for the metal/metal compounds of concern, it is recommended that the no observed effect concentrations (NOECs) and/or the effect concentrations for 10% of the tested species (EC10) are expressed on a 'bioavailable' basis (free metal ion concentrations if speciation models are used; normalised dissolved metal concentrations when regression models and BLMs are used).

Bioavailability models should, however, only be applied within their development/validation domains. The ranges applicable to the models, such as those for pH, hardness (H) and DOC, should therefore be specified in the manuals of the models that are used. In other cases, the use of such bioavailability models is allowed on a case-by-case basis only when strong scientific arguments can be formulated to support their application.

For bioavailability to be incorporated into compliance checking, the relevant physicochemical parameters of the investigated site/region (for example pH_{site}, H_{site}, DOC_{site}) affecting metal bioavailability need to be gathered and checked against the applicability domain of the bioavailability model. Site-specific physicochemical parameters are preferred, but if these are not available, information from adjacent sites or similar eco-regions can be used.

The incorporation of (bio)availability into the QS means that compliance monitoring must also be based on (bio)available concentrations. Details are given below.

<u>Implementing a bioavailability based EQS</u>

The following options can be used to correct for availability/bioavailability and for compliance checking (see also Figure 3-1):

Option 1: If there is no relationship between the abiotic factors and toxicity the only viable option is implementing a $QS_{generic,fw}$ as the AA-EQS based, if possible on the lowest species-specific geometric mean EC10s and/or NOECs or SSD approaches as described in Appendix 1. Compliance monitoring is then simply based on dissolved concentrations of metals.

If a bioavailability based approach can be adopted then there are two ways of implementing the QS.

Option 2: The first tier consists of comparing the monitoring results for the dissolved metal from a particular region or site (site-specific C_{TRA}) with the $QS_{reference,fw}$ value.

This $QS_{reference,fw}$ should in principle be protective for all waterbodies that may be monitored. Where possible, the toxicity data should be normalised to a well-defined 'reference' condition that is based on a reasonable worst case (to ensure all waterbodies are protected). Different options are possible to define a reference condition and thus to derive a $QS_{reference,fw}$.

[16] The BLM mathematically integrates the interaction of a trace metal with solution phase ligands to predict its speciation and its subsequent interaction with receptor sites (the biotic ligand) on the organism (ICMM fact sheet No. 7).

Examples of this may be:

- Use the relevant 10th or 90th percentile (depending on parameter) of the bioavailability parameters in Europe, e.g. if DOC is an important parameter, the DOC level used should correspond to the lower 10th percentile of DOC concentrations found across Europe. Unrealistic scenarios induced by combining parameters (e.g. pH, hardness) need to be avoided.
- Use conditions that apply to a sensitive eco-region or river representative of a reasonable worst case of the area to be protected by the $QS_{reference,fw}$.
- Considering that ecotoxicity tests are usually carried out under conditions that maximise bioavailability, an alternative option would be to use the $QS_{generic,\ fw}$, (non-normalised QS), as the $QS_{reference,\ fw}$. This alternative has the disadvantage that the water conditions in ecotoxicity tests are variable and, thus, the actual boundaries of the $QS_{reference,\ fw}$ water conditions are not well defined or would have to be obtained indirectly from model calculations. However, this option allows a common approach to setting $QS_{reference,\ fw}$ for metals, irrespective of whether bioavailability models are available or not (see Option 1).
  To avoid the situation in which some EU countries have waterbodies that are unprotected by the $QS_{reference,\ fw}$, the assessor should also define, when publishing the $QS_{reference,\ fw}$, the boundaries of the water conditions for which the $QS_{reference,\ fw}$ is derived. If the physicochemical conditions of a specific river basin fall outside the $QS_{reference}$ protection zone (e.g. DOC and/or pH values of <10th percentile of Europe or the most-sensitive eco-region), but inside the BLM developed/validated boundaries; then to ensure protection of the ecosystem, for each of these sites, a $QS_{site\text{-}specific,\ fw}$ may be derived and assessed against the monitoring data for compliance. If the physico-chemical conditions of the site fall outside of the BLM boundaries the $QS_{generic,\ fw}$ is applied.

Compliance is achieved when measured concentrations are less than the $QS_{reference,\ fw}$ value. If the $QS_{reference,\ fw}$ value is exceeded (bearing in mind that the EQS derived from this value may be expressed as an annual average, in which case several samples taken over the period defined in the standard contribute to the decision about compliance or failure), then a (bio)availability factor (BioF) will be applied to the monitoring data C_{TRA}. The BioF is based on a comparison between the expected bioavailability at the reference site and that relating to site-specific conditions.

Option 3: This is identical to that described in Option 2 except that bioavailability correction is applied to the QS instead of the monitoring data. The end result is the same but Option 3 results in a site-specific QS, which might be preferable in some cases. If the $QS_{reference}$, fw is exceeded then a site-specific QS is derived relevant to the site-specific conditions ($QS_{site\text{-}specific,\ fw}$), which is assessed against the monitoring data for compliance. Effectively, (bio)availability is accounted for in the QS rather than in the monitoring data – the reverse of Option 2.

Options 2 and 3 only differ in that they apply the bioavailability correction to the exposure and effects side of the assessment respectively.

The preferred choice of Options 1 to 3 and practice for site-specific QS and BioF calculations depends on (1) the availability of suitable models (see Criterion 1 below), (2) the extent to which it is possible to read across between species for which a BLM has been developed and species for which a BLM has not been developed (Criterion 2) and (3) preferences from policy/administrative points of view.

Criterion 1: The availability of models

If the (bio)availability correction relates to chemical availability (e.g. speciation modelling), it is not organism-specific because it applies to the medium in which all organisms are living. In such cases, if a quantitative relationship between the parameter (e.g. [M^{2+}]) and ecotoxicity (NOECs/EC50s) has been developed, the observed quantitative relationship can be applied to all ecotoxicity data selected for EQS derivation, and a $QS_{reference,\ fw}$ corrected for availability can be derived as described under one of Options 2 or 3.

If models are available that involve bioavailability correction (e.g. BLMs), the models may be species-specific and, therefore, bioavailability correction is only possible if the BLM models have been developed and validated for at least three higher taxonomic groups, including an algal, an invertebrate and a fish species. Bioavailability corrections based on the three species only is considered as the baseline correction. **If read-across of the models to other species cannot be demonstrated, bioavailability corrections can only be carried out for the BLM species and the $QS_{generic,\ fw}$ can not be translated to a $QS_{reference,\ fw}$. Therefore the most-conservative BioF is subsequently used on a metal by metal basis**. The most-conservative BioF or baseline BioF is the ratio of $QS_{generic,\ fw}/QS_{site\text{-}specific,\ fw}$, determined as the highest ratio of the $NOEC_{generic}/NOEC_{site\text{-}specific}$ calculated for the three BLM (regression model) species. This approach is expected to provide the most-conservative implementation of bioavailability. In such cases, bioavailability correction of monitoring data is preferred over adjustments to the toxicity data. For compliance assessment, the bioavailable exposure concentration of the monitoring data value is, therefore, calculated as $C_{TRA} \times$ BioF, and this is compared with the $QS_{generic,\ fw}$ (Option 2).

Criterion 2: BLM read-across between species

Full BLM normalisation of the entire NOEC (for chronic data) dataset is justified and full bioavailability correction can be performed only if models are available (Criterion 1) and if additional quantitative evidence is available to confirm the applicability of the three BLMs to at least three additional taxonomic groups (at least at the level of class, but preferably at the level of phylum, eg Cyanophyta, Protozoa, Mollusca, Rotifera, Insecta, higher plants). The accuracy of the BLM predictions for the additional taxonomic groups should be proven by showing that the model actually decreases the variability in the data for the investigated additional species, otherwise the BLM read-across is not applicable for that species. In such cases, chemical (abiotic) normalisation might be considered (more details are available from the background document). Full BLM normalisation consists of applying the bioavailability model across species of similar trophic levels (e.g. applying the *Daphnia magna* BLM for normalisation of the toxicity data from other invertebrates). The bioavailability model normalises the chronic effects concentrations (NOEC or EC10) of the metal for each species' endpoint, and a normalised $QS_{site\text{-}specific,\ fw}$ (i.e. a site-specific QS) is calculated. This $QS_{site\text{-}specific.\ fw}$ is compared to the monitoring data for compliance checking (Options 3). Alternatively, the $QS_{site\text{-}specific,\ fw}$ can be used to calculate the site-specific BioF. In this case, the BioF full bioavailability correction is calculated as $QS_{reference,\ fw}/QS_{site\text{-}specific,\ fw}$ ($QS_{site\text{-}specific,\ fw}$ calculated from full BLM normalisations). The bioavailable exposure concentration is then calculated as $C_{TRA} \times$ BioF, and this is compared with the $QS_{reference,\ fw}$.

STEP 3 – Accounting for backgrounds: total risk versus added risk approach

In a TRA, no explicit account is taken of natural background levels; this approach accounts for the total dissolved amount of a metal in a waterbody. This means that no distinction is made between the fraction of a metal that is present in a waterbody for natural reasons and the fraction added because of anthropogenic activities.

Preferably, metal QSs should be based on the TRA. However, QS values below natural background levels may be generated if:

(1) The QS has been set to an unrealistically low level simply because of a (too) conservative approach adopted in the QS derivation (i.e. a large AF) to compensate for uncertainties arising from a lack of reliable (eco)toxicological data.

(2) The QS was set using ecotoxicity tests with organisms cultured/tested under conditions of low metal concentrations compared with the surface water background levels (i.e. organisms locally

may have adapted to higher natural concentrations). This may occur, especially for metals with a significant background concentration in relation to the estimated QS.

Setting QSs below the natural background level would result in an EQS that serves little regulatory purpose and is scientifically indefensible. Furthermore, many waterbodies would fail the QS even though there is no risk to biota. A pragmatic way to overcome this problem is

- to evaluate the scope for refining the QS by reducing uncertainty (including making a correction for bioavailability) and/or
- to use the added risk approach (ARA).

To assess the need for applying the ARA, the $QS_{reference,\ fw}$ (or $QS_{generic,\ fw}$) and the background metal concentration in the EU, taken as the 90th percentile value from the FOREGS database (http://www.gsf.fi/foregs/geochem), should be compared. If the 90th percentile background value is higher or similar to the QS, the ARA should be used preferentially. The procedure for determining local 'natural' background levels is described in Section 3.6.

The ARA was discussed for the purpose of setting QSs by Lepper (2005). This approach accounts for natural background concentrations and avoids setting regulatory standards below this background level in a simple manner: a maximum permissible addition (MPA) to the background level of a certain metal is calculated. The MPA is the maximum amount of a metal that may be added to the local background concentration of this metal without adversely affecting the assessed ecosystem. Correct determination of the natural background level is key in this approach, and this may not be easy to achieve. As background concentrations are often estimated from relatively small datasets, the calculation of background concentrations should be an iterative process, reviewing the values when new monitoring data become available.

In the ARA, the $QS_{added,\ fw}$ is derived from toxicity data that are based on the added concentration of the metal in the toxicity tests without the background concentration in the test media. In order to use the ARA, the toxicity data should thus be re-evaluated. From each toxicity study, the background concentrations presen tin test medium or test water should be subtracted from the total measured concentrations in the test. The result of the study (NOEC, EC10) should then be calculated on the basis of these 'added' concentrations. The QS should be derived using these 'background-corrected' NOECs or EC10s and is termed $QS_{added,\ fw}$. Where bioavailability correction is possible an ARA approach will not normally be used – only the TRA approach.

To assess compliance, the background concentration (Cb) can either be added to the $QS_{added,\ fw}$ ($QS = QS_{added,\ fw} + Cb$) or the monitoring data can be corrected for background concentration ($C_{ARA} = C_{TRA} - Cb$). If the $C_{TRA} < QS$ or $C_{ARA} < QS_{added}$, then compliance is demonstrated. If, for example, the background is expressed as total dissolved metal, but the QS is expressed as bioavailable metal, then the two options may not be comparable. These approaches require that the monitoring data (including the background) and the QSs are compared on the same basis: dissolved concentration or the bioavailable metal fraction.

Under specific local geological circumstances (e.g. in mineralised areas), the local background concentration can be substantially higher than the regional background concentration. The ARA may still be used to assess the possible risk related to anthropogenic emissions in such areas. However, the variability of the local background levels can be substantial under such conditions and policymakers will need to decide on a case-by-case basis whether the (generic) QS can still be applied at all (the local natural ecosystem may be different from the generic ecosystem used to derive the QS). In this respect, it should also be noted that the principle of the ARA cannot be stressed infinitely: if possible, an upper limit for the value of the QS + background level ($QS_{ARA,dissolved/bioavailable}$) may be derived. In practice, this upper value may be formed by the calculated predicted no-effect concentrations for secondary poisoning or human health in water ($QS_{fw,\ secpois}$ or $QS_{dw,\ hh}$) that have also to be considered when local background values are (very) high. Another reason for setting an upper value is that, in reality, the relationship between toxicity and natural background concentrations is unknown, and that some populations might in fact live close to their tolerance limit. It should be stressed that this upper value is **not** a maximum acceptable concentration (MAC-EQS). The MAC-EQS refers to short-term exposures that occur in peaks and in connection with intermittent releases, while the above-mentioned upper limit refers to long-term exposures and to an average concentration (typically based on a year) for the release period.

With data-poor substances, there will often be no information available on the relationship between total and dissolved concentrations, or between abiotic parameters and the dissolved fraction. Therefore, it will not be possible to take bioavailability into account if only total concentrations are given. However, extra effort should always be made to try to take availability into account in the reference ecotoxicity value to which the assessment factor is applied.

The decision to follow the ARA approach will be made after comparing the QS with the background.

Following the ARA, bioavailability can further be considered as in Step 2, but considering only the added fraction at the exposure side (Step 2, Option 2) or the added fraction at the effects site (Step 2, Option 3). Under no conditions should background levels be considered if a total $QS_{reference,\ fw}$ is used.

3.5.2.2 Bioavailability correction for saltwater

Freshwater and marine organisms face very different iono- and osmoregulatory issues related to living in either a very dilute or concentrated salt environment. Differences in iono- and osmoregulatory physiology may also lead to differences in metal accumulation and metal toxicity (Prosser, 1991; Wright 1995; Rainbow, 2002). Despite these apparent physiological differences, it has been shown that marine fish also suffer from osmoregulatory disturbances under metal exposure and, therefore, similar toxicity mechanisms may apply (ECI, 2008).

As for freshwater, the influence of DOC binding, metal speciation and metal ‘availability’ on metal toxicity to marine organisms has been demonstrated for some metals (e.g. Smolders *et al.*, 2004, Cu RAR, 2008). The data show that metals binding to organic ligands can reduce metal toxicity to marine organisms, so an availability correction may be needed. Therefore, if experimental data allow the assessor to derive a quantitative relationship between DOC and ecotoxicity ($NOEC/EC_{50}$), this equation can be used to normalise all marine ecotoxicity data.

In marine waters (coastal and open sea), hardness, pH and alkalinity do not play a role because coastal/open sea waters are characterised by high pH (typically between 7.8–8.3), high salinity (35‰) and high ionic strength. Unlike the inorganic composition of marine waters, DOC levels may vary considerably between marine waterbodies. The MAMPEC model[17] defines receiving marine environment scenarios. The model includes DOC values for coastal and open ocean waters of 2.0 and 0.2 $mg \cdot l^{-1}$, respectively. The applicability of 2.0 $mg \cdot l^{-1}$ DOC as a reasonable worst case for coastal waters was further confirmed from an extensive literature search (see Cu RAR, 2008). A DOC normalisation of the ecotoxicity data to a standard level of 2.0 $mg \cdot l^{-1}$ DOC is,[18] therefore, to be used for deriving a coastal water $QS_{reference,\ sw}$. Alternatively, and if no bioavailability correction can be carried out, a non-normalised generic QS can be used as $QS_{generic,\ sw}$. This corresponds to the Option 1 or Figure 3-1.

Where the waterbody does not comply with the $QS_{reference,\ sw}$, availability can be accounted for by applying Step 2 (see Figure 3-1). Similar to the procedure described for the freshwater compartment (Section 3.5.2.1), availability can be corrected by several means:

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[17] Standard model employed for the risk assessment of antifouling paints in marine environments.

[18] If DOC has been added to the test media (e.g. as humic acids), the difference in binding strength of the natural DOC compared with added DOC is to be considered.

Option 2: If the marine $QS_{reference,\ sw}$ is exceeded (Tier 1), then a BioF can be applied to the monitoring data value. The BioF is based on a comparison between the expected availability at the reference site and that relating to site-specific conditions. The bioavailability correction for a site can be performed (Tier 2) as follows:

Calculate the BioF using BioF = $QS_{reference,\ sw}$ (2.0 $mg \cdot l^{-1}$ DOC)/$QS_{site\text{-}specific,\ sw}$ (normalised to the site-specific $mg \cdot l^{-1}$ DOC.

Determine the available dissolved metal concentration at the site, calculated as dissolved metal concentration × BioF.

Compliance then can be checked as available dissolved metal concentration at the site < $QS_{reference,\ sw}$.

Option 3: If the marine $QS_{reference,\ sw}$ is exceeded (Tier 1), then a marine $QS_{site\text{-}specific,\ sw}$ is derived based on the site-specific DOC concentration (using the empirically observed relationship between the NOECs/EC10s and DOC) and this value is assessed against the monitoring data for compliance (Tier 2).

The DOC correction proposed for the marine environment is a simple 'availability' correction, irrespective of the species considered and it is, therefore, not necessary to demonstrate the applicability of the DOC correction for a wide range of species.

For estuarine waters, salinity, alkalinity or total carbonate also should be considered, if possible.

3.5.2.3 Using mesocosm and field data for metals

Similar to deriving a QS for organic substances, high quality mesocosm and field data can be used for QS derivation for metals. The quality criteria to be used are the same as those used for organic substances, but some metal-specific issues are to be considered as outlined in Section 3.6.

If a bioavailability correction can be applied, then QSs normalised to the physicochemistry of the mesocosm/field studies are recommended .

3.6 Estimating background levels of metals

3.6.1 General comments

If the QS is below or close to the natural background level and there is no further scope for reassessing either backgrounds or the derivation of the QS, then the ARA may be applied. The general definition of natural background level is the concentration that is present owing to natural and geological processes only, i.e. the background level with no anthropogenic contribution ('pre industrial' levels). In reality, true pristine areas are rare within Europe, and it must be considered on a case-by-case basis whether a given area represents a pristine condition for a specific metal.

In most areas in Europe, any estimate of a natural background concentration will inevitably include a small contribution from anthropogenic sources because much of Europe's landscape has been altered by man's activities for mineral extraction, agriculture or habitation for millennia and this historical contribution may be obscure. In addition, long-term anthropogenic activities, such as drainage, irrigation and special crops (e.g. conifers creating acid soil conditions), may influence environmental release of metals. This contribution is difficult to quantify and distinguish from what concentrations might have been in the absence of such activities. Finally, contributions from diffuse anthropogenic sources, eg aerial deposition, may be impossible to eliminate entirely.
Therefore, any estimate of a background concentration will more likely be an 'ambient' background concentration rather than a value relating to a purely natural pristine environment.

3.6.2 Estimating backgrounds for freshwater

The natural background concentration is determined by mineral and biological factors. A major contribution to the background concentration will be from weathering of surface geology and any groundwater spring inputs. Therefore, a ‘global’ natural background level will normally not be meaningful because of the great variation between different regions.

In freshwater, the preferred procedure for assigning a ‘natural’ background will usually be to determine the concentrations in springs and/or in waterbodies in ‘pristine’ areas in the given region, e.g. headwaters. Other possibilities are:

- To measure concentrations in deep groundwater. In some cases, however, the concentration of the metal may be higher in the groundwater than in the surface water, e.g. because of the groundwater’s contact with deep lying mineral rocks or soils and subsequent dilution by rain.
- To gather information from national or international databases, such as the FOREGS Geological Baseline Programme (http://www.gsf.fi/foregs/geochem).
- Geological modelling, to estimate the contribution from erosion.
- To estimate the concentration in the water from natural background concentrations found in the sediment by means of equilibrium partitioning models.

Pristine waters are scarce and, in practice, mainly restricted to the immediate vicinity of a source. Further downstream, the water will take up the remnants of decaying organic material in the form of DOC. Plants contain substantial amounts of essential elements extracted from the soil that remain present through binding to DOC, thereby causing a natural increase in metal background concentrations. De Schamphelaere et al. (2003b) have measured the natural zinc and copper content bound to DOC. If such bound DOC concentrations measured in practice are taken into account in many surface waters, this natural contribution appears to exceed the mineral contribution described above (see VROM report VEM july 2004, appendix 3 in Dutch).

In other situations, biological depletion may take place, c.f. the great lakes in the USA, but also European mountain lakes with long residence times. In such cases, the natural background concentration might be below the pristine source concentration. This is due to the uptake of essential elements from the upper water layers by organisms which, after death, fall to the deeper regions of the waterbody, thereby taking with them the essential metal. Natural background concentrations may decline in this biological depletion process by over one order of magnitude (e.g. Nriagu *et al*., 1996).

In practice, the input data needed to determine background concentrations in pristine areas by modelling may be inadequate to estimate a reliable value. An alternative pragmatic approach in these cases is to take the 10th percentile dissolved metal concentration of all the monitoring data available for the waterbody or region (after removing sample results with elevated concentrations from known point source discharges or pollution events). If this technique is used, some interpolation of the distribution of values is needed from the laboratory’s reporting limit (the ‘less than’ value) and zero. Using this approach, an example from the Mersey hydrometric area (UK) produces 5th and 10th percentile values of 3.0 and 3.7 $\mu g \cdot l^{-1}$, respectively for dissolved zinc (Figure 3-2).

Further, ‘hot spots’ may also be located using geological information.

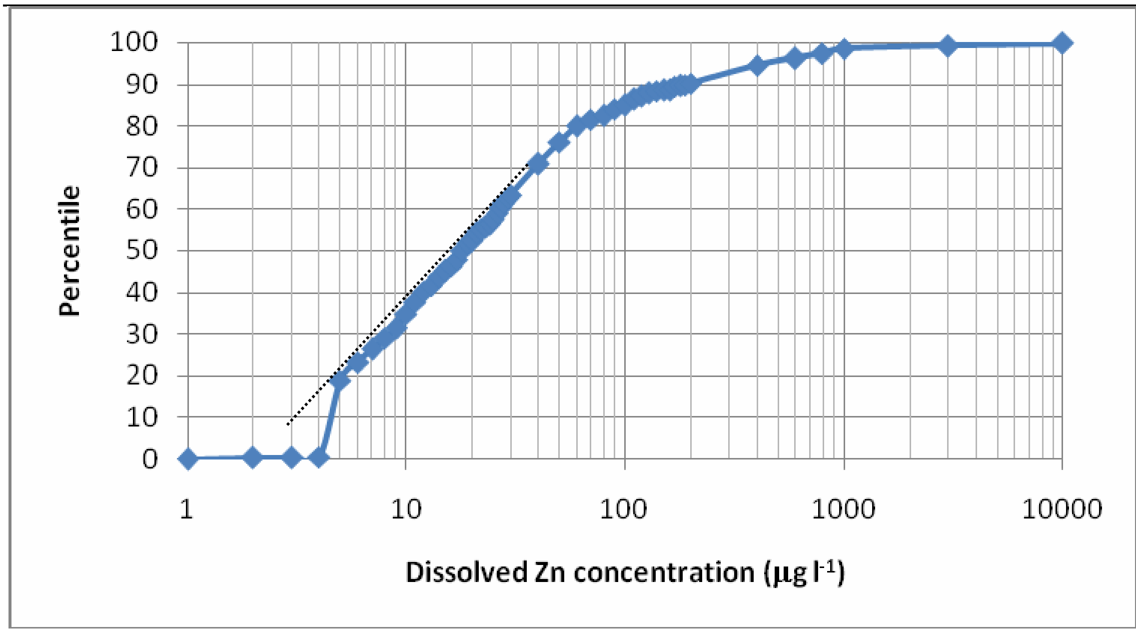


Figure 3.2 Distribution of dissolved zinc concentrations in the Mersey hydrometric area (UK)

A comparison of freshwater background concentrations based on a wider river basin level or more-local hydrometric area is given in Table 3.6. The British Geological Survey (BGS) Geochemical Baseline Survey of the Environment (G-BASE) project data of single measurements taken at small, relatively unimpacted streams are also shown.

Table 3.6 Example freshwater background concentrations based on river basin and hydrometric area levels obtained from different sources

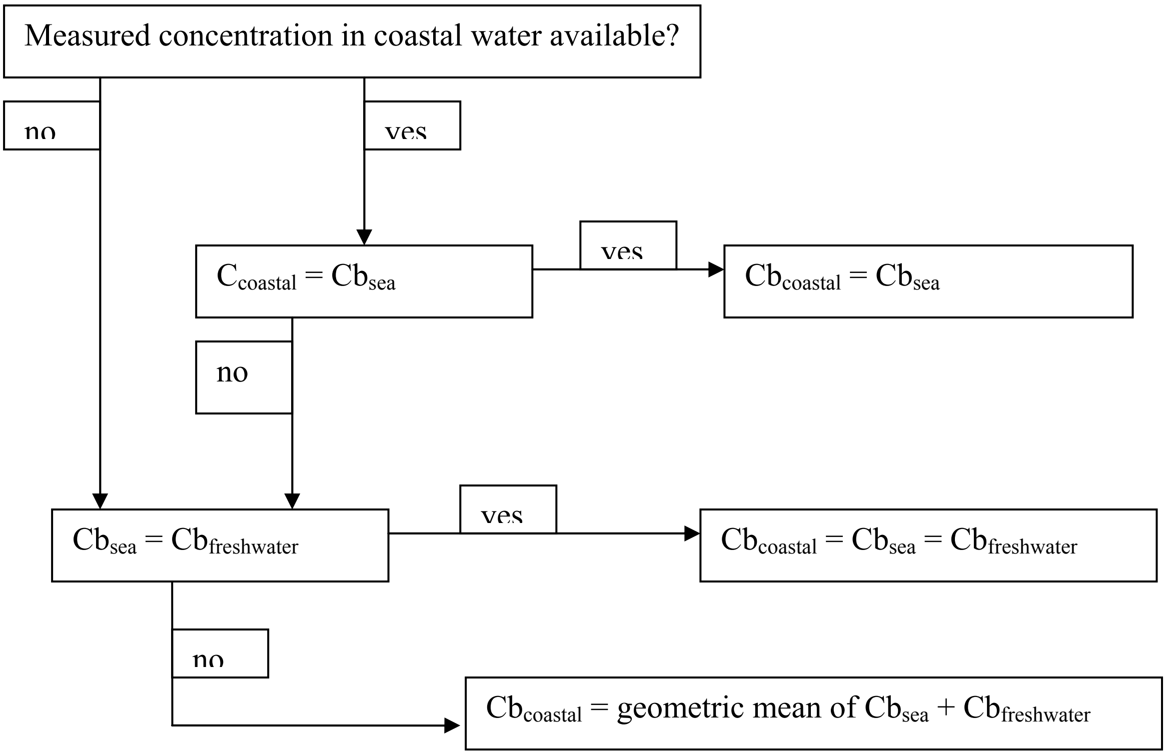
Metal (Dissolved)	FOREGS Ranges (µg·l^{-1})	BGS G-BASE (Median) (µg·l^{-1})	10th Percentile of Monitoring Data (µg·l^{-1})
Cu UK South West England river basin district default	1.45–1.97	1.6	1.8
Tamar hydrometric area specific	<1.97	1.0	0.5
Zn UK South West England river basin district default	2.68–4.00	3.4	3.2
Tamar hydrometric area specific	<2.86	2.0	2.5

3.6.3 Estimating background concentrations for saltwaters

In saltwater, the concentrations of metals (dissolved) far at sea will normally suffice as natural background levels. Natural background concentrations (Cb) may be higher in coastal waters because of the natural input from rivers and the settling of particles. The determination of the $Cb_{coastal}$ in such waters may, however, be very difficult because rivers are likely to drain pristine areas as well as areas influenced by anthropogenic inputs, and thus a pragmatic approach is needed. As a starting point (see Figure 3-3), the dissolved metal concentration in the coastal water is compared with the Cb at sea (Cb_{sea}). If these values are equal, then the $Cb_{coastal}$ for the coastal water is set equal to the Cb_{sea}. If there are no measurements in the coastal water or if the concentration is greater than Cb_{sea} then the Cb in freshwater and at sea are compared. If they are the same, it will be reasonable to set the Cb in estuaries and coastal waters equal to those in freshwater and at sea. If the $Cb_{freshwater}$ is different from $Cb_{sea,}$ the geometric mean of the two values may be used for coastal waters. In cases where the concentration in coastal water is between $Cb_{freshwater}$ and Cb_{sea}, the $Cb_{coastal}$ is set equal to the measured value. If the $Cb_{coastal}$ values derived as above create no problems in relation to measured concentrations and compliance, then no further refinement will be necessary. Alternatively, the $Cb_{coastal}$ can be derived as the 10th percentile of concentrations measured in coastal waters draining only relatively uncontaminated areas.

Guidance is given in OSPAR (2004) on ambient metal concentrations measured in the waters of the Convention area. However, these data should be interpreted with care when deriving coastal background values. Indeed, the ranges presented for the different metals refer to open ocean ranges which are usually lower in value than those for near and on the shelf (e.g. for Cd and Cu).

It is important to note that preference should be given to values reflecting natural background concentrations for coastal zones, and that some might be found in the literature (e.g. see Laane et al., 1992 for the North Sea; Landing et al., 1995 for the Atlantic Ocean, the UK National Marine Monitoring Programme 2004 http://www.jncc.gov.uk/pdf/nmmp2ndreport.pdf; and ICME, 1996).



Alternatively, $Cb_{coastal}$ = the 10th percentile of concentrations measured in coastal waters draining only relatively uncontaminated areas. If the concentration in coastal waters is between Cb_{sea} and $Cb_{freshwater}$ then $Cb_{coastal} = C_{coastal}$

Figure 3.3 Determining the natural background concentration of a metal in coastal waters;
$C_{coastal}$ = concentration measured in coastal water, $Cb_{coastal}$ = natural background concentration in coastal water, Cb_{sea} = natural background concentration at sea, $Cb_{freshwater}$ = natural background concentration in freshwater; concentrations refer to the dissolved metal

3.7 Data requirements for deriving QSs for metals

As for organic substances, aquatic toxicity data to be used for the setting of water (sediment/biota) quality criteria for metals are evaluated as described in Appendix 1. However, the following metal-specific aspects need to be considered:

1. *Measured versus nominal test concentrations*: Because it is important to understand the true exposure concentrations (including the background concentration in the culture medium), **any ecotoxicity study not supported by analytical data (i.e. endpoint concentrations reported as nominal values) would automatically be excluded from the most reliable studies**. Nominal concentrations will usually[19] overestimate the final concentration. Therefore, if the

[19] Except for essential metals (nutrients may be added to the test waters) and if natural waters are used as test waters (the metal concentrations in the natural waters may substantially contribute to the dissolved metal concentration).

lowest effect concentration is a nominal value, then the study should not be discarded unless there are other reasons to invalidate it.

2. *Total versus dissolved metal concentrations in test media*: Measured data on the dissolved fraction (0.45 µm) are required in order to obtain the most reliable toxicity test data. Measurements of dissolved metal concentrations are critical to the assessment of sparingly soluble metals (particles and precipitation may occur) and in the use of natural waters as test media (adsorption to suspended solids may occur). If only total metal measured data are available, it may be possible, in some cases, to estimate the dissolved fraction from published solubility constants for the principal anions present, e.g. sulphate or carbonate, and/or suspended solids/water partitioning coefficients.

3. *Culture conditions*: If the test organisms have been cultured in conditions that are outside the natural background concentration ranges (see Section 3.6), such data should be discarded from the high quality database and, at best, may only be considered as supporting evidence when selecting the assessment factor[20].

4. *Chelators*: Data from studies in which the test media contain artificial chelators (e.g. EDTA) should be excluded from EQS derivation, except in algal tests where small amounts of chelators (EDTA (can be replaced by natural DOC)) are unavoidable.

5. *Test medium characteristics:*

   For water: Considering the strong influence of water physicochemistry on metal toxicity, the physicochemical conditions in a test should be adequately described, especially if corrections for bioavailability are carried out. The aquatic medium used should be characterised by DOC concentration, hardness, pH, alkalinity, presence of complexing agents, such as humic acids and EDTA, and any other specific parameters of importance to the metal in question. Where all the physicochemical data have not been reported for a test and are important for speciation models, it may be possible to estimate the missing data from known physicochemical parameters (e.g. estimate alkalinity from Ca and alkalinity relationships (Adams et al., 2008)) or to use default values derived from other studies using standard test media or from historic monitoring data for natural waters (Santore et al., 2002). The physicochemical parameters should not only be measured at the beginning of the test because the factors may change, e.g. because of food addition.

   Metal–DOC equilibrations: The kinetics of metal–DOC binding in aqueous and sediment test media may require an equilibration period between the metal and test medium prior to exposing the organisms. This is to allow full metal–OC binding in a way that is representative of natural environments (e.g. Ma et al., 1999). Where the kinetics for reaching equilibrium conditions for binding to OC, etc., are known to be slow and may affect the test outcomes, reviewing the details of the test design may provide additional information on the reliability of the data, particularly for any extreme values.

6. *Oxidation state*: Many metals have more than one oxidation number, which poses several complications. Firstly, chemical characteristics, and thus toxicity, can vary markedly between different oxidation states. Consequently, the oxidation number of the trace element(s) in a given substance must be known. This is not necessarily a trivial problem, as mixed oxidation states can occur. Secondly, some oxidation states may be unstable in specific or all environmental compartments, meaning that distinct changes in bioavailability may occur during even a short-term toxicity assay (e.g. Cr(III)/Cr(VI)). In such cases, it may be necessary to derive a separate EQS for each of the relevant oxidation states.

[20] This is especially relevant under the TRA.

7. *Read-across and QSAR*: If ecotoxicity data are lacking for a specific metal or metal compound, read-across of ecotoxicity data from other inorganic compounds of the same metal should be considered. The basic assumption is that the bioavailable metal ion is responsible for toxicity. Ecotoxicity data for simple soluble metal salts, therefore, can be combined on condition that the metal ion alone is responsible for the effects observed for all of the metal salts considered (e.g. $CuSO_4$, $CuCl_2$). Toxicity data measured for all soluble metal salts should, therefore, be used and the effects data (NOECs/EC_{10}s or EC_{50}s) should be expressed as the dissolved (bioavailable) metal ion concentration ($\mu g\ M \cdot l^{-1}$).

   The development of QSAR methods for metals and inorganic metal compounds has not been as actively pursued as for organic substances. However, for some inorganic substances, predicting toxicity from chemical properties may be relevant. In this respect, quantitative ion character–activity relationships (QICARs) and quantitative cationic activity relationships (QCARs) have recently been developed (Ownby and Newman, 2003; Walker et al., 2003).

8. *Combining freshwater and saltwater toxicity data*: As explained in Section 3, **freshwater and saltwater data for metals should generally not be pooled if availability corrections have been applied**.

9. *Interpreting biological effects*: Metals can exhibit physical toxic effects (e.g. smothering by metal precipitates) as well as effects caused by systemic toxicity. Some metals (e.g. Fe, Al) precipitate over short timescales compared with the duration of chronic toxicity tests, making the data difficult to interpret. Chronic data for metals exhibiting this behaviour should be treated with caution. Greater reliance may need to be placed on field data for such metals.

10. *Estimating bioaccumulation (for back-calculating water concentrations from biota standards)*: Section 4.7.2 details how to determine the relevant experimental bioconcentration factor (BCF) or bioaccumulation factor (BAF) data for metals.

3.8 Assessing compliance with a water-column EQS for organic compounds

3.8.1 Option to translate an EQS for dissolved water into an equivalent EQS for total water and/or suspended particulate matter

Standard laboratory toxicity and bioconcentration tests contain low levels of total organic carbon (TOC) in the test system[21]. As a result, the resulting EQSs refer to **dissolved concentrations**. It follows that compliance assessment with a water column EQS should ideally be based on the sampling and analysis of the dissolved fraction. This is similar to the way the PNEC is used according to the TGD (Part 2, Section 2) (EC 2003) and REACH (R.16)(ECHA 2008).

Discrepancies between total and dissolved concentrations may only become evident for very hydrophobic substances, ie K_p values in excess of 10000 $l.kg^{-1}$ or K_{oc} values for linear partitioning into amorphous organic matter in excess of 100000 l kg^{-1}. This will generally only be found for substances with a log K_{ow} above 6. Thus, for compounds with log K_p<4 (or, if this value is not available, log K_{ow} <6), the $EQS_{water,\ total}$ is equivalent to the $EQS_{water,dissolved}$.

[21] OECD guidelines for the acute and chronic daphnid test, the fish early life stage test and short-term fish embryo and sac-fry stage tests, the fish juvenile growth test, the chironomid test and the bioconcentration test with fish all set a maximum level of 2 $mg \cdot l^{-1}$ to the TOC content. In most laboratory studies, however, the TOC content will not reach this level, which means that in practice toxicity results reflect dissolved concentrations.

As explained in Section 2.11 some Member States may have a preference to undertake monitoring using total water samples, incorporating both the dissolved fraction and the chemical that is sorbed onto suspended particulate matter (SPM) or the SPM fraction only. The fraction found on SPM is likely to be particularly important for hydrophobic substances. To allow for this option, guidance is provided here on converting the water column standard as derived for the dissolved concentration (the final EQS value) into an equivalent total concentration in water ($EQS_{water,total}$) that corresponds to the quantity of the substance that is in true solution plus any of the substance sorbed to SPM. In some cases, laboratory tests include significant levels of SPM (OECD test guidelines permit some SPM). For such cases, the dissolved concentration must first be determined (Step 1). Only then can the $EQS_{water,total}$ be estimated (Step 2).

Step 1 – Estimation of $EQS_{water,dissolved}$

If no organic carbon content is present, the concentration is assumed to be fully dissolved and this step can be omitted. The derived quality standard should then be considered to refer to the dissolved concentrations ($EQS_{water,\ dissolved}$). If organic carbon is measured in the critical toxicity studies, the dissolved concentration ($C_{water,\ dissolved}$) can be calculated from the total concentration in critical ecotoxicity experiments ($C_{test\ water,\ total}$) and the total organic carbon content in these experiments ($TOC_{test\ water}$) as follows, , where K_{oc} is in l kg^{-1} and $TOC_{test\ water}$ is in mg l^{-1}.

$$C_{\text{water,dissolved}} = C_{\text{test water, total}} \cdot \frac{1}{1 + K_{\text{oc}} \cdot \text{TOC}_{\text{test result}} \cdot 10^{-6}}$$

In this case, the concentrations are corrected for organic carbon, including DOC, that limits the substance's (bio)availability.

This equation may be used for laboratory toxicity or bioconcentration data, but could also be used to convert data from a mesocosm study or a field bioaccumulation study. Where an EQS has been derived using an SSD approach, it is useful to examine all studies that lie around or below the HC.

Step 2 – Estimation of $EQS_{water,total}$

For highly hydrophobic compounds the final derived EQS (which is an $EQS_{water,\ dissolved}$) should be corrected using the default concentration of suspended matter (C_{SPM}) and the partition coefficient to suspended matter (Kp,susp).

$$\text{EQS}_{\text{water,total}} = \text{EQS}_{\text{water, dissolved}} \cdot (1 + K_{\text{p,susp}} \cdot \text{C}_{\text{SPM}} \cdot 10^{-6})$$

where:

- $EQS_{water,total}$ = quality standard for the total concentration in water;
- $EQS_{water,dissolved}$ is the value of dissolved concentration in water, mostly directly derived from the toxicity or bioaccumulation tests;
- $K_{p,susp}$ = partition coefficient to suspended matter (l·kg^{-1}), which might be estimated as the product of the K_{oc} value for the substance (l·kg^{-1}) and the organic carbon content (f_{oc}) of suspended matter (EU default from TGD (EU 2003) 0.1);
- C_{SPM} = concentration of suspended matter (mg·l^{-1}; For several water types like large rivers the SPM content is reasonably constant and a default value has been proposed for this type of river. EU defaults are 15 mg·l^{-1} for freshwaters and 3 mg·l^{-1}/L for marine waters and for example, the annual average TOC content of the Rhine in the Netherlands is about 4mg l^{-1}, however, under deviating 'local' environmental conditions other values need to be applied); and
- 10^{-6} is = a conversion factor to convert mg into kg.

A further refinement is to base compliance monitoring on the analysis of the SPM instead of the unfiltered water samples. This is because hydrophobic substances are more likely to be sorbed to SPM than to be freely dissolved in the water column. For the purpose of comparing the analyses of

SPM to the derived water column EQS, guidance is provided below on how to convert the water column EQS into an EQS based on SPM (EQS_{SPM}).

When the EQS for an organic chemical is expressed as dissolved concentration in water (referred to as $EQS_{water,dissolved}$ in this section) , a corresponding concentration in SPM may be calculated and used as a surrogate standard. This should be done for hydrophobic organic substances whose partition coefficient triggers exceed those given above.

The algorithms to calculate the concentration in SPM from the dissolved concentration in water and vice versa are as follows:

$$EQS_{SPM} = EQS_{water,\, dissolved} \cdot K_{p,\, susp}$$

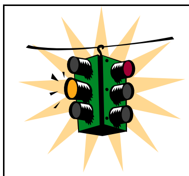
where:

– EQS_{SPM} = quality standard for water referring to the substance concentration in SPM (EU TGD (EU 2003) default has an organic carbon content of 10%);

– $EQS_{water,\, dissolved}$ = quality standard for water referring to the dissolved concentration;and

– $K_{p,\, susp}$ = substance-specific partition coefficient for SPM–water (e.g. f_{oc} . K_{oc} or any valid experimental value);

3.9 Deriving quality standards for water abstracted for drinking water ($QS_{dw,\, hh}$)



Look Out!

The approach chosen in this guidance in case of the absence of a drinking water standard is based on human toxicity. This implies that the precautionary principle and organoleptic aspects such as smell, taste and colour are overlooked. For the production of drinking water these elements play an important role. This means that for some substances there is need for specific measures to limit the risks because of concerns for the potability of drinking water in respect of taste and odour as a consequence of exposure (Commission Recommendation 2001/838/EC).

3.9.1 Overview

In addition to potential exposure through the consumption of fishery products (see Section 4.5), a second route for human exposure to substances in water is through drinking water. The WFD therefore requires quality standards to protect humans against this route of exposure.

In principle, existing drinking water standards are adopted, e.g. EU drinking water standards from Drinking Water Directive 98/83/EC and the World Health Organization (WHO) drinking water standards. These drinking water standards are used to set the $QS_{dw,\, hh}$ for those water bodies used for the abstraction of drinking water ($QS_{dw,\, hh}$). A treatment factor should be applied to the drinking water standard so that the $QS_{dw,\, hh}$ relates to the ‘raw’ water (i.e. it is an ‘environmental’ standard). Drinking water standards and treatment processes used to achieve them should be taken into account in determiing quality standards for water abstraction resources. This should have regard to Article 7 of the WFD with reference where appropriate to simple treatment.

WFD (Article 7(2) and (3)) and DWD (Article (4) require Member States to prevent any deterioration of the present quality of water intended for human consumption or any increase in the pollution of waters used for the production of drinking water.

If no existing drinking water standards are available (either DWD or WHO standards) a standard for drinking water abstraction from surface water may be derived by the procedure described in Section 3.9.2.

3.9.2 $QS_{dw, hh}$ for drinking-water abstraction

A QS for the abstraction of drinking water ($QS_{dw,hh}$) needs to be derived as follows (see also Figure 3-4)[22]:

1. If an EU drinking water standard (from Directive 98/83/EC) or a WHO drinking water standard is available, follow the procedure described below. If both the WHO and EU have a drinking water standard and the values are different, the WHO drinking water standard is preferred,.because it is health-based.

   - o If the drinking water standard is less stringent than the other QS_{water} values already derived (i.e. $QS_{fw, eco}$, $QS_{sw, eco}$, $QS_{fw, ,secpois}$, $QS_{sw, secpois,}$ $QS_{water, hh food}$), it could be decided that a $QS_{dw, hh}$ need not be derived.

   - o If the drinking water standard is more stringent than the other QS_{water} values already derived (i.e. $QS_{fw, eco}$, $QS_{sw, eco}$, $QS_{fw, ,secpois}$, $QS_{sw, secpois,}$ $QS_{water, hh food}$), the $QS_{dw, hh}$ is derived as follows:
     - Substance-specific removal efficiencies are estimated. This may require consultation with drinking water experts. The removal efficiency is expressed as the *fraction (F) not removable by treatment*.
     - The $QS_{dw, hh}$ is then calculated using equation A.

$$QS_{\mathrm{dw,hh}} = \frac{drinking\ water\ \mathrm{standard}\,(98/83/\mathrm{EC})}{F_{\mathrm{not\ removable\,by\ treatment}}} \qquad \text{(A)}$$

2. If neither an EU or WHO drinking water standard is available,, follow the procedure described below:
   - A provisional drinking water standard is calculated according to equation B.

---

[22] High treatment factors reflect the need for a high removal rate. Even where highly effective treatment is already in place, relying on this to compensate for contamination is not the most sustainable approach. Drawbacks include: (i) higher treatment costs; (ii) higher energy consumption and carbon footprints; (iii) compromise of the multiple barrier principle - i.e. an inadequate margin of safety between pollutant concentrations in raw water and drinking water, such that treatment failure could lead to exceedance of maximum acceptable concentrations in drinking water. For this reason Art. 7(3) WFD requests, that “Member States shall ensure the necessary protection for the bodies of water identified with the aim of avoiding deterioration in their quality in order to reduce the level of purification required in the production of drinking water.”

Therefore, in line with the combined approach laid down in the WFD, when deriving EQS for water abstracted for drinking water using treatment factors, Member States should in parallel strive to reduce pollution in the raw water body (e.g. as part of the Programmes of Measures) to reduce the treatment required to reliably meet the drinking-water standards. At a local level, the process of planning the (combined) control measures for the drinking-water supply system, which determine the treatment factors, calls for cooperation between the drinking-water sector experts and the authorities that manage the raw water bodies

$$QS_{\mathrm{dw,\,hh}} = \frac{0.1 \cdot TL_{\mathrm{hh}} \cdot bw}{uptake_{\mathrm{dw}}} \qquad \text{(B)}$$

Use a human body weight (bw) of 70 kg and a daily uptake of drinking water ($uptake_{drw}$) of 2 litres (ECHA, 2008). By default, a fraction of 0.1 of the human toxicological standard (TL_{hh}) is allocated to intake of the substance via drinking water. This default may be adapted, but this should only be done when sufficiently underpinned data (e.g. total diet studies and total coverage of possible intake routes) are available demonstrating that either a higher or lower value is justified. The value for TL_{hh} should be the acceptable daily intake (ADI) or tolerable daily intake (TDI) if these are available, a reference dose (RfD) or a benchmark dose.
If no ADI or TDI is available, the TL_{hh} could be calculated from the $NOAEL_{min}$ (the lowest no observed adverse effect level value from a review of mammalian toxicology data) using equation C. However, before deriving a TDI or an ADI from a NOAEL, a human toxicologist should be consulted in any case.

$$TL_{\mathrm{hh}} = \frac{NOAEL_{\mathrm{min}}}{100} \qquad \text{(C)}$$

If the compound of interest is potentially carcinogenic[23], the TL_{hh} is equal to the concentration corresponding to an additional risk of cancer for 1×10^{-6} (for 70 years exposure).

- If the (provisional) drinking water standard is less stringent than the other QS_{water} values already derived (i.e. $QS_{fw,\ eco}$, $QS_{sw,\ eco}$, $QS_{fw,\ ,secpois}$, $QS_{sw,\ secpois}$, $QS_{water,\ hh\ food}$), it could be decided that an $QS_{dw,\ hh}$ need not be derived and no further work is required.
- If the $QS_{dw,hh}$ calculated using equation B is more stringent than the other AA-QS_{water} values already derived (i.e. $QS_{fw,\ eco}$, $QS_{sw,\ eco}$, $QS_{fw,\ ,secpois}$, $QS_{sw,\ secpois}$, $QS_{water,\ hh\ food}$), the $QS_{dw,\ hh}$ is derived as follows:
  1. The removal efficiency of the substance is estimated. This may require consultation with drinking water experts. The removal efficiency is expressed as $F_{\text{not removable by treatment}}$.
  2. The $QS_{dw,\ hh}$ is then calculated using equation A.

For metals, the same approach as described here is followed.

[23] No guidance is given on how to establish the potential carcinogenicity of a compound, but the assessor should check the appropriate R phrases. No guidance is available on how to estimate a concentration that corresponds to an excess cancer risk of 10^{-6}. Therefore, a human toxicologist should be consulted.

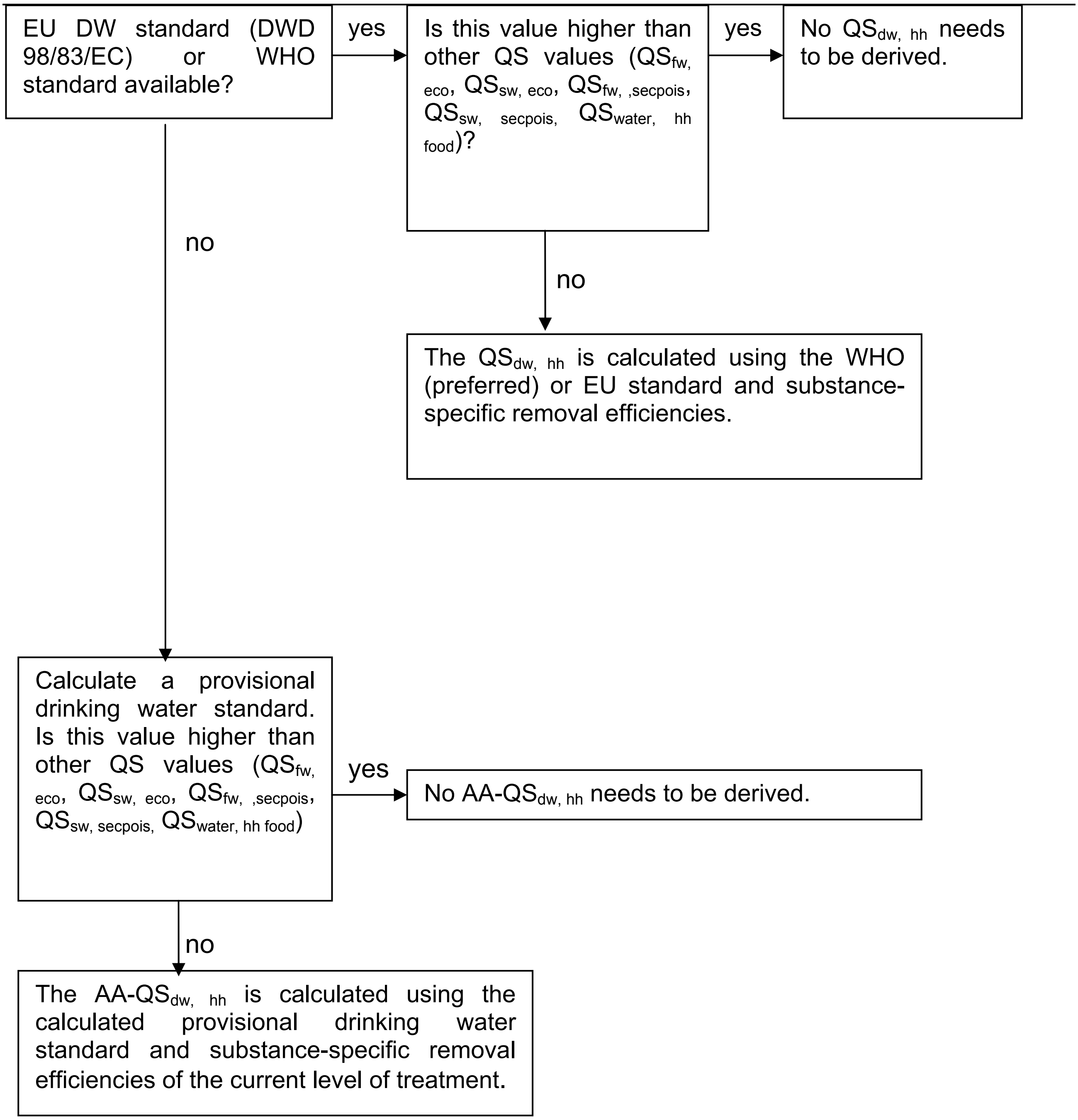


Figure 3.3 Schematic overview of the derivation of the quality standard for drinking water abstraction from surface water ($QS_{dw, hh}$)

4 DERIVATION OF BIOTA STANDARDS

4.1 Introduction

One of the factors leading to unmanageable water column standards is the very low concentrations that may be estimated for some substances, especially those with very low water solubility or a tendency to bioaccumulate through the food web. If these substances pose a significant risk through indirect toxicity (i.e. secondary poisoning resulting from food-chain transfer) and their analysis is more feasible in other environmental matrices, such as biota and/or sediments, then a biota standard may be required alongside, or instead of, the water column EQS. This is typically the case for hydrophobic substances, and biota standards have been proposed for hexachlorobenzene, hexachlorobutadiene and mercury and its compounds in the Daughter Directive to the WFD on EQSs (2008/105/EC), establishing concentration limits in prey tissue (fish, molluscs, crustaceans and other biota). In line with the requirements of the EQS Directive, these biota standards are presented as possible alternatives to a water column standard.

4.2 Protection goals

The WFD requires biota EQSs to protect:

1. Humans from adverse effects resulting from the consumption of chemical-contaminated food (fish, molluscs, crustaceans, etc.).
2. Top predators, such as birds and mammals, from risks of secondary poisoning brought about by consuming toxic chemicals in their prey.
3. Benthic and pelagic predators (e.g. predatory fish) that may also be at risk from secondary poisoning.

This section provides guidance for dealing with the first two protection goals (for which the temporary standards $QS_{biota,hh}$ and $QS_{biota,secpois}$are derived, see Appendix 6). The methodology applies to biota standards for freshwater (inland waters) and marine (transitional, coastal and territorial waters) ecosystems. Currently, technical guidance for benthic and pelagic predators (the third protection goal) is not well-developed. Possible approaches for the future are set out in Appendix 4, but these will need to be developed and tested before they can be adopted as formal guidance. **At present, biota standards developed for birds and mammals are assumed to be sufficiently protective for benthic and pelagic predators**.

The process for deriving and using biota standards to meet these protection goals is illustrated in Figure 4-1. In principle, to derive a biota standard, the assessor must estimate an acceptable level of chemical input when it occurs in the organism's food. Standard toxicity tests are available that estimate a no observed adverse effect level (NOAEL) or a no observed effect concentration ($NOEC_{oral}$) and these values are used to derive a predicted no-effect concentration for the ingestion of food ($PNEC_{oral}$) (taking account of variations between studies, species and test endpoints). Extrapolation from $NOEC_{oral}$ data to a $PNEC_{oral}$ (equivalent to a QS_{biota}) is detailed in Section 4.4.

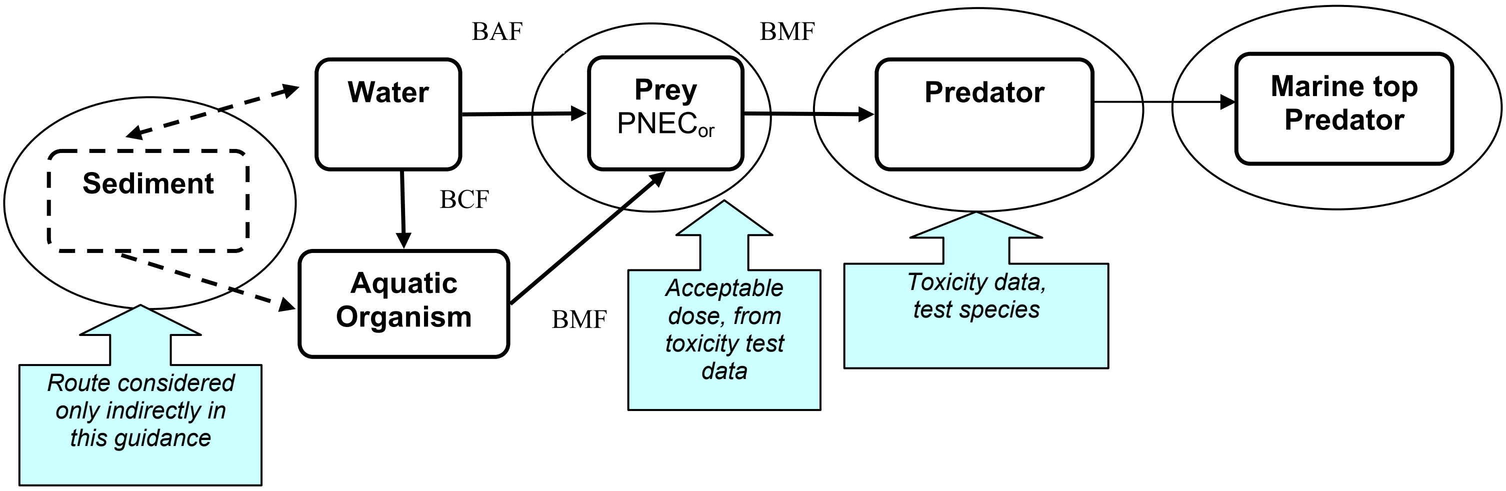


Figure 4.1 Steps involved in deriving a biota standard

Biota standards are preferably expressed as a concentration in an organism – corresponding to the prey items that may form the diet of top predators (including humans). Following the CSTEE (2001, 2004) opinion, biota quality standards are preferably expressed as biota concentrations and assessment is based on direct assessment and monitoring of biota. However, some Member States may wish to retain an option to sample and analyse only water column samples. Translation of the biota standard to a water column threshold is also helpful when selecting an overall EQS (Section 2.5), so that standards can be compared on the same (mass/volume) basis.

Whilst a biota standard could, in principle, be converted into the equivalent water concentration (one that is predicted to give rise to the critical concentration in biota), there are technical disadvantages with this approach for highly hydrophobic substances (those identified as B or vB according to Annex XIII of REACH). The translation to an equivalent water concentration depends on a good understanding of the bioconcentration, bioaccumulation and biomagnification processes from water and through the food web which can be uncertain for such substances.

4.3 Expression of a biota standard

There are several options for expressing a biota standard depending on the methodology used to derive it. A biota standard may refer to:

- A specific species or group of species
- A surrogate matrix for a particular species (e.g. eggs, pellets, etc.)
- A specific group of food (diet products from aquatic ecosystems)

Any of these is acceptable, but prey species are prefereable. The QS should be expressed in terms of g/kg (wet weight) of the whole organism. Since hydrophobic organic chemicals tend to accumulate in body lipids, experimental residue data are sometimes expressed in terms of a lipid-normalised concentration. If lipid normalisation is possible and scientifically justified (i.e. the substance primarily accumulates in lipids), all data should be lipid normalised to a standard lipid content of 5% (ECHA, 2008).

For water column standards, protection against long-term exposure is addressed by expressing the standard as an average over a fixed time (usually a year). Although a biota standard is also intended to protect against prolonged exposure, residues in animals and plants effectively integrate exposure over a period of time and, in any case, sampling of biota is likely to be rather infrequent. Unlike water standards, there is likely to be greater variability in exposure between sites than there is over time. Greater emphasis should be placed on the spatial design of sampling schemes.

4.4 Deriving a biota standard to protect against the secondary poisoning of predators

Secondary poisoning is concerned with toxic effects at higher trophic levels of the food chain which result from the ingestion of contaminated aquatic organisms from lower trophic levels.
In accordance with Romijn *et al*. (1993) and following the paradigm used under TGD (EC, 2003) and REACH (ECHA, 2008), we will define our food chain with its trophic levels as water –BCF→ aquatic organisms –BMF_1→ fish → fish-eating predator for freshwater ecosystems. For marine ecosystems, however, another trophic level may be introduced: water –BCF→ aquatic organisms –BMF_1→ fish –BMF_2→ fish-eating predator → top predator (where BCF is the bioconcentration factor and BMF is the biomagnification factor). This is illustrated in Figure 4.1.

A QS expressed as the concentration found in prey tissue which should protect predators from secondary poisoning ($QS_{biota,secpois}$) is often referred to as the diet-based approach. In terms of deriving the standard, only one extrapolation step, from food to predator (Figure 4.1), is necessary. Extrapolation to take account of possible differences in sensitivity between species is covered in detail in Section 4.4.4.

4.4.1 Identifying the critical data

Few data for an oral route of exposure are available for organisms other than birds and mammals. Whilst scientific and data developments may allow us to assess risks to aquatic predators in the future, in the meantime we must adopt biota standards for birds and mammals, assuming these values provide adequate protection to other taxa that might be at risk from secondary poisoning (e.g. predatory fish). This assumption might only be valid if the secondary poisoning of predators is the most-sensitive route and if the $QS_{biota,\ secpois}$ with the corresponding water concentration is significant lower than a QS for protecting pelagic species.

If relevant ecotoxicological information (e.g. fish feeding studies) can be found in the literature or can be produced for supporting sound QSs, the same approach developed for bird and mammals can be used for pelagic fish species.

The general methodology to derive a $QS_{biota,\ secpois}$ is based on the simple food chain described above and assumes that all species at a certain trophic level contain similar concentrations of pollutants. In addition, it assumes 100% reliance on a particular prey item. This assumption is appropriate where EU-wide standards are required (e.g. for Priority Substances and Priority Hazardous Substances) and to promote consistency in approaches across Member States for Annex VIII substances (Specific Pollutants) of the WFD. However, if a site-specific assessment is required, these assumptions may be refined as described in Appendix 4. The lowest reference concentration is used to derive a $QS_{biota,\ secpois}$ for predators. For substances with a high potential to biomagnify within food chains, it is important that the $QS_{biota,\ secpois}$ be applied to the appropriate aquatic trophic level to protect all predators feeding. Application of the $QS_{biota,\ secpois}$ at that level will also protect wildlife feeding at lower trophic levels. Monitoring should be based on the sampling and analysis of tissues from the prey species.

Although it is not currently practical to develop separate quality standards for the protection of pelagic predators, it is useful to assess whether or not the quality standard for biota is likely to be protective of exposures via food and whether or not the quality standard for water is likely to be protective of exposures via the water. It may be necessary to review this position if information becomes available suggesting that combined exposures (i.e. from both the water and food) lead to greater risks. Under these circumstances, the quality standards may not be protective and a review may be warranted.

4.4.2 Data requirements

Only toxicity studies reporting on dietary and oral exposure are relevant because the pathway for secondary poisoning deals exclusively with uptake through the food chain. Studies that assess effects on developmental or reproductive endpoints are likely to be critical studies because these tend to be more-sensitive endpoints (i.e. give rise to lower $NOEC_{oral}$ values) than survival endpoints.

As secondary poisoning effects rarely become manifest in short-term studies, results from long-term studies establishing long-term NOECs are strongly preferred. A QS derived where no chronic effects data are available is subject to high uncertainty and this must be flagged in the datasheet. The minimum duration for the study requirements is dependent on the characteristics of the chemical and the lifespan and life-stage of the test species. Effects data should ideally relate to tests of 90 days duration or longer (this would result in an AF of 90 or lower according to the TGD and REACH guidance). However, many mammalian toxicity data are generated from 28-day studies. These may be used after correction for daily food intake, as described in Section 4.4.3. The risk of selecting a study with an insufficient length of exposure as the critical datum could underestimate the potency of a compound, and therefore the $QS_{biota,\ secpois}$ may not be protective. On the other hand, by applying a higher assessment factor than needed, the QS may be over protective.

As toxicity data for wildlife species are not normally available, it will be necessary to extrapolate threshold levels from toxicity data of laboratory test species to wildlife species. If studies are available for wildlife species as well as for conventional laboratory test species, both should be included in the assessment.

Further guidance on bird and mammalian toxicity data and their evaluation is provided in the REACH guidance (ECHA, 2008) and in the European Food Safety Authority guidance document (EFSA, 2007).

4.4.3 Expressing toxicological endpoints as a concentration in food

Mammalian or avian toxicity data may be expressed as NOECs relating to concentration in food ($NOEC_{oral}$, expressed in units of $mg \cdot kg^{-1}$ food) or as no observed adverse effect levels relating to dose ($NOAEL_{oral}$, expressed in units of $mg \cdot kg^{-1}\ bw \cdot d^{-1}$). For the standard derivation of EQSs for secondary poisoning, the results need to be expressed as the concentration in food because this is the basis of the adopted risk model. The general rule for the conversion is that the concentration in food is equal to the daily dose multiplied by the body weight (bw) divided by the daily food intake (DFI), or

$$NOEC_{oral} = NOAEL_{oral} \frac{bw}{DFI}$$

where:

– $NOEC_{oral}$ = no observed effect concentration ($mg \cdot kg^{-1}$ food);
– $NOAEL_{oral}$ = no observed adverse effect level [$mg \cdot kg^{-1}\ bw \cdot d^{-1}$];
– DFI = daily food intake ($g\ food \cdot d^{-1}$); and
– bw = body weight (g).

Table 4.1 presents a guide with a standard set of conversion factors that can be used to promote internal consistency when converting concentrations from dose into diet for mammals. The guide should be used only in the absence of more specific data from the study itself or other sources. For example, a chicken (Gallus domesticus) typically consumes around one eighth of its body weight per day, and so the conversion factor in this case would be 8 kg bw·d·kg–1 food. It should be noted that the conversion factors for young birds and mammals might differ from those for adults. For avian reproduction studies, a default factor of 10 can be used as a conversion factor (i.e. bw/DFI = 10) (see Appendix 6 of EFSA, 2008). For this conversion to be valid, no food avoidance should have occurred in the study. Recommendations from EFSA (2008) should be considered as indicative. REACH guidance (ECHA, 2008) should be followed rather than EFSA (2008).

Table 4.1 Conversion factors for converting NOAELs (dose) from mammalian toxicity studies into NOECs (concentration)

Species	Age/study	**Conversion Factor** (bw/DFI) (ECHA, 2008; EC, 2003)	**Conversion Factor** (bw/DFI) (EFSA, 2008)
Rat (Rattus norvegicus	>6 weeks	20	
Rat (Rattus norvegicus)	<6 weeks	10	
Rat	28 and 90days		10
Rat	Two generation study first mating[a]		12.5
Rat	Two generation study overall (females)[a]		8.33
Mouse (Mus musculus)	28 and 90days	8.3	5.0
Vole (Microtus spp)		8.3	
Rabbit (Oryctolagus cuniculus)		33.3	
Dog (Canis domesticus)	Adult/all	40	40
Monkey (Macaca spp)		20	
Chicken (Gallus domesticus)		8	

[a] The first mating value for a two-generation study should be used for assessment when effects (general or on reproduction) are seen to relate to the pre-mating phase of the first mating, or effects are seen only in male F0 parents at any time. For all other aspects of a two-generation study, the overall conversion figure should be used.

NOECs derived from NOAELs in this way are assumed to be equivalent to directly measured NOECs.

4.4.4 Extrapolation to derive a $QS_{biota,\ secpois}$

Two approaches can be followed to determine this quality standard for biota. These approaches are briefly described here with further detail provided in the following sections.

The first is the standard approach from the TGD (EC, 2003; ECHA, 2008). In this methodology, the concentration in the diet of the toxicity test is the basis for the quality standard in biota. The extrapolation from diet to biota comprises the interspecies variation, differences in exposure duration, as well as the difference in caloric content of the diet of laboratory animals and the diet of fish-eating birds or mammals (EC, 2003).

In the second approach, the dose rather than the diet concentration, is used as a starting point (EFSA, 2008), which helps to minimise bias relating to different food intake rates between laboratory and field situations. A group of key species should represent all the organisms at risk from secondary poisoning. Information on body weight, dietary composition and feeding rate by predators are necessary to select those species most likely to experience the highest exposures to contaminants through the aquatic food web. By definition, if these are protected (and the assumptions are correct) other species will also be protected.

4.4.4.1 Derivation of QSbiota, secpois according to the standard approach in REACH

The quality standard that describes the threshold concentration of a substance in the food of a predator, $QS_{biota,\ secpois}$ (≈ $PNEC_{oral}$, in $mg{\cdot}kg^{-1}$ food), is derived by applying appropriate assessment factors (AF_{oral}; see Table 4.3) to the selected NOEC oral for each species. There may be more than one chronic study for the same species. Under these circumstances, the assessor should select the more sensitive study. Data from two different toxicological studies should only be merged if they have been conducted according to a similar guideline, use the same species and test conditions and report the same key endpoints. It may be that a test with a shorter exposure duration reports a more sensitive endpoint than the test with longest exposure duration. In such a case, the assessment factor corresponding to the longest exposure time may be applied to the most sensitive endpoint.

Table 4.2 Assessment factors for the extrapolation of mammalian and bird toxicity data into $QS_{biota,\ secpois}$ (EC, 2003)

TOX_{oral}	Duration of test	AF_{oral}
$NOEC_{oral,birds}$	chronic	30
$NOEC_{oral,mammals}$	28 days 90 days[a] chronic	300 90 30

[A] for consideration of reproduction studies

Since monitoring in biota in the marine compartment is preferably performed at the level of fish rather than e.g. seals, the $QS_{biota,\ secpois}$ for the marine compartment should include BMF_2 (cf. figure 4-1 in section 4.3. Therefore:

$$QS_{biota,secpois,\ fw} = \frac{TOX_{oral}}{AF_{oral}}$$

$$QS_{biota,secpois,sw} = \frac{TOX_{oral}}{AF_{oral} \cdot BMF_2}$$

The final value for the $QS_{biota,\ secpois}$ is selected by comparison of the different values for the tested species and choosing the lowest resulting values (EC, 2003; Lepper, 2005). If sufficient data are available, there is no reason why a probabilistic approach to extrapolation (ie an SSD approach) should not be used. However it should be noted that in the applied assessment factor the factor of 10 to extrapolate from the lowest chronic NOEC values to the $QS_{biota,\ secpois}$ is already included and that when applying a statistical extrapolation, the NOECs need ony to be converted from subacute

(28d; factor 10) and subchronic (90d; factor 3) to chronic and from laboratory diet to fish or mussels (all data; factor 3). For the application of a species sensitivity distribution (SSD), data should be available for a minimum of 10 species. The dataset should include both birds and mammals and should also include wildlife-relevant predatory species of both birds and mammals. For further considerations, the assessor is referred to Section 3.2.4.2.

If chronic NOECs for both birds and mammals are available, the lower of the toxicity values is used in the secondary poisoning assessment. In many cases, only acute toxicity data for birds will be available. Although there is no predictable link between and acute and long term toxicity (ie a substance that is of low acute toxicity will not necessarily be of low long-term reproductive toxicity), a pragmatic approach in the absence of a chronic study is to derive an 'indicative' $QS_{biota,\ birds}$ by applying a large (precautionary) AF of 3000 to the lowest reliable lethal concentration for 50% of the individuals (LC50) value (ECHA, 2008, section R.10.8.2). If the resulting 'tentative' $QS_{biota,\ birds}$, is lower than the $QS_{biota,\ mammals}$ then, given the lack of information on relative sensitivities between birds and mammals, the uncertainties should be highlighted in the datasheet.

4.4.4.2 Derivation of QSbiota, secpois according to the refined approach using key species

If it is possible to identify the key indicator wildlife species in the ecosystem the following approach can be used to derive the $QS_{biota,\ secpois}$. The key species is defined as the most susceptible species on the basis of its ratio of body and daily food intake and its position in the trophic chain (the latter only of the substance is subject to significant biomagnification). The NOEC for the key indicator wildlife species can then be calculated from the lowest reliable NOAEL from laboratory studies using information on body weight (bw) and daily food intake (DFI) for these species as indicated below:

$$NOEC_{wildlife} = NOAEL_{laboratory} * (bw_{wildlife}/DFI_{wildlife})$$

Only the mammals NOAEL is used to extrapolate to mammalian wildlife species. Similarly, only the avian NOAEL is used to extrapolate to avian wildlife species. Then the $QS_{biota,\ secpois}$ is derived from the $NOEC_{wildlife}$ in this case using the assessment factors from Table 4.4. In this table the extra factor of three for the difference in caloric content between laboratory food and a diet based on fish and/or mussels is omitted.

Table 4.3 Assessment factors for the extrapolation of mammalian and bird toxicity data into $QS_{biota,secpois}$ in a refined assessment

TOX_{oral}	Duration of test	AF_{oral}
$NOEC_{oral,\ birds}$	Chronic	10
$NOEC_{oral,\ mammals}$	28days [a]	100
	90days	30
	Chronic	10

[a] Note: The AF of 3 accounting for extrapolation from laboratory to field is omitted because the method already takes the dietrary intake differences between laboratory and field into account

The resulting AF should allow for interspecies variation in sensitivity to account for differences in toxicity. A factor of 10 accounting for interspecies variation is appropriate for this purpose. An additional AF of 3 to 10 is applied when exposure periods are not truly chronic (ie subchronic to chronic extrapolation).

The same considerations as in the standard approach may be applied with regard to the use of acute avian data and data treatment for the same species. For application of the SSD method the same considerations as in the standard approach are valid with the exception that in this case the input data should be based on dose and not diet concentrations.

4.5 Protection of humans against adverse health effects from consuming contaminated fisheries products

The QSbiota, hh food is intended to protect all humans against adverse health effects from consuming contaminated fishery products. Dealing with risks to human health from substances in drinking water is covered in Section 3.9. Like the biota standards for protecting predators, the standards described here are expressed in terms of body residues in food items.
No internationally recognised approach exists for determining the uptake of contaminants from fishery products by humans. However, several EU Directives (Council Directives 91/414/EEC and 97/57/EC) specifically deal with the risks to humans from several classes of organic contaminants, such as dioxins, dioxin-like polychlorinated biphenyls (PCBs) – PCB congeners that exhibit toxicological properties similar to dioxins – and polyaromatic hydrocarbons (PAHs) (Council Regulation (EC) No 1881/2006 of 19 December 2006), and metals, such as lead, cadmium and mercury (Council Regulation (EC) No 78/2005, amending Regulation 466/2001), via edible aquatic species, such as fish, molluscs, crustaceans and cephalopods. Therefore, when legislation has already led to the derivation of standards, the $QS_{biota,\ hh\ food}$ should refer to the maximum allowable concentration in $\mu g \cdot kg^{-1}$ wet weight in the specific tissue or sampling material.

Where no established $QS_{biota,\ hh\ food}$ value exists, the procedure described in Lepper (2005) is recommended. It assumes that the uptake of a substance from fishery products does not exceed 10% of the relevant threshold level (TL), estimated from experimental data and expressed in $\mu g \cdot kg^{-1}\ bw \cdot d^{-1}$ for humans. For practical purposes, the acceptable daily intake (ADI), tolerable daily intake (TDI) or $NOAEL_{oral}$ (the latter divided by an assessment factor) provides such an estimate. The $QS_{biota,\ hh,\ food}$ (expressed as $\mu g \cdot kg^{-1}$) is calculated using defaults for human bw (70 kg) and for the consumption of fishery products ($0.115\ kg \cdot d^{-1}$) as follows:

$$QS_{biota,\,hh\ food} = \frac{0.1 \cdot TL \cdot 70}{0.115}$$

This approach does not specifically consider possible sensitive groups, such as the developing foetus or subpopulations that consume more fishery products than the European average. However, the assumption that fishery products make up no more than 10% of the threshold level value (0.1·TL) at the European average level of compound uptake provides a margin of safety.

4.6 Metals

The approach described above for secondary poisoning and human consumption of fishery products, whereby NOEL, NOAELs for secondary poisoning and ADI, TDI or a comparable human threshold values for fishery products are used, is also applicable to metals. After the quality standard in biota has been derived, it should be compared to the background levels of metals in biota. The definition of the natural background level for metals in biota is as for in water, and the same types of difficulties exist when determining the level. In general, the considerations concerning natural background levels in biota are as for water (see Section 3.5).
Preferably, measurements of metals in biota should be taken from species living close to springs or far at sea. It should be recognized that biota may take up metals from the water as well as from particulate matter in water, including plankton, or from the sediment. In general, measurements in biota living in water where metal levels are elevated in either the sediment or the water should not be used for the determination of the natural background level of the substance in biota. The background concentration in biota is species specific and is further influenced by organisms age/size and the local food habits. Therefore background concentrations for biota should always be reported with species age or size and origin.

4.7 Monitoring compliance with biota standards

4.7.1 Biota monitoring

Procedures for species monitored through international conventions for inland, transitional, coastal and marine waters already exist, e.g. Helsinki Commission (HELCOM), OSPAR, International Commission for the Protection of the Rhine (ICPR). A separate background document summarises current monitoring programmes in Europe, and detailed guidance on the sampling and analysis of chemical residues in biota and sediments is the objective of another guidance document that is being prepared by the Chemical Monitoring Activities Working Group (EC, 2010).

4.7.1.1 Selection of species for monitoring

The primary aim of existing biota monitoring programmes is to assess environmental concentrations through long-term surveillance monitoring but, in principle, species that are already used in existing national or international monitoring programmes should be used for biota monitoring. The choice of particular species is not specified here, but certain criteria should ideally be met:

- The choice of species monitored should depend on the identified protection goal (e.g. humans, top predators).
- The standard in biota refers to a trophic level that is defined by the simple food chain (Section 4.4).
- The sampled organisms need to be potential food for predatory organisms or humans.

To provide an unbiased sample, the use of bulk samples of many individuals is recommended. Furthermore, those life-cycle stages that are most likely to be consumed by predators should be preferred and/or the organisms need to be of a size that is relevant to predator species. Large animals have fewer predators and analysis of these individuals may not provide any useful additional information about predator exposure. However, if the species selected is not high enough in the food chain, the outcome from monitoring could be underprotective for biomagnifying substances (if the concentration of a biomagnifying substance is close to the biota standard at lower trophic level, the concentration would exceed the biota standard at higher trophic levels for such substances). If selection of such a representative species is not possible from the point of view of standard organisms to be monitored in routine monitoring programmes, the biota standard should be adjusted to the appropriate trophic level of the monitored species .

4.7.1.2 Biota monitoring to infer water concentrations

Some Member States may prefer to monitor compliance with EQSs expressed as water concentrations from residues in biota, i.e. to use biota for inferring concentrations in water. This might apply when an EQS is lower than three times the LOQ[25] (limit of quantification). In this case, it is not always possible to quantify some substances in water. In addition, because of dilution effects and a decrease in the solubility of hydrophobic pollutants and metals in transitional, coastal and marine waters, it is expected that low concentrations might occur in these systems. Biota and sediments are able to integrate the pollutant concentrations over a period of time (usually months/years), while water is more variable and, in the case of sea water, levels can be related to the tide period as well as the main current or predominant wind during the sampling. If biota sampling is used in this way, there must be a good correlation between levels of the contaminants in the organism and in the surrounding water so that the biota concentration can be used to estimate the water concentration with confidence. For example, mussels (*Mytilus edulis*, *Mytilus galloprovincialis*) are likely to be a favoured genus in the marine environment because of the existence of historical datasets.

4.7.1.3 Sampling

The sampling frequency, sampling methods, sample preservation and cleanup should follow the guidelines already defined in the WFD monitoring guidance (EC, 2010). Although there are greater unit costs associated with collecting samples and performing the analysis for biota than for water, the sampling frequency is lower than for water.

4.7.2 Converting QSs expressed as biota concentrations into equivalent water concentrations

4.7.2.1 Organics

Normally, the $EQS_{biota}$is expressed as a body residue. It follows that monitoring is also performed in biota. The biota standard ($\mu g \cdot kg^{-1}{}_{diet}$) could, however, be converted into a water column concentration standard ($QS_{fw,secpois}$ or $QS_{sw, secpois}$ in $\mu g \cdot l^{-1}$), e.g. for comparison with other water column standards (see Section 2.5) to select an overall EQS, or to fit in with national monitoring regimes that use only water sampling. This conversion uses the threshold in prey (QS_{biota}) and bioaccumulation data (BCF, BMF and/or trophic magnification data) of the substance concerned. Effectively, the back calculation to a water concentration is equivalent to estimating the PEC_{oral} in chemical risk assessment. As explained below, it is necessary to account for the longer food chains in the marine environment where it concerns the secondary poisoning route, by incorporating not only biomagnification in the prey of predators (BMF_1, as for freshwater), but also in the prey of top predators (BMF_2). This does not apply to the EQS derivation for human fish consumption as here, fish is the species consumed by the 'top predator' (humans). However, the BMF_2 is also needed to set the EQS_{biota} for the marine environment because it is unacceptable to monitor at the trophic level of the marine predators, such as seals, that serve as food for the top predators, such as killer whales and polar bears. This leads to a different value for QS_{biota} for freshwater and QS_{biota} for saltwater where it concerns secondary poisoning, which is explained in the next section.

There are important issues involved in expressing the biota standard as a concentration in prey or as as a concentration in water and these are summarised in Table 4-5.

Table 4.4 Considerations in expressing a biota standard as a concentration in prey or in the water column

	Conversion into a water-column QS	Expression of the standard as body residue
Selection of a suitable 'matrix' for monitoring	• Easy (Daughter Directive text currently requires whole water for organics) • Analytical sensitivity issues likely (see below)	• Need to decide on appropriate trophic level, and species and tissue for monitoring (whole body or specific organ?)
Uncertainty in deriving EQS	• Uncertainty in BCF/BMF or BAF used in converting into water-column standard	• Uncertainty concerning AFs applied to TOX_{oral} and TDI and BMF_2 (only for the marine environment) • Uncertainty in converting into water-column standard eliminated
Comparison with other water-column EQSs	• Direct comparison possible	• Different matrix so cannot compare directly
Availability of data	• Requires toxicity data from feeding studies and BCF and BMF, or BAF	• Requires only toxicity data from feeding studies and BMF_2 (only for the marine environment)
Analysis	• Consistent with existing practice • $QS_{fw, secpois}$ or $QS_{sw. secpois}$ or $QS_{water, hh food}$ often < LOQ • Individual sample costs < biota sample costs, but method development required to achieve required sensitivity • Several samples needed per year	• Method development (e.g. cleanup) may be required to deal with biological matrix • Individual sample costs > water sample costs, but only infrequent sampling needed (requested actually 1/year, but 3 to 4 times/year seems more reasonable)
Relevance to water quality classification	• Need high quality data on food webs and the identification of the correct trophic level • Existing classification rules can apply, e.g. QA/QC Directive, but with high uncertainties and, therefore, low confidence that failure has actually occurred, in part because of sampling uncertainties that come with spot samples	• High – biota residue effectively integrates exposure over long time periods • Need high quality data on food webs and the identification of the correct trophic level for sampling the correct species

Where a QS_{biota} (in general) is to be converted into QS_{water}, experimental BCF and BMF data, or a field derived BAF, are required. The water concentration value is calculated as follows:

$$QS_{water} = \frac{QS_{biota}}{BAF}$$

The term bioaccumulation refers to transfer mechanisms of hydrophobic contaminants by both bioconcentration (accumulation via media) and biomagnifications (accumulation via food). Normally, the combined effects of each step are combined in a multiplicative approach. Therefore, the BAF may be calculated as:

$$BAF = BCF \cdot \prod_{i=1}^{n} BMF_i$$

where the number of BMFs depends on the trophic level or position of the organism in the food web. According to REACH Guidance (ECHA, 2008), a simple food web is assumed that consists of water –BCF→ aquatic organisms –BMF_1→ fish → fish-eating predator. As indicated above, for marine top predators, an additional BMF in prey of top predators (BMF_2) should be applied. Therefore:

$$QS_{fw,\sec pois}(\mu g / l) = \frac{QS_{biota,\sec pois,\ fw}(\mu g / kg)}{BCF(l / kg) \cdot BMF_1}$$

$$QS_{sw,\sec pois}(\mu g / l) = \frac{QS_{biota,\sec pois,\ sw}(\mu g / kg)}{BCF(l / kg) \cdot BMF_1}$$

There are ways in which uncertainty in the calculation can be reduced:

1. The field BAF value for the correct trophic level should be used.
2. The laboratory BCF value is multiplied by the field BMF.

Ideally, the BMFs should be based on measured data. In general, the most reliable data on biomagnification originate from trophic magnification studies. In such studies, the levels of contaminants in several species in an ecosystem are measured and expressed as a function of the trophic level. The trophic level is mostly derived from stable nitrogen isotope ratios and a regression is made between contaminant concentration and trophic level. The contaminant values should preferably be normalised to the fraction in the organisms that contains the substance, e.g. lipids.

The advantage of this method is that it takes into account magnification along the whole food chain and it is not subject to the rather arbitrary choice of two species for which a BMF is calculated. The BMF_1 may be deduced from the increase in (lipid-normalised) concentration of the contaminant over one trophic level in a simple pelagic food chain. Food web magnification factors (FWMFs) or trophic magnification factors (TMFs) are based on the slope of the regression of the logarithm of the concentration versus trophic level. The trophic level is calculated assuming an enrichment of 2 to 5‰ (usually 3.4 or 3.8‰) for $\delta^{15}N$ (based on stable nitrogen isotope ratios) per trophic level. The value of the FWMF or TMF can be taken as the BMF over one trophic level, equivalent to BMF_1 in a pelagic food chain. Care must be taken that the regression is based on trophic level rather than $\delta^{15}N$. If this is not the case, a correction for the increase of $\delta^{15}N$ per trophic level has to be applied.

For the marine environment, an extra BMF is included. In this case, poikilotherms (invertebrates and fish) and homeotherms (seabirds and mammals) should be distinguished. As the first group is related to the first BMF for fish, the second group is representative for the biomagnification in predating birds and mammals. Thus, BMF_2 should preferably be extracted from a study that describes such a food chain. In general, the biomagnification in homeotherms is larger than that in poikilotherms and, thus, BMF_2 is generally larger than BMF_1.

If it appears that the FWMF or TMF is not significantly greater than one, it is reasonable to conclude that there is no significant biomagnification, and both values for BMF may be set to one. If the value for FWMF or TMF is significantly below one, trophic dilution is indicated. For the pelagic food chain, BMF_1 then equals one, as the BMF value represents biomagnification from small fish to predatory fish, while the metabolic capacity in fish is assumed to be uniform and the BCF will mostly refer to fish. For the marine environment, not only the top predators, but also the predators that feed on fish should be protected. Therefore, even if trophic dilution occurs from predator to top predator, this step in the food chain is then superfluous as both refer to toxicity of mammals and birds. In this case, BMF_2 has to be set equal to one as well.

Other sources of information are BMFs from field or laboratory studies. Care should be taken in interpreting these values because they only represent one link in the food chain and may not represent the overall biomagnification potential of a substance. A BMF is restricted to the ratio between the concentrations in the predator and in its prey or food in the case of a laboratory study.

The availability of biomagnification data is limited; therefore, the default BMF values given in Table 4-6 (EC, 2003) may be necessary. However, a reliable experimental BCF value is always preferred above the log K_{ow} to estimate the BMF value because it takes the metabolism of the substance into account, which is an important parameter in food web accumulation.

Table 4-5 Default BMF values for organic substances

log K_{ow} of substance	BCF (fish)	BMF_1	BMF_2
<4.5	<2000	1	1
4.5–<5	2000–5000	2	2
5–8	>5000	10	10
>8–9	2000–5000	3	3
>9	<2000	1	1

The conversion from a biota standard into an equivalent water concentration can introduce uncertainty, especially for highly lipophilic substance (i.e. BCF >2000). Generally, substances with a BCF of 500 or less can be converted into an equivalent water concentration with reasonable confidence. Where it is necessary to convert a biota QS into an equivalent water-column concentration, the uncertainties involved in making the extrapolation may be taken into account by performing the conversion for extreme BAF values as well as using the typical BAF value. If the QS for water lies within the range of possible extrapolated values of the QS for biota, when considering the uncertainties of the extrapolation, it is not possible to determine with high confidence which is the ‘critical’ QS. The worked examples for hexachlorobenzene (HCB) and lindane below show that for HCB the biota QS is likely to be the critical QS regardless of the uncertainties of the extrapolation, whereas in the case of lindane there is uncertainty as to whether the biota QS or the water QS is the critical QS.

HCB example

QS_{water}	13 ng·l^{-1} (EQS Substance data sheet, 2005)
$PNEC_{oral}$	16.7 g·kg^{-1}(EQS Substance data sheet, 2005)
BAF	52,300 L·kg^{-1} (mean value; 26 experimental fish BAF values, min 8130, max 550,000, median 51,900) (Arnot and Gobas, 2006)

$$EQS_{water} = \frac{EQS_{biota}}{BAF}$$

Extrapolated QS_{water}

Calculated with median BAF	0.3 ng·l^{-1}
Calculated with minimum BAF	2 ng·l^{-1}
Calculated with maximum BAF	0.03 ng·l^{-1}

Lindane example

QS_{water}	20 ng·l^{-1} (EQS Substance data sheet, 2005)
$PNEC_{oral}$	33 g·kg^{-1}
BCF	1300 (selected in the EQS datasheet, min 220, max 2200) (EQS Substance datasheet, 2005)[24]
BMF	A BMF of 1 was assumed according to the TGD (EC, 2003)

$$EQS_{water} = \frac{EQS_{biota}}{BCF.BMF}$$

Extrapolated QS_{water}

Calculated with selected BCF	25 ng·l^{-1}
Calculated with minimum BCF	150 ng·l^{-1}
Calculated with maximum BCF	15 ng·l^{-1}

4.7.2.2. Metals

If a secondary poisoning risk (to birds and mammals) from metals is identified (Section 2.4.3.1), or a risk for human fish consumption then the methodology described in Section 4.4 for the derivation of the $QS_{biota,secpois}$ or Section 4.5 for the derivation of the $QS_{biota,\ hh\ food}$ should be followed.

Where toxicological information on critical body (or organ/tissue) levels is lacking, BCFs or BAFs may be used to estimate metal accumulation in animals relative to the concentration in water.

There are added complexities when selecting an overall EQS because BCFs used to back-calculate to a water concentrationmay depend on water concentration. For naturally occurring substances, such as metals, many species regulate their internal concentrations through (1) active regulation (2) storage or (3) a combination of active regulation and storage over a wide range of environmental exposure conditions. Although these homeostatic control mechanisms have evolved largely for essential metals, they are not entirely metal specific and will, to some extent, apply to non-essential metals. A list of metals and metalloids classified by their essentiality to organisms is given in Table 4-7 (ICME, 2001)

[24] Note that the example for lindane used here follows the EQS datasheet (2005), but does not use a BAF value, or apply a BMF value. Use of a BAF value (e.g from Arnot and Gobas, 2006) results in the biota QS being the critical QS.

Table 4-6 Metals and metalloids classified by essentiality to living organisms

Essential	Non-essential
Cr, Co, Cu, Fe, Mn, Mo, Ni, Se, Zn	As, Sb, Cd, Pb, Hg, Tl, Ag, Sn

At low metal concentrations organisms accumulate essential metals (and often non-essential metals via the same uptake mechanisms) more actively in order to meet their metabolic requirements. At higher concentrations organisms with active regulation mechanisms even limit their uptake by the extraction of excess metals (ECHA, 2008). As a consequence metal concentrations in tissue based on a range of exposure concentrations may be quite similar yet the BCFs/bioaccumulation factors (BAFs) are variable, even showing an inverse relationship with external metal concentrations (ie higher BCFs at lower exposure concentrations and lower BCFs at higher exposure concentrations). This means that the use of BCF values for metals must be performed with care.

The text below sets out the steps to be used to select an overall EQS for metals:

1. **Derive standards in biota**
- Derive the $QS_{biota,\ secpois\ fw}$ or the $QS_{biota,\ secpois\ sw}$ following guidance in Sections 4.4 and 4.5.
- Compare the derived value to background levels of the substance for biota and ensure that the QS_{biota} > background concentration in biota (Section 4.6).

2. **Estimate biomagnification (BMF) and bioconcentration (BCF, BAF)**
- Collect (preferably) field-determined BAF data, e.g. of fish and molluscs, in which both internal and external metal concentrations have been reported.
- Determine the relationship between internal and external concentrations for the metal for several species (e.g. fish, molluscs). The $QS_{fw,\ secpois}$ or $QS_{sw,\ secpois}$ and $QS_{wataer,\ hh\ food}$ should be included in the range of internal concentrations (biota concentrations) or, alternatively, the $QS_{fw,\ eco}$ or $QS_{sw,\ eco}$ should be included in the range of external concentrations (water concentrations).
- Collect any relevant data that can be used to assess the bioavailability/bioaccessibility of tissue-associated metal.
- Determine the BMF relevant to the food chain considered.

3. Compare tissue concentration or water concentrations for the routes of direct ecotoxicity and secondary poisoning
- Compare the QS_{biota}/BAF or QS_{biota}/(BCF·BMF) with $QS_{water,eco}$ using a BAF or BCF and BMF that is determined at an internal (biota) concentration equal to the QS_{biota} or, alternatively, compare the $QS_{water,eco}$·BAF or $QS_{water,eco}$·BCF·BMF with the QS_{biota} using a BAF or BCF and BMF that is determined at an external (water) concentration equal to the $EQS_{water,eco}$. A prequisite is that the relationship between internal and external concentrations should be well determined, otherwise this approach cannot be followed.
- If a specific BAF or BCF is not available, a worst case approximation can be made using a BAF or BCF determined at a concentration in water *lower* than the $QS_{water,eco}$.

Does secondary poisoning lead to lower levels than direct ecotoxicity?

$QS_{water,secpois}$ is protective for these effects – no further work

Adopt EQS_{biota} as the overall EQS

For metals, BCF values may be obtained in a variety of ways:

- In cases where there is evidence of concentration dependency of BCFs (i.e. the BCF is higher at lower environmental levels), regression models based on the observed inverse relationship should be used to derive the most-appropriate BCF value for the prey organisms considered (Brix et al., 2001; Efroysmen et al., 2001, McGeer et al., 2003, DeForest et al., 2007).

- Where regression lines cannot be calculated, BCFs may be obtained either by calculating species-specific arithmetic means from BCF studies using environmentally relevant metal concentrations in the test media or by using BAFs observed in the field (Lepper, 2005).

Where there is a choice of BCF or BAF values, the use of BAF is preferred because it considers not only uptake via water, but also exposure via food or sediments, and is therefore considered to be ecologically more relevant than BCF values.

5. STANDARDS TO PROTECT BENTHIC (SEDIMENT DWELLING) SPECIES

5.1 Introduction

Sediments can act as a sink for chemicals through sorption of contaminants to particulate matter, and may act as a source of contaminants to particle feeders through resuspension (eg by dredging or natural events) or back to the water phase by desorption. The derivation of sediment EQSs is particularly relevant for hydrophobic substances and some metals (see 2.4.2). EQSs for sediments are used instead of alongside or, instead of, EQSs for other compartments to assess the status of water bodies. EQSs for sediments are required to protect benthic (sediment-dwelling) species.

Sediments are a major sink for historic pollutants and changes in bioavailability of such contaminants makes compliance assessment more complex than in other compartments. As with other standards, major sources of uncertainty in standard derivation should be highlighted in the technical datasheet dealing with sediment EQSs, along with suggestions on how they might be ameliorated. Section 5.3 provides further suggestions to policy makers on how sediment quality can be assessed and how to identify where management measures may be warranted.

5.2 Derivation of sediment standards

The derivation process is based on that used for effects assessment under REACH (ECHA, 2008) but with an additional consideration of field or mesocosm data. This enables different lines of evidence (sediment toxicity tests, aquatic toxicity tests in conjunction with equilibrium partitioning (EqP) and field/mesocosm studies) to be used to generate the final standard (Figure 5-1). Further detail on each of these steps, eg the use of Equilibrium Partitioning, is provided in the following sections. The temporary standards used in the derivation of sediment standards are explained in Appendix 6.

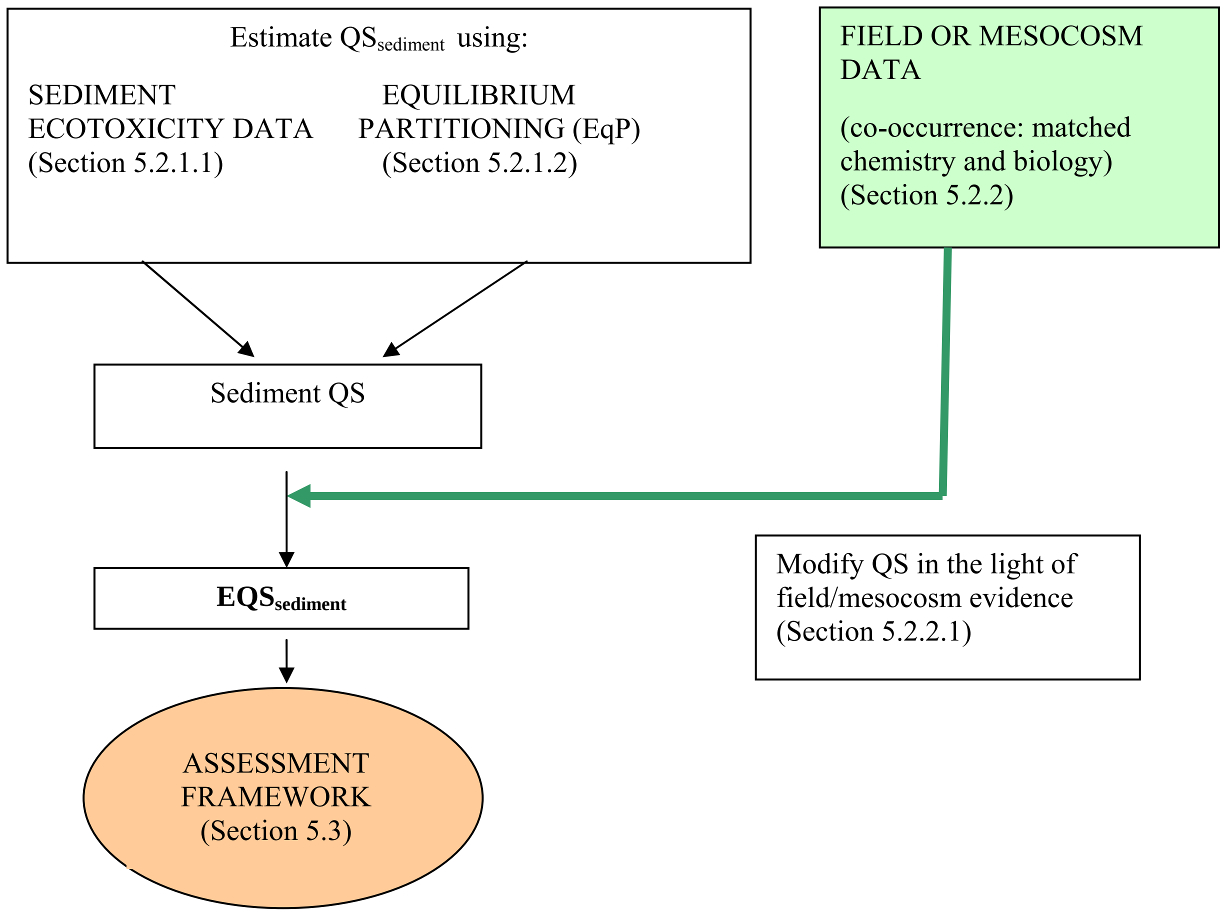


Figure 5.1 Overview of process for deriving a sediment standard

5.2.1 Derivation of $EQS_{sediment}$ for the protection of freshwater benthic organisms

Data used for the derivation of EQS for sediment can include:

(i) ecotoxicity data from experiments with benthic organisms (Section 5.2.1.1)
(ii) water column ecotoxicity data used in conjunction with equilibrium partitioning (Section 5.2.1.2)
(iii) empirical field or mesocosm data (e.g. co-ocurrence of benthos and chemical contamination in the field (Section 5.2.1.3)

Where sediment ecotoxicity data are available, option (i) is preferred over option (ii) because of the assumptions and uncertainties inherent in the equilibrium partitioning approach (detailed in Section 5.2.1.2).

5.2.1.1 Use of sediment toxicity data to derive quality standards

Most sediment laboratory toxicity data are based on the use of spiked sediments in which clean sediment has been deliberately contaminated in the laboratory and test organisms introduced to this spiked sediment. Most tests have been performed according to OECD, ASTM or USEPA guidelines using benthic invertebrates (e.g. *Chironomus riparius* OECD 218 - chironomid test/spiked sediment / growth and emergence). Other test species may be used but details on the test conditions must be reported and the data should be assessed for reliability and relevance as described in Section 2.6.2. Further guidance, specific to sediment toxicity tests, is to be found in Appendix 1.

Test data in which availability of the contaminant is maximised are preferred. Maximising exposure should lead to the derivation of more protective values and decrease the uncertainty associated with EQS (ie reflect a 'worst case' scenario). In the EU, a 'standard sediment' has a default organic carbon (OC) content of 5% and for organic chemicals a normalisation of toxicity data to this standard sediment is preferred for the derivation of the $EQS_{sediment}$.

For substances for which the bioavailability is dependent on the organic carbon content of the sediment, the variability introduced by the presence of toxicity values generated at different organic carbon concentrations can be accounted for by normalizing each (valid) toxicity test result (LC50, EC50, EC10, NOEC) to organic carbon and then express all results in sediment with a standard organic carbon content. The resulting sediment standard can be recalculated to any organic carbon content measured in the field. The organic carbon content of the EU standard sediment is 5%, equal to that used in the TGD, REACH and EUSES.

$$\text{TEST RESULT}_{\text{EU standard sed}} = \frac{\text{TEST RESULT}_{\text{test sed}} \text{ x } F_{\text{oc, EU standard sed}}}{F_{\text{oc, test sed}}}$$

Parameter	**Description**	**Unit**	**Default Value**
TEST RESULT	Outcome of toxicity experiment with benthic organism, expressed as EC50, LC50, EC10, LC10, NOEC etc	mg kg_{dw}^{-1}	
TEST RESULT EU standard test	Test result expressed in EU standard sediment	mg kg_{dw}^{-1}	
TEST $RESULT_{test\ sed}$	Test result expressed in EU standard sediment		
$F_{oc,\ EU\ standard\ sed}$	Organic carbon content (w/w) of EU standard sediment	kg kg^{-1}	0.05
$F_{oc,\ test\ sed}$	Organic carbon content (w/w) of the experimental sediment	kg kg^{-1}	

Results of long-term toxicity tests with sediment organisms are preferred for deriving sediment standards due to the generally long term exposure of benthic organisms to sediment bound substances. If such studies are available, a $QS_{sediment,\ fw\ eco}$ or $QS_{sediment,\ sw\ eco}$ is determined using the assessment factors (AFs) in Table 5-1, applied to the lowest credible datum. The assessment factors are based on those used within the REACH guidance (ECHA, 2008) and applied as follows:

$QS_{sediment}$ [mg/kg] (dry weight) = lowest NOEC or EC10 [mg/kg] /AF (range 100 – 10)

Table 5.1 Assessment factors applied to spiked sediment tests (ECHA, 2008)

Available data	Assessment factor
One long term test (NOEC or EC10)	100
Two long term tests (NOEC or EC10) with species representing different living and feeding conditions	50
Three long term tests (NOEC or EC10) with species representing different living and feeding conditions	10

If only results from short-term tests with sediment-dwelling organisms are available, an assessment factor of 1000 is applied to the lowest reliable value. In situations where only short term test data is available a QS should also be derived using the Equilibrium Partitioning approach (See Section 5.2.1.2). The lowest value would be proposed as the $QS_{sediment}$ in these situations.

In principle, the species sensitivity distribution (SSD) modelling approach (Section 3) can be applied to sediment toxicity data rather than the deterministic (AF) approach. In practice however, the minimum data requirements for an SSD will rarely be met, except perhaps for a few well-studied metals. Guidance on the use of SSD for the derivation of sediment thresholds has not been included within the REACH guidance (ECHA, 2008) however the approach was used within the Voluntary Risk Assessment undertaken on copper (ECI, 2008).

5.2.1.2 Equilibrium Partitioning

If no reliable sediment toxicity data are available, Equilibrium Partitioning (EqP) can be used to estimate the $QS_{sediment, fw EqP}$ or the $QS_{sediment, sw EqP}$

EqP is a mechanistic approach developed by Di Toro *et al*. (1991) for deriving sediment quality guidelines. Assuming the toxicity of a non-ionic organic chemical in sediment is proportional to its concentration in water, then the concentration of this chemical in sediment that will cause toxicity can be estimated if the relationship between the chemical concentration in the pore water and that in sediment is understood.

The partitioning of a chemical between sediment and pore water can be represented by a simple equilibrium equation:

$$C_{SOC} = C_{PW} \times K_{OC}$$

C_{SOC} is the concentration of the chemical in the sediment per unit mass of organic carbon, C_{PW} is the concentration of the chemical in pore water, K_{OC} is the partition coefficient of the chemical to sediment organic carbon). The C_{PW} can be replaced with the chemical concentration in water associated with a biological effect in the water column ($C_{effect\text{-}water}$).

Replacing CPW by the $QS_{fw, eco}$ or the $QS_{sw, eco}$ (Section 3) will yield a $QS_{sediment, fw EqP}$ or the $QS_{sediment, sw EqP}$. For EqP calculations, the equations outlined in the REACH guidance and EUSES will be used.

Calculation of Kcomp-water

In the EqP method outlined in ECHA guidance, the ‘dimensionless’partition co-efficient Ksed-water is used in untis of m3m-3. This parameter is also called a total compartment-water partition coefficient. It is calculated according to the equations given in REACH guidance (ECHA, 2008) R.16, which are presented here for the sediment compartment only. Note that EqP to the bulk-sediment compartment is performed within the current EQS guidance, while REACH guidance uses suspended matter characteristics. This is done for several reasons: the REACH standard organic carbon content of suspended matter is relatively high (viz 10%) for most sediments; compliance checking will be performed with sediemtns rather than suspended matter and sediment standards based on suspended matter characteristics bear more relevance to the water column than do standards based on sediment characteristics. The default values for compartment specific characteristics (Faircomp, RHO solid etc) from the REACH (ECHA, 2008) should be used; their values are listed in the table below the equations.

$$Kp_{sed} = Foc_{sed} \times K_{oc} \qquad 2$$

$$K_{sed-water} = \frac{Ctotal_{sed}}{Cporew_{sed}} \qquad 3$$

$$K_{sed\text{-}water} = Fair_{sed} \times K_{air-water} + Fwater_{sed} + Fsolid_{sed} \times \frac{Kp_{sed}}{1000} \times RHOsolid \qquad 4$$

$$K_{air-water} = \frac{H}{R \times TEMP} \qquad 5$$

Description:

Parameter	Description	Unit	Default value
1000	conversion factor from m^3 to litre	$L\ m^{-3}$	1000
$Cporew_{sed}$	total concentration in pore water of sediment	$mg\ m^{-3}$	
$Ctotal_{sed}$	total concentration in sediment	$mg\ m^{-3}$	
$Fair_{sed}$	fraction air in sediment	$m^3\ m^{-3}$	0
Foc_{sed}	weight fraction of organic carbon in sediment	$kg\ kg^{-1}$	0.05
$Fsolid_{sed}$	fraction solids in sediment	–	0.2
$Fwater_{sed}$	fraction water in sediment	$m^3\ m^{-3}$	0.8
H	Henry's law constant	$Pa\ m^3\ mol^{-1}$	
$K_{air\text{-}water}$	air-water partition coefficient	$m^3\ m^{-3}$	
K_{oc}	partition coefficient between organic carbon and water	$L\ kg^{-1}$	
Kp_{sed}	partition coefficient solid-water in sediment	$L\ kg^{-1}$	
$K_{sed\text{-}water}$	partition coefficient between sediment and water	$m^3\ m^{-3}$	
R	gas constant	$Pa\ m^3\ mol^{-1}\ K^{-1}$	8.314
RHO_{sed}	bulk density of wet sediment	$kg_{ww}\ m^{-3}$	1300
$RHOsolid$	density of the solid phase	$kg_{solid}\ m_{solid}^{-3}$	2500
$TEMP$	environmental temperature	K	285

Calculation of $QS_{sediment,\ fw\ EqP}$ or $QS_{sediment,\ sw\ EqP}$

The calculation of the QS for sediment by equilibrium partitioning according to the REACH guidance (ECHA, 2008) R.10 is given below.

- The $QS_{sediment,fw\ EqP}$ is calculated for freshwater sediments according to EqP from the QS for aquatic organisms, $QS_{fw,\ eco}$ using Eqs 6 and 8 or in the case of marine sediment, from $QS_{sw,\ eco}$
- When the $QS_{sediment}$ has been calculated using EqP and log Kow >5 for the compound of interest, $QS_{sediment}$ is divided by 10. This correction factor is applied because EqP only considers uptake via the water phase. Extra uncertainty due to uptake by ingestion of food should be covered by the applied assessment factor of 10.

$$QS_{\text{sediment, EqP, ww}} = \frac{K_{\text{sed-water}}}{RHO_{\text{sed}}} \times QS_{\text{fw, eco}} \times 1000 \qquad 6$$

$$CONV\text{sed} = \frac{RHO_{\text{sed}}}{F\text{solid}_{\text{sed}} \times RHO\text{solid}} \qquad 7$$

$$QS_{\text{sediment, EqP, dw}} = CONV\text{sed} \times QS_{\text{sediment, EqP, ww}} \qquad 8$$

Description (some of the variables are listed in the previous table):

Parameter	Description	Unit	Default value
1000	conversion factor from m^3 to litre	L m^{-3}	1000
*CONV*sed	conversion factor for sediment concentration wet-dry weight sediment	$kg_{ww} \cdot kg_{dw}^{-1}$	
*F*solid$_{sed}$	fraction solids in sediment	–	0.2
$K_{sed\text{-}water}$	partition coefficient between sediment and water	$m^3\ m^{-3}$	
$QS_{sediment,\ EqP,\ dw}$	dry weight quality standard for sediment based on equilibrium partitioning	mg kg_{dw}^{-1}	
$QS_{sediment,\ EqP,\ ww}$	wet weight quality standard for sediment based on equilibrium partitioning	mg kg_{ww}^{-1}	
$QS_{fw,\ eco}$	quality standard for direct ecotoxicity on freshwater aquatic organisms	mg L^{-1}	
RHO_{sed}	bulk density of wet sediment	$kg_{ww}\ m^{-3}$	1300
*RHO*solid	density of the solid phase	$kg_{solid}\ m_{solid}^{-3}$	2500

Experimentally determined values for K_{OC} are preferable. These K_{OC} values may be derived from standardised tests (e.g. OECD Guideline 106) or from other studies published in scientific literature. Koc values equation (van Vlaardingen and Verbruggen 2007). Examples of QSPRs for defining the relationship between Kow and Koc for different substance groups are provided in Table 5.2.

The EqP approach assumes that phases are at equilibrium, and thus exposure through pore water determined by the HPLC method (OECD guideline 121) should be considered as estimates of the real Koc values and consequently, these values are not used as experimental values. Because K_{OC} values may vary widely and no value for Koc can be considered as the most reliable value, the geometric mean of all valid K_{OC} values is calculated, including one value estimated from K_{OW}. This geometric mean K_{OC} will be used in the above equation. For highly lipophilic substances (Kow > 5), equilibrium may not be achieved, so a correction for exposure through food was introduced in the TGD (EC, 2003). For such substances, an additional AF of 10 is recommended.

Reliance on EqP alone involves several important assumptions such as equilibrium among phases, similar sensitivities among pelagic and benthic species. In a risk assessment scenario, potential sediment risks indicated by EqP would trigger further sediment toxicity testing. This is not always possible in QS derivation so any $QS_{sediment}$ that is based on EqP (or indeed a small toxicity test dataset) carries a high degree of uncertainty that must be highlighted in the datasheet for consideration by policymakers.

Table 5.2 QSPRs for soil and sediment sorption for different classes (Sabljic et al, 1995)

Chemical class	Equation	Statistics
Predominantly hydrophobics	$logK_{OC}$=0.81*$logK_{OW}$+0.10	n=81, r^2=0.89,s.e.=0.45
Non hydrophobics	$logK_{OC}$=0.52*$logK_{OW}$+1.02	n=390, r^2=0.63,s.e.=0.56
Phenols, anilines, benzonitriles, nitrobenzenes	$logK_{OC}$=0.63*$logK_{OW}$+0.90	n=54, r^2=0.75,s.e.=0.40
Acetanilides, carbamates, esters, phenylureas, phosphates, triazines, triazoles, uracils	$logK_{OC}$=0.47*$logK_{OW}$+1.09	n=216, r^2=0.68,s.e.=0.43
Alcohols, organic acids	$logK_{OC}$=0.47*$logK_{OW}$+0.50	n=36, r^2=0.72,s.e.=0.39
Acetanilides, carbamates, esters, phenylureas, phosphates, triazines, triazoles, uracils	$logK_{OC}$=0.40*$logK_{OW}$+1.12	n=21, r^2=0.51,s.e.=0.34
Alcohols, organic acids	$logK_{OC}$=0.39*$logK_{OW}$+0.50	n=13, r^2=0.77,s.e.=0.40
Amides	$logK_{OC}$=0.33*$logK_{OW}$+1.25	n=28, r^2=0.46,s.e.=0.49
Anilines	$logK_{OC}$=0.62*$logK_{OW}$+0.85	n=20, r^2=0.82,s.e.=0.34
Carbamates	$logK_{OC}$=0.37*$logK_{OW}$+1.14	n=43, r^2=0.58,s.e.=0.451
Dinitroanilines	$logK_{OC}$=0.38*$logK_{OW}$+1.92	n=20, r^2=0.83,s.e.=0.24
Esters	$logK_{OC}$=0.49*$logK_{OW}$+1.05	n=25, r^2=0.76,s.e.=0.46
Nitrobenzenes	$logK_{OC}$=0.77*$logK_{OW}$+0.55	n=10, r^2=0.70,s.e.=0.58
Organic acids	$logK_{OC}$=0.60*$logK_{OW}$+0.32	n=23, r^2=0.75,s.e.=0.34
Phenols, benzonitriles	$logK_{OC}$=0.47*$logK_{OW}$+1.08	n=24, r^2=0.75,s.e.=0.37
Phenylureas	$logK_{OC}$=0.49*$logK_{OW}$+1.05	n=52, r^2=0.60,s.e.=0.34
Phosphates	$logK_{OC}$=0.49*$logK_{OW}$+1.17	n=41, r^2=0.73,s.e.=0.45
Triazines	$logK_{OC}$=0.30*$logK_{OW}$+1.50	n=16, r^2=0.32,s.e.=0.38

The process for using laboratory toxicity data and the EqP approach in deriving a $QS_{sediment}$ is summarised in Figure 5.2.

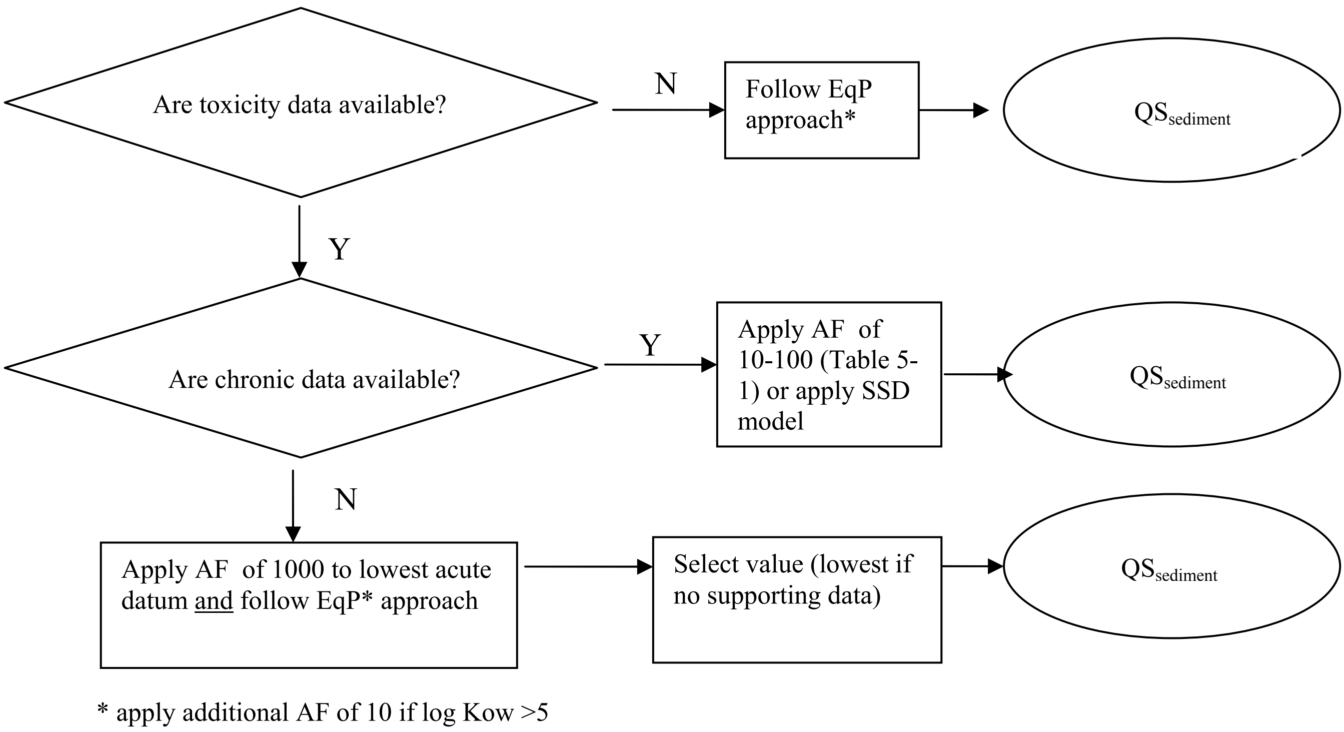


Figure 5.2 Process for the derivation of a $QS_{sediment}$

5.2.1.3 Use of field or mesocosm data

Role of field and mesocosm data

Field and/or mesocosm data should be considered, where available, in the derivation of the $QS_{sediment}$. This approach is consistent with the guidance for water column QSs (Section 2.8.2) and with Annex V of the WFD where it states that *"… the standard thus derived should be compared with any evidence from field studies. Where anomolies appear, the derivation shall be reviewed to allow a more precise safety factor to be calculated …"*

It should be borne in mind that laboratory experiments are likely to result in high levels of chemical availability because spiked sediments are rarely aged. This is in contrast with field or mesocosm data where chemical exposures are more likely to be closer to equilibrium. For these reasons, we would expect a bias in laboratory data toward higher toxicity (and more stringent standards). Lower toxicity under field conditions could reflect the real effect of ageing that should be accounted for, if possible, in standard setting.

In the absence of useful corroborating evidence from the field or mesocosms the QS derived from chronic toxicity data is retained. If this is not possible, the lowest of the QSs derived based on the EqP approach or short term toxicity data is taken as an interim standard (Figure 5-1).

Types of field and mesocosm data

Mesocosm studies may be available which have generated NOEC/EC10 data. Effect concentrations may also be available from field studies. If such tests are considered reliable the results can be used in the derivation of the $QS_{sediment}$ (Section 5.2.1.3.3).
A number of empirical approaches that link biological responses of benthos to chemical contamination in the field have been described (Batley *et al.*, 2005). They are based primarily on field data, in which matched sediment chemistry and biological effects data are analysed using

various statistical approaches to relate chemical concentrations to the frequency of biological effects. Further details on these analyses are to be found in the following sources:

- Threshold effect level (TEL) / probable effect level (PEL)(Smith, Mc Donald et al. 1996), effect range low (ERL) – effect range medium (ERM) (Long, Mc Donald et al. 1995)
- Screening level concentration (SLC) (E.C. 1992; Persaud, Jaagamugi et al. 1993)
- Logistic regression modelling (LRM) (Field, Mc Donald et al. 1999; Field, MacDonald et al. 2002). The LRM approach focuses on establishing the probability of adverse effect as a function of sediment chemical concentration. As this relationship is continuous, this approach can be used to define sediment standards associated with any desired probability of impact. For practical purposes the 10th percentile is the preferred cut-off; this also corresponds to the ERL (see below)
- Field-based species sensitivity distribution (Kwok *et al*. 2008)

For the purposes of QS derivation, field thresholds referring to concentrations where biological effects are unlikely to occur (sometimes referred to as 'threshold effect levels' (TEL), 'effect range low' (ERL) or 'no-effect level' (NEL, in the SLC approach)) are preferred over thresholds associated with a significant biological impact (e.g. 'probable effects level', PEL). The definition of ERL or TEL specify that not more than 20-25% of samples should display a toxic effect..
If a field threshold has not been calculated, one of the approaches referred to above can be applied to matching chemistry and biological data, e.g:

- ERL is the 10^{th} percentile of the distribution of concentrations (dry weight) associated with an effect in a database matching chemistry and ecotoxicological tests applied to sediments collected from the field.
- TEL is the geometric mean of the 50^{th} percentile of concentrations (dry weight) associated with a biological effect and the 15^{th} percentile of the no-effects set.

None of these approaches should be used without a thorough assessment of the reliability of the data and their relevance. Entries associated with an effect for a given chemical are relevant if the concentration for this chemical is at least 2-fold above the background (McDonald *et al.* 1996).

Application of the field/mesocosm data within $QS_{sediment}$ derivation

Reliable data arising from field/mesocosm studies can be used to influence the derivation of the $QS_{sediment}$ as follows:-

1. If the TEL or ERL, or mesocosm NOEC/EC10, is higher than, or equal to the $QS_{sediment, eco}$, derived based on available ecotoxicity data, either the latter is used as the $EQS_{sediment}$ or there may be a case for reducing the size of the AF applied to the laboratory data, but only if the field or mesocosm data are reliable and relevant to a wide range of European (or national, in the case of Specific Pollutants) conditions.

2. If the TEL or ERL is lower than the $QS_{sediment}$ derived based on ecotoxicity tests, there might be a case for increasing the size of the AF if the field or mesocosm data are reliable.

3. If the TEL or ERL is higher than, or equal to, the value calculated by applying the equilibrium partitioning, the latter is used for the derivation of the $EQS_{sediment}$.

4. If the TEL or ERL is lower than the value calculated by applying equilibrium partitioning, the former value is used with an assessment factor (AF) to derive a sediment QS. The AF value would be set at 5.

5.2.2 Metals and the need to cope with bioavailability issues

Where possible, consideration should be given to those factors that affect the availability (and hence toxicity) of contaminants in sediment. Natural sediments used in ecotoxicological tests contain different binding ligands which restrict the mobility of metals. As a consequence, this may also influence the availability and the toxicity of metals to sediment dwelling organisms. Major binding ligands for cations in the aerobic layer of sediments are iron and manganese oxyhydroxides (FeOOH and MnOOH), carbonates and organic carbon (OC). In anoxic sediments, bioavailability of metals can also be controlled by the formation of stable complexes with sulphide. The environmental fate of metals present in anionic forms is dominated by different sorption properties . For metals that have a high affinity to bind to these ligands, it is worthwhile exploring whether a relationship can be established between the observed toxicity levels and the presence of one or more of the ligands. If so, the toxicity of a metal in sediments can then be normalised towards a standard or a specific local condition.

5.2.2.1 Use of data from direct (spiked) toxicity tests

The approach previously described in section 5.2.1.1 will be applied to the set of data constituted on the basis of the following requirements. See also list of general requirements in section 2

- *Sediment:* For deriving sediment QSs from direct sediment toxicity data, information on the sediment chemistry is needed for data interpretation, especially if bioavailability corrections are carried out. In the latter case artificial sediments used in studies should be characterised (e.g. particle size, pH of pore water, organic matter (OM), cation exchange capacity (CEC)/anion exchange capacity (AEC), as well as iron and manganese oxides). If natural sediment is used, SEM (Simultaneously Extracted Metals) and AVS (Acid Volatile Sulphides) concentrations should be measured.
- *Metal-OC equilibrations*: The kinetics of metal-DOC binding in aqueous and sediment test media may require an equilibration period between the metal and test medium prior to exposing the organisms. This is to allow full Me-OC binding in a way that is representative of natural environments (e.g. Ma *et al*., 1999). Where the kinetics for reaching equilibrium conditions for binding to OC etc are known to be slow and may affect the test outcomes, reviewing the details of the test design may provide additional information on the reliability of the data, particularly for any extreme values.
- *Metal-sediment equilibration*: After spiking the water-sediment system with the test substance, an equilibrium period is crucial to ensure partitioning of the substance between the water-phase and solid-phase. For metals and inorganic metal compounds, the concentration of the test substances should be measured in the overlying water of semistatic and static sediment toxicity tests, and testing preferably initiated only when the overlying water concentration reaches stable concentrations (this can be more than 2 months for metals). If these criteria are not met, the tests cannot be assigned Q1.

If a relationship with OC can be discerned, the same normalisation as above (section 5.2.1.1) will also be applicable to metals. In addition for metals, toxicity values are preferred, originating from tests carried out under aerobic conditions, with low acid-volatile sulphide (AVS) levels (e.g. < 1.0 µmol AVS/g dry wt or tests with artificial sediments). These sediments could be considered as realistic "worst cases" for aerobic sediments, since ferric- and sulfide binding to metals is not present.

5.2.2.2 Accounting for background concentrations in sediments

The methodology described for considering metals in the pelagic- water compartment - using an added risk approach where needed (Section 3.5.2.1) - can also be applied to the sediment compartment.

The definition of the natural background levels for metals in metals is similar to that for water. Again, the default procedure will be to search for baseline levels in pristine or close to pristine areas. Unlike the situation for water, the analysis of deeper, undisturbed bed sediments, combined with radio-isotopic techniques, may allow one to estimate historical ambient concentrations, and thus to judge 'pre-industrial' levels.

Other possibilities are to:

- To gather information from national or international databases, for example, FOREGS Geological Baseline Programme (http://www.gsf.fi/foregs/geochem)

- Geological modelling, to estimate the contribution from erosion

5.2.2.3 Equilibrium partitioning

When using the EqP approach for metals, measured Kd values for sediment/suspended solids from freshwater, estuarine and marine waterbodies respectively can be used. Preference is given to Kd values derived from field measurements and not laboratory sorption or toxicity experiments. However, large variations in Kd are often observed even among different field-based measurements and therefore, for freshwater sediments, the QS derived from EqP may be refined by using Kds, modeled from WHAM speciation models (Tipping 1994). It should be noted however that the only solid phase that can be estimated by WHAM is organic carbon. Before using this approach, the validity of organic carbon determined WHAM Kd values should be checked, as other factors may contribute to partitioning.

5.2.3 Dealing with bioaccumulated/biomagnified substances

For some very hydrophobic organic substances such as polychlorobiphenyls (PCBs) polychlorodibenzo-dioxins (PCDDs) or furans (PCDFs), the protection of sediment-dwelling organisms may not be the key objective. Direct toxic effects may arise at concentrations far above the concentrations of concern for predators located at higher levels in food webs, such as predatory fish or mammals. In this case, biota standards should be set. Nevertheless, sediment standards might also be useful, for management or monitoring purposes, as long as they fulfil the trigger criteria set out in Section 2.4.2.

When sediment is the primary source of exposure for target species (fish or mammals), $QS_{sediment}$ for such substances should be derived from the QS_{biota}. Available exposure models range from very simple ones, based on BSAFs (accumulation factors from sediment to biota), to food-web models (Section 4). BSAFs are not recommended, as published values are highly variable. Moreover, studies on uncontaminated areas tend to yield higher BSAFs (Burzynski 2000) than studies on contaminated sites. Food-web modelling would thus be more appropriate but are more appropriately applied at local or regional scales, yielding site-specific or region-specific EQSs. For this reason, this step is not relevant for substances for which a Europe-wide EQS is sought.

5.2.4 Protection of saltwater benthic organisms

The same approach as that described for freshwater sediments are recommended for the derivation of $QS_{sediment}$ for marine waters. Marine and freshwater sediment toxicity data may be pooled unless it can be documented that differences in toxicity exists between freshwater and saltwater sediments. Further refinements of the process for deriving sediment standards for metals are given in Section 5.3

5.2.4.1 Spiked sediment (ecotoxicity) testing

In principle the same approach as that outlined in Section 5.2.1.1 with regard to sediment of inland surface waters is adopted. However, larger assessment factors may apply depending on the quality and quantity of toxicity data available (Table 5-3).

Table 5.3 Assessment factors for derivation of the $QS_{sediment, sw\ eco}$ based on the lowest available NOEC/EC10 from long-term tests (ECHA, 2008)

Available test results	Assessment factor [a)]
One acute freshwater or marine test (L(E)C50)	10000 [b)]
Two acute test including a minimum of one marine test with an organism of a sensitive taxa (lowest L(E)C50)	1000 [b)]
One long term freshwater sediment test	1000
Two long term freshwater sediment tests with species representing different living and feeding conditions	500
One long term freshwater and one saltwater sediment test representing different living and feeding conditions	100
Three long term sediment tests with species representing different living and feeding conditions	50
Three long term tests with species representing different living and feeding conditions including a minimum of two tests with marine species	10

[a)] The general principles of notes (c) and (d) as applied to data on aquatic organisms (Table 3.3) shall also apply to sediment data. Additionally, where there is convincing evidence that the sensitivity of marine organisms is adequately covered by that available from freshwater species, the assessment factors used for freshwater sediment data may be applied. Such evidence may include data from long-term testing of freshwater and marine aquatic organisms, and must include data on specific marine taxa.

[b)] If an indicative $QS_{sediment, sw\ eco}$ is calculated with short-term toxicity data, an alternative EQS must be calculated using the equilibrium partitioning approach (see section 5.2.1.2). The final value is selected by expert judgement, taking all available information into account.

As other combinations of data could occur (van Vlaardingen and Verbruggen 2007), the following additional guidance is offered:

- an assessment factor of 500 is applied if only one long-term marine but no freshwater test is available
- If two long-term tests with marine species representing different living and feeding conditions are available, but there are no freshwater tests, an assessment factor of 100 is applied.
- an assessment factor of 1000 might only be applied to a short-term toxicity test if the lowest value available is for a marine species.

5.2.4.2 Other derivation approaches

The derivation approaches described in Section 5.2.1 also apply to marine and coastal sediments. The standards selected should refer to marine or coastal environments.

5.2.5 Derivation of sediment QS for transitional waters

The same derivation approaches described in Section 5.2.1 and 5.2.4 also apply to sediment in transitional waterbodies.

Specific data for transitional waters will probably be lacking in most cases. To decide whether a freshwater or saltwater sediment QS is most appropriate for a particular location, the most convenient approach would be to assess the diurnal range of salinities, decide whether the considered ecosystem (in a transitional waterbody) is closer to a freshwater system or to a saltwater system, and apply the corresponding QS.

5.3 Using sediment QS that are subject to high uncertainty

5.3.1 Overview

Sediment standards allow the assessment of good status alongside standards for other compartments. The following guidance suggests how we might assess situations where the sediment standard fails. A simple pass/fail approach to assessment is not always appropriate, especially as residual uncertainties in sediment standards can be high making compliance assessment difficult. For this reason, we recommend a tiered assessment framework in which decisions to take remedial measures use sediment standards as only one of a number of lines of evidence. A similar framework has been adopted by OSPAR for monitoring of marine sediments[25]. Member States or Basin Authorities can either implement directly remediation measures or apply either tier.

Detailed advice on monitoring lies outside the scope of this guidance. However, if policymakers deem that formal assessments of compliance using an $EQS_{sediment}$ are necessary, a tiered assessment framework is recommended that uses evidence to corroborate any risks indicated by exceedances of the $EQS_{sediment}$ (Figure 5-3)[26].

In this framework, chemical analysis at Tier 1 provides a ‘face value’ assessment of compliance. This should use an $EQS_{sediment}$ that has been based on data simulating worst-case conditions for availability (Section 5.2.1.1). EQS exceedence would trigger a more detailed assessment (i.e. Tier 2) that accounts for bioavailability or uses biological data to assess whether the benthic community is actually impaired or not. If no risks are expected after accounting for bioavailability, or the biological community was not impaired – even though an EQS exceedance is indicated – any further action might be restricted to further monitoring instead of more costly risk reduction measures. On the other hand, demonstrable impacts coupled with EQS exceedances would be good evidence for a need for risk reduction.

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[25] Final report of the OSPAR/ICES Workshop on the Evaluation and Update of Background Reference Concentrations (BRCs) and Environmental Assessment Criteria (EACs) and How These Assessment Tools Should Be Used in Assessing Contaminants in Water, Sediment and Biota (February 2004), presented to ASMO as ASMO 04/4/5 Add 1.

[26] Nevertheless, the framework is not mandatory; local authorities may disregard this framework and manage directly to recover a quality matching the standard

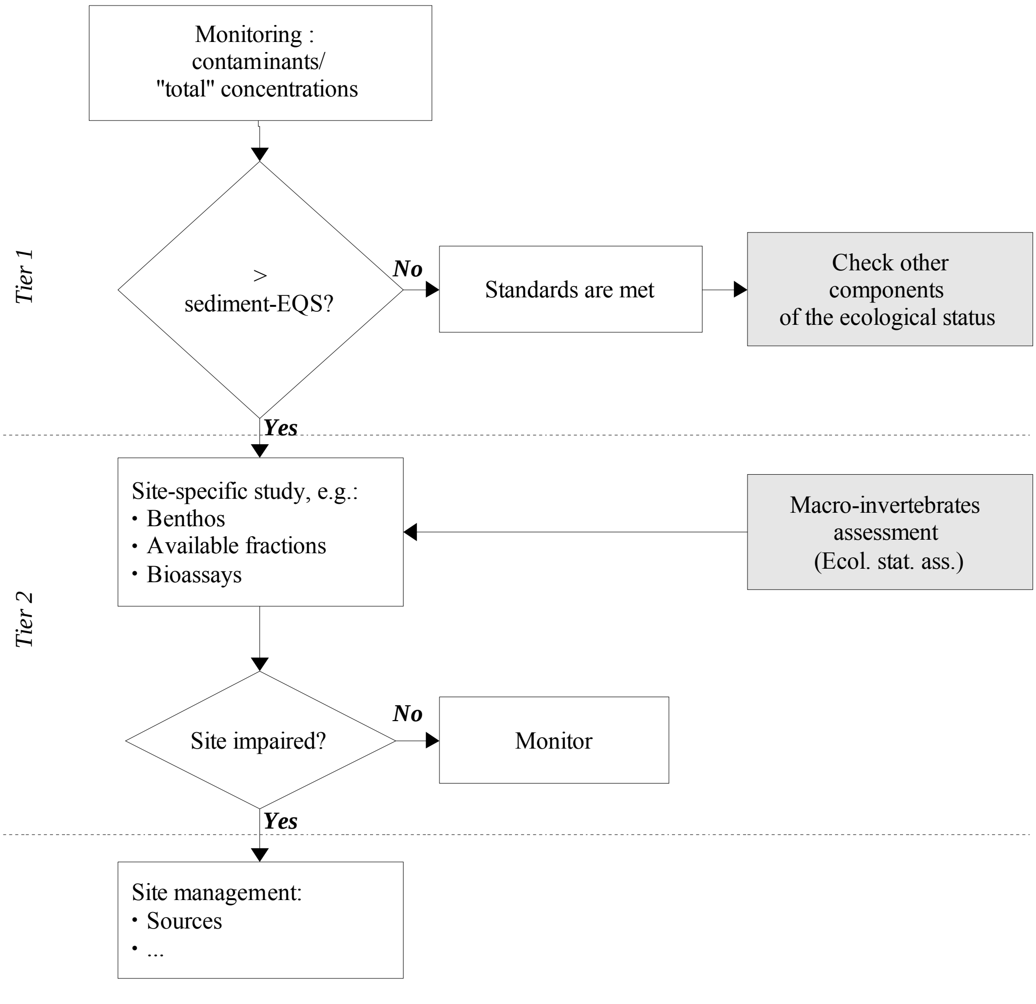

Figure 5.3 Tiered assessment framework for sediments

There are several possible approaches for the second tier, depending on the factors most likely to affect the risks posed by a particular substance. These might include assessment of the bioavailable fraction (Section 5.3.2), benthic community assessment or even bioassays conducted *in situ* or *ex situ*. While benthos assessment and bioassays may provide valuable additional information, they can be difficult to use and should be considered as options, to be selected on a case by case basis.

5.3.2 Assessing the bioavailable fraction

This assessment seeks to refine the exposure concentration to which sediment-dwelling organisms are exposed. One possible way to estimate the bioavailable fraction is to measure the extractable fraction in amorphous organic matter by extraction with a solid sorbent (e.g. Tenax ®) for a set time (e.g. 6h) (Cornelissen, Rigterink *et al*. 2001). This extraction is based on differences in contaminant desorption kinetics between amorphous organic carbon and hard carbon. The concentration in amorphous organic matter is then related to the freely dissolved concentration in pore water (N'Guyen *et al*. 2005; Schüürmann *et al*. 2006). These Tenax ® extractable concentrations are highly related to concentrations in organisms (Landrum, Robinson *et al*. 2007). The concentrations extracted from amorphous organic matter could be compared directly with the sediment quality standards.

Another approach could be to estimate the bioavailable fraction through porewater sampling with SPME (solid phase micro-extraction) or POM (poly-oxy-methylene)[27] or direct measurements in organisms. In this case, measured concentrations should be compared with the $QS_{fw, eco}$ or $QS_{sw, eco}$ (Table 5-4).

Table 5.4 Interpretation of bioavailability measurements

Method	*Exposure concentration compared to*
SPME	Water EQS
POM	Water EQS
Tenax ®	Sediment EQS
Organism	Biota EQS

For metals, several methods for measuring bioavailability are under development such as e.g. “Diffusive Gradients in Thin-films” (DGT) (Cornu &Danaix 2006), “Sediment or Fauna Incubation Experiment” (SOFIE) (Duester, Vink & Hirner 2008), and “Simultaneously Extracted Metals – Acid Volatile Sulphides” (SEM-AVS).

In the EU risk assessments for cadmium, zinc, and nickel, and in the voluntary industry risk assessments for copper and lead, the SEM-AVS concept has been employed.

For metals the anoxic sediment could be of greatest concern as these tend to be depositional, clayey sediments where metals accumulate. In these sediments, bioavailability of metals can be controlled by formation of stable complexes with sulphide. More erosional sediments that are oxic and have larger grain sizes have no or very low AVS, but also rarely have metal contamination (Burton *et al*. 2007).

The binding strength of the metal sulphide (MS) is inversely related to its solubility product and therefore, metals characterised by the lowest MS solubility product (K_{sp}) will have the highest affinity for sulphides. The MS solubility products, described in Table 5-5 illustrates the large difference in MS solubility products. This means that the presence of FeS and MnS indicates that MS, with solubility product lower then the ones of MnS and FeS are formed by preference, may actually displace the less stable FeS and MnS and are less vulnerable to oxidation.

[27] For a detailed review, see ICES (2008). Report of the Working Group on Marine Sediments in Relation to Pollution (WGMS). Copenhagen, International council for the Exploration of the Sea: 64.

Table 5.5 Solubility products of metal sulphides

Metal sulphide	Log K[(a)]	Log K[(b)]
MnS (s)	-19.15	- 13.50
FeS (amorphic)	-21.80	-
FeS (s)	-22.39	-18.10
NiS (s)	-27.98	-
ZnS (s)	-28.39	-24.70
CdS (s)	-32.85	-27.00
PbS (s)	-33.42	-27.50
CuS (s)	-40.94	-36.10
Ag_2S (s)		-50.10
HgS	-57.25	-52.70

a Di Toro et al, 1990
b Stumm and Morgan, 1981

Based on field validation data, it has been demonstrated that the fraction of metals bound to sulphides in the sediment, and thus sequestered in the solid phase of sediments, is not available for exposure to benthic organisms via the pore water route and toxicity to benthic organisms and can be estimated from SEM-AVS (Simultaneously Extracted Metals – Acid Volatile Sulphides) measurements.

The basic concept behind the SEM-AVS approach is that the Acid Volatile Sulphides (AVS) present in the sediment reacts with the Simultaneously Extracted Metals (SEM). SEM and AVS are operationally defined parameters. AVS (Acid Volatile Sulphides) are those sulphides that are extracted by cold extraction (1 M HCl) of sediments. SEM (Simultaneously Extracted Metals), is the term used for those metals that are liberated under the conditions of the AVS analysis (ICMM fact sheet No. 10).

The SEM-AVS concept has been shown to be predictive of the toxicity of those metals having a high affinity for AVS: e.g. Cd, Cu, Pb, Ag, and Zn. For Ni, field data exist that support the SEM-AVS concept, but as laboratory studies did not constitute a test of this theory further research is still ongoing. For metals with lower sulphide solubility products, the applicability of the SEM-AVS approach has still to be demonstrated and may be questionable. Thus, the SEM-AVS approach cannot be used at this time for metals other than those referred to above.

As several factors influence metal availability, the SEM-AVS approach could be used as a line of evidence in the weight of evidence to predict the absence of metal toxicity, i.e. when SEM-AVS ratio is <1.

Metals act in a competitive manner when binding to AVS. Applying the principles of competitive displacement kinetics, the SEM-AVS model can be made metal-specific. The procedure assigns the AVS pool to the metals in order of their solubility products. For example, ranked from the lowest to the highest solubility product the following sequence is observed for these six metals: SEMHg SEMAg, SEMCu, SEMPb, SEMCd, SEMZn and SEMNi. This means that mercury has the highest affinity for AVS, followed by silver, copper, lead, cadmium, zinc and nickel until the AVS is exhausted. The remaining SEM is that amount present in excess of the AVS and potentially available.

For divalent metals, one mole of SEM will react with one mole of AVS. For silver the stoichiometric relationship differs slightly and one mole of SEM silver reacts with two moles of AVS.

When applying the SEM-AVS concept to compliance checking, consideration is to be given to seasonal and vertical variations on AVS measurements. It is therefore recommended to assess the SEM and AVS in the same sample and to sample sediments for SEM and AVS measurements preferably in spring and from the upper 5 to 10 cm (AVS lowest in spring and upper sediment layer) or on a regionale scale to take the 10th percentile of available AVS.

For more background information on the SEM-AVS concept the reader is referred to the risk assessment made under the EU Existing Substance Regulation for Cd, Zn and Ni and the voluntary risk assessments for Cu and Pb that have been discussed by Technical Committee for New and Existing substances.

6. LIMITATIONS IN EXPERIMENTAL DATA – USE OF NON-TESTING APPROACHES

Several databases of physicochemical and biological effects data are available and data have also been published in the literature. However, the number of tested chemicals with reliable test data remains small compared to regulatory inventories of interest [Netzeva et al, 2007]. Data gaps may be filled by commissioning physical, degradation or ecotoxicological studies but this is not always possible.

A lack of data reflects a lack of knowledge about the properties or effects of a substance and this gives rise to uncertainty. The conventional way to respond to this uncertainty is to apply larger AFs, but this can result in very low QSs that cannot be implemented in practice. In some cases, it may not be possible to derive a QS due to the lack of data. If that uncertainty can be reduced, the need for such large AFs may be reduced accordingly. If carefully chosen, the use of a relevant and reliable non-testing method can provide additional information which can lower the overall uncertainty and result in the use of a smaller AF. Non-testing methods will not be useful in all circumstances however.

Three non-testing approaches to filling data gaps are recognised. These are:

- Grouping methods (Section 6.1)
- QSARs (Section 6.2)
- Analogue approach / read-across (Section 6.3)

Non-testing methods may be used under REACH to fill data gaps, provided that:

- The model used is shown to be scientifically valid
- The model used is applicable to the chemical of interest
- The prediction is relevant for the regulatory purpose (in this case, EQS derivation)
- Appropriate documentation on the method and result is given (e.g. by using the QSAR Model Reporting Format recommended by the European Commission)

All assessments using non-testing methods should be reviewed and updated as new information is generated, and as experience in forming and assessing non-testing methods is continually growing. Figure 6.1 illustrates a scheme for deciding how non-testing methods may be deployed for EQS derivation.

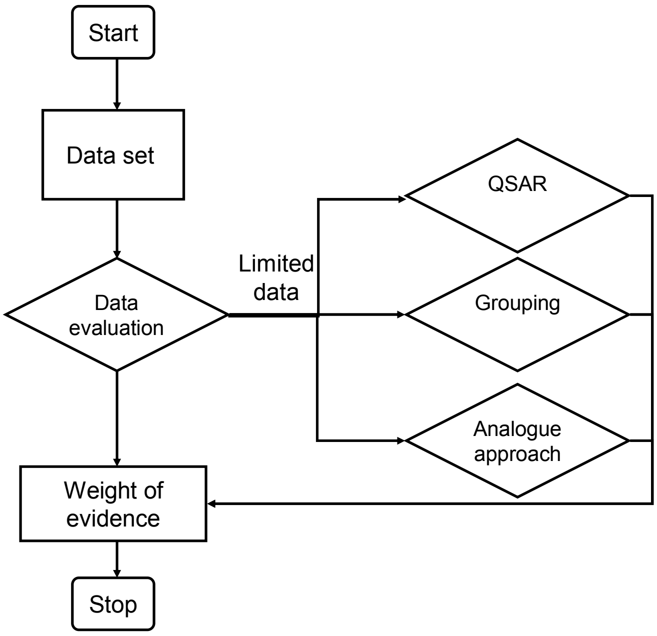

Figure 6.1: Application of non-testing methods

6.1 Grouping of substances / category approach

A chemical category is a group of chemicals whose physicalchemical properties, fate and behaviour and mammalian or environmental toxicological properties, are likely to be similar or follow a regular pattern as a result of structural similarity, e.g. PAHs or another shared characteristic.

The assessment of chemicals using a category approach differs to the assessment of chemicals on an individual basis. The effects of the individual chemicals within a category are assessed on the basis of the evaluation of the category as a whole, rather than being based on measured data for any one particular substance alone. For a substance (a category member) that lacks data for a particular endpoint (e.g. there are no chronic aquatic toxicity data), the data gap can be filled in a number of ways, including read-across from one or more other category members. If the similarity of category members is very high, e.g. for PAHs with the same number of rings, it may only be necessary to use data from one category member using read-across principles to adequately characterise the category member for which data is lacking.

In an ideal situation a category would include all potential members of the category (e.g. all homologues in a series), but this ideal situation will be difficult to achieve in practice. The successful use of a category approach should lead to the identification and characterisation of the hazards for all the members of the category, irrespective of their production volume / exposure.

A chemical category should be described by a matrix consisting of the category members and the relevant endpoints e.g. BCF, log K_{ow}. In some cases, an effect can be present for some but not all members of the category, and then sub-categories should be built (e.g. the 16 hydrocarbon 'blocks' used for hydrocarbons in PETROTOX). Figure 6.2 shows the procedure for category development.

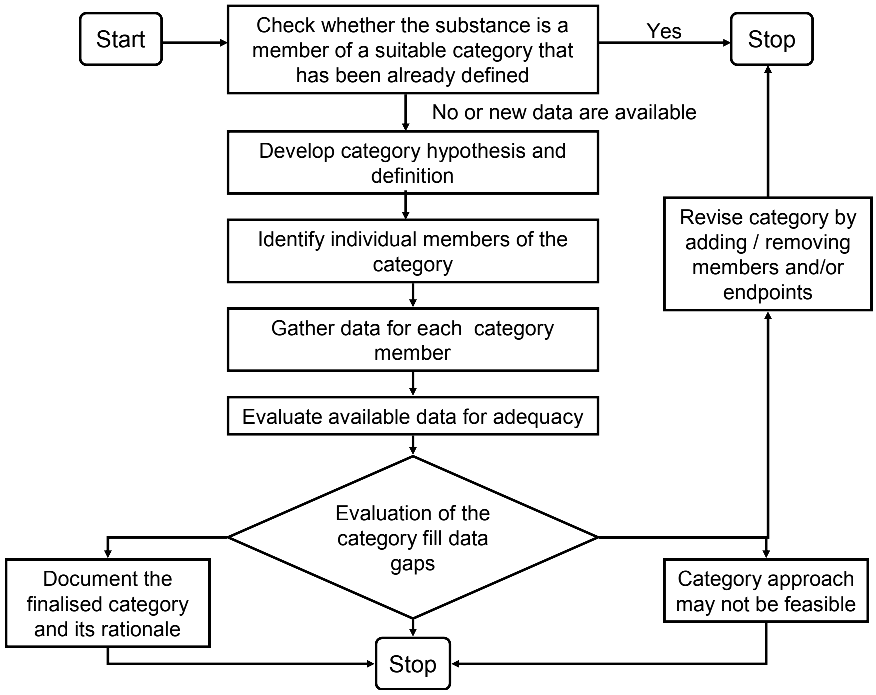

Figure 6.2. Stepwise procedure for category development

Before considering whether to develop a category for a group of substances, the first step should be to determine whether the chemicals of interest are named members of a category that has already been evaluated. The category definition should list all of the substances and endpoints covered. Although the chemical structure is usually the starting point, a category definition could also refer to a group of chemicals related by a mechanism of action (e.g. non-polar narcotics) or a particular property. For each member of the category, relevant data should be gathered and quality assessed as described in Section 2.6.2.

A matrix of data (category endpoints vs. members) should be constructed with the category members arranged in a suitable order (e.g. according to ascending log K_{OW}). The ordering of the members should reflect any trends or progression seen within the category. The cells of the matrix should indicate whether data are available or missing. Categories may be revised by adding or removing member(s) and endpoint(s).

The finalised category should be documented. A category may be revised subsequently in the light of new data or experience.

6.2 QSARs

The chemical category and Quantitative Structure-Activity Relationship (QSAR) concepts are strongly connected. A QSAR is a quantitative (mathematical) relationship between a numerical measure of chemical structure, or a physicochemical property, and an effect/activity e.g. acute toxicity to the waterflea, *Daphnia magna*. QSARs often taken the form of regression equations, and can make predictions of effects/activities that are either on a continuous scale (e.g. reproductive output) or on a categorical scale (e.g. mortality).

For a given category endpoint, the category members are often related by a trend (e.g. increasing, decreasing or constant) in a particular effect, and a trend analysis can be carried out using a model based on the data for the members of the category.

Similarly, a Quantitative Activity-Activity Relationship (QAAR) is a mathematical relationship, but between two biological endpoints, which can be in the same or different species. QAARs are based on the assumption that knowledge about the mechanism or mode of action, obtained for one endpoint, is applicable to the same endpoint in a different species, or to a similar endpoint in the same species, since the main underlying processes are the same (e.g. partitioning, reactivity, enzyme inhibition). QAARs are less widely used than QSARs but also provide a means of performing trend analysis and filling data gaps.

Thus, a chemical category can be seen as a set of internal QSARs (and possibly also internal QAARs) for the different endpoints. Data gaps can also be filled by an external QSAR model, where the category under examination is a subcategory of the wider QSAR (Netzeva *et al* 2008).

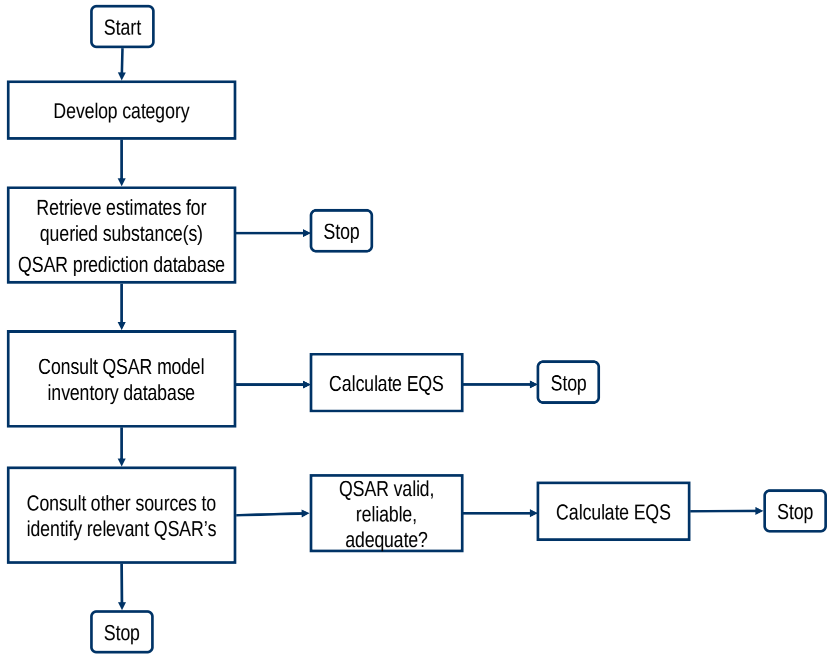

Figure 6.3 Stepwise approach to applying QSARs

There are various publically and commercially available computational tools and databases available to predict data endpoints [Bassan and Worth 2008]. Information regarding QSAR software tools for regulatory purposes is available on

http://ihcp.jrc.ec.europa.eu/our_labs/computational_toxicology/qsar_tools/qsar-tools

If relevant QSAR prediction databases do not include predictions for the particular substance(s) of interest, relevant QSAR models can be searched for in the QSAR database. Failing this, others models can be searched for in the literature, external databases and tools.

Harmonised templates such as the QSAR Model Reporting FormatQMRF and the QSAR Prediction Reporting Format (QPRF) should be used to document the results. The QMRF is a harmonised template for summarising and reporting key information on QSAR models, including the results of any validation studies. The information is structured according to the OECD (Q)SAR validation principles. The QPRF is a harmonised template for summarising and reporting substance-specific predictions generated by QSAR models.

QSARs are suitable for identifying a substance as potentially PBT/vPvB. BIOWIN, BCFWIN and ECOSAR are thought to be reliable models for these assessments. However, mammalian toxicity

QSARs are presently not sufficiently reliable for use in estimating secondary poisoning QS. Although they have a place in supplementing experimental ecotoxicity data, sole reliance on QSARs in ECOSAR for estimating acute or chronic toxicity, and the subsequent use of these results for deriving a QS, is not recommended because of the tendency for ECOSAR to underestimate toxicity for the types of substances prioritised or proposed for QS derivation, sometimes by a substantial amount.

6.3 Analogue approach / read-across

If it is not possible to associate the compound of interest with any existing category, similar compounds may be identified by performing a similarity assessment procedure, as described below. Figure 6.4 describes the application of the analogue approach.

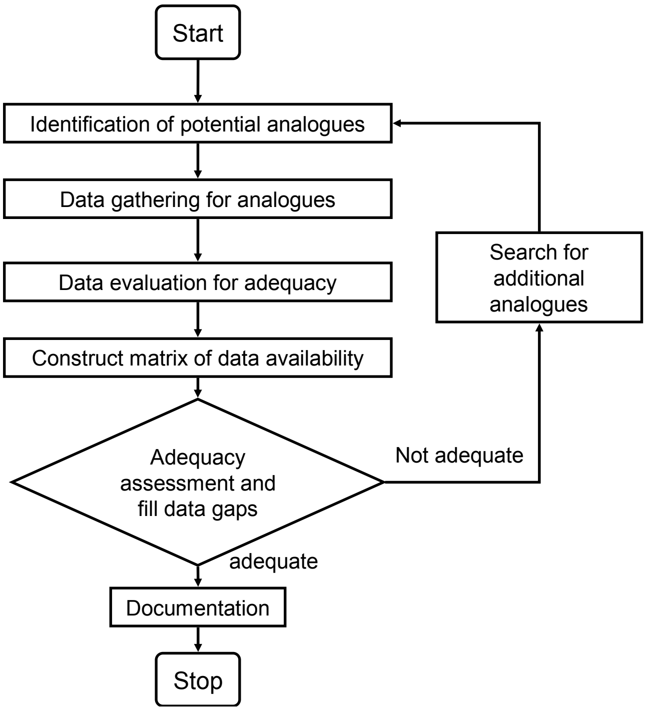

Figure 6.4. Stepwise procedure for the analogue approach

Computational tools, e.g. Toxmatch

http://ihcp.jrc.ec.europa.eu/our_labs/computational_toxicology/qsar_tools/qsar-tools or the OECD Toolbox should be used for analogue selections in combination with electronic substructure searching using molecular similarity indexes (e.g. the Tanimoto similarity index or Hellinger distance [atom environments]) and other molecular descriptors [e.g. log K_{ow}]). For each analogue, relevant data should be gathered and quality assessed as described in Section 2.

The decision about whether data from an analogue can be used to fill a data gap depends largely on expert judgement at present. Wherever possible, the relevance of the read-across should be evaluated in the light of known or suspected mode of action. If the read-across from an analogue is suitable, the approach should be documented according to an appropriate format.

The OECD Toolbox was used to identify suitable analogues for indeno(1,2,3-cd)pyrene by Crane *et al.* (2008). They concluded that read-across using a weight of evidence approach and all relevant measured and estimated values for physical and eco-toxicological properties could be a valuable approach for deriving QSs, if measured data are available for interpolation to the substance and endpoint(s) of interest, or if a reliable trend with low variability exists.

The *de minimis* dataset for reliable read-across consists of:

a) For endpoints that incorporate an assessment of potency (dose-effect): Evidence of a consistent and reliable trend within a category of relevance to the endpoint of interest (e.g. a monotonic increase in log Kow with an increase in measured BCF and toxicity).
b) Consistent and reliable measured values to identify the most sensitive trophic group, if toxicity is the endpoint of interest.
c) Reliable measured data for the endpoint of interest that allow interpolation to a value for the substance of interest.

d) QSAR estimates may be useful in a weight of evidence role for supporting read-across, but should not be used to replace the measured values identified in a – c above.

7. CALCULATION OF QS FOR SUBSTANCES OCCURRING IN MIXTURES

For well-defined mixtures, ie those with a well defined qualitative and quantitative composition, the toxic unit (TU) approach (e.g.Altenburger and Greco 2009) may be used to calculate the EQS. A Toxic Unit (TU) is defined as the ratio of the exposure concentration to the effect concentration for a specific medium (e.g. water). A TU for each constituent$_i$ in a substance / group of substances should be calculated as,

$$TU_i = \frac{C_{w,i}}{QS_i}$$

Cw,i Concentration in water of the constituent i

QSi PNEC for the constituent i

To estimate the toxicity of the mixture, the TU_i for all constituents in the mixture/group of substances are summed.

$$TU_{mixture} = \Sigma TU_i$$

When the $TU_{mixture}$ equals one or is greater than one, the mixture is expected to be above the threshold (ie QS).

EQSs may be defined for grouped substances that exert a similar mode of action and may be expressed according to the concept of Toxic Equivalent [TEQ] concentrations in environmental samples. The Toxic Equivalency Factor [TEF] is the fraction of the PNEC of constituent$_i$ divided by the lowest PNEC measured or calculated for a constituent that belongs to the group of substances being considered (Di Toro, 2000).

$TEQ = \Sigma_n (TEF_i * c_i)$

TEFi Toxic Equivalency factor for constituent i

Ci concentration of constituent i

The TU concept is equivalent to the Toxic Equivalency Factors (TEFs) for PCB's, PCDD's and PCDF's for humans and wildlife which were agreed by the World Health Organization (WHO) in 1997 and have been revised for dioxin-like compounds by the WHO in 2005, including criteria to take substances into the TEQ concept (Van den Berg *et al*. 1998, 2006)

Some substances are of unknown or variable composition, complex reaction products or biological materials (UVCBs). The variability in composition can be large and unpredictable. Methods for assessing UVCBs are still under development but current approaches focus on identified constituents, where assessment can be limited by a lack of data. However some UVCBs, like petroleum substances, can be assessed using the hydrocarbons block method and the use of non-testing methods (eg PETROTOX) to fill data gaps as demonstrated for the case study of gasolines (McGrath, 2005).

PETROTOX (CONCAWE) is a tool to assess aquatic toxicity hazard of complex petroleum and related substances; it:

- includes a library of about 1500 individual hydrocarbons, grouped in 16 hydrocarbon blocks, with details on their physical chemical properties and estimated PNECs

- predicts toxicity of substances to different aquatic organisms (based on the Narcosis Target Lipid Model);

- assesses impact of composition/test design on toxicity results; and

- estimates Predicted No-Effect Concentrations (PNECs) needed as input to environmental risk assessments of petroleum substances using the Hydrocarbon Block Method.

- estimates HC5 of the individual components needed as input to environmental risk assessments of petroleum substances using the Hydrocarbon Block method.

Petrotox estimates the HC5 for the different components and hydrocarbon blocks of the original petroleum product prior to any treatment that occurs prior to discharge. As the shift of the hydrocarbon block composition is not taken into account the estimated HC5 can not be used for EQS setting as it requires the recalculation taking into account the hydrocarbon block composition in the receiving environment. To estimate the toxicity of hydrocarbon mixtures in environmental samples, the HC5 of all the components present in a hydrocarbon block and subsequent calculation of the Toxic Unit (TU) is required. An EQS for hydrocarbon mixtures may be set by grouping them into hydrocarbon blocks.

The PETROTOX model uses QSAR modelling to predict the toxicity of the different fractions. In an alternative approach to derive quality standards for total petroleum hydrocarbons, a fraction based approach was used to calculate the internal concentrations in organisms exposed to spiked sediments. This calculation was based on partitioning of the different fractions between sediment, oil, pore water and the lipids of membranes. The toxicity observed in these spiked sediments for six benthic species was related to the calculated membrane concentrations. HC5 could thus be based on these internal membrane concentrations (Verbruggen et al, 2008). The observed values are lower than the QSAR estimates from the PETROTOX model.

When establishing EQSs for UVCBs such as petroleum products separate values should be defined for different fractions or blocks of the mixture. In compliance checking the concentrations of these individual fraction should be measured and a concentration addition approach should be applied to assess the effect of the total mixture in the environment.

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APPENDIX 1: DATA COLLECTION, EVALUATION AND SELECTION

Contents

A1.1. INTRODUCTION

This background document covers the collection of data that may be used to derive Environmental Quality Standards (EQSs), and its evaluation and selection for actual use in EQS derivation.

To promote consistency, it also gives guidance on the presentation and reporting of data. The topics covered are physicochemical data (Section 2), toxicity data (Section 3), bioconcentration and biomagnification data (Section 4) and toxicity data for the protection of humans (Section 5).

This background document is based on that provided in Van Vlaardingen and Verbruggen (2007)

A1.2. PHYSICOCHEMICAL DATA

A1.2.1. Data collection

A1.2.1.1. Identity

The following data on substance identity are collected:

- IUPAC name
- structural formula
- CAS registry number
- EINECS number
- chemical formula
- SMILES code

IUPAC name, CAS registry number, EINECS number and chemical formula are primarily derived from the ESIS database (JRC website http://esis.jrc.ec.europa.eu/). A structural formula can also be obtained here for a great number of compounds. If a structural formula cannot be obtained from the ESIS database, EPI Suite software can be used (US EPA, 2007b) or handbooks can be consulted, e.g. Tomlin (2002) for pesticides or more general handbooks like Mackay *et al*. (2006). The SMILES code is generated by EPI Suite software. If the compound of interest is not available in the EPI Suite database, the SMILES code can be generated using chemical drawing software, e.g. ChemSketch (ACD/Labs, 2006).

A1.2.1.2. Physicochemical properties

Physicochemical parameters should be collected for each compound for which EQSs are being derived. These parameters provide information on the behaviour of the compound in the environment. Data on the following parameters are collected (name, symbol, unit):

- molecular weight: M_w ($g \cdot mol^{-1}$);
- melting point: T_m (°C);
- boiling point: T_b (°C);
- vapour pressure: P_v (Pa), experimental melting point and boiling point can be useful for estimation of the vapour pressure;
- Henry's law constant: H ($Pa \cdot m^3 \cdot mol^{-1}$);
- water solubility: S_w ($mg \cdot L^{-1}$), experimental melting point can be useful for the estimation of the solubility from log K_{ow};
- dissociation constant: pK_a (-);
- *n*-octanol/water partition coefficient: K_{ow} (-);
- sediment/water partition coefficient: K_p ($L \cdot kg^{-1}$). For organic substances, the partition coefficients normalised to organic carbon are preferred: K_{oc} ($L \cdot kg^{-1}$). For metals, field-based partition coefficients (K_p) for suspended matter are searched.

The following steps should be followed to collect physicochemical data:

1. The following databases and estimation methods are used to retrieve or calculate data on physicochemical parameters (Table 1).

Table 1. Sources and estimation methods to be screened for physicochemical parameters.

Parameter	Sources/methods
M_W	Mackay, EPI Suite, SPARC, IUCLID
T_m	Mackay, EPI Suite, IUCLID
T_b	Mackay, EPI Suite, SPARC, IUCLID
P_v	Mackay, EPI Suite, SPARC, IUCLID
H	Mackay, BioLoom, EPI Suite, SPARC, IUCLID
S_w	Mackay, EPI Suite, SPARC, IUCLID
pK_a	Mackay, BioLoom, SPARC, IUCLID
K_{ow}	BioLoom, Mackay, EPI Suite, SPARC, IUCLID
K_{oc}	Mackay, BioLoom, Sabljić, EPI Suite, IUCLID
K_p (metals)	Sauvé, Bockting, scientific literature

References to the sources and programs mentioned in Table :

Mackay = Mackay *et al*. (2006);

EPI Suite = US EPA (2007b);

SPARC = SPARC online calculator (Karickhoff *et al*., 2007);

IUCLID = International Uniform Chemical Information Database (European Commission (Joint Research Centre), 2007);

Bioloom = BioByte including internet database (BioByte, 2004);

Sabljić = Sabljić and Güsten (1995) cited in European Commission (Joint Research Centre). (2003b) or
Sabljić *et al*. (1995).

Sauvé = Sauvé *et al*. (2000)

Bockting = Bockting *et al*. (1992)

2. Scientific literature. For all of the listed parameters, the open literature may be searched if a reliable estimate is lacking or if the number of reliable or relevant data is very low. This might be most applicable to K_p values for metals (see Annex).

3. Contact people from environment agencies in other countries asking if they have access to specific information on ecotoxicological toxicity data (see Section 0) and/or physicochemical data and are willing to share those data.

4. The industry parties involved in production or use of the compounds under investigation are invited to submit relevant studies, making clear these will be treated as public literature.

A1.2.2. Data evaluation and data tables

All retrieved literature is read and evaluated to assess its relevance and reliability. Important aspects for evaluation are discussed in the annex.

After evaluating a study, the results of the study are summarised by entering these into a data table (Table 2). The structural formula of the compound is also placed in this table.

Table 2. Overview and default table structure for identity and physicochemical parameters listed for each compound.

Properties	Value	Reference
IUPAC Name		
Structural formula		
CAS number		
EINECS number		
Chemical formula		
SMILES code		
Molecular weight ($g \cdot mol^{-1}$)		
Melting point (°C)		
Boiling point (°C)		
Vapour pressure (Pa)		
Henry's law constant ($Pa \cdot m^3 \cdot mol^{-1}$)		
Water solubility ($mg \cdot L^{-1}$)		
pK_a		
n-Octanol/water partition coefficient (log K_{ow})		
Sediment/water sorption coefficient (log K_{oc})		
Sediment/water sorption coefficient (log K_p)		
Suspended matter/water partition coefficient		

A1.2.3. Data selection

A1.2.3.1. K_{ow}

The K_{ow} value that is selected for use in EQS derivation is preferably the experimental value (MlogP) presented by BioLoom (BioByte, 2004). This value is assigned the highest quality in the underlying database (MedChem). Only if this database does not give a value or when careful considerations lead to a different selection, The selected (log) K_{ow} value is the average value of all reliable values determined by the shake flask, slow stirring or generator column method, for which guidance is given in the annex. K_{ow} values estimated using the HPLC method are indirect estimates of octanol/water partitioning and are therefore not regarded as most reliable. They should not be used when more reliable data are available.

When no, or only unreliable, experimental data on K_{ow} are available, the selected data should be calculated with a QSPR programme. The use of the K_{ow} values obtained with the ClogP program (BioByte, 2004) is preferred.

A1.2.3.2. K_{oc}

For the selection of the K_{oc} value, experimentally determined values should be retrieved. These K_{oc} values may be derived from standardised tests (e.g. OECD guideline 106; OECD, 2000) or from other studies published in scientific literature. K_{oc} values determined by the HPLC method (OECD guideline 121; OECD, 2001) should be considered as estimates of the real K_{oc} values and consequently, these values are not used as experimental values. Because K_{oc} values may vary widely and no value for K_{oc} can be considered as the most reliable value, the geometric mean of all valid K_{oc} values is calculated, including one value estimated from K_{ow}. This geometric mean K_{oc} will be used as the selected value in EQS derivations (Otte *et al.*, 2001).

A1.2.3.3. $K_{p,\ susp\text{-}water}$

For organic substances, the value of $K_{p,\ susp\text{-}water}$ is derived from the K_{oc} value and the fraction organic carbon of suspended matter used within the EU ($Foc_{susp,TGD}$), applying Eq. 1. Note that the fraction of organic carbon is equal to 0.1 in this case (the EU standard): the outcome of this equation triggers $EQS_{sediment}$ derivation and should be uniform within Europe.

$$K_{\mathrm{p,\ susp-water}} = K_{\mathrm{oc}} \times F\mathrm{oc}_{\mathrm{susp,\ TGD}} \tag{1}$$

If site-specific data for suspended matter are available these can be used directly as well and might be preferred. The value for $K_{p,\ susp\text{-}water}$ for metals is derived from experimental data. The geometric mean value is calculated from the valid $K_{p,\ susp\text{-}water}$ values summarised in the table containing physicochemical properties (see Annex); this value is used in EQS derivations. If experimental data on K_p for metals are lacking, the data gap is reported and its possible solution suggested.

A1.2.3.4. Water solubility

The selected value for the water solubility may be calculated from the geometric mean of all valid values for the water solubility. Values below 10 $mg{\cdot}L^{-1}$ determined with the shake-flask method should be considered as unreliable. For these poorly soluble compounds, the geometric mean of the generator column and slow-stirring is the value to be used.

A1.2.3.5. Vapour pressure

In general, the guidance in Table 1 of the annex can be used to determine which values for the vapour pressure are reliable. However, if results from different methods deviate significantly from each other, only the methods with a direct analysis of the compound should be used, e.g. the gas saturation method. Complementary to this, the data from GC retention times may be used if there are not enough reliable data. If no experimental data are available, the estimate from EPI Suite can be used (US EPA, 2007b).

A1.2.3.6. Henry coefficient

The validity of values for the Henry coefficient should be considered on a case-by-case basis. When no reliable experimental values are available, the Henry coefficient can be estimated from the quotient of the vapour pressure and the water solubility, provided that reliable values are available for both parameters. If this is not the case, the estimate from EPI Suite can be used (US EPA, 2007b).

A1.3. TOXICITY DATA

A1.3.1. Data collection

To collect toxicity data for a compound the following steps are recommended:

1. Environment agencies in other countries are consulted by sending out an e-mail enquiry, in which they are asked if they have access to specific information on toxicity data and/or physicochemical data (see Section 2.1.2) and are willing to share those data.
2. Industry parties involved in production or use of the compound under investigation are invited to submit relevant studies, which will be treated as public literature.
3. The on-line literature systems Current Contents and TOXLINE are screened.
4. It is important to perform a retrospective literature search. The reference lists of publications or reports obtained should be carefully checked for related studies that have been published at earlier dates. A hard copy of each study that is deemed relevant should be obtained.
5. The ECOTOX database from the US EPA (US EPA, 2007a) is searched for relevant ecotoxicological studies. A copy of all studies retrieved from the search results is requested. Other national or organisational databases may also be searched.
6. The IUCLID database is searched for the compound of interest (European Commission (Joint Research Centre), 2007).
7. The availability of OECD SIDS documents or EU risk assessment reports is checked.
8. The database of the Japanese National Institute of Technology and Evaluation (NITE) is searched.
9. For pesticides, public assessment reports are available online at several locations. The following websites are recommended:
   UK Pesticides Safety Directorate (PSD): http://www.pesticides.gov.uk/psd_evaluation_all.asp
   US EPA: http://www.epa.gov/pesticides/reregistration/
   Health Canada: http://www.pmra-arla.gc.ca/english/pubs/reeval-e.html
   EU Pesticides Database: http://ec.europa.eu/sanco_pesticides/public/index.cfm
10. A further search may be performed in libraries.
11. If no or very few data are found in the steps described above, an additional internet search can be performed on the chemical name and CAS number of the compound using established search engines.

In principle, all ecotoxicological studies are evaluated for usefulness in EQS derivation. Studies from which one of the endpoints LC50, EC50, LC10, EC10 or NOEC can be calculated using data presented by the author(s) are also used. Studies that show results in a graph of good quality that can be used to extract raw data are also relevant.

Ecotoxicity studies conducted in freshwater, seawater, brackish water, groundwater (usually no data) and sediment are relevant. Whether or not data on secondary poisoning should be collected is dependent on whether an assessment is required (see main guidance) some trigger values. In the case that secondary poisoning should be assessed, toxicity data for birds and mammals should be collected, screening the appropriate sources described above. In the case of toxicity to birds, acute 5-day studies generating LD50 values should be collected too.

A1.3.2. Data evaluation and data tables

An outline of the general procedure of the evaluation of the toxicity data is given below.

1. All retrieved literature is read and evaluated with respect to its relevance and reliability.
2. Each study should be assigned a quality code. Section 0 provides more detail.

3. After evaluating a study, the results of the study are summarised by entering it into the data table (see Sections 0 and 0).
   - Toxicity data on freshwater organisms and on marine organisms are placed in separate tables.
   - Data on aquatic and benthic species are separated into acute and chronic data, with a separate table for each category (see Section 0 for more guidance).
   - Toxicity data on birds and mammals are placed in separate tables. If many data are available, a distinction can be made between studies with oral (gavage) and dietary (food) exposure.
4. Each row of the toxicity data table contains a test result for one species, endpoint and summary statistic. The columns of the toxicity data table contain the various study parameters. Columns should be filled as completely as possible. When there is no value for a given parameter, the table cell is filled with 'n/d'.
5. All references of toxicity studies should be included.
6. In the toxicity data tables, all tested species are clustered according to taxonomic groups (see Sections 0 and 0), usually: fish, amphibians, crustaceans, insects, molluscs, annelids, macrophytes, algae, birds, mammals.
7. For benthic toxicity data for organic compounds, recalculate toxicity test results to standard sediment with an organic carbon content of 5% (Section 0). In the toxicity toxicity data table on benthic data, both the test result in the test sediment (expressed as a dry weight concentration) as well as the test result in standard sediment (expressed as a dry weight concentration) are reported. For metals, tests should not be normalised to a standard sediment (Section 0).
8. Finally, a new table of selected toxicity data is created in which toxicity data are aggregated to one toxicity value per species. The table will contain the data that are used for the actual EQS derivation. Guidance to compile this table is given in Section 0.

A1.3.2.1. Study quality: validity codes

Studies are quality assessed according to the scheme developed by Klimisch *et al*. (1997). The quality codes assigned are:

1 = reliable without restrictions: 'studies or data...generated according to generally valid and/or internationally accepted testing guidelines (preferably performed according to GLP) or in which the test parameters documented are based on a specific (national) testing guideline...or in which all parameters described are closely related/comparable to a guideline method.'

2 = reliable with restrictions: 'studies or data...(mostly not performed according to GLP), in which the test parameters documented do not totally comply with the specific testing guideline, but are sufficient to accept the data or in which investigations are described which cannot be subsumed under a testing guideline, but which are nevertheless well documented and scientifically acceptable.'

3 = not reliable: 'studies or data...in which there were interferences between the measuring system and the test substance or in which organisms/test systems were used which are not relevant in relation to the exposure (e.g., unphysiologic pathways of application) or which were carried out or generated according to a method which is not acceptable, the documentation of which is not sufficient for assessment and which is not convincing for an expert judgment.'

4 = not assignable: 'studies or data....which do not give sufficient experimental details and which are only listed in short abstracts or secondary literature (books, reviews, etc.).'

In general, when a test has fundamental shortcomings, it should be classified as not reliable (3). This applies to situations where the test was incubated too long (e.g. for algae), the oxygen content was too low, control mortality was too high, solubility of the test substance was exceeded (see Section 0 for more detail), a co-solvent or emulsifier has been used in high concentrations (see Section 0), pH was out of the appropriate range (see Section 0 for specific guidance), the light used had an unrealistic UV intensity, the identity of the substance is not clear (see Section 0 for more guidance), or the actual concentrations are unknown because of significant but unquantified losses.

If the experiment is carried out in a medium that is not the natural habitat of the tested species, these tests are generally not reported rather than being classified as not reliable (see Section 0 for more guidance).

When a study contains useful toxicity information, but it cannot be used directly for derivation of EQSs, it is still tabulated. Examples are a NOEC value from a short term test, or a value higher than the highest tested concentration or lower than lowest tested concentration (see Section 0 for more detail). The test can then still be classified as reliable or reliable with restrictions.

A1.3.2.2. Acute and chronic studies

A chronic toxicity study is defined as a study in which:

(i) the species is exposed to the toxicant for at least one complete life cycle, or
(ii) the species is exposed to the toxicant during one or more sensitive life stages.

This definition is in line with REACH guidance, which states that NOECs from chronic/long-term studies should preferably be derived from full life-cycle or multi-generation studies (ECHA, 2008). True chronic studies cover all sensitive life stages.

Unfortunately, no clear guidance is provided on individual studies, whether these are to be considered as chronic studies or as acute studies. What is considered chronic or acute is very much dependent on 1) the species considered and 2) the studied endpoint and reported criterion.

For most common species, toxicity studies with fish are considered acute if mortality is determined after 96 hours (standard acute test) or after 14 days (prolonged acute toxicity test). The most common chronic toxicity tests for fish are early life-stage tests (ELS), in which eggs or larvae are exposed and the effects on hatching, malformation and growth are considered. Reproduction studies and most ELS tests for fish, but also for other species such as amphibians (FETAX test) or echinoderms, can be considered as chronic toxicity studies. For daphnids, the standard exposure time for acute toxicity is 48 hours, but with regard to chronic toxicity, there is a factor of three difference between the tests with *Daphnia magna* (21 days) and *Ceriodaphnia dubia* (7 days), the latter having a much shorter reproduction time. For algae, the standard exposure time is 72 hours. In this time, the algae regenerate several times. However, the EC50 of this test is considered as acute, while the NOEC or EC10 of the same test is regarded as a chronic value.

A1.3.2.3. Comparison of toxicity value with water solubility

In principle, toxicity studies that have been conducted at concentrations above the water solubility should not be used. However, depending on the uncertainty in the estimate of the water solubility, test results (L(E)C50, NOEC, EC10) that are ≤2 times the estimated value might be included. The factor of 2 is a rather arbitrary value; when experimental data show that the variation in the estimate of the water solubility is lower, it should be lowered accordingly. When the variation in the estimate of the water solubility is higher than a factor of 2, it may be increased to a factor of 3 (maximum). Toxicity studies showing results above the water solubility receive a footnote stating: 'test result above water solubility'.

A1.3.2.4. Use of co-solvents, emulsifiers and dispersants

Sometimes, the solubility of a compound is so low that a solvent, emulsifier or dispersant is used to prepare suitably concentrated stock solutions of the test substances. Such vehicles may not be used to enhance the solubility of the test substance in the test medium, and in any case the compounds used for this purpose may not be toxic to the tested species. Therefore, a control with the vehicle (solvent control) used should be incorporated in the set-up of the test. According to several OECD test guidelines for aquatic toxicity testing (see Section 0) the concentrations of the solvent, emulsifier or dispersant should not exceed 100 mg/L^{-1} (or 100 µL/L^{-1} or 0.01%).

A1.3.2.5. pH of test water and pK$_a$ and ionisation of test compound

When a test has been performed according to a guideline, the pH should be within the required range and, if not, the test validity should be reviewed, e.g. for effects on organism health or test substance hydrolysis.

In some cases, the compound itself may alter the pH strongly. In such cases, it should always be checked whether any observed toxicity might be caused by this change in pH. If so, the test must not be used because the buffering capacity of the environment will usually prevent such a pH effect in the field. For compounds containing functional groups with acidic or basic properties, the pK_a value(s) should be reported in the table with physicochemical properties (Section 0).

Attention should be paid to possible relationships between pH and toxicity of the tested compound, for example, due to a reduced availability (speciation, precipitation, hydrolysis, etc.) of the test compound. The toxicity of a compound may be influenced by its degree of ionisation[28]. As a rule, hydrophobicity, and consequently bioaccumulation and toxicity, will increase with decreasing ionisation. The degree of ionisation of a compound in a toxicity test is determined by several factors:

- the pK_a (s) of the test compound,
- the concentration of the test compound,
- pH of the test compartment (water, sediment),
- the buffering capacity of the test-matrix.

In practice, a compound's potential to ionise (pK_a in physicochemical table) should be checked. The presence of one or more pK_a value(s), or ionisable group(s), triggers attention for pH effects in toxicity studies. If toxicity test results show that toxicity is dependent on the pH of the test medium, the results are rejected if the pH falls outside the range of what can be expected naturally.

Test results should be rejected when the toxicity in a given study is not caused by the compound alone, but also by a pH change. Hence, results from tests with ionisable compounds performed in buffered media (providing sufficient buffering capacity) are more reliable than those performed without a buffer. Studies that explicitly measure pH after addition of the toxicant are most useful in this respect.

A1.3.2.6. Purity and identity of the test substance

In some tests the identity of the test substance is largely unknown or the purity of the test substance is very low. Depending on the nature of the impurities present, if these have been identified at all, a minimum purity of 80% is required, unless it is known that the impurities do not cause any toxic effects by themselves and do not influence the toxicity of the substance of interest. When the purity of the tested compound is <90%, the test result should be corrected for purity. For pesticides, toxicity should be expressed in terms of the concentration of active ingredient.

[28] 'Degree of ionisation' as used in this section expresses the ratio of the number of charged molecules over the total number of neutral and charged molecules at a given concentration and at a given pH.

A1.3.2.7. Toxicity studies performed in other media

Benthic species are sometimes tested in a water-only system. In such cases the data are still tabulated, but for organisms that normally live in the sediment and not on the surface of the sediment, the test should be assigned the code ‘invalid’.

A1.3.2.8. Dealing with toxicity values higher or lower than range of test concentrations

If the highest concentration in a toxicity test is not high enough to determine the NOEC or L(E)C50, the result of that study should be tabulated as NOEC ≥ or L(E)C50 >, followed by the value of the highest test concentration. The test result should be reported in the toxicity data tables. The result itself cannot be used in calculations of EQSs. However, it is valuable information that a species from this taxon (or trophic level) has been tested and that it was not sensitive to the toxicant at a known concentration. It may therefore have a useful supporting role. For example: when NOEC values for algae, *Daphnia* and fish are found, of which one is a ‘NOEC ≥ ’ value, and this value is not the lowest effect concentration, an assessment factor (AF) of 10 may be applied, whereas the AF would have been 50 if the study had been rejected.

For similar reasons, the data from tests resulting in an effect at the lowest test concentration should be tabulated as NOEC < or L(E)C50 <, followed by the value of the lowest test concentration. Although these values cannot be used directly for the derivation of EQSs, useful information can be obtained from comparing the sensitivity of that species with the EQS. This comparison may permit an adjustment to the AF.

A1.3.2.9. Quality Assurance

Toxicity studies originate from various sources, which are tracked as much as possible to the original source. The two key sources are (i) publications in scientific journals and (ii) original study reports that have not been published elsewhere. The latter category has been in the minority since, for reasons of confidentiality, original study reports are often unpublished and may not be accessible.

Studies do not need to have been performed under a formal quality assurance scheme, such as Good Laboratory Practice (GLP). The reported description of a study and comparison with results from comparable studies and organisms, should provide all information necessary to assess its quality.

A1.3.2.10. Use of toxicity tests performed according to established guidelines

International guidelines exist for performing toxicity studies for many species. If such protocols are followed and the requirements for the study are met, the results from such studies are generally reliable. Quality data do not, however, have to conform to formal test guidelines. The most frequently used guidelines for ecotoxicological studies are summarised in this section, although others may also be reported.

- OECD guideline 201: Alga, Growth Inhibition Test. The EC50 from this 72-h algae test is considered an acute value, the NOEC or EC10 a chronic value. The guideline version from 1984 mentions both biomass (sometimes called growth) and growth rate as endpoints. From studies based on the OECD 201 - 1984 guideline, the value for the growth rate is preferred, because this is the more relevant parameter (European Commission (Joint Research Centre), 2003a). However, if only growth is presented, this value can be used as well. The result for the endpoint biomass (growth) is generally somewhat lower than the growth rate and can therefore be considered as a conservative value.

N.B. This guideline was revised in 2006. Endpoints derived from a study conducted following the revised (2006) are valid.

- OECD guideline 202: *Daphnia* sp., Acute Immobilisation Test. For the derivation of EQSs for water, only the EC50 from this 48-h acute toxicity study is considered. The endpoint is immobility, as indicated by the inability to swim after agitation.
- OECD guideline 203: Fish, Acute Toxicity Test. For the derivation of EQSs for water, only the LC50 from this 96-h acute toxicity study is considered. The recorded endpoint is mortality.
- OECD guideline 204: Fish, Prolonged Toxicity Test: 14-day Study. This study is also considered as an acute toxicity study, and consequently, in most cases, only the LC50 is used for the derivation of EQSs.
- OECD guideline 205: Avian Dietary Toxicity Test. This test can be used as an acute toxicity test with birds for the assessment of secondary poisoning.
- OECD guideline 206: Avian Reproduction Test. This test can be used as a chronic toxicity test with birds for the assessment of secondary poisoning, because the exposure duration is at least 20 weeks.
- OECD guideline 210: Fish, Early-life Stage Toxicity Test. This test with fish is a chronic test which covers the life cycle of fish from eggs to free feeding juvenile fish. The recorded endpoints are mortality at all stages, time to hatch, hatching success, length, weight and any morphological or behavioural abnormalities.
- OECD guideline 211: *Daphnia magna* Reproduction Test. This is a chronic test with water fleas. The most important endpoint is the number of young per female (both young and parent alive). Other endpoints are the survival of the parent animals and time to production of first brood. Additionally, parameters such as growth (e.g. length) of the parent animals, and possibly intrinsic rate of increase are useful endpoints.
- OECD guideline 212: Fish, Short-term Toxicity Test on Embryo and Sac-fry Stages. In the guideline it is stated that this test can be used as a screening test for chronic toxicity. Especially for species that cannot be kept under laboratory circumstances for a period long enough to perform a full early-life stage (ELS) test, this test can be a useful alternative. Because the sensitive life stages from egg to sac-fry are covered in this test, it can be considered a chronic test. However, it is expected to be less sensitive than the full ELS test. The same endpoints are recorded as for the full ELS test.
- OECD guideline 215: Fish, Juvenile Growth Test. Because the recorded endpoint is growth during 28 days and the criterion is the NOEC or EC10, the test can be regarded as chronic.
- OECD guideline 218: Sediment-Water Chironomid Toxicity Test Using Spiked Sediment. This is a chronic toxicity study with a chironomid species. The measured endpoints are the total number of adults emerged and the time to emergence. Additionally, larval survival and growth after a ten-day period are recommended endpoints.
- OECD guideline 219: Sediment-Water Chironomid Toxicity Test Using Spiked Water. This test is similar to OECD guideline 218. However, for reasons of stability of the test concentrations, the OECD 218 is preferred. If a test with spiked water is available this test should always be accompanied by a determination of actual concentrations in the sediment.
- OECD guideline 220: Enchytraeid Reproduction Test. The 14-d range finding test from this guideline in which mortality is recorded is an acute test. The definitive test that lasts for 6 weeks is a chronic test. In this test the number of offspring is recorded as well as the mortality of the parent animals, which are only exposed for three weeks and are thereafter removed from the system.
- OECD Revised Proposal for a New Guideline 221: *Lemna* sp. Growth Inhibition Test. For this 7-d test with duckweed the same considerations can be made as for the algal test (OECD 201): the EC50 from this test is considered an acute value, the NOEC or EC10 a chronic value. Both chronic and acute data should be retrieved from the test. The preferred endpoints are growth rate (based on frond number) or biomass (dry weight, fresh weight or frond area).

- FETAX (Frog Embryo Teratogenesis Assay *Xenopus*): This test is a rather short test of 96 hours duration, possibly extended with a few hours, if the larvae have not reached a certain developmental stage. However, considering the sensitive endpoints (next to mortality also development and malformation) and the sensitive life stage (embryonic stages), this test can be considered as chronic for the derivation of EQSs.
- EPA. Ecological Effects Test Guidelines. OPPTS 850.1735. Whole sediment acute toxicity invertebrates, freshwater. Draft, 1996. This test can be used as a chronic test for species such as *Hyalella azteca*.

In addition to tests on birds (OECD guidelines 205 and 206), the OECD has a series of guidelines of toxicity tests with mammals for use in human health risk assessment. These data might also be used in the derivation of EQSs (secondary poisoning of top predators) provided that the test endpoints relate to the effects at the population level of the species. The following OECD guidelines are most important in this respect:

- OECD guideline 401: Acute Oral Toxicity
- OECD guideline 407: Repeated Dose 28-day Oral Toxicity Study in Rodents
- OECD guideline 408: Repeated Dose 90-Day Oral Toxicity Study in Rodents
- OECD guideline 409: Repeated Dose 90-Day Oral Toxicity Study in Non-Rodents
- OECD guideline 414: Prenatal Development Toxicity Study
- OECD guideline 415: One-Generation Reproduction Toxicity Study
- OECD guideline 416: Two-Generation Reproduction Toxicity

A1.3.3. Aquatic toxicity data tables

The following subsections (Sections 0 to 0) discuss the data to be reported in the aquatic toxicity data tables. The parameters are treated in the same order as they appear in the default toxicity data table. The following subsections have titles identical to the column headings in the data tables.

A1.3.3.1. Species

All available toxicity data for a given compound are ordered by test organism. Species are grouped in taxonomic groups. Species names are reported in Latin. Taxonomic groups are shown in bold font, species names are shown in italic font. Species names within a taxon are listed in alphabetical order. For example:

Bacteria

Pseudomonas putida

Algae

Chlorella vulgaris

Pseudokirchneriella subcapitata

Scenedesmus acuminatus

Crustacea

Daphnia pulex

A1.3.3.2. Test organism information

The most relevant properties of the test organism are mentioned in this column; e.g. age, size, weight, life stage or larval stage. Toxicity data for organisms of different ages, size, life stage, etc., are presented as individual entries (i.e. one entry in each row) in the data table.

A1.3.3.3. Chemical analysis

This column reports whether the test compound is analysed during the experiment. Y (Yes) is entered in this column when the compound has been analysed. When no analysis for the test compound is performed, N (No) is entered in this column.

In some cases the test compound is analysed, but the test results (L(E)C50, EC10, NOEC) are not calculated from the measured concentrations. If the test result is based on nominal concentrations, this is mentioned in a footnote to this study: ‘Test result based on nominal concentrations’. This is valid when measured concentrations are close to initial concentrations (drop in concentration <20% over exposure period) and ‘Test result based on nominal concentrations, measured concentrations were >80% of nominal’ is noted.

If the test compound is analysed, but not used for the test results and there is considerable change in the concentration during the test (>20% loss of test compound), the test result should be recalculated using *actual* concentrations. In such cases, a footnote should mention that test results are recalculated to actual concentrations.

In static or renewal tests, when samples are analysed at different points of time, the mean of the measured values is used. When the initial concentration is not measured and one or more samples during the test are, a mean of the initial nominal and the measured concentration(s) is used. In general, taking the average of start and end concentrations slightly overestimates the average concentration during the whole experiment, while the geometric mean underestimates the concentration. For calculating the mean concentration during the course of a static experiment, the best assumption is an exponential decay of the concentration in time. In continuous flow experiments, the concentrations are usually reported as mean measured values and, here, no further calculations are necessary.

A1.3.3.4. Test type

The following test types are distinguished:

S	static system
Sc	static system in closed bottles or test vessels
R	renewal system (semistatic)
F	flow-through system
CF	continuous flow system
IF	intermittent flow system

A1.3.3.5. Test compound

- This column can be deleted when the compound under consideration has only one structural molecular configuration.
- If the tested compound is a metal, the tested metal salt should be reported here.

- If the tested compound is a stereoisomer[29] or consists of a mixture of isomers, the name of the tested molecule(s) should be reported here. For some stereoisomers it might be appropriate to derive individual EQSs. The stereoisomers dieldrin and endrin are an example of such a case.
- If the tested compound is a structural isomer, the individual compounds, in general, have different physicochemical and toxicological properties and each compound will be the subject of a separate EQS derivation (e.g., anthracene and phenanthrene).
- Formulated products (e.g. biocides, pesticides) should be reported here.

A1.3.3.6. Purity

Unit: %

The purity of the test compound expressed as percentage is reported in this column. Alternatively, the following abbreviations may be entered for the designation of chemical purity.

ag	analytical grade
lg	laboratory grade
rg	reagent grade
tg	technical grade
fp	formulated product

Here, the first four have a relatively high purity, while technical grade is in general somewhat less pure. When the purity of the test compound is expressed only by an abbreviation, this abbreviation is reported. However, a purity expressed as percentage is preferred.

A1.3.3.7. Test water

In this column, the test water or medium is reported using abbreviations. Choose from the following list. A footnote to the test may be added if further description of the test medium is needed.

am	artificial medium, such as media used for bacterial and algal tests, artificial seawater
dw	de-ionised water, dechlorinated water or distilled water
nw	natural water, such as lake water, river water, sea water, well water
rw	reconstituted water: (natural) water with additional salts
rtw	reconstituted tap water: tap water with additional salts
tw	tap water

A1.3.3.8. pH

If possible, measured pH values should be reported. If a pH range is given, this range is reported.

A1.3.3.9. Temperature

Unit: °C

[29] Stereoisomers: geometric isomers (*cis*- and *trans*-isomers or *E*- and *Z*-isomers), optical isomers (+- and –-isomers or *R*- and *S*-isomers) and conformational isomers (e.g. chair and boat structures in cyclohexane ring structures).

In this column the temperature at which the test is performed should be reported, preferably a measured temperature. If a temperature range is given, the range is reported.

A1.3.3.10. Hardness

Unit: mg $CaCO_3 \cdot L^{-1}$

This column is shown in tables showing data from freshwater experiments, not for marine water. The hardness of the test water should be reported here. If the hardness of an artificial medium is not reported, but the composition of the medium is reported, the hardness should be calculated. Recalculation should be performed by summing the molar concentrations of all calcium (Ca) and magnesium (Mg) salts and expressing the result as $CaCO_3$ in units of $mg \cdot L^{-1}$.

A1.3.3.11. Salinity

Unit: ‰

This column is only shown in tables showing data from saltwater experiments, and replaces the column for hardness in the freshwater tables. In practice salinity may be determined by recalculating the measured chloride ion only to total salinity, using the assumption that the total amount of all components in the oceans is constant. The average salinity of seawater is around 35‰ (roughly 35 g of salts per litre of seawater). The unit of salinity might also be found expressed in parts per *thousand* (ppt) as w/w. To derive the salinity expressed in ppt the following conversion can be applied:

- when only chloride ions (Cl^-) have been measured, the salinity can be recalculated to ‰ from the chloride concentration using: S(ppt) = 1.80655 × chloride concentration (ppt), in which S = salinity
- psu = practical salinity units[30]. One psu roughly equals one ppt (‰). Seawater has a salinity of approximately 35 psu ≈ 35 ‰ = 35 $g.kg^{-1}$.

Animals living (and tested) in brackish water environments are not placed in separate tables, but are included in the saltwater tables. The division between freshwater, brackish water and seawater on the basis of salinity is given in Table . The division in these categories is rather arbitrary and depends on the source used. For the division between freshwater and brackish water, the value of 0.5‰ is defined in the Water Framework Directive (European Commission, 2000).

Table 3: Classification of water according to salinity.

Water type	Salinity (‰)
Freshwater	<0.5
brackish water	0.5–30
Seawater	30–40

A1.3.3.12. Exposure time

The duration of exposure to the toxicant in the toxicity experiment is given in this column. The abbreviations listed below in Table 4 can be used. A rule of thumb is to stick to the most common expression of test duration in case of standardised tests (e.g. OECD or ISO tests) where this is

30 However, because of the qualitative nature in which salinity is used in EQS derivation, this definition and its inherent accuracy are not relevant.

possible. For example, for a reproduction study with Oncorhynchus mykiss, 60 days (post-hatch) is noted rather than ‘2 months’.

Table 4: Used abbreviations for exposure times.

Test duration in	Abbreviation	
Minutes	min	
Hours	h	
Days	d	
Weeks	w	
Months	mo	
Years	y	

A1.3.3.13. Summary statistics

The summary statistics commonly encountered in ecotoxicological tests are summarised in Table . Their use in EQS derivation is described in the third and fourth columns of this table.

Table 5. Summary statistics derived from toxicity studies and their use in EQS derivation.

Test type	Criterion	Use in EQS derivation?	Action
acute test	EC10 or LC10	No [a]	▪ Tabulate value; may be valuable as additional information
acute test	EC50 or LC50	Yes	▪ Tabulate value
acute test	ECx or LCx	No	▪ Tabulate value; may be valuable as additional information
acute test	LOEC	No	▪ Omit if NOEC is also available from same experiment ▪ Else: tabulate value; may be valuable as additional information
acute test	MATC[31]	No	▪ Omit if NOEC is also available from same experiment ▪ Else: tabulate value; may be valuable as additional information
acute test	NOEC	No [a]	▪ Tabulate value; may be valuable as additional information
acute test	TLm	Yes	▪ Tabulate as LC50 [b]
Chronic test	EC10 or LC10	Yes	▪ Tabulate value
Chronic test	EC50 or LC50	No [a]	▪ Tabulate value; may be valuable as additional information
Chronic test	ECx (x < 10)	No	▪ Omit if NOEC is also available from same experiment ▪ If more than one ECx value is available, try to establish an EC10 from a reliable dose-response relationship ▪ Else: tabulate value; may be valuable as additional information
Chronic test	ECx (10 < x < 20)	Yes	▪ Omit if NOEC is also available from same experiment ▪ If more than one ECx value is available, try to establish an EC10 from a reliable dose-response relationship ▪ Tabulate value if the ECx is the lowest effect concentration measured. Calculate NOEC = ECx/2 (TGD guidance) and tabulate this NOEC [c]
Chronic test	ECx (x ≥ 20)	No	▪ Tabulate value; may be valuable as additional information ▪ If more than one ECx value is available, try to establish an EC10 from a reliable dose-response relationship
Chronic test	LOEC	No	▪ Omit if NOEC is also available from same experiment ▪ Else: (i) if percentage effect is known, see ECx in this table for further guidance ▪ Else: (ii) if percentage effect is unknown: tabulate value; may be valuable as additional information
Chronic test	MATC - single value, no further information	Yes	▪ Omit if NOEC is also available from same experiment ▪ Else, if no further information is available, calculate NOEC = MATC/√2 (TGD guidance) and tabulate this NOEC [d]
Chronic test	MATC - reported as a range	Yes	▪ Omit if NOEC is also available from same experiment ▪ Else, if no further information is available, tabulate the lowest value of the range as NOEC [e]
Chronic test	MATC – spacing factor is given [f]	Yes	▪ Omit if NOEC is also available from same experiment ▪ Else, if no further information is available, calculate NOEC = MATC/√(spacing factor)[f] and tabulate this NOEC [g]

[31] The MATC is the geometric mean of NOEC and LOEC.

Test type	Criterion	Use in EQS derivation?	Action
Chronic test	NOEC	Yes	▪ Omit LOEC if it is also available from same experiment

Notes to Table 5.

a) For toxicity tests with algae and *Lemna* sp., both the EC50 and the EC10 or NOEC are used in the EQS derivation, if available.

b) A footnote should be added to the toxicity data table stating that the TLm is used as LC50.

c) A footnote should be added to the toxicity data table stating that the NOEC is calculated as ECx/2.

d) A footnote should be added to the toxicity data table stating that the NOEC is calculated as MATC/√2.

e) A footnote should be added to the toxicity data table stating that the lowest value of the MATC range is taken as NOEC.

f) The spacing factor is the factor of difference between two subsequent testing concentrations employed in the toxicity experiment.

g) A footnote should be added to the toxicity data table stating that the NOEC is calculated as MATC/√(spacing factor).

The most common summary statistics are either EC50 or LC50 in the case of acute toxicity tests and EC10 or NOEC in the case of a chronic test. Other examples of summary statistics that are regularly found in the literature are LOEC, MATC (the geometric mean of NOEC and LOEC) and TLm, which is equivalent to the LC50. If a NOEC is reported, the LOEC can be omitted.If the endpoint presented is an ECx or LOEC value with an effect between 10 and 20% (i.e., x = 10-20), then a NOEC can be derived according to the TGD, by dividing the ECx by a factor of 2. In such a case, the NOEC can be presented in the toxicity data table, with a note that this value is estimated from an ECx value.

In a strict sense, calculating NOEC as ECx/2, according to the TGD, is only allowed for ECx values with an effect smaller than 20%. However, EC20 values are often presented in the literature. If there is no other information on the dose-response relationship (e.g. a companion EC50, which enables the calculation of an EC10), the EC20 divided by 2 can be considered as NOEC as well, accompanied by a footnote in the table with selected toxicity data (see Section 0).

The information on dose–response relationship should be used as much as possible. If it is possible to derive EC50 and EC10 values from a range of tabulated or graphically presented ECx values, these derived endpoints can be included in the toxicity data table as well, accompanied by a footnote stating the method of derivation.

A1.3.3.14. Test endpoint

The list below shows some relevant endpoints:

growth (weight, length, growth rate, biomass)

number (cells, population)

mortality

immobilisation

reproduction

hatching (rate, time, percentage)

sex ratio

development (egg, embryo, life stage)

malformations (teratogenicity)

proliferation (cells)

filtration rate

carbon uptake (algae)

reburial (of e.g. certain crustacean species)

This list is not exhaustive. In general only those endpoints that have consequences at the population level of the test species (see main guidance). Toxicity test results based on endpoints of whose relationship to effects at the population level is uncertain are not included in the toxicity data tables. Some examples of endpoints where effects at population level are unclear include:

blood or plasma protein levels

histopathological endpoints

organ weights (e.g. hepatosomatic index, gonadosomatic index)

mRNA induction

endpoints determined *in vitro* tests

behavioural responses (e.g. swimming behaviour, antenna motility, etc.)

coloration

However, it should be noted that these endpoints might be reconsidered when a definite correlation or causal relationship with population sustainability can be established.

A1.3.3.15. Value

Unit: $mg \cdot L^{-1}$, $\mu g \cdot L^{-1}$.

The unit in which the results of toxicity tests are expressed is optional. For reasons of comparison and to avoid errors, the same unit is used throughout all aquatic toxicity data tables in one report. In general, values are expressed in two or three digits. At most, four significant digits are reported. However, further calculation with these data may be necessary: averaging, dividing the values by an AF, use of the results in species sensitivity distributions (SSDs), etc.

Toxicity data for metal compounds are always expressed in quantities of the cation, not the salt. For example, a test performed with $CoSO_4 \cdot 7H_2O$ is expressed as Co^{2+}. Test results are recalculated if necessary. A similar approach is followed for all charged substances with a non-toxic counterion.

A1.3.3.16. Validity

This column contains a number (1, 2, 3 or 4) indicating the quality of the study. Section 0 describes the background of the quality scoring system.

A1.3.3.17. Notes

This column contains references to footnotes that are listed below the toxicity data tables. Numbers are used to refer to footnotes.

A1.3.3.18. Reference

The reference to the study from which data are tabulated has the following format:

1 author	Bringmann, 1956
2 authors	Bringmann and Kühn, 1976
3 or more authors	Bringmann *et al*., 1977

If two or more studies have the same citation, distinguish between the different studies by adding a character to the year, e.g. 1980a. All cited references are listed in a reference list.

A1.3.4. Sediment toxicity data tables

The following subsections (Sections 3.4.1 to 3.4.18) discuss the parameters that are reported in the toxicity data tables on acute and chronic toxicity data for benthic species. The parameters are treated in the same order as they appear in the default toxicity data table. The following subsections have titles identical to the column headings in the data tables.

A1.3.4.1 Species

See Section A1.3.3.1. for guidance on reporting data on species.

A1.3.4.2. Test organism information

See Section A1.3.3.2.

A1.3.4.3. Sediment type

In this column, list the sediment type: e.g. fine sandy or organic rich, muddy.

A1.3.4.4. Chemical analysis

See Section A1.3.3.3.

A1.3.4.5. Test compound

See Section A1.3.3.5.

A1.3.4.6. Purity

See Section A1.3.3.6.

A1.3.4.7. pH

Report the pH or the range of pH values, of the test sediment in this column.

A1.3.4.8. Organic carbon

Unit: %

In this column the weight percentage of organic carbon in the sediment is reported. When the percentage organic matter (om) is given, recalculation to percentage organic carbon (oc) is necessary according to Eq. 2:

$$\%\, om = 1.7 \times \%\, oc \qquad (2)$$

This is the general conversion between organic matter and organic carbon used throughout the whole process of deriving EQSs. The value of 1.7 is derived from the TGD (based on standard soil in the TGD containing 2% oc or 3.4% om).

A1.3.4.9. Temperature

See Section A1.3.3.9.

A1.3.4.10. Exposure time

See Section A1.3.3.12.

A1.3.4.11. Summary statstic

Extensive information on the summary statistics is given in Section A1.3.3.13. ECx data are treated in the same way as ECx data for aquatic species.

A1.3.4.12. Test endpoint

See Section A1.3.3.14.

A1.3.4.13. Result for test sediment

Unit: $mg{\cdot}kg^{-1}$, $\mu g{\cdot}kg^{-1}$

The unit in which the results of toxicity tests are expressed is optional. For reasons of comparison and to avoid errors, the same unit is used for all benthic toxicity data tables. This column shows the result as obtained in the experiment, expressed in weight per kg dry weight of the test sediment (i.e. *not* recalculated to standard sediment). For further guidance, see Section A1.3.3.15.

A1.3.4.14. Result for standard sediment

Unit: $mg{\cdot}kg^{-1}$, $\mu g{\cdot}kg^{-1}$

The unit in which the results of toxicity tests are expressed is optional. For reasons of comparison and to avoid errors, the same unit is used for all benthic toxicity data tables. This column shows the result recalculated into weight per kg of standard sediment (dry weight).

The bioavailability of compounds in sediment is influenced by properties like organic matter content, pH, etc. This hampers direct comparison of toxicity results obtained for the same substance in different sediments. To make results from toxicity tests conducted in different sediments more comparable, results should be normalised using relationships that describe the bioavailability of the compound in sediment. Results are converted into a standard sediment, defined as having an organic carbon content of 5% (w/w, see Section A1.3.4.8).

<u>Organic compounds</u>

For non-ionic organic compounds, it is assumed that bioavailability is determined by organic matter content only.

Recalculation to standard sediment is possible with the software program EUSES (European Union System for the Evaluation of Substances; European Commission, 2004).

Metals

In general, toxicity data for metals should not be normalised to a standard sediment. For EQS derivation, all reliable toxicity results with metals to benthic organisms are grouped in the appropriate data table without normalisation.

A1.3.4.15. Validity

This column contains a number (1, 2, 3 or 4), indicating the quality of the study summarised. Section 0 describes the background of the quality scoring system.

A1.3.4.16. Notes

See Section A1.3.3.17.

A1.3.4.17. Reference

See Section A1.3.3.18.

A1.3.5. Bird and mammal toxicity data tables

When secondary poisoning is assessed, results from toxicity studies with birds and mammals are tabulated in separate tables. Data on bioconcentration and biomagnification should be collected as well. For information on the collection of these parameters, see Section A1.4. An expert on human toxicology should be consulted when interpretation of toxicity tests with mammals is complex, e.g. multiple dosing.

A1.3.5.1. Species

See Section A1.3.3.1.

A1.3.5.2. Test organism information

See Section A1.3.3.2.

A1.3.5.3. Product or substance

Toxicity studies on birds or mammals may also be carried out with formulations or products rather than individual substances. Report the name of the substance, product of formulation that has been used in this column.

A1.3.5.4. Purity or active ingredient content

In the case that a product (or formulation) is tested, report the content of active ingredient (a.i.) present in the product, expressed in %. If the purity of the active ingredient (used in formulation) is also known, report this in a footnote.

If a single substance has been applied in the test, report the purity of the tested compound in this column.

A1.3.5.5. Application route

Relevant are those toxicity tests in which the animals are dosed orally. This might be achieved via a direct method (intubation, gavage) or by dosing via the food or water.

A short list of application routes is given below:

- intubation or gavage

- capsule
- diet
- water or feeding solution

A1.3.5.6. Vehicle

A carrier used to dose the test substance to the test animals is reported here.

A1.3.5.7. Test duration

The value in this column reports the total duration of the test. The abbreviations listed in Table 4 can be used. This column should also be filled in when the test duration is equal to the exposure duration. The test duration might be longer than the exposure time, which is reported in the next column (Exposure time). For example in the acute avian dietary toxicity test, in which the exposure lasts 5 days, but the minimal recommended test duration is 8 days.

A1.3.5.8. Exposure time

The duration of exposure to the toxicant in the toxicity experiment is expressed in this column. The abbreviations listed in Table 4 can be used.

A1.3.5.9. Summary statistics

Short term toxicity tests will either yield an LC50 ($mg{\cdot}kg_{food}^{-1}$) or an LD50 ($mg{\cdot}kg_{bw}^{-1}{\cdot}d^{-1}$ in the case of repetitive dosing). Long-term toxicity tests will generally result in a NOEC (no observed effect concentration in diet; $mg{\cdot}kg_{food}^{-1}$), or a NOEL (no observed effect level in a dosing study; $mg{\cdot}kg_{bw}^{-1}{\cdot}d^{-1}$). Results from long-term toxicity tests may also be reported as a NOAEL (no observed adverse effect level), which is the no observed adverse effect level. However, the effects generally observed for the derivation of the NOEC/NOEL are adverse to the organisms.

A1.3.5.10. Test endpoint

The toxicological parameter for which the test result is obtained is tabulated here. Screening for clinical parameters at haematological, histopathological or biochemical level is common in these types of tests. However, secondary poisoning only aims at taking into account effects at the population level.

The list below shows only some of the relevant endpoints:

body weight

egg production

eggshell thickness

hatchability

hatchling survival

mortality

reproduction (e.g. litter size, teratogenic effect, malformation, gestation duration…)

viability (percentage of viable embryos per total number of eggs)

A1.3.5.11. Value from repetitive oral dosing studies

Unit: $mg{\cdot}kg_{bw}^{-1}{\cdot}d^{-1}$.

See also Section 0 for data handling.

From short term toxicity experiments with repetitive dosing on consecutive days (5 d LD50 for birds) and long-term oral dosing studies, a value expressed in $mg.kg_{bw}^{-1}.d^{-1}$ is obtained. The results from such studies (*viz.* LD50 and NO(A)EL) are reported in this column.

A1.3.5.12. Value from diet studies

Unit: $mg.kg_{food}^{-1}$.

See also Section 0 for data handling.

The results of toxicity tests in which the substance of interest is administered via the food are expressed in $mg.kg_{food}^{-1}$. The results of dietary studies (*viz*. LC50 or NOEC values) are reported in this column.

A1.3.5.13. Validity

This column contains a number (1, 2, 3 or 4), indicating the quality of the study summarised. Section 0 describes the background of the quality scoring system.

A1.3.5.14. Notes

See Section A1.3.3.17.

A1.3.5.15. Reference

See Section A1.3.3.18.

A1.3.6. Data selection

A1.3.6.1. Aquatic compartment

One value per species and endpoint is selected for use in the assessment. Where multiple data are available for the same species/endpoint, individual toxicity data may be aggregated using the same principles as those in Chapter R.10 of the REACH Guidance (ECHA, 2008):

1. Identify particularly sensitive species and/or endpoints that may be lost upon averaging data to single values.
2. Investigate multiple values for the same endpoint on a case-by-case basis and seek to explain differences between results.
3. Where valid data show high variation that can be explained, grouping of data is considered, e.g. by pH ranges. If an effect of test conditions is expected to be the cause of variation in toxicity values (hardness of test water, life stage of the test animal, etc.), averaging of data per species should not be performed.
4. Data used for EQS derivation should be selected on the relevance of test conditions (pH, hardness, etc.) to the field.
5. If the variation in test results of different life stages of a test animal is such that averaging data would cause significant underprotection of sensitive life stages, only the data for the most sensitive life stage should be selected. In other words, it is important that sensitive life stages are protected.
6. Calculate the geometric mean of multiple comparable toxicity values for the same species and the same endpoint. This applies to both acute and chronic data.
7. If multiple toxicity values or geometric means for different endpoints are available for one species, the most-sensitive endpoint is selected as long as it is relevant to population sustainability. If multiple valid toxicity data for one species are left that cannot be averaged, the *lowest* value is selected.

Example: There are values (of NOECs or EC10 values) for three different endpoints, derived from several chronic studies with *Daphnia magna.* The geometric mean of NOECs for reproduction is 0.49 mg·L^{-1}, the geometric mean of NOECs for mortality = 3.1 mg·L^{-1} and there is a single EC10 value for growth of 0.67 mg·L^{-1}. The geometric mean value of 0.49 mg·L^{-1} for reproduction is selected for use in EQS derivation.

8. If differences in the chemical form of the test compound (congeners, stereoisomers, etc.) are the cause of variation in toxicity values for a test species, data should not be averaged. In these cases, the *lowest* reliable toxicity datum is selected and separate EQSs should be derived for each chemical form.
9. Particular steps have been developed for metals to account for variations in the toxicity of different metal species. These are explained in Section 4 of the main guidance.
10. Limitations of toxicity data should be explained, for example, when toxicity results are not valid at low pH. Explanation for these types of limitations should be reported in the datasheet in the section dealing with key assumptions and uncertainties.

A1.3.7. Data treatment

A1.3.7.1. Combining freshwater and marine datasets for EQS derivation

1. To derive EQSs for transitional, coastal and territorial waters, toxicity datasets of marine and freshwater species are normally combined because current marine risk assessment practice suggests a reasonable correlation between ecotoxicological responses of freshwater and saltwater biota (i.e. the same datasets can be used interchangeably for freshwater and saltwater effects assessment). Where this is not justified based on the available evidence (i.e. there is a clear difference in the sensitivity of the freshwater and saltwater biota), EQSs for inland surface waters and transitional, coastal and territorial waters must be derived on the basis of distinct datasets for freshwater and marine organisms.Toxicity data for freshwater organisms and marine organisms are combined *before* EQS derivation for the aquatic compartments. If there are doubts as to whether organisms from both environments show similar sensitivity, differences may be tested in the following way:All freshwater data that are going to be used for EQS derivation are collected (note: this dataset contains one toxicity value per species, see Section 0) and the $\log_{10}$ value of each of these toxicity values is calculated.
2. Repeat the above step for all marine toxicity data.
3. Test whether the two log-transformed datasets have equal or unequal variances using an *F*-test. Perform the test at a significance level (α) of 0.05.
4. A two tailed *t*-test, with or without correction for unequal variances as determined in point 3, is performed to test for differences between the datasets. Perform the test at a significance level (α) of 0.05.
5. When using a statistical test, be aware of some confounders. For example: (i) a specific group of organisms might be more sensitive than other organisms; (ii) over-representation of data from one study or species from a specific taxonomic group in one of the two datasets might cause bias. Results of a *t*-test become increasingly meaningful with increasing sample size.

If the null hypothesis is supported, the datasets may be combined. This procedure must not be applied to metals. For metals, the freshwater and saltwater datasets must always be kept separate.

A1.3.7.2. Conversion of data on birds and mammals

For each of the selected avian or mammalian toxicity studies, the test result is expressed as a $NOEC_{oral}$ in $mg \cdot kg_{food}^{-1}$. No observed adverse effect concentrations (NO(A)ELs, expressed on a basis of $mg \cdot kg_{bw}^{-1} \cdot d^{-1}$), are converted into $NOECs_{oral}$ (in $mg \cdot kg_{food}^{-1}$) using the following equations (Eqs. 3 and 4), with the conversion factors from Table or a suitable factor for the daily food intake for any other species:

$$NOEC_{\text{bird}} = NOAEL_{\text{bird}} \cdot CONV_{\text{bird}} \qquad (3)$$

$$NOEC_{\text{mammal,food\_chr}} = NOAEL_{\text{mammal,oral\_chr}} \cdot CONV_{\text{mammal}} \qquad (4)$$

Table 6. Conversion factors from NOAEL into NOEC for several species.

Species	Common name	Conversion factor ($bw \cdot DFI^{-1}$)
Canis domesticus	Dog	40
Macaca sp.	Macaque species(monkey)	20
Microtus spp.	Vole species	8.3
Mus musculus	House mouse	8.3
Oryctolagus cuniculus	European rabbit	33.3
Rattus norvegicus (>6 weeks)	Brown rat	20
Rattus norvegicus (≤ 6 weeks)	Brown rat	10
Gallus domesticus	Chicken	8

bw = body weight (g); DFI = daily food intake ($g \cdot d^{-1}$).

A1.4. BIOCONCENTRATION AND BIOMAGNIFICATION DATA

A1.4.1. Data collection

The literature should be searched for bioconcentration (BCF) and biomagnification (BMF) studies if a biota EQS is triggered (see Section 2 of the main guidance). Useful data sources for BCF values are the physicochemical properties and environmental fate handbook (Mackay *et al.*, 2006) and ECOTOX (US EPA, 2007a). The BCF and BMF data should be tabulated separately.

A1.4.2. Data evaluation and data tables

In principle, the evaluation of bioaccumulation data follows the evaluation for toxicity. All retrieved literature is read and evaluated with respect to its relevance and reliability. The most relevant BCF studies are those performed with fish, but studies performed with molluscs are important for secondary poisoning as well. The BCF data for other species should be carefully checked because they are prone to experimental errors, e.g. accumulation may not reflect uptake, but adsorption to the outside of the organism. For this reason, BCF values for algae are rarely reliable. A reliable BCF study should be similar in experimental set-up to the updated OECD guideline 305 (OECD, 1996). At least the concentration of the (parent) compound in the aqueous phase, and in fish, has to be measured at several time points. No specific guidance is available for BMF studies, which are mostly derived from field studies. Apart from the analysis, a reliable BMF study requires that the prey and predator species originate from the same area and from the same period in time. After evaluating a study, the results of the study are summarised by entering it into the appropriate data table (Section 0).

A1.4.3. Bioaccumulation data tables

The following subsections (Sections 0 to 0) discuss the parameters that are to be reported in the bioaccumulation data tables. The parameters are treated in the same order as they appear in the default bioaccumulation data table. The following subsections have titles identical to the column headings in the data tables.In the following sections, it is assumed that fish are the test organism most frequently encountered in BCF studies. However, BCF studies with molluscs may also be found. These data are relevant, as the food chain water → mollusc (→ fish) → mollusc/fish-eating bird or mammal is also important.

A1.4.3.1. Species

See Section A1.3.3.1.

A1.4.3.2. Test organism information

See Section A1.3.3.2.

A1.4.3.3. Test substance

Clearly report what compound is used. If a radiolabelled compound is used, it should be reported in this column of the bioaccumulation data table. For organic compounds that have one or more isomers, the specific isomer (or mixture of isomers) used in the test is reported, e.g. diastereomers, *cis*/*trans* conformation, *o*, *m*, *p* substitution, formulations, etc.

A1.4.3.4. Substance purity

See Section A1.3.3.6.

A1.4.3.5. Chemical analysis

A column in the bioaccumulation data table is included that gives information on the analysis of the aqueous phase/biological matrix. However, as the determination of the water and biota concentration is a prerequisite of any good BCF study, this column should give information on how the concentration is determined, e.g. GC-FID or GC-MS (gas chromatography coupled to a flame ionisation detector or a mass spectrometer, respectively) and HPLC-UV (high-performance liquid chromatography). Where a radiotracer is used, the method of detection is important. Liquid scintillation counting (LSC) measures total radioactivity, including the parent compound and metabolites. HPLC used in combination with radiodetection can be used to resolve only the parent compound.

A1.4.3.6. Test type

See Section A1.3.3.4.

A1.4.3.7. Test water

See Section A1.3.3.7.

A1.4.3.8. pH

See Section A1.3.3.8.

A1.4.3.9. Hardness/Salinity

See Sections A1.3.3.10 and A1.3.3.11.

A1.4.3.10. Temperature

See Section A1.3.3.9.

A1.4.3.11. Exposure time

In this column, the times of the uptake phase and, if carried out, the depuration phase are listed. If both phases are determined, the exposure time and depuration time are listed as two separate time spans: e.g. 14 + 14 d.

A1.4.3.12. Exposure concentration

The concentration at which the bioaccumulation study is performed is given in this column table. This is important because guidelines require that the concentration meets some conditions. For example, according to the OECD guideline 305 (OECD, 1996), the highest aqueous concentration should be about one hundredth of the acute LC50 or the acute LC50 divided by an appropriate acute-to-chronic ratio, while the lowest concentration should preferably be a factor of ten below the highest concentration, but at least ten times above the limit of detection in the aqueous phase. As explained in the main guidance (Section 2), the exposure concentration can have a major influence on BCF values. For metals, BCF data are invalid.

A1.4.3.13. Bioaccumulation

Unit: $L \cdot kg^{-1}$.

Here, the value of the BCF or BMF is denoted. The basis for the BCF value is the ratio of the concentration in wet weight (ww) of the organism, mostly fish, divided by the water concentration. The unit of the BCF is $L \cdot kg_{ww}^{-1}$; if the BCF is normalised to dry weight or lipid weight, this should be explicitly indicated with a note describing the origin of the value.

BCF values used for triggering and calculating the routes of secondary poisoning and human consumption of fishery products should be whole body BCFs, expressed in $L \cdot kg^{-1}$. This allows for variation since these BCFs are not normalised to lipid or fat content, which dominates accumulation. The EQS derivation is dependent on the available studies. In most older BCF studies, fat content is often not reported. It is preferable to include such studies because, otherwise, risks to predators and humans may be overlooked.

A1.4.3.14. Biological matrix

In this column in the table, it is reported what part of the organism the BCF has been determined for. Possibilities are, for example, whole fish ww, whole fish dw, edible parts, non-edible parts viscera, etc.

A1.4.3.15. Method

The method used to calculate the bioaccumulation value is reported in this column. Basically, the method can be based on equilibrium concentrations or on kinetics, including the uptake and depuration rate constants (k_1 and k_2). With equilibrium concentrations (noted as equilibrium), the BCF is determined as the quotient of the concentrations in organisms, mostly fish, and water at equilibrium. When the kinetic constants (k_1/k_2) are used to calculate the BCF, the BCF is calculated as the quotient of uptake rate (k_1) and depuration rate (k_2), mostly determined independently during an uptake and a depuration phase (k_1, k_2 independent). However, in some studies, k_2 is first determined from the depuration phase and k_1 estimated from the data of the uptake phase, with this value of k_2 implied to take the non-linearity of the uptake into account (k_1 implied by fitted k_2). A further possibility is that k_1 and k_2 are fitted simultaneously by a non-linear regression model.

If the method cannot be described easily, a footnote to the table can be entered.

A1.4.3.16. Notes

Additional notes may include information on the analysis, the basis of the BCF value (dry weight or lipid weight) or the method used to determine the BCF.

A1.4.3.17. Reference

See Section A1.3.3.18.

A1.4.4. Data selection

A1.4.4.1. BCF – experimental data

Aquatic compartment

From the valid studies summarised in the data table (Section 0) calculate the geometric mean values per species. Of these values per species, the most reliable should be taken unless they are equally reliable, in which case the geometric mean of several BCFs is selected. For metals, BCF values should not be used. Instead, BMF data should be used or an assessment as described in the main guidance.

A1.4.4.2. BCF – calculation method

Aquatic compartment

When a BCF cannot be derived on the basis of experimental data, a BCF may be calculated as described below for substances whose log K_{ow} value is ≥3.

For substances with a log K_{ow} of 2–6, the following linear relationship (Eq. 5), as developed by Veith *et al*. (1979), can be used:

$$\log BCF_{\text{fish}} = 0.85 \times \log K_{\text{ow}} - 0.70 \quad (5)$$

For substances with a log K_{ow} higher than 6, a parabolic equation can be used (Eq. 6):

$$\log BCF_{\text{fish}} = -0.20 \times \log K_{\text{ow}}{}^{2} + 2.74 \times \log K_{\text{ow}} - 4.72 \qquad (6)$$

Because of experimental difficulties in determining BCF values for such substances, this mathematical relationship has a higher degree of uncertainty than the linear one (Eq. 5). Both relationships apply to compounds with a molecular weight of less than 700. Further discussion can be found in REACH guidance, Chapter R.11 (ECHA, 2008).

A1.4.4.3. BMF – experimental data

Experimental BMF values generally originate from field studies. From the valid BMF studies summarised in a BMF data table, the geometric mean value is calculated.

A1.4.4.4. BMF – calculation method

When a BMF cannot be derived on the basis of experimental data, a BMF may be estimated using log K_{ow} data as described in Table 7. In this table, BMF_1 is a value for the biomagnification in the prey of predators for the freshwater environment. For the marine environment, an additional biomagnification step is included, which is reflected in the BMF_2 value. This BMF_2 is a value for biomagnification in the prey of top predators.

The most relevant values for BMF_1 are those for biomagnification from small to larger fish (either fresh or marine water). These larger fish then serve as food for predators such as otters and herons, or seals in the marine environment. Data for biomagnification from other small species such as crustaceans to fish might be useful as well, but care must be taken that in the further assessment of secondary poisoning, BCF and BMF values are consistent. For comparison, the default values from Table can be used. Another group of prey that might be relevant to the route of secondary poisoning are mussels. If mussels are directly consumed by birds or mammals and a BCF value for mussels is available, a biomagnification step would be absent. However, there are also several common fish species that feed on mussels. In such a case BMF data on accumulation from mussels to fish would be relevant.

For the marine environment a further biomagnification step is considered by introducing the BMF_2 value. This step refers to the biomagnification from fish to small mammals and birds. For the marine environment, a good example is the biomagnification from fish to seals. The latter species then serve as prey for top predators such as polar bears and killer whales. However, besides data for the marine environment, other data for biomagnification from fish to fish-eating birds and mammals should be considered as well.

Table 7 Default BMF values for organic substances.

log K_{ow} of substance	BCF (fish)	BMF_1	BMF_2
<4.5	<2000	1	1
4.5–<5	2000–5000	2	2
5–8	>5000	10	10
>8–9	2000–5000	3	3
>9	<2000	1	1

The second column of Table 7 also shows (ranges of) BCF values. However, if one or more experimental BCF data are available, the BCF values from the tables are not needed. If there is no experimental BCF value, the numbers from Table cannot be regarded as guidance, because they represent ranges instead of single values. In such a case, it is better to estimate the BCF from the log K_{ow}. This procedure is described in Section A1.4.4.2. The results are broadly consistent with the ranges presented in Table 7.

A1.5. TOXICOLOGICAL DATA FOR THE PROTECTION OF HUMANS

A1.5.1. Threshold limits

A human toxicological threshold value may be needed for EQS derivation in two cases:

- in the derivation of the $QS_{hh\ food,water}$ (consumption of fishery products)
- in the derivation of the $QS_{dw,water}$ (drinking water)

The human toxicological threshold values that can be used are the ADI (acceptable daily intake) and TDI (tolerable daily intake). The US ATSDR uses the term MRL (minimum risk level) while the US EPA uses the term RfD (reference dose). The basis for the human-toxicological threshold levels is in principle a NO(A)EL from a mammalian toxicity study, which is useful if established threshold levels are unavailable. However, the NOAEL is not a human toxicological threshold limit and an AF (typically 100) must be used. To derive a TDI or ADI from a NOAEL a human toxicologist should be consulted.

Effect data are the relevant NOAEL, ADI, TDI values identified in the human health section of risk assessments according to Council Regulation (EEC) No. 793/93 or Council Directive 91/414/EEC. The ADI or TDI values adopted by international bodies such as the World Health Organization may also be used. Where a threshold level cannot be given, unit risk values corresponding to an additional risk of, for example, cancer over the whole life of 10^{-6} (one additional cancer incident in 10^{6} persons taking up the substance concerned for 70 years) may be used, if available.

A list of organisations or frameworks that have published human toxicological threshold limits is presented in Table (extracted from Hansler *et al*., 2006). In general, it is advised to take the most recent value and consult a human toxicologist on the final choice of the value. If a clear value is reported in a European risk assessment report, this should be used.

Table 8: Sources for the retrieval of human toxicological threshold limits.

Source name and publisher	Available at
HSDB (NLM/NIH)	http://toxnet.nlm.nih.gov/
ATSDR Toxicological Profiles (ATSDR)	http://www.atsdr.cdc.gov/mrls/index.html (MRLs) http://www.atsdr.cdc.gov/mrllist_12_05.pdf
CEPA Priority Substances Assessments (Environment- & Health-Canada)	http://www.cen-rce.org/eng/projects/cepa/
CICAD (IPCS)	http://www.inchem.org/pages/cicads.html
EHC (WHO/IPCS)	http://www.inchem.org/pages/ehc.html
ESIS (ECB)	http://ecb.jrc.it/esis/
HSG (WHO)	http://www.inchem.org/pages/hsg.html
IARC Monographs (WHO)	http://monographs.iarc.fr http://www.inchem.org/pages/iarc.html
ICSC (IPCS-EU)	http://www.inchem.org/pages/icsc.html
IRIS (US-EPA)	http://cfpub.epa.gov/ncea/iris/index.cfm
JECFA Monographs (WHO/FAO)	http://www.inchem.org/pages/jecfa.html
JMPR Monographs (WHO/FAO)	http://www.inchem.org/pages/jmpr.html
WHO/FAO (pesticides)	http://www.fao.org/docrep/W3727E/w3727e00.HTM
MPC_{human} values for the derivation of SRC_{human}	http://www.rivm.nl/bibliotheek/rapporten/711701025.pdf
NTP (NIH-NIEHS)	http://ntp-server.niehs.nih.gov/
OEHHA Toxicity Criteria Database (Cal-EPA)	http://www.oehha.org/risk/chemicalDB/index.asp
SIDS (OECD-UNEP)	http://www.chem.unep.ch/irptc/sids/OECDSIDS/sidspub.html
TERA (TERA)	http://www.tera.org/ITER
DWQG (WHO)	http://www.who.int/water_sanitation_health/dwq/guidelines/en/

Source name and publisher	Available at
Umwelt-Online	http://www.umwelt-online.de/recht/gefstoff/g_stoffe/adi.htm

A1.6. REFERENCES TO APPENDIX 1

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A1.7. ABBREVIATIONS, VARIABLES AND DEFAULT VALUES

ACD	Advanced Chemistry Development
ADI	acceptable daily intake
AF	assessment factor
ag	analytical grade
a.i.	active ingredient

am	artificial medium
ATSDR	Agency for Toxic Substances and Disease Registry
BCF	bioconcentration factor
BMF	biomagnification factor
bw	body weight
CAS	Chemical Abstracts Service
CEPA	Canadian Environmental Protection Act
CF	continuous flow system
CICAD	concise international chemical assessment document
ClogP	log octanol/water partitioning coefficient, calculated by software program BioLoom
d	days
DFI	daily food intake
dw	de-ionised water, dechlorinated water or distilled water
	dry weight
DWQG	drinking-water quality guidelines
EC	effect concentration
	European Commission
ECHA	European Chemicals Agency
ECB	European Chemicals Bureau
ECx	effect concentration at which an effect of x% is observed, generally EC10 and EC50 are calculated
EEC	European Economic Community (replaced by EU)
EHC	environmental health criteria
EINECS	European inventory of existing commercial chemical substances
ELS	early life stage
EPA	Environmental Protection Agency
EPI	estimation programs interface
EPICS	equilibrium partitioning in closed systems
EqP	equilibrium partitioning
EQS	environmental quality standard
ESIS	European Chemical Substances Information System
EU	European Union
EUSES	European Union System for the Evaluation of Substances

F	flow-through system
FAO	food and agriculture organisation
FETAX	frog embryo teratogenesis assay *Xenopus*
GC	gas chromatography
GC-MS	gas chromatography–mass spectrometry
GC-FID	gas chromatography–flame ionisation detection
GLP	good laboratory practice
h	hours
HPLC	high-performance liquid chromatography
HSDB	hazardous substances databank
HSG	health and Agency for Research on Cancer
ICSC	international chemical safety cards
IF	intermittent flow system
IPCS	International Programme on Chemical Safety
IRIS	Integrated Risk Information System
ISO	International Organisation for Standardisation
IUCLID	International Uniform Chemical Information Database
IUPAC	International Union of Pure and Applied Chemistry
JECFA	Joint Expert Committee on Food Additives
JMPR	Joint Meeting on Pesticide Residues
*K*oc	organic carbon adsorption coefficient
*K*ow	octanol/water partition coefficient
LCx	effect concentration at which x% lethality is observed, generally LC50 and LC10 are calculated
LD50	dose that is lethal to 50% of the tested animals
lg	laboratory grade
LSC	liquid scintillation counting
LOEC	lowest observed effect concentration
MATC	maximum acceptable toxicant concentration
MCI	molecular connectivity indices
MlogP	log octanol/water partitioning coefficient, measured value selected by software program BioLoom
min	minutes

mo	months
MPC	maximum permissible concentration
MRL	minimum risk level
mRNA	messenger ribonucleic acid
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NOEL	no observed effect level
NTP	National Toxicology Program (United States)
nw	natural water, such as lake water, river water, sea water, well water
oc	organic carbon
OECD	Organisation for Economic Co-operation and Development
OEHHA	office of environmental health hazard assessment
om	organic matter
OPPTS	office of prevention, pesticides and toxic substances
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppt	parts per thousand or parts per trillion
psu	practical salinity unit
QS	quality standard
QSAR	quantitative structure–activity relationship
QSPR	quantitative structure property relationship
R	renewal system
RfD	reference dose
rg	reagent grade
rtw	reconstituted tap water: tap water with additional salts
rw	reconstituted water: (natural) water with additional salts
RIVM	National Institute for Public Health and the Environment
S	static
Sc	static, closed system
SIDS	screening information dataset

SMILES	simplified molecular input line entry system
sp.	species
SPARC	SPARC performs automatic reasoning in chemistry
SRC_{human}	human toxicological serious risk concentration
susp	suspended particulate matter
SSD	species sensitivity distribution
TDI	tolerable daily intake
TERA	toxicology excellence for risk assessment
tg	technical grade
TGD	Technical Guidance Document
TLm	median tolerance limit; also encountered as median threshold limit
tw	tap water
UNEP	United Nations Environment Programme
US	United States
UV	ultraviolet
w	weeks
WAF	water accommodated fraction
WHO	World Health Organization
ww	wet weight
y	years

List of defaults and variables.

Symbol	Description of variable	Unit	Value
AF	assessment factor	–	1–5
bw	human body weight	kg_{bw}	70
$Foc_{standard\ sediment,TGD}$	fraction of organic carbon in standard sediment as defined in the TGD	$kg \cdot kg^{-1}$	0.05
$Foc_{susp,TGD}$	weight fraction of organic carbon in suspended matter as defined in the TGD	$kg \cdot kg^{-1}$	0.1
R	gas constant	$Pa \cdot m^3 \cdot mol^{-1} \cdot K^{-1}$	8.314
TEMP	environmental temperature	K	285

ANNEX TO APPENDIX 1: DATA EVALUATION OF PHYSICOCHEMICAL DATA

1. Evaluation of the vapour pressure for use in EQS derivation

An OECD guideline exists for the experimental determination of the vapour pressure of a compound (OECD guideline 104; OECD, 1995b). In this guideline several methods are discussed, each with its own range of applicability. The following table presents information from the guideline, which specifies what method is suitable for which compound.

Table 9: Domain of applicability of different methods for the determination of vapour pressure

Method	Suitable for liquids	Suitable for solids	Recommended range
Dynamic method	low melting	yes	10^3-10^5 Pa
Static method	Yes	yes	10-10^5 Pa
Isoteniscope	Yes	yes	10^2-10^5 Pa
Effusion method	Yes	yes	10^{-3}-1 Pa
Gas saturation method	Yes	yes	10^{-5}-10^3 Pa
Spinning rotor method	Yes	yes	10^{-4}-0.5 Pa

In the dynamic method (Cottrell's method), the boiling point of a compound is determined at various pressures between about 10^3 and 10^5 Pa. In the static method, the vapour pressure is determined at one specified temperature by means of a manometer (e.g. 25 ºC). The isoteniscope method is based on the same principle as the static method. In the effusion method the weight loss of the compound is measured. This can be done directly by measuring the mass of the remaining substance or by analysing the volatilised amount by gas chromatography (GC). In the proposed update of guideline 104 (OECD, 2002), isothermal gravimetry is added for the effusion method. The weight loss is then determined at different temperatures and an extrapolation to 20 or 25 ºC can be made. The range of vapour pressures that can be determined with this method is 10^{-10} to 1 Pa. The gas saturation method makes use of a column containing a carrier material supporting the substance, through which an inert gas is passed. The concentration of the substance in this carrier gas is then determined, usually by gas chromatography (GC). The last method is the spinning rotor method, where the retardation of a spinning ball due to the friction with the gas phase is measured.

In general, the methods that make use of an analysis of the substance, for example, by gas chromatography, are less prone to errors due to impurities than the other methods. The OECD guideline does not mention this explicitly. However, degassing of more volatile compounds prior to the determination of the vapour pressure also enhances the reliability of the determination.

The retention time in gas chromatography can be used to estimate the vapour pressure of a compound. Although this is not a direct determination of the vapour pressure, it generally gives rather accurate results and is applicable to substances with a very low vapour pressure. In addition to this, the vapour pressure can be estimated by the programme MPBPwin, which is incorporated in EPI Suite (US EPA, 2007b). The programme makes use of three estimation methods, which are the Antoine method, the modified Grain method and the Mackay method. All three methods make use of the boiling point for their estimation of the vapour pressure. Also the melting point of the compound is a necessary parameter for the estimation. Both boiling and melting point can be estimated by the programme, but experimental values can also be entered if known. For solids, the result of the modified Grain method is presented as the preferred value, while for liquids this is the mean of the Antoine method and the modified Grain method. A value for the vapour pressure can also be estimated by SPARC (Karickhoff *et al.*, 2007), which has a mechanistic thermodynamic basis. In the data tables, both estimated values are reported as well.

2. Henry coefficient

No general accepted guideline exists for the determination of the Henry coefficient. However, several methods exist to determine the Henry coefficient experimentally.

In the batch stripping method, gas is bubbled at a known rate through a solution of the compound in water. The Henry coefficient is calculated with a mass balance from the decrease in the aqueous concentration. The concentration in air is generally not measured. This method works well for fairly volatile compounds with Henry coefficients higher than 2.5 and occasionally down to 0.25 $Pa \cdot m^3 \cdot mol^{-1}$ (Mackay *et al.*, 2000).

One common method, very similar to the batch stripping method, is the gas stripping method in which a gas is bubbled through the aqueous solution and both the aqueous concentration and the gas concentration are determined. The technique was applied to chlorobenzenes, PAHs, and PCBs in a range from 0.018 to 276 $Pa \cdot m^3 \cdot mol^{-1}$ (Ten Hulscher *et al.*, 1992).

A method for highly volatile compounds (i.e. higher than 120 $Pa \cdot m^3 \cdot mol^{-1}$) is the equilibrium partitioning in closed systems (EPICS) method. With this method a known volume of solute in water solution is equilibrated with air in sealed vessels. The headspace air concentrations are measured. The method has a high precision (Mackay *et al.*, 2000). A number of other headspace analysis techniques that are used, are slightly different from the EPICS method, in some techniques not only the headspace but both phases are analysed (Mackay *et al.*, 2000).

A method for less volatile compounds is the wetted-wall method. In this method the solute is equilibrated between a thin flowing film of water and a concurrent air flow in a vertical column. Both phases are measured. The method has been applied to pesticides and other less volatile compounds, but no recommended range is given (Mackay *et al.*, 2000). In the handbook (Mackay *et al.*, 2006), values for polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and two pesticides are tabulated using this method. Values for PCBs and PAHs range from 0.91 to 74.3 $Pa \cdot m^3 \cdot mol^{-1}$. One of the pesticides (alachlor) has a much lower Henry coefficient of $8.43 \cdot 10^{-4}$ $Pa \cdot m^3 \cdot mol^{-1}$. This is in agreement with the method being suitable for less volatile compounds.

Also the Henry coefficient is sometimes related to retention times (Mackay *et al.*, 2000). However, results obtained using this method should be considered as an estimate. Another estimation that is often used for the Henry coefficient is the quotient of vapour pressure and solubility. This method works quite well for substances that have a solubility of less than 1% in water. The Henry coefficient can also be calculated by a bond contribution method as included in EPI Suite (US EPA, 2007b). These estimated values should be included in the data table.

3. Evaluation of the water solubility for use in EQS derivation

For the experimental determination of the water solubility, an OECD guideline is available (OECD guideline 105; OECD, 1995c), in which two methods are discussed. These methods are the flask method (shake-flask) and the column elution method (generator column). The flask method can be used for compounds with a solubility higher than 10 $mg \cdot L^{-1}$. Below that value, colloid formation will overestimate the true aqueous solubility and in that case the column elution method should be used, which prevents this phenomenon.

Apart from the methods proposed in the OECD guideline, the water solubility of poorly soluble liquid compounds can be accurately determined by means of the slow-stirring method. The reliability of the slow-stirring method applied to liquid substances can be considered as equivalent to that of the column elution method. Only few examples are available of the use of this method for the determination of the solubility, mostly for hydrocarbons and phthalate esters (Tolls *et al.*, 2002; Letinski *et al.*, 2002; Ellington, 1999). This method is often used to prepare saturated solutions of hydrocarbon mixtures (oil products) in water (water accommodated fractions or WAF), by which information on the solubility of a mixture is given (Schluep *et al.*, 2002).

Estimates of the water solubility can be made by two different programmes included in EPI Suite (US EPA, 2007b). These programmes are WSKOWwin, which estimates the solubility from log K_{ow}, and WATERnt, which is a fragment method for water solubility independent of log K_{ow}. Experimental values for log K_{ow} and melting point can be entered in WSKOWwin if available. Otherwise WSKOWwin will use the default values (experimental or calculated) from EPI Suite for these parameters. Another estimation method for the water solubility is the calculation performed by SPARC (Karickhoff *et al.*, 2007), which has a mechanistic thermodynamic basis. These estimated values are reported as well in the data tables.

4. Evaluation of K_{ow} values for use in EQS derivation

Several methods are available for the experimental determination of log K_{ow}. In the OECD guidelines, two methods are available and further there is one draft guideline. The first method is the shake-flask method (OECD guideline 107; OECD, 1995a). This method works well for log K_{ow} values in the range between -2 and 4 (occasionally up to 5), but is impossible to use with surface-active materials. For these materials, a calculated value (using BioLoom; BioByte, 2004) or an estimate based on individual *n*-octanol solubility and water solubility should be provided, preferably in mutually saturated *n*-octanol and water (Sijm *et al.*, 1999; Li and Yalkowsky, 1998a; Li and Yalkowsky, 1998b).

The second method is the HPLC method. Values of log K_{ow} in the range between 0 and 6 can be estimated using high performance liquid chromatography (OECD guideline 117; OECD, 2004). The HPLC method is not applicable to strong acids and bases, metal complexes, surface-active materials or substances which react with the eluent. The HPLC method is less sensitive to the presence of impurities in the test compound than is the shake-flask method. Nevertheless, in some cases impurities can make the interpretation of the results difficult because peak assignment becomes uncertain. For mixtures which give an unresolved band, upper and lower limits of log K_{ow} should be stated.

Before deciding on what procedure to use, a preliminary estimate of the log K_{ow} should be obtained from calculation (see the annex to OECD guideline 117), or where appropriate from the ratio of the solubilities of the test substance in the pure solvents. Still, the HPLC method should be regarded as an estimation method of the log K_{ow}, because it does not directly measure the distribution of a compound between octanol and water.

Another method that determines the distribution of a compound between *n*-octanol and water directly, but whose reach extends beyond the range of the shake-flask method, is the slow-stirring method (draft OECD guideline 123; OECD, 2003). With this method, log K_{ow} values up to 8.2 can be accurately determined, making it suitable for highly hydrophobic compounds. This method prevents the formation of micro droplets of *n*-octanol in the aqueous phase, which results in an overestimation of the water concentration and, consequently, an underestimation of the log K_{ow} value. For the same reason, the shake-flask method can only be used up to log K_{ow} values of around 4 and definitely not higher than 5.

Another method that is not mentioned in OECD guidelines is the generator-column technique. Although this technique is most frequently used for the determination of the water solubility, it is occasionally used for the determination of log K_{ow}. Because the supporting material silica, saturated with *n*-octanol containing the compound, is held in a column, the formation of micro droplets is excluded. For this reason, the results from this technique can be considered equivalent to results obtained with the slow-stirring method. In general, good correlation exists between the slow-stirring method and the generator-column technique, within the experimental error of both methods. However, only a limited number of studies is available that makes use of this technique, primarily for chlorinated biphenyls and dibenzodioxins (e.g. Tewari *et al.*, 1982; Miller *et al.*, 1984; Doucette and Andren, 1987; Doucette and Andren, 1988; Hawker and Connell, 1988; Shiu *et al.*, 1988; Li and Doucette, 1993; Yeh and Hong, 2002).

Except from experimental determination, log K_{ow} values can also be calculated with a QSAR programme. The log K_{ow} values calculated with ClogP (BioByte, 2004) and EPI Suite (US EPA, 2007b) are always presented for comparison. Both programmes are based on a fragment contribution method. Besides this, SPARC (Karickhoff *et al.*, 2007) is a third estimation programme for the log K_{ow} that is frequently used. This programme is not based on a fragment contribution but has a mechanistic thermodynamic basis.

5. Evaluation of K_{oc} values for use in EQS derivation

The organic carbon normalised partition coefficient (K_{oc}) is calculated or directly retrieved from literature for all valid adsorption studies collected. The sediment type that underlies these partition coefficients is reported in the table. The organic carbon content is also reported. The method to determine the K_{oc} most accurately is the OECD guideline 106 (OECD, 2000). All K_{oc} values that are determined with a method similar to this guideline can be regarded as reliable. However, the TGD also allows K_{oc} values to be derived from field studies or simulation studies. Therefore, whether or not a sorption study is reliable remains subject to expert judgement.

The K_{oc} may also be calculated. Estimation of K_{oc} from K_{ow} is the preferred route, following the QSAR method described in the TGD (cited in the next section). A short description of the use of the method is given after the citation.

Citation from TGD, part III (European Commission (Joint Research Centre), 2003b):

> 'The models are based on linear regression analysis and log K_{ow} as descriptor variable. It should be noted that all models are developed assuming an equilibrium state. For certain classes of chemicals, e.g. anilines and carbamates, this assumption is not correct, because the sorption to soil is irreversible due to the formation of bonded residues. Improvements of the more specific models is certainly feasible if parameters for more specific interactions are taking into account.
>
> '*Domain*

An extensive description of the domain is given in Table [32]. The description is made in terms of chemical structures as well as in terms of log K_{ow} ranges.

> '*Accuracy*

The standard errors of the estimates (± 2σ range = 95%)[33] range from 0.35 to 1.0 log units for the different models. The standard errors are indicated in Table 3[5] for each model. A cross-validation has not been performed yet. External validation is not possible, because all available data have been used to generate the models (Sabljić *et al.*, 1995 cited in: European Commission (Joint Research Centre), 2003a).'

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[32] The number of the table refers to that given in this annex and not the table number in the TGD.

[33] For clarification, the standard error is equal to σ.

Table 10. Domain of the sorption models (Sabljić et al., 1995 cited in: European Commission (Joint Research Centre), 2003a).

Model	X-variable domain log K_{ow} in log units	Chemical domain	Substituents or Warnings
Hydrophobics	1–7.5	All chemicals with C, H, F, Cl, Br, and I atoms	
Nonhydrophobics	(–2.0)–8.0	All chemicals that are not classified as hydrophobics	Overestimated *n*-Alkyl Alcohols (0.9 log units) Organic Acids (0.55 log units) Underestimated Amino-PAHs (1–2 log units) Aliphatic Amines (1–2 log units) Alkyl Ureas (1.0–1.5 log units)
Phenols	1.0–5.0	Phenols	Cl, Br, CH_3, OH, NO_2, CH_3O
		Anilines	Cl, Br, CH_3, CF_3, CH_3O, NMe
		Benzonitriles	Chlorinated
		Nitrobenzenes	Cl, Br, NH_2
Agricultural	(–1.0)–8.0	Acetanilides	
		Carbamates	
		Esters	
		Phenylureas	
		Phosphates	
		Triazines	
		Uracils	
Alcohols, acids	(–1.0)–5.0	Alcohols	Alkyl, Phenalkyl, OH
		Organic Acids	All
Acetanilides	0.9–5.0	Anilides	CH_3O, Cl, Br, NO_2, CF_3, CH_3
Alcohols	(–1.0)–5.0	Alcohols	Alkyl, Phenalkyl, OH
Amides	(–1.0)–4.0	Acetamides	F, Cl, Br, CH_3O, Alkyl
		Benzamides	NO_2, NMe
Anilines	1.0–5.1	Anilines	Cl, Br, CF_3, CH_3, NMe, N, NMe_2
Carbamates	(–1.0)–5.0	Carbamates	Alkyl, Alkenyl, Cl, Br, NMe, CH_3O

Model	X-variable domain log K_{ow} in log units	Chemical domain	Substituents or Warnings
Dinitroanilines	0.5–5.5	Dinitroanilines	CF_3, Alkyl-SO_2, NH_2SO_2, CH_3, *t*-Bu
Esters	1.0–8.0	Phthalates	Alkyl, Phenyl, Cl
		Benzoates	Alkyl, Phenyl, NO_2, OH, Cl, NH_2
		Phenylacetates	Alkyl, Phenalkyl
		Hexanoates	Alkyl
		Heptanoates	Alkyl
		Octanoates	Alkyl
Nitrobenzenes	1.0–4.5	Nitrobenzenes	Cl, Br, NH_2
Organic Acids	(–0.5)–4.0	Organic Acids	All
Phenols	0.5–5.5	Phenols	Cl, Br, NO_2, CH_3, CH_3O, OH
		Benzonitriles	Cl
Phenylureas	0.5–4.2	Phenylureas	CH_3, CH_3O, F, Cl, Br, Cycloalkyls, CF_3, PhO
Phosphates	0.0–6.5	All Phosphates	
Triazines	1.5–4.0	Triazines	Cl, CH_3O, CH_3S, NH_2, N-Alkyl
Triazoles	(–1.0)–5.0	Triazoles	Alkyl, CH_3O, F, Cl, CF_3, NH_2

Table 11. QSARs for sediment sorption for different chemical classes (Sabljić et al., 1995 cited in European Commission (Joint Research Centre), 2003a).

Chemical class	Equation	Statistics
Predominantly hydrophobics	$\log K_{oc} = 0.81 \log K_{ow} + 0.10$	n=81, r^2=0.89, s.e.=0.45
Nonhydrophobics	$\log K_{oc} = 0.52 \log K_{ow} + 1.02$	n=390, r^2=0.63, s.e.=0.56
Phenols, anilines, benzonitriles, nitrobenzenes	$\log K_{oc} = 0.63 \log K_{ow} + 0.90$	n=54, r^2=0.75, s.e.=0.40
Acetanilides, carbamates, esters, phenylureas, phosphates, triazines, triazoles, uracils	$\log K_{oc} = 0.47 \log K_{ow} + 1.09$	n=216, r^2=0.68, s.e.=0.43
Alcohols, organic acids	$\log K_{oc} = 0.47 \log K_{ow} + 0.50$	n=36, r^2=0.72, s.e.=0.39
Acetanilides	$\log K_{oc} = 0.40 \log K_{ow} + 1.12$	n=21, r^2=0.51, s.e.=0.34
Alcohols	$\log K_{oc} = 0.39 \log K_{ow} + 0.50$	n=13, r^2=0.77, s.e.=0.40
Amides	$\log K_{oc} = 0.33 \log K_{ow} + 1.25$	n=28, r^2=0.46, s.e.=0.49
Anilines	$\log K_{oc} = 0.62 \log K_{ow} + 0.85$	n=20, r^2=0.82, s.e.=0.34
Carbamates	$\log K_{oc} = 0.37 \log K_{ow} + 1.14$	n=43, r^2=0.58, s.e.=0.41
Dinitroanilines	$\log K_{oc} = 0.38 \log K_{ow} + 1.92$	n=20, r^2=0.83, s.e.=0.24
Esters	$\log K_{oc} = 0.49 \log K_{ow} + 1.05$	n=25, r^2=0.76, s.e.=0.46
Nitrobenzenes	$\log K_{oc} = 0.77 \log K_{ow} + 0.55$	n=10, r^2=0.70, s.e.=0.58
Organic acids	$\log K_{oc} = 0.60 \log K_{ow} + 0.32$	n=23, r^2=0.75, s.e.=0.34
Phenols, benzonitriles	$\log K_{oc} = 0.57 \log K_{ow} + 1.08$	n=24, r^2=0.75, s.e.=0.37
Phenylureas	$\log K_{oc} = 0.49 \log K_{ow} + 1.05$	n=52, r^2=0.62, s.e.=0.34
Phosphates	$\log K_{oc} = 0.49 \log K_{ow} + 1.17$	n=41, r^2=0.73, s.e.=0.45
Triazines	$\log K_{oc} = 0.30 \log K_{ow} + 1.50$	n=16, r^2=0.32, s.e.=0.38
Triazoles	$\log K_{oc} = 0.47 \log K_{ow} + 1.41$	n=15, r^2=0.66, s.e.=0.48

n is the number of data, r^2 is the correlation coefficient and s.e. the standard error of estimate.

(End of citation)

The QSARs in Table 3 are from a report cited in the TGD, but they can also be found in the public literature (Sabljić *et al*., 1995). In principle, the appropriate QSAR should be chosen on basis of this table. For many compounds with polar groups attached, a separate QSAR is available for that particular chemical class. In general, these QSARs do not deviate very much from the QSARs for larger subsets of chemical classes. However, if there is doubt about which QSAR to use, for example, due to the presence of more than one functional group, it is often most convenient to use the more general QSARs, in particular the QSAR for non-hydrophobic chemicals. This QSAR, together with the QSAR for predominantly hydrophobic compounds provides a reasonable estimate of the K_{oc} for most compounds.

The K_{oc} can also be estimated with an HPLC method (OECD guideline 121; OECD, 2001). As the title of the method indicates, this is no direct determination of the K_{oc} but an estimate based on another property (retention in HPLC). Also the estimation routine PCKOCwin, which employs a calculation method based on molecular connectivity indices (MCI), may be used to estimate the K_{oc}. PCKOCwin is embedded in the EPI Suite software (US EPA, 2007b). Both methods can aid in the decision by means of an independent estimation, in the case that the interpretation of the estimation method based on log K_{ow} according to the TGD is difficult. Both the estimated value from molecular connectivity and values estimated with the HPLC method, if any available, should be reported.

6. Evaluation of K_p values for metals for use in EQS derivation

Adsorption of metals to the solid fraction of sediment or particulate (suspended) matter is dependent on many variables such as cation exchange capacity, organic matter content and clay content, pH, redox potential, etc. In contrast to organic compounds, there is no estimation method to predict metal–solids partitioning in environmental compartments from compound properties. Thus, partition coefficients for metals have to be determined in and retrieved from experimental studies.

The K_p values are collected from all valid studies reporting metal partition coefficients.

Relevant studies are those that report K_p values for sediment or suspended matter (or K_d values) determined in *field* samples. Batch adsorption studies, performed in the laboratory, are a second type of potentially relevant studies. An established data source of metal K_p values for bulk compartments (sediment, suspended matter) does – to our knowledge– not exist. A few references that are of interest are Sauvé *et al*. (2000) and Bockting *et al*. (1992), although values of the latter have been criticised (Koops *et al.*, 1998). Due to the heterogeneity of adsorbents encountered in various compartments, K_p values for metals usually show a high variation. Since normalisation is generally impracticable, selection of the K_p value(s) to be used in equilibrium partitioning (EqP) needs careful consideration.

APPENDIX 2: PROFORMA FOR EQS DATASHEET

NAME OF THE SUBSTANCE

1 CHEMICAL IDENTITY

Common name	
Chemical name (IUPAC)	
Synonym(s)	
Chemical class (when available/relevant)	
CAS number	
EU number	
Molecular formula	
Molecular structure	
Molecular weight (g.mol^{-1})	

2 EXISTING EVALUATIONS AND REGULATORY INFORMATION

Annex III EQS Dir. (2008/105/EC)	Not Included / Included
Existing Substances Reg. (793/93/EC)	Not applicable / Liste No
Pesticides(91/414/EEC)	Not included in Annex I / Included in Annex I
Biocides (98/8/EC)	Not included in Annex I / Included in Annex I
PBT substances	Conclusions / Not investigated
Substances of Very High Concern (1907/2006/EC)	Yes / No
POPs (Stockholm convention)	Yes / No
Other relevant chemical regulation (veterinary products, medicament, ...)	Information / No
Endocrine disrupter	Available information / Not investigated

3 PROPOSED QUALITY STANDARDS (QS)

3.1 Environmental Quality Standard (EQS)

QS for -- is the “critical QS” for derivation of an Environmental Quality Standard

Add any comment on possible residual uncertainty.

	Value	Comments
Proposed AA-EQS for [matrix] [unit] Corresponding AA-EQS in [water] [µg.L^{-1}]		**Critical QS is QS--.** **See section 0**
Proposed MAC-EQS for [freshwater] [µg.L^{-1}] **Proposed MAC-EQS for [marine waters] [µg.L^{-1}]**		**See section 0**

3.2 Specific Quality Standard (QS)

Protection objective*	**Unit**	**Value**	**Comments**
Pelagic community (freshwater)	[µg.l^{-1}]		See section 0
Pelagic community (marine waters)	[µg.l^{-1}]		
Benthic community (freshwater)	[µg.kg^{-1} $_{dw}$]		e.g. EqP, see section 0
	[µg.l^{-1}]		
Benthic community (marine)	[µg.kg^{-1} $_{dw}$]		
	[µg.l^{-1}]	-	
Predators (secondary poisoning)	[µg.kg^{-1}$_{biota\ ww}$]		See section 0
	[µg.l^{-1}]	(freshwaters) (marine waters)	
Human health via consumption of fishery products	[µg.kg^{-1}$_{biota\ ww}$]		See section 0
	[µg.l^{-1}]	(freshwaters) (marine waters)	
Human health via consumption of water	[µg.l^{-1}]		

4 MAJOR USES AND ENVIRONMENTAL EMISSIONS

4.1 Summary of Uses and Quantities

4.2 Summary of Estimated Environmental Emissions

5 ENVIRONMENTAL BEHAVIOUR

5.1 Environmental distribution

		Master reference
Water solubility (mg.l^{-1})	at 20°C	
Volatilisation		
Vapour pressure (Pa)	at 20°C	
Henry's Law constant (Pa.m^3.mol^{-1})		
Adsorption	**The range - is used for derivation of quality standards.**	
Organic carbon – water partition coefficient (K_{OC})	K_{OC} = -	
Suspended matter – water partition coefficient($K_{susp-water}$)	-	
Bioaccumulation	**The BCF value - on fish is used for derivation of quality standards.**	
Octanol-water partition coefficient (Log Kow)		
BCF (measured)		

5.2 Abiotic and Biotic degradations

		Master reference
Hydrolysis	DT_{50}= d at °C (distilled water) DT_{50}= d at °C (salt water)	
Photolysis	DT_{50}=	
Biodegradation	$DT_{50\ (type\ of\ water)}$= d	

6 AQUATIC ENVIRONMENTAL CONCENTRATIONS

Estimated concentrations

Compartment	Predicted environmental concentration (PEC)	Master reference
Freshwater		
Marine waters (coastal and/or transitional)		
Sediment		
Biota (freshwater)		
Biota (marine)		
Biota (marine predators)		

Measured concentrations

Compartment	Measured environmental concentration (MEC)	Master reference
Freshwater		
Marine waters (coastal and/or transitional)		
WWTP effluent		
Sediment		
Biota		
Biota (marine predators)		

EFFECTS AND QUALITY STANDARDS

Acute and chronic aquatic ecotoxicity

ACUTE EFFECTS			Master reference
Algae & aquatic plants ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d or h EC_{50} :	
	Marine	*Gender species* / d or h EC_{50} :	
Invertebrates ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d or h EC_{50} :	
	Marine	*Gender species* / d or h EC_{50} :	
	Sediment	*Gender species* / d or h EC_{50} :	
Fish ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d or h EC_{50} :	
	Marine	*Gender species* / d or h EC_{50} :	
	Sediment	*Gender species* / d or h EC_{50} :	
Other taxonomic groups		*Gender species* / d or h EC_{50} :	

CHRONIC EFFECTS			**Master reference**
Algae & aquatic plants ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d NOEC :	
	Marine	*Gender species* / d NOEC :	
Invertebrates ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d NOEC :	
	Marine	*Gender species* / d NOEC :	
	Sediment	*Gender species* / d NOEC :	
Fish ($mg.l^{-1}$)	**Freshwater**	*Gender species* / d NOEC :	
	Marine	*Gender species* / d NOEC :	
	Sediment	*Gender species* / d NOEC :	
Other taxonomic groups		*Gender species* / d NOEC :	

Tentative QS_{water}	**Relevant study for derivation of QS**	**Assessment factor**	**Tentative QS**
$MAC\text{-}QS_{fw, eco}$	*Gender species* / d or h EC_{50} : $mg.l^{-1}$		$\mu g.l^{-1}$
$MAC\text{-}QS_{sw, eco}$			$\mu g.l^{-1}$
$QS_{fw, eco}$	*Gender species* / 21d NOEC : $mg.l^{-1}$		$\mu g.l^{-1}$
$QS_{sw, eco}$			$\mu g.l^{-1}$
$QS_{sediment, fw, EqP}$	-	EqP	- $\mu g.kg^{-1}_{ww}$ - $\mu g.kg^{-1}_{dw}$

$QS_{sediment,\ sw\ EqP}$	-	EqP	- $\mu g.kg^{-1}{}_{ww}$ - $\mu g.kg^{-1}{}_{dw}$

Secondary poisoning

Secondary poisoning of top predators		**Master reference**
Mammalian oral toxicity	Species / Oral / duration / Endpoint NOAEL : $mg.kg^{-1}{}_{bw}.d^{-1}$ NOEC : $mg.kg^{-1}{}_{biota\ ww}$ (CF=)	
	Species / Oral / duration / Endpoint NOAEL : $mg.kg^{-1}{}_{bw}.d^{-1}$ NOEC : $mg.kg^{-1}{}_{biota\ ww}$ (CF=)	
Avian oral toxicity	Species / Oral / 14 d EC 50 : $mg.kg^{-1}{}_{bw}.d^{-1}$ NOEC : $mg.kg^{-1}{}_{biota\ ww}$	

Tentative QS_{biota}	**Relevant study for derivation of QS**	**Assessment factor**	**Tentative QS**
Biota	NOEC : $mg.kg^{-1}{}_{biota\ ww}$		-- $\mu g.kg^{-1}{}_{biota\ ww}$ corresponding to -- $\mu g.L^{-1}$ (freshwater) -- $\mu g.L^{-1}$ (marine waters)

Human Health

Human health via consumption of fishery products		**Master reference**
Mammalian oral toxicity	Species / Oral / duration / Endpoint NOAEL : $mg.kg^{-1}{}_{bw}.d^{-1}$ NOEC : $mg.kg^{-1}{}_{biota\ ww}$ (CF=)	
CMR		

Tentative $QS_{biota, hh}$	**Relevant study for derivation of $QS_{biota, hh food}$**	**Assessment Factor**	**Tentative $QS_{biota, hh food}$**
Human health	-- $mg.kg^{-1}_{biota\ ww}$		-- $\mu g.kg^{-1}_{biota\ ww}$ (-- $\mu g.L^{-1}$)

Human health via consumption of drinking water		**Master reference**
Existing drinking water standard(s)	$\mu g.L^{-1}$ (preferred regulatory standard)	Directive 98/83/EC
Any guideline		

8. IDENTIFICATION OF ISSUES RELATING TO UNCERTAINTY IN RELATION TO THE QSs DERIVED

9. IDENTIFICATION OF ANY POTENTIAL IMPLEMENTATION ISSUES IN RELATION TO THE QSs DERIVED

10. BIBLIOGRAPHY, SOURCES AND SUPPORTIVE INFORMATION

APPENDIX 3: BIOCONCENTRATION, BIOMAGNIFICATION AND BIOACCUMULATION

Accumulation is a general term for the net result of absorption (uptake), distribution, metabolism and excretion (ADME) of a substance in an organism. Information on accumulation in aquatic organisms is vital for understanding the fate and effects of a substance in aquatic ecosystems. In addition, it is an important factor when considering whether long-term ecotoxicity testing might be necessary. This is because chemical accumulation may result in internal concentrations of a substance in an organism that cause toxic effects over long-term exposures even when external concentrations are very small. Highly bioaccumulative chemicals may also transfer through the food web, which in some cases may lead to biomagnification.

The change in concentration of a chemical in biota (C_b) over time can be described as:

$$\frac{dC_b}{dt} = k_{upt} \cdot C_w + k_{food} \cdot C_{food} - k_{dep} \cdot C_b - k_{exc} \cdot C_b - k_{met} \cdot C_b$$

where C_w and C_{food} represent the concentrations of the chemical in the water column and in the food; and the subscripts *upt*, *dep*, *exc* and *met* refer to uptake, depuration, excretion and metabolism, respectively (Gobas *et al*., 1988).

Bioconcentration refers to the accumulation of a substance, dissolved in water, by an aquatic organism. The bioconcentration factor (BCF) of a compound is defined as the ratio of the concentration of the chemical in the organism and in water at equilibrium.

$$BCF = \frac{C_b}{C_w}$$

The uptake of a chemical from water is a passive diffusion process across the skin or gill membrane, similar to oxygen uptake. Several factors affect this uptake, such as the physicochemical characteristics of the compound, the characteristics of the receptor and the environmental conditions. For example, Boese (1984) demonstrated that decreasing oxygen level in the water accelerated the accumulation of contaminants in the body of clams.

Bioconcentration is normally related to the octanol-water partition coefficient of the compound and the lipid fraction in tissues of the organism (Van der Oost *et al*., 2003). Several log-linear correlations exist between the logarithm of the octanol-water partition coefficient and the BCF (e.g.: Devillers *et al*., 1996; Hawker and Connel, 1985, 1986).

The existence of equilibrium between the concentration of the chemical in the organism and the concentration in the water is not easy to assess. For example, for rainbow trout Vigano *et al*. (1994) measured a time range between 15 and 256 days to reach equilibrium after exposure to different concentrations of PCBs.

Biomagnification refers to the accumulation of substances via the food chain. It may be defined as an increase in the (fat-adjusted) internal concentration of a substance in organisms at successive trophic levels in a food chain. The biomagnification factor is defined as the ratio between the uptake of a contaminant from food and its removal by depuration (*dep*), excretion (*excr*) and metabolism (*meta*)(Sijm *et al*., 1992),

$$BMF = \frac{k_{food}}{k_{dep} + k_{excr} + k_{meta}}$$

The uptake from food can be also defined as:

$$k_{food} = F_F \cdot eff_F$$

where F_F is the quantity of food ingested per unit mass per unit time and eff_F is the efficiency of uptake of the chemical from food.

The BMF can also be expressed as the ratio of the concentration in the predator and the concentration in the prey:

$BMF = C_o/C_d$

where BMF is the biomagnification factor (dimensionless)

C_o is the steady-state chemical concentration in the organism (mg/kg)

C_d is the steady-state chemical concentration in the diet (mg/kg)

Russell *et al*. (1999) demonstrated that significant biomagnification is not observed for values of log K_{ow} lower than 5.5. Moreover, Fisk *et al*. (1998) observed a high potential to accumulate along aquatic food webs for chemicals with log $K_{ow} \approx 7$.

Laboratory experiments demonstrated that digestibility and absorption of food are critical parameters controlling the BCFs in fish (Gobas *et al*. 1999). Furthermore, Opperhuizen (1991) found that biomagnification accounts for a more important fraction of accumulation of chemicals for larger fish than for smaller fish, which is probably due to a decrease in gill ventilation volume while the relative feeding rate is almost the same.

The term **bioaccumulation** refers to uptake from all environmental sources including water, food and sediment. The bioaccumulation factor (BAF) can be expressed for simplicity as the steady-state (equilibrium) ratio of the substance concentration in an organism to the concentration in the surrounding medium (e.g. water). Normally, it is evaluated using a multiplicative approach. Therefore, the Bioaccumulation Factor (BAF) may be calculated as:

$$BAF = BCF \cdot \prod_{i=1}^{n} BMF_i$$

where the number of biomagnifications factors depends on the trophic level or position of the organism in the food web.

In a recent review, which recommends the use of a high quality field derived BAF, Arnot and Gobas (2006) analysed 392 scientific literature and database sources which included 5317 BCFs and 1656 BAFs values measured for 842 organic chemicals in 219 aquatic species. Their results indicate that 45% of BCF values are subject to at least one major source of uncertainty and that measurement errors generally result in an underestimation of actual BCF values; the situation is similar for BAF, however there are much less published values.

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APPENDIX 4: INVESTIGATION OF FURTHER METHODOLOGIES TO IMPROVE THE PROTECTION OF PREDATORS AGAINST SECONDARY POISONING RISK

A4.1. Introduction

In Section 4 (Derivation of Biota Standars) only the protection of top predators' birds and mammals species is considered against the secondary poisoning risk. However the CSTEE (2004) expressed their concerns on the fact that the exposure of chemicals through the food chain is not only relevant for secondary poisoning in birds and mammals, but also for aquatic invertebrates and fish.

Few data assessing the oral route toxicity are currently available for organisms other than birds and mammals. However some relevant ecotoxicological information can be found in the literature or can be produced, as strongly recommended by the CSTEE, for the very limited number of chemicals selected as priority substances.

In order to improve the development of quality standards for the protection of predatory organisms some further methodologies to assess secondary poisoning are discussed.

On one hand, if relevant chronic toxicity data, expressed in terms of the concentration of the chemical in food to which the test subjects were exposed, is available for sediment and pelagic predators e.g. aquatic invertebrates and fish, then a secondary poisoning assessment based on the diet approach set for birds and mammals top predators can be followed, see Section 4. On the other hand, if toxicological data, related to tissue residues in the considered organisms, are available, taking into account all exposure routes for different sediment and pelagic predators, the so-called Critical Body Burden (CBB) approach can be applied for organics as well as for metals. The advantages and disadvantages of this approach are discussed below.

In addition, for the very few data rich cases, the Species Sensitivity Distribution (SSD) approach can be used for both the diet approach and critical body burden approach, to derive an EQS.

Finally, the fish predator is presented as a case study to investigate the potential to derive an EQS based on the previous approaches.

A4.2. Diet Approach

A diet based approach, similar to the one adopted to protect Birds and Mammals Top Predators and in which the concentrations of contaminants in the food of the organisms to be protected are compared against acceptable concentrations in the organisms food, derived from feeding studies, may offer considerable potential for the development of quality standards for the protection of other predatory organisms. A key advantage of this approach is that currently many of the available and relevant chronic toxicity data are expressed in terms of the concentration of the chemical in food to which the test subjects were exposed.

Where this approach is taken it is important that the matrix which is analysed for the assessment of compliance against the quality standard is representative of the food of the organisms to be protected. The species receiving the greatest exposure will be the species with the highest food ingestion rate relative to its body weight and feeding at the highest trophic level(s).

The information presented in Figure 1 indicates that the food ingestion rates, when expressed as a percentage of the organism’s body weight consumed per day, are highest for small organisms, and are higher for small birds than for small mammals.

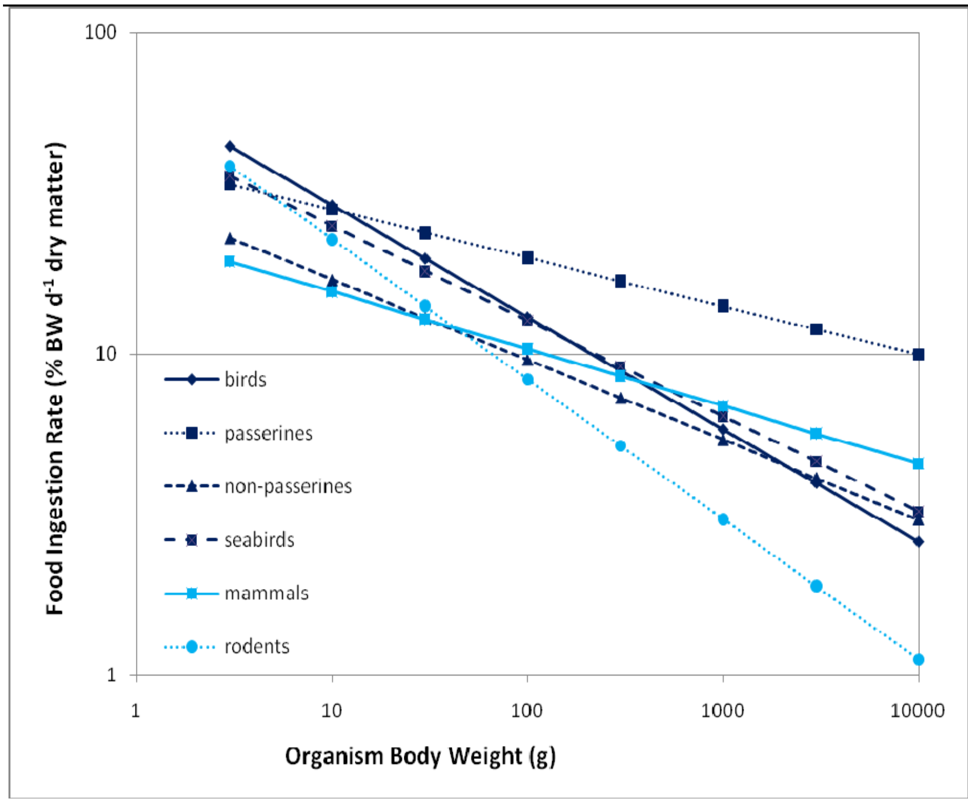

Figure 1 Variation in food ingestion rates, expressed as dry matter and as a percentage of organism body weight per day. Food ingestion relationships from USEPA (1993).

The diet based approach is considered to be a practical option for a relatively large number of substances which may require quality standards deriving for the protection of secondary poisoning.

For the description of the methodology to derive an EQS according to the diet approach please refer to the general and refined approach for birds and mammals top predators in Section 4 of the guidance.

Consideration of mixed diet

If a mixed diet must be considered, the daily food intake rate for food item is not simply achieved by applying the respective fraction as a factor to the respective DFI for a "pure" diet. Instead, the DFI has to be adjusted to reflect the actual contribution of each food item to the daily energy expenditure (DEE) of the indicator species. Starting from a given diet composition in terms of fresh weight, first, the energy content of 1g of the mixed diet (fresh weight) is calculated, taking into account the fractions of individual food items and their respective specific energy contents. Using this figure, DFI_{total}, i.e. the required amount of the mixed diet to reach the DEE of the indicator species can be determined.

$$DFI_{total} = \frac{DEE}{\sum_i PD_i \cdot FE_i \left(1 - \frac{MC_i}{100}\right)\left(\frac{AE_i}{100}\right)}$$

In which:
DFI_{total} = Daily Food Intake rate of total mixed diet (g fresh weight/d)
DEE = daily energy expenditure of the indicator species (kJ/d)
PDi = Fraction (percentage in diet) of food item [i] in mixed diet (related to fresh weight)
FEi = Food energy of food item [i] in mixed diet (kJ/dry g)
MCi = Moisture content of food item [i] in mixed diet (%)

AEi = Assimilation efficiency of food item [i] in mixed diet (%)

The actual DFI_i for one food item [i] in the mixed diet (g fresh weight/d) is then achieved by multiplying DFI_{total} by PDi the fraction for the respective food item.
If the food composition is given in terms of dry weight, the same calculation is applied to achieve DFI_{total}, but the DFIi have to be recalculated to fresh weight to be compliant with the derivation of an $EQS_{biota.TopPredators}$.

Further refinement of the assessment factors

The TGD (2003) highlighted some specific considerations that need to be made in selecting an AF for predators.

- CCME (1998) contains wildlife data on body weight and daily food ingestion rates for 27 bird and 10 mammalian species. In addition, Schudoma *et al*. (1999) derived the mean body weight and daily food intake for the otter. The currently available set on wildlife *bw/DFI* ratios ranges from 1.1 to 9 for birds and from 3.9 to 10 for mammalian species. Comparison of these wildlife conversion factors with the values given in Table 4.4 for laboratory species (8.3 – 40) shows that the wildlife species often have a lower *bw/DFI* ratio than laboratory animals. The difference can be up to a factor 8 for birds and 10 for mammals.
- The interspecies variation, however, should comprise more than just the *bw/DFI* differences between species, e.g. the differences in intrinsic sensitivity. The protective value of the "normal" interspecies variation factor may therefore be questionable in case of predators.
- On top of that, many predator species are characterised by typical metabolic stages in their life-cycle that could make them extra sensitive to contaminants in comparison with laboratory animals (e.g. hibernation or migration). Similar to the *bw/DFI* differences, also this aspect goes beyond the 'normal' interspecies variation.

The Table 4.5 gives AF values corresponding to an AF of 10 for the interspecies variations, (excluding the AF of 3 which take into account differences in ingested dose between the test and wildlife species) and an AF ranging from 3 to 10 for the subchronic to chronic extrapolation.

It should be noticed that in the only study found that examined the use of uncertainty factors for the development of wildlife criteria (U.S. EPA, 1995), a value ranging from 1 to 100 is applied to account for uncertainties when extrapolating toxic effect across species (based on the analysis that 91% of 246 separate interspecies NOAEL ratios for wildlife were less than or equal to a factor of 100) and a value ranging between 1 to 10 is applied to account for the subchronic to chronic extrapolation. In the U.S. EPA (1995) document some guidance is given to select the most appropriate assessment factors on a case-by-case basis. Basically to set the AF for interspecies variation the experts consider the physicochemical, toxicokinetic and toxicodynamic properties of the chemical of concern and the amount and quality of the available data. Selection of the subchronic to chronic assessment factor includes consideration of the amount of time required for the chemical to reach equilibrium in the tissues.

The Canadian Council of Ministers of the Environment adopted the same strategy in their guidelines (CCME, 1998) and proposed an AF ranging from 10 to 100 for the interspecies variations and an AF of 10 for the subchronic to chronic extrapolation.
According to these studies there are still some possibilities to refine the AFs for $EQS_{biota\text{-}TopPredators}$ derivation by increasing the knowledge on the interspecies sensitivity at a site or at EU level and on the toxicokinetic properties of the tested substances.

Finally it should be mentioned that further refinement of the interspecies variation should include more information on the intrinsic and the metabolic stages (e.g. hibernation or migration) sensitivities of the organisms intended to be protected.

Protection of fish predators: Case Study

There are currently a number of standard tests for assessing the potential effects of chemicals on fish, in terms of both their direct toxic effects and their uptake and potential for food-chain transfer.

However, these tests do not usually determine the various effect levels (e.g. NOEC, EC10, etc.) relating to the food exposure so there is currently insufficient information to derive a specific quality standard for pelagic predators. Food ingestion rates for fish assumed within the AQUAWEB model (Arnot and Gobas 2004) range from <0.1, for large fish, up to approximately 15 percent body weight per day, for very small fish (on a wet weight basis). Assuming the food to be 90% moisture the food ingestion rates on a dry weight basis are an order of magnitude lower (i.e. less than 2% body weight per day), the data are shown in Figure 3. These food ingestion rates are much lower than those assumed for birds and mammals, when expressed on a dry weight basis (see Figure 1). This might indicate that quality standards derived for the protection of small piscivorous birds are also likely to provide adequate protection for piscivorous fish when exposed by food ingestion. However differences in species sensitivity and trophic level of the food basket must also be considered.

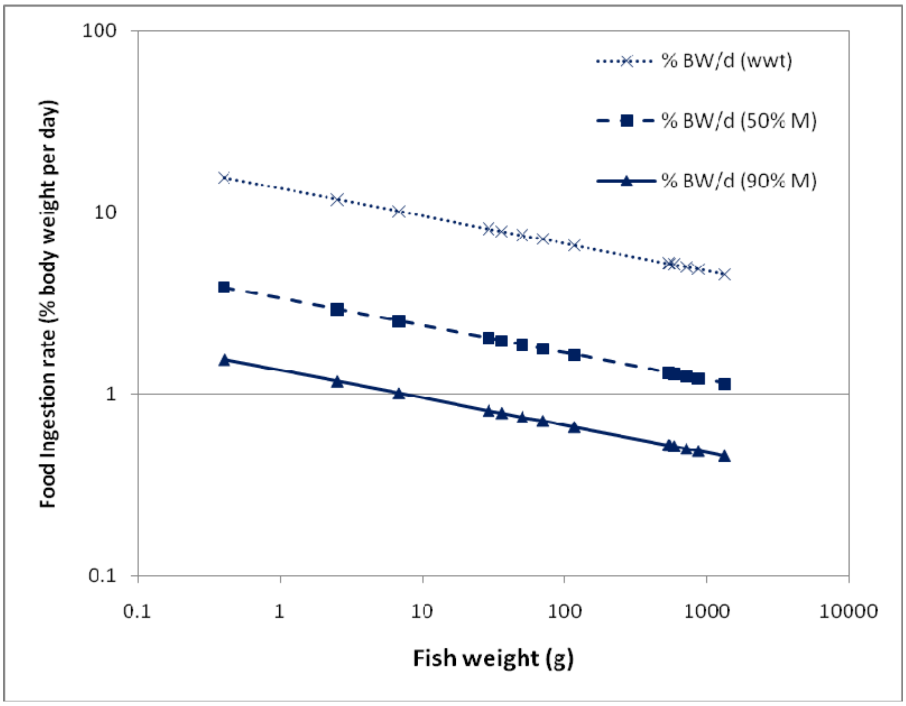

Figure 2 Variation in food ingestion rates for fish, expressed as wet weight (%bw/d (wwt)) and as dry matter assuming 50% (%bw/d (50% M)) and 90% (%bw/d (90% M)) moisture content of the food. All expressed as a percentage of organism body weight per day. (Data from Arnot and Gobas, 2004).

It is not currently considered to be practical to develop separate quality standards for the protection of pelagic predators because of the lack of data. A first approach is to assess if the quality standard for biota is likely to be protective of exposures via the food, and the quality standard for water is likely to be protective of exposures via the water. It may be necessary to review this position should information become available suggesting that where combined exposures occur, from both the water and food, the available quality standards may not be protective and adequate information is available for their derivation and implementation.

A4.3. The critical body burden (CBB) or critical body residues (CBR) approach

The approach of relating ecological toxicity with external concentrations (in this case water values) has some disadvantages for highly hydrophobic substances that do not show toxicity below their solubility values and for substances that tend to bioaccumulate through the food web. For this reason it may be more convenient to change scale of the x-axis when measuring dose and effects and to use concentration in the organisms. In addition measuring concentrations in biota provides indication on the specific bioavailability of a chemical and an integrated estimation of the environmental exposure routes and duration and a strong causality link between acquired dose and biological effect (Meador, 2006). Finally by comparing both metrics in the same experiment it is possible to estimate toxicity and BCF reducing the number of animal tests. Table 4 summarises the main characteristics of this approach when compared with the measurement of water concentrations.

Table 12. Tissue versus water concentration measurements

Tissue concentration	Water concentration
Direct measure of accumulated dose	Indirect measure
Indication of specific bioavailability	Does not consider bioavailable concentration
Integration of exposure routes	Biomagnification not included
Integration of exposure duration	Variable on exposure dynamics (pulse, seasonal, etc.)

The use of Critical Body Burden (CBB) or Critical Body Residue (CBR) - the molal tissue concentration (mmol/kg) of a toxic chemical able to produce a toxic effect, i.e. mortality, reduced growth, reduced reproduction- has been recently promoted by various stakeholders for European risk assessment (see TGD RIP 3.3 and RIP3.2, Chapter R.7B, Appendix 7.8-4), for use in the derivation of environmental quality standards under the Water Framework Directive and in the process of adding substances to the Stockholm Convention on POPs. Under this Convention, CBRs are recommended as a means to compare with environmental concentrations.

This approach was originally proposed after the determination that the tissue concentration of many chemicals with the same mode of toxic action[34] was relatively constant for a defined level of toxicity (McCarty, 1986). McCarty and Mackay (1993) reviewed the CBB approach distinguishing by several model of action, i.e. narcotic, excitatory agents, acetylcholinesterase (AChE) inhibitors, reactives/irritants, central nervous system (CNS) seizure agents, aryl hydrocarbon (Ah) receptor agonists, etc. and between polar and nonpolar compounds. However, even though experimental data supported the application of the CBB approach they cautioned that not all mode of action may support it.

In a recent review, Barron *et al*. (2002) found that experimental data available showed a high variability in tissues residues associated with adverse effects, both within and between chemicals. In addition, dependence on pH, temperature and metabolism showed that the applicability of the CBB approach was not as widely as initially thought. Verhaar *et al*. (1999) showed also that with receptor mediated toxicity the approach did not work. Furthermore, Schuler *et al*. (2004) showed that the CBB approach is not able to deal with substances that form toxic metabolites.

[34] Mode of toxic action is defined as a common set of physiological and behavioural signs that characterize a type of adverse biological response and it can be divided into specific and non-specific. This later is generally referred as the narcosis mode of action (Meador, 2006)

However the inherent advantages of the CBB approach, the great variability range for some substances may exclude the use of one concentration value by model of action and probably a more suitable approach would consists on developing dose-response curves based on tissue concentration like in water and then using the Species Sensitivity Distribution (SSD) approach to arrive at a definition of an EQS. Probably the best approach is to consider case by case. If evidence shows that, for example LR50 (Lethal Residue for 50% mortality), is approximately constant for several species then one value could be used. On the contrary, if the chemical compound shows variable potency between species then the SSD (see below) is the most appropriate method for selecting the tissue residue that will protect the more sensitive species.

Fundamentally, the approach to follow with CBB is the same than using ambient exposure concentrations and both can be combined to produce more results from a single test. In fact, Landrum *et al*. (2004, 2005) provide a methodology for calculating LR50 and MLR50 (mean lethal residues). The main departure from standard toxicity tests (time period ≤96 hours) is that to characterise acute CBR tests should be conducted for a sufficient period of time (7-10 days) to assure that steady-state conditions have been attained. In addition, the same methods to estimate dose-response curves from standard tests (Scholze *et al*., 2001) can also be applied to obtain ER_x (Effective Residues at x proportion) or LR_x (Lethal residue at x proportion). In a similar fashion NOER (No Observed Effect Residue) may be calculated. However, at present stage, we recommend the derivation of a CBB guidance to standardise its application by defining the methodology, the necessary tests as well as the representative species that should be considered. Whereas this already exists for standard toxicity tests an effort is necessary in this case. The coupling with already developed standard toxicity tests is also recommended to reduce animal testing and to obtain already the right conversion values between tissue concentration and water concentration avoiding the high uncertainty of this conversion using the standard approach.

Finally, toxic effects of metabolites should be considered before applying the CBB approach to decide whether to monitor or not the metabolites. In addition, CBB approach does not work for compounds that do not bioaccumulate but cause only a toxic response. These compounds will be eliminated quickly from the organisms and therefore a dose-response curve would not exist or measured concentration will tend to be too low. In this case, probably the food intake would be a more adequate approach. For compounds where exposure and response are separated by long periods of time, i.e. mutagenic chemicals, CBB is not adequate.

Critical Body Residue approach for dietborne metal

As some metals bioaccumulate significantly in metal specific target organs, for example: liver for lead, kidney for cadmium, brain for mercury and eggs for selenium (Beyer *et al*. 1996), it is recommended to identify Critical Organ/Tissue Residues for relevant species instead of the overall CBR proposed for organic compounds. This approach would involve the comparison of measured metal concentrations in the organs of animals with critical established concentrations for the selected organs.

However, in order to apply this approach, relevant indicator species and organs/tissues of these species that are sensitive to the analysed metal would need to be identified and critical concentrations for the organs need to be defined. Afterwards, levels should be monitored. As for the case of organics, it has to be stressed that the interpretation of such data might be hampered by the fact that internal concentrations may result from exposure at different sites. This problem can be overcome by choosing appropriate indicator species foraging and living constantly in a local habitat e.g mussels. The possibility to directly link measured concentrations in organs of indicator organisms to environmental concentrations prevailing in their habitat does increase the relevance of such analyses.

As before, it has to be stressed that due to animal welfare concerns and in order to be in line with the new REACH legislation, the CBB approach should be minimised in vertebrates organisms and should be avoided in top predators.

A4.4. The species sensitivity distribution (SSD) approach

In data rich cases a species sensitivity distribution (SSD) approach using chronic toxicity data for a range of predators might be used in order to estimate an HC5 (Hazardous Concentration for 5% of species). The data requirements for such an approach (i.e. a sufficient number of species will have been tested in long-term tests) are currently unlikely to be fulfilled for many, if not all, substances. This should consider issues such as the applicability of different species, minimum data sets for the use of a species sensitivity distribution in the derivation of a $PNEC_{oral}$ for consumers (variability of species tested, test duration and endpoint, number of data, etc.) and the identification of suitable'representative prey' organisms.

However, an example of how this might be done extracted from Environment Agency Report (2008) is provided below to illustrate its application.

No Observed Effect Concentrations (NOECs) are reported in the draft lead Risk Assessment Report (RAR). Values that are 'greater than' are unbounded NOECs and their use in an SSD is conservative because the true NOEC will be higher.

According to Figure 4 the lognormal model fit meets all normality and goodness-of-fit statistics at the 1% level. The HC5 (50%) is 28.13 mg Pb kg^{-1} wwt and the HC5 (90%) is 10.43 mg Pb kg^{-1} wwt. Only one, unbounded, value of >25 mg Pb kg^{-1} wwt falls marginally below the HC5 (50%), suggesting that the HC5 (50%) is a robust threshold.

If bird and mammal SSDs are constructed separately, the bird HC5 (50%) is 23 mg Pb kg^{-1} wwt and the HC_5 (90%) is 6.72 mg Pb kg^{-1} wwt, and the mammal HC_5 (50%) is 50.7 mg Pb kg^{-1} wwt and the HC5 (90%) is 5.7 mg Pb kg^{-1} wwt. A log-normal model meets all normality and goodness-of-fit statistics at the 1% level for both SSDs. This suggests that, for some substances at least, it may be possible to use an SSD approach in the effects assessment. Whilst it is likely that an assessment factor would be considered for application to the HC5, a lower one might be applied than when using the lowest reported NOEC. Two tests with low NOEC values have been reported for the American Kestrel, which would be considered as a relevant species for wildlife assessment.

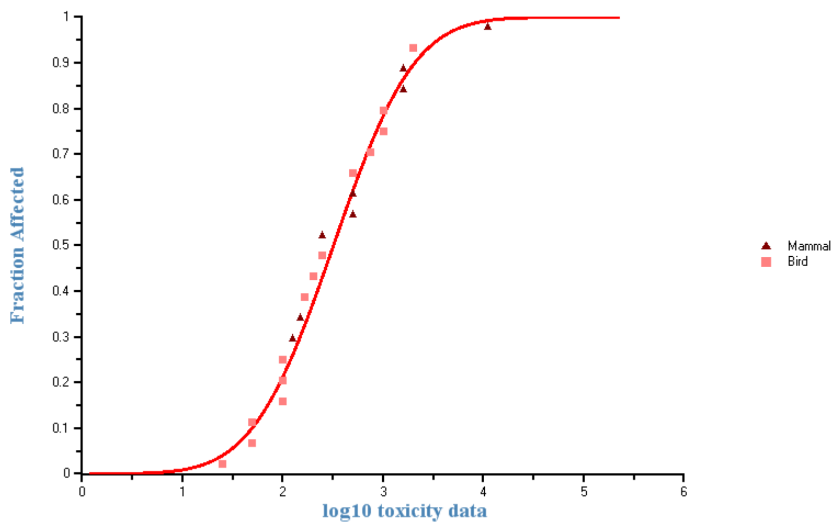

Figure 3. SSD based on mammal and bird oral toxicity data (Peters and Crane, 2008).

Further background information on the use of species sensitivity distributions can be found in the report from the Avian Effects Workshop held in Woudschoten (Hart *et al.* 2001), the publication of

Posthuma et al. (2002) and Section R 10.2.4 of Chapter R 10 of RIP 3.2-2 of the TGD in support of the New EU Chemicals Legislation (REACH).

References to Appendix 4

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APPENDIX 5: GLOSSARY

5P-COV	5th percentile cut-off value; the 5th percentile of a species sensitivity distribution.
AA-EQS	annual average environmental quality standard
ADI	acceptable daily intake
AF	assessment factor
AF_{oral}	assessment factor applied in extrapolation of $EQS_{biota.Predators}$
ARA	added risk approach
AVS	acid volatile sulphide
B	bioaccumulative
BAF	bioaccumulation factor
BCF	bioconcentration factor
BioF	bioavaiability factor
BMF	biomagnification factor
bw	body weight
CONV	conversion factor from NOAEL into NOEC
CSTEE	Scientific Advisory Committee on Toxicity and Ecotoxicity of Chemicals of the European Commission
Cb	background concentration
C_{ARA}	concentration of dissolved metal monitored at a site excluding the background concentration
C_{SPM}	concentration of suspended matter
C_{TRA}	concentration of dissolved metal monitored at a site
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DFI	daily food intake ($kg_{Food\ (FW)}.d^{-1}$)
dw	dry weight
EC	European Commission
EC_x	effect concentration for X% of the individuals in a toxicity test
EFSA	European Food Safety Authority
EQS	environmental quality standard
EU	European Union
f_{oc}	fraction of organic carbon
FWMF	food web magnification factor
GLP	Good Laboratory Practice
H	hardness
HC_5	hazardous concentration for 5% of the species (based on the SSD)
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
HELCOM	Helsinki Commission: Baltic Marine Environment Protection Commission
Hg	mercury
ICES	International Council for the Exploration of the Sea
ICME	International Council on Metals and the Environment
ICPR	International Commission for the Protection of the Rhine
K_{ow}	octanol–water partition coefficient
K_{oc}	organic carbon adsorption coefficient
K_p	partition coefficient
$K_{p,susp}$	partition coefficient to suspended matter
LC_{50}	lethal concentration for 50% of the individuals in a toxicity test
log K_{ow}	logarithm (base 10) of the octanol–water partition coefficient
LOEC	lowest observed effect concentration
LOQ	limit of quantification
M	metal
MAC	maximum acceptable concentration

MPA	maximum permissible addition
MS	metal sulphide
$NOAEL_{oral}$	no observed adverse effect level, direct oral dosing tests
NOEC	no observed effect concentration
$NOEC_{oral}$	no observed effect concentration in a toxicity test, feeding tests
$NOEC_{reference}$	reference no observed effect concentration based on a worst case approach
$NOEC_{site\text{-}specific}$	site-specific no observed effect concentration based on local physicochemical conditions
OCP	organochlorine pesticide
OECD	Organisation for Economic Development
OSPAR	Commission for the Protection of the Marine Environment of the North-East Atlantic
PAH	polyaromatic hydrocarbon
PBDE	polybrominated diphenylether
PBT	persistent, bioaccumulative and toxic
PCB	polychlorinated biphenyl
PEC	predicted environmental concentration
PFOS	perfluorooctane sulfonate
PHS	priority hazardous substance
PNEC	predicted no-effect concentration
$PNEC_{oral}$	predicted no-effect concentration for the ingestion of food
$PNEC_{biota}$	predicted no-effect concentration in biota
$PNEC_{secpois}$	predicted no-effect concentration for secondary poisoning
$PNEC_{hh}$	predicted no-effect concentration for the protection of human health
PPP	plant protection product
PS	priority substance
QCAR	quantitative cationic activity relationships
QICAR	quantitative ion character–activity relationships
QS	temporary quality standards, defined during derivation. An overview of temporary standards can be found in Appendix 6
QSAR	quantitative structure–activity relationship
QSPR	quantitative structure-property relationship
RA	risk assessment
RAR	risk assessment report
REACH	Registration, Evaluation and Authorisation of Chemicals
RfD	reference dose
SEM	simultaneously extracted metals
SETAC	Society for Environmental Toxicology and Chemistry
SOP	standard pperating procedure
SPM	suspended particulate matter
SSD	species sensitivity distribution
TDI	tolerable daily intake
TGD	Technical Guidance Document (EC 2003)
TMF	trophic magnification factor
TL	threshold level
TOC	total organic carbon
TOX_{oral}	$NOEC_{oral,bird}$ or $NOEC_{oral,mammals}$ or LC_{50} (as indicative value and not for EQS derivation) in $kg.kg_{food\ (FW)}^{-1}$
TRA	total risk approach
$uptake_{dw}$	daily uptake of drinking water
UVCB	substances of unknown or variable composition, complex reaction products or biological materials
vB	very bioaccumulative
vPvB	very persistent, very bioaccumulative
WFD	Water Framework Directive
ww	wet weight

APPENDIX 6: OVERVIEW OF TEMPORARY STANDARDS FOR EQS DERIVATION

Freshwater	Saltwater	short description	REMARK
TEMPORARY STANDARDS, DURING DERIVATION (QS)			
$QS_{fw,\ eco}$	$QS_{sw,\ eco}$	direct ecotoxicity	
$QS_{dw,\ hh}$		drinking water	standard for saltwater and freshwater is identical
$QS_{biota,\ secpois,\ fw}$	$QS_{biota,\ secpois,\ sw}$	secondary poisoning expressed in biota	sp standard *in* biota is NOT identical for fresh and salt since BMF2 is applied for saltwater
$QS_{fw,\ secpois}$	$QS_{sw,\ secpois}$	secondary poisoning expressed in water	
$QS_{biota,\ hh\ food}$		human consumption of fishery products, expressed in biota	hh standard *in* biota is identical for fresh and salt
$QS_{water,\ hh\ food}$		human consumption of fishery products, expressed in water	this standard is equal for fresh and marine water (only BMF_1) as the top predator (i.c. human) is identical for fresh and marine (has the same trophic position). Is this clear from the guidance?
$MAC\text{-}QS_{fw,\ eco}$	$MAC\text{-}QS_{sw,\ eco}$	standard for short term exposure protective for the ecosystem	
$QS_{sediment,\ fw,\ eco}$	$QS_{sediment,\ sw,\ eco}$	sediment, based on sediment toxicity data (expressed in dry weight)	
$QS_{sediment,\ fw,\ EqP}$	$QS_{sediment,\ sw,\ EqP}$	sediment, based on EqP, expressed in dry weight sediment	
$QS_{sediment,\ fw,\ field}$	$QS_{sediment,\ sw,\ field}$	sediment standard, adjusted for field or mesocosm data	
SPECIFIC TEMPORARY STANDARDS IN METAL QS DERIVATION			

Freshwater	Saltwater	short description	REMARK
$QS_{generic, fw, eco}$	$QS_{generic, sw, eco}$	uncorrected standard for ecosystem	
$QS_{reference, fw, eco}$	$QS_{reference, sw, eco}$	standard for ecosystem for reference conditions	
$QS_{site-specific, fw, eco}$	$QS_{site-specific, sw, eco}$	site specific standard for ecosystem	
$QS_{added, fw, eco}$	$QS_{added, sw, eco}$	standard for the ecosystem following added risk approach – added part only	
FINAL SELECTED STANDARDS (EQS)			
$AA\text{-}EQS_{fwr}$	$AA\text{-}EQS_{sw}$	selected overall standard for water compartment	
$MAC\text{-}EQS_{fw}$	$MAC\text{-}EQS_{sw}$	selected overall standard protective for short term exposure	
$EQS_{biota, fw}$	$EQS_{biota, sw}$	selected overall standard in biota	secpois standard *in* biota is NOT identical for fresh and salt since BMF2 is applied for saltwater
$EQS_{sediment, fw}$	$EQS_{sediment, sw}$		

APPENDIX 7: LEADERS OF THE ACTIVITY / MEMBERS OF THE EXPERT GROUP

1. LEADERS of the Activity

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Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Guidance Document No. 28

Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances

Environment

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Disclaimer:
This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

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Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances

FOREWORD

In 2000, the European Union Member States, Norway, and the European Commission jointly developed a common strategy for implementing Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive). The main aim of this strategy is to allow coherent and harmonious implementation of the Directive. The focus is on methodological questions relating to a common understanding of the technical and scientific implications of the Water Framework Directive. In particular, one of the objectives of the strategy is the development of practical non-legally binding Guidance Documents on relevant technical issues. These Guidance Documents are targeted at the experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of those experts, and formal, legalistic language is avoided wherever possible.

Under the WFD Common Implementation Strategy, a Drafting Group was established in 2010 to produce guidance on the preparation of the inventory of emissions, discharges and losses, as required by Article 5(6) of the Environmental Quality Standards Directive 2008/105/EC. The Drafting Group worked under the umbrella of the CIS Working Group E on Chemical Aspects and was co-led by Germany, France and the Environment Directorate General. The Working Group E is chaired by the Commission and consists of experts from Member States, EFTA countries, candidate countries and more than 25 European umbrella organisations representing a wide range of interests (industry, agriculture, water, environment, etc.).

The Water Directors endorsed the Guidance during their informal meeting under the Polish Presidency in Warsaw (8-9 December 2011).

The Guidance is a living document that will need to be reviewed and improved as experience is gained in its application.

CONTENTS

I. PURPOSE OF THE GUIDANCE

I.1 Introduction and legal requirements

According to Article 5 of the Directive 2008/105/EC on Environmental Quality Standards in the Field of Water Policy (the EQS Directive), Member States (MS) are obliged to establish an inventory of emissions, discharges and losses of all Priority Substances (PS) and pollutants listed in Part A of Annex I to this Directive.

Pursuant to Article 5(6), technical guidelines for the establishment of inventories are to be adopted in accordance with Water Framework Directive (WFD) regulatory procedure. This guidance document aims to help MS establish the inventories and to reduce the burden by focusing on substances that are relevant at the River Basin District (RBD) level. European wide comparability of the results is another objective.

The inventories should give information on the relevance of PS at the spatial scale of the RBD or the national part of an international RBD, and on the loads discharged to the aquatic environment, thus supporting MS in subsequent river basin management and WFD implementation. For the public, the inventories should give greater transparency with regard to existing problems and on the need for measures to address them. Additionally these inventories will be used by the Commission for compliance checking with the environmental objectives of the WFD (WFD, Article 4) on reduction of discharges, emissions and losses for PS and cessation or phase out of discharges, emissions and losses for Priority Hazardous Substances (PHS). These inventories will be an important input for the Commission report according to Art. 7(1) of the EQS Directive on the possible need to amend existing acts, and the need for additional specific Community-wide measures such as emission controls.

Furthermore, the preamble of the EQS Directive (Recital 20) foresees the need to have an appropriate tool for quantifying losses of substances occurring naturally, or produced through natural processes, in which case complete cessation or phase out from all potential sources is impossible.

These inventories are to be compiled for every RBD or the national part of international RBDs and to provide not only yearly inputs but also to include, as appropriate, concentrations in sediment and biota (e.g. helping to substantiate the relevance of a substance for the RBD).

Article 5 of the EQS Directive requires MS to establish the inventory on the basis of information collected under Articles 5 and 8 of the WFD, under Regulation (EC) No 166/2006 and other available data. Each of these information sources is briefly described in the next section.

I.1.1 Information to be used in compiling the Inventory

Article 5 of Directive 2000/60/EC (the WFD) requires MS to provide, for each RBD, an analysis of its characteristics, a review of the impact of human activity on the status of surface waters and on groundwater, and an economic analysis of water use. Reports prepared under WFD Article 5 need to include, amongst other things:

- assessment of the likelihood that surface waters bodies within the RBD will fail to meet the WFD ecological and chemical status objectives;
- identification of significant point source pollution from urban, industrial, agricultural and other installations and activities; and
- identification of significant diffuse source pollution from urban, industrial, agricultural and other installations.

Article 8 of the WFD requires MS to establish programmes to monitor surface water status, groundwater status and protected areas, with the aim of establishing a coherent and comprehensive overview of water status within each RBD. For surface water monitoring programmes must include not only ecological and chemical status in accordance with the requirements of Annex V of that Directive, but also the volume and level or rate of flow as relevant to ecological and chemical status. Chemical status of surface waters is defined by Environmental Quality Standards (EQS), established to protect both environmental quality and human health. For groundwater such programmes are to cover monitoring of the chemical and quantitative status.

Regulation (EC) No 166/2006 concerns the establishment of a European Pollutant Release and Transfer Register (E-PRTR) at EU level in the form of a publicly accessible electronic database and lays down rules for its functioning, in order to; implement the UNECE Protocol on Pollutant Release and Transfer Registers; facilitate public participation in environmental decision-making and; contribute to the prevention and reduction of pollution of the environment. E-PRTR builds upon but also extends the principles of the European Pollutant Emission Register (EPER), requiring the reporting of pollutant 'releases' to water from industrial and other facilities, provided certain specified thresholds are exceeded.

Other available data encompasses monitoring data collected for other purposes (e.g. research studies, compliance monitoring for waste water discharges by Competent Authorities) describing, for example, substance concentrations in water, sediment and biota, and trend information. It also includes information describing the production and use of a substance and, if and when it has been banned or restrictions on its use have been implemented. Given the connectivity between ground and surface water, those substances exceeding national groundwater thresholds can also be considered to be potentially of relevance.

I.1.2 Timetable

MS will establish the first inventories under the EQS Directive as part of the review of the WFD Article 5 analysis of pressures that is scheduled for December 2013. Both point and diffuse sources should be addressed. Article 5 of the EQS Directive requires the compilation update and reporting of the inventory on a regular basis as part of the river basin management process. Table 1 lists the relevant deadlines for the subsequent River Basin Management Plan (RBMP) cycles.

Table 1: Deadlines for the RBMP cycles

Reporting under Article 13 of the WFD	Preparation of the inventory	Publication of the RBMP	Communication to the Commission
1st cycle of the RBMP	--	22.12.2009	22.03.2010
2nd cycle of the RBMP	22.12.2013	22.12.2015	22.03.2016
3rd cycle of the RBMP	22.12.2019	22.12.2021	22.03.2022
……			

I.2. Practical uses of emissions inventories (who will use them and for what purposes)

This guidance applies to the substances contained in Annex 1, Part A of the EQS Directive. However, it is recommended that MS also use it to establish inventories for their national, regional or local specific pollutants (Annex VIII of the WFD).

In practical terms, an emission inventory should be seen as a tool which may be used to:

- assist in establishing and implementing targeted reduction of emissions, discharges and losses of PS eventually leading to the cessation of emissions, discharges and losses of PHS (e.g. by identifying the main sources, their relative share with respect to pollution and, their pathways);
- demonstrate the efficacy of RBMP Programmes of Measures (PoM);
- assess if or to what extent monitored concentrations are caused by natural sources or processes (e.g. geogenic background) or long-range transport processes;
- support the Commission in checking compliance with the environmental objectives under the WFD.

- assist in checking the effectiveness of measures implemented to achieve the reduction and phasing out of emissions required by the provisions of the WFD.
- identify gaps in knowledge and hence where there is a need to develop new strategies/policies.
- assist with the implementation of the Marine Strategy Framework Directive (MSFD).

An emissions inventory can therefore assist in a range of ways with the implementation of the WFD.

This guidance document is targeted at those experts who are directly or indirectly involved in the establishment, at the national level, of the inventories of emissions, discharges and losses. It will also support decision makers. The structure, presentation and terminology are therefore adapted to the needs of these categories of experts and formal, legalistic language is avoided wherever possible.

I.3. General approach and minimum expectations

An inventory of annual emissions, discharges and losses of PS is required at national RBD scale. It should in principle cover all substances listed in Annex I of the EQS-Directive.

The practical usefulness of an inventory in River Basin Management significantly increases with a more detailed analysis and higher spatial resolution (see section III.2 for a more detailed discussion on the spatial scale).

The scale of pressures caused by certain substances might be very different throughout Europe. Therefore a two-step analysis (Figure 1) is recommended, which allows for a prioritisation of resources to compile the inventory.

1) As a first step, an assessment of current relevance of the substances at the RBD level should be undertaken.

The aim of the first step is to identify those substances which are clearly of minor relevance for the RBD at present and in the foreseeable future and to concentrate the efforts of subsequent inventory development on the remaining substances. Consequently, the criteria for this first selection round must not be too strict.

This assessment of relevance should draw upon the information sources identified in Article 5 of the EQS Directive (see Section 1.1), namely the results of the WFD compliance monitoring as well as information on existing restrictions on production and marketing. Using this information a set of transparent criteria should be applied for this initial assessment. A substance should be included for in-depth inventory compilation if at least one of the following possible criteria (when considering data from the last 3-5 years) is met:

- The substance causes a failure of good chemical status in at least one water body

- The level of concentration for a substance is above half of the EQS in more than one water body
- Monitoring results show an increasing trend of concentration which may cause problems within the next RBMP cycles
- PRTR data show releases which might lead to concentrations matching the criteria above
- Known sources and activities causing inputs in the RBD exist which might lead to concentrations matching the criteria above.

This selection criteria and results should be reported in the inventory. For the substances discarded (i.e. for substances of minor relevance) MS should try to provide a basic estimation of emissions, discharges and losses from available data. This is especially important for PHS.

2) As a second step, for the substances which pass the relevance criteria a more detailed analysis using a tiered approach should be performed. It should aim at providing further estimates of emissions, discharges and losses from point and diffuse sources, as well as loads transported in rivers.

The analytical approach chosen (from those in chapter III.4) should be based on the required output information, the available data and practical experience.

As a minimum requirement for the first inventory, point discharges of PS from industrial facilities and municipal wastewater plants (e.g. as required to be reported under E-PRTR) and, a basic or approximate estimation of diffuse inputs, via, for example, the calculation of riverine loads should be provided. The riverine load approach has the advantage of a) being an approach that a number of MS will have already adopted under regional sea conventions such as OSPAR and HELCOM and; b) providing a means of verifying estimates arising from other methodologies.

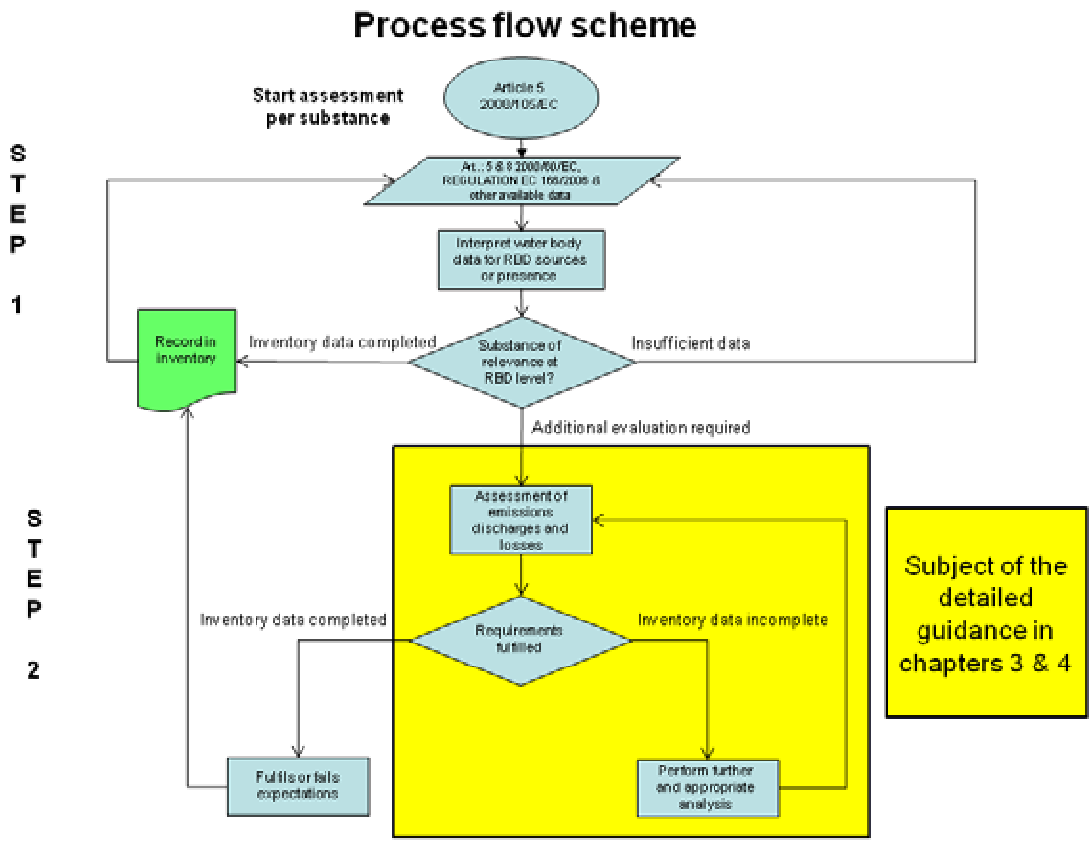

Figure 1: Overview of the 2-step inventory building process

For the first inventory, one year's worth of data is required between 2008 and 2010 (see section III.3 on temporal scale). Since diffuse inputs are strongly and positively correlated with rainfall/river flow (diffuse inputs can increase markedly in wet years) this has to be taken into account.

Where ‘higher tier’ methods are introduced, re-calculation of more basic estimates for earlier reporting dates should be undertaken and reported. In this way, not only will the quality of the original estimate be improved but consistency in methodology over time is maintained.

II. DEFINITION OF TERMS

II.1. Discharges, emissions and losses

The term "discharges, emissions and losses" was used for the first time in the Esbjerg Declaration of the 4th North Sea Conference in 1995[1] with respect to the prevention of pollution by hazardous substances.

The use was in conjunction with the *"generation goal"* which is described as *"the prevention of the pollution of the North Sea by continuously reducing discharges, emissions and losses of hazardous substances thereby moving towards the target of their cessation within one generation (25 years) with the ultimate aim of concentrations in the environment near background values for naturally occurring substances and close to zero concentrations for man-made synthetic substances."*

This somewhat complicated term "discharges, emissions and losses" was chosen in the Esbjerg Declaration to make it clear that all inputs

- coming from land and sea based sources,
- coming from point and diffuse sources,
- reaching the marine environment via direct discharges, riverine inputs or airborne transport,

are addressed and have to be included in the required reduction measures to reach the generation goal.

The requirements of Art. 16 of the WFD regarding PHS also have their origin in the North Sea generation goal and aim to make it operational.

Although some terms (e.g. emissions) have been defined elsewhere in other legislation (e.g. the IPPC Directive[2]) the overall meaning of "discharges, emissions and losses" has not changed. Consequently, in the context of the PS inventory "emissions, discharges and losses" should be used in this broad sense.

Thus, for the purpose of the inventory the term "discharges, emissions and losses" means that the inventory has **to address all inputs of the relevant substances into the environment**, **irrespective of the compartment involved, that are likely to reach surface waters (the main routes of transport into surface waters are described in III.1)**. So, for example, a restriction to point sources only, without a comprehensive justification of why this would be the only relevant input route to the aquatic environment, clearly would not meet the requirement of the EQS Directive.

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[1]http://www.ospar.org/html_documents/ospar/html/4NSC-1995_Esbjerg-declaration.pdf

In this guidance document, "input" is used as a generic term for the movement of a substance into the aquatic environment.

II.2. Sources

In the conceptual framework of this inventory, all processes and activities that are likely to contribute to the input of pollutants into the environment are defined as sources.

The reader should bear in mind that the principal focus of this guidance is the identification and quantification of anthropogenic sources, although some substances may also have a significant naturally occurring source.

For pragmatic reasons it is useful to distinguish between point and diffuse sources.

A **point source** is a single localized point of discharge of wastewater containing one or more pollutant(s). The most important ones are industrial facilities, waste water treatment plants (although strictly speaking the plant itself is not the source), untreated sewage, waste disposal systems and mining sites[3]. Some of these sources are also modelled as diffuse sources due to data restrictions.

The E-PRTR Regulation (EC) No 166/2006 gives the following definition of **diffuse sources**: *"diffuse sources' means the many smaller or scattered sources from which pollutants may be released to land, air or water, whose combined impact on those media may be significant and for which it is impractical to collect reports from each individual source"*. Diffuse sources include agricultural activities, some urban related emissions, atmospheric deposition, and rural dwellings. Typically, they are more variable in space and time than point sources.

Regarding Plant Protection Products (PPPs) in agriculture, the definition of point source and diffuse source is different from that described above due to the specific temporal and spatial context. "Point source" for PPPs includes any spills of concentrated or diluted PPP during transport, storage, filling, spraying, cleaning, management of residual spray and maintenance. In particular it includes use or handling in areas not covered by approved label recommendations for spraying or guidance/codes of practice for correct filling, cleaning or disposal. It also includes uncontrolled release of an excessive amount of PPP during treatment (overdosing). "Diffuse source" for PPPs is related to undesired movement of PPPs in soil, water or air following application on crops and within areas agreed for use

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[2]Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control

[3] The general term mining sites comprises active and abandoned/historic sites. Active modern mining sites operate well-organised waste water treatment and therefore correspond to point sources. In Fig 2 they are considered in the box Industry and in pathway 10. In contrast the discharges from abandoned or historic mining sites may arise from a distinct point, such as waste water treatment, or be scattered and untreated. Emissions from abandoned or historic mining may therefore correspond to pathway 10 or 11.

according to approved label recommendations. These definitions may be relevant to pesticides other than PPPs, e.g. certain biocides, depending upon their mode of use.

Due to the discrepancies in the definitions of diffuse and point sources, whether an input is dealt with as a diffuse or a point source must be documented in the inventory.

II.3. Pathways

Pathways are the means or routes by which specific substances can migrate or are transported from their various sources to the aquatic environment. Following release, substances may be directly emitted to a waterbody or transferred to and stored within environmental media including soil and impermeable surfaces, before entering the aquatic environment. Aerial emission is an important pathway for certain PS and can result in subsequent direct deposition to a waterbody or indirect entry via soil or a sewer system.

II.4. Processes in the river system

In surface waters a wide range of processes occur, e. g. sorption on suspended particles, degradation, biodegradation, biotransformation or bioaccumulation in plants or animals. Retention is a broad term used to describe the outcome whereby loads from sources entering surface water remain there, without for example being discharged to coastal waters. The fractions that are retained have the potential to become mobilised in the future, however, this is not always the case. The extent of retention depends on the physical-chemical properties of the PS as well as on the flow velocity of the river, type and number of particles in the water or the available retention area such as wooded floodplains.

II.5. Riverine load

Riverine loads describe the mass of a contaminant transported per unit of time, typically expressed as kg or tonnes per year. Their calculations have value with respect to establishing a PS emissions inventory for two reasons:

1.) The load for any given contaminant reflects the sum of inputs upstream of the monitoring point at which these are calculated. As such these provide a check or means of validation - the sum of inputs from individual and separate sources should broadly equate to the total riverine load;
2.) Riverine loads can be used to estimate and/or verify the contribution from diffuse sources.

II.6. Emission factor

An emission factor is a coefficient linking the estimated average quantity of emission of a given pollutant during a representative time interval to an easily accessible emission variable, also called characteristic unit (inhabitant, p.e., car, ha of land…) with the following formula:

Estimated emission = number of characteristic units x emission factor

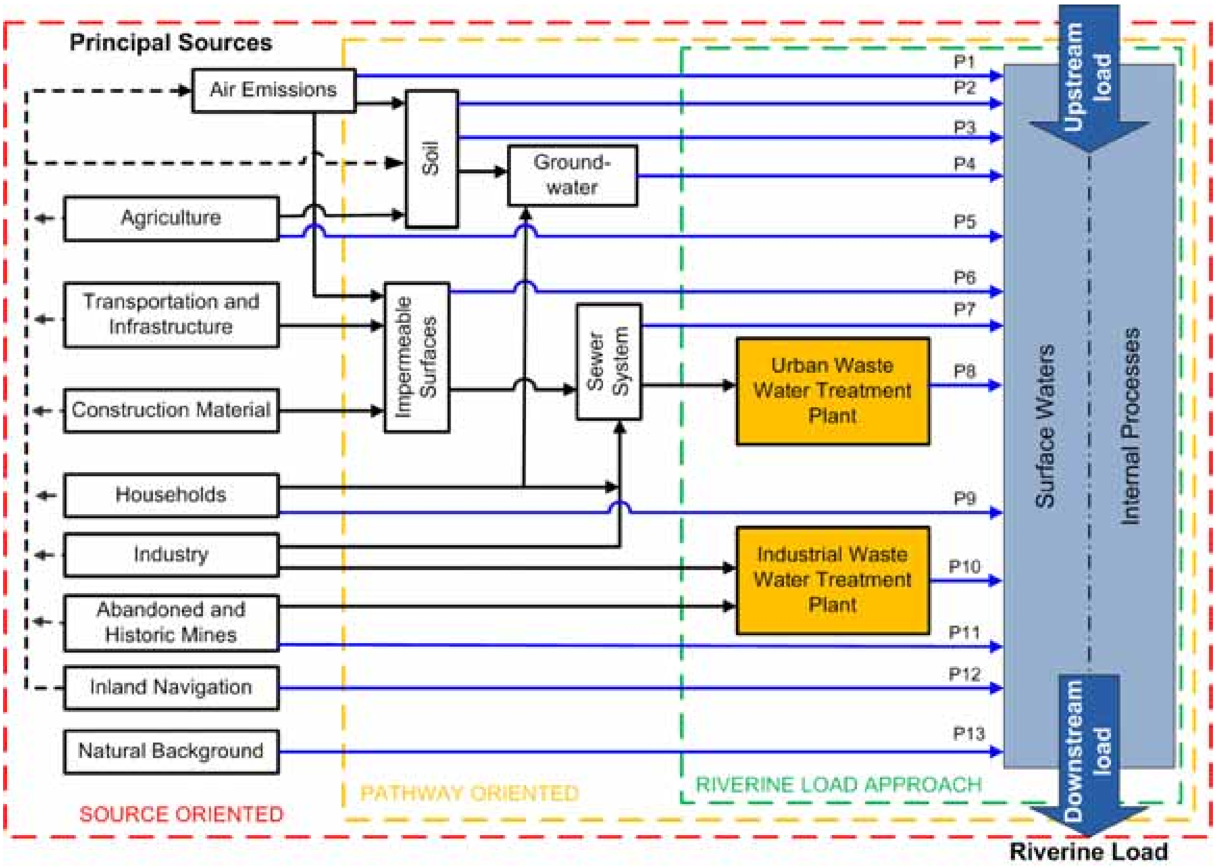
Most emission factors are developed by taking the average measured pollutant quantity, measured at easily accessible points (stack, discharge point…), for a representative sample of the targeted sources, during a representative time interval. The average measured pollutant quantity is related to the extent of the activity for which emission estimation is needed using a quantitative unit, the characteristic unit, for which statistics are easy to obtain from several bibliographical sources (trade associations, national statistics, research institutes databases …).

The application of emission factors will provide information about the average emission of many installations but cannot provide reliable data for a single installation.

III. GENERAL COMPONENTS OF AN INVENTORY

III.1. General working scheme

The principal components of the inventory and their inter-linkages are shown in Figure 2. The main routes of transport into surface waters are shown from left to right.



P1: Atmospheric Deposition directly to Surface Waters

P2: Erosion

P3: Surface Runoff from Unsealed Areas

P4 Interflow, Tile Drainage and Groundwater[4]

P5: Direct Discharges and Drifting

P6: Surface Runoff from Sealed Areas

P7: Storm Water Outlets, Combined Sewer Overflows and Unconnected Sewers

P8: Urban Waste Water Treated

P9: Individual - Treated and Untreated- Household Discharges

P10 Industrial Waste Water treated

P11: Direct Discharges from Mining Areas[5]

P12: Direct Discharges from Navigation[6]

P13 Natural Background

Figure 2: General working scheme of the inventory

[4] This pathway comprises also emissions from contaminated land

[5] A portion of the total emissions from abandoned and historic mining sites is discharged to groundwater. Active mines are covered under "Industry".

[6] Inland navigation also comprises waterway construction materials.

The most important sources for the release of substances into the environment are shown on the left of the figure. Substances may be released to water, air or soil. Direct input routes into surface water are indicated by blue arrows, other transport routes by black arrows.

Substance inputs into waste water should undergo treatment in Urban Waste Water Treatment Plants (UWWTPs) before entering surface waters. Substances emitted indirectly to surface waters may be first temporarily detained in “interface media” like soil or impermeable surfaces, and then subsequently transported to surface waters by other processes (erosion, urban storm water etc.). Some of these intermediate processes may take a very long time (decades and beyond) to reach surface waters. The interface media are shown in the middle part of the figure.

The internal removal, transport or storage processes in the surface water itself (like degradation, sedimentation, re-suspension) are indicated on the right side of the figure. So the quantity to be observed (the load in the river system) is the result of all these indicated processes and their respective time constants.

Due to the complexity of the system and the challenges associated with data collection, different approaches arise with respect to the establishment of inventories. In principle, three broad approaches can be distinguished:

- the riverine load oriented approach, which estimates the observed total load in the river. This information can be used together with a quantification of point source inputs to calculate an estimate of the diffuse inputs.
- the pathway oriented approach, also called Regionalised Pathway Analysis (RPA), models the different transport phenomena for the final input routes to the river system starting from the “interface media”. This approach calculates regionalised emissions for small catchments (termed analytical units) which can be subsequently aggregated to RBDs or sub-units.
- the source oriented approach addresses the whole system starting from the principal sources of substance release. Such an approach includes Substance Flow Analysis (SFA).

The scope of these approaches is indicated by the dashed boxes in diagram. The complexity of the approaches increases from right to left. The different approaches are discussed in more detail in chapter IV; limitations of the different approaches are discussed in III.2.

III.2. Spatial resolution of the inventory

The EQS Directive formally requires a spatial resolution of the inventory at RBD scale or the national part of an international RBD. The current reporting practice for the RBMP requests information on the sub-unit scale to improve pan-European comparability (5000-50000 km²). The inventory is not aimed at waterbody level.

Regarding the usefulness of the inventory for RBMP purposes, e.g. for identifying hot spots (areas with high specific inputs of substances) or estimating the effectiveness of measures, a significantly higher spatial resolution (~100-~1000 km²) is desirable. To support water management at a local scale, an even higher spatial resolution is necessary.

The spatial resolution of substance inputs is determined by the nature and distribution of sources (location of production and consumption sites, including share and type of agricultural land), and the structure and characteristics of transport pathways to surface water (e.g. regional geography and the regional meteorological and hydrological situation).

Point source information can normally cover all spatial requirements, as the inputs are located at the point of discharge, but if emission factors have to be used the spatial resolution is lower, as the specifics of the installation concerned are not covered.

The determination of the spatial distribution of inputs is dependent on the estimation methodology applied. When estimating substance inputs via the monitoring of riverine loads, the area covered by the inventory is by definition the whole catchment upstream of the monitoring station investigated. Neglecting the problems of load monitoring, the observed (measured) loads are the sum of all inputs plus all transport phenomena (remobilization) minus the sum of all retention processes (degradation and intermediate storage processes). Estimated contributions of larger tributaries are only accessible using proxy parameters like area or population share. This is generally only a rough estimate.

When applying the RPA (pathway oriented approach) method the spatial resolution is theoretically limited by the size of the catchments (Analytical Units) used in the emission calculations, which are normally in the range of 100-1500 km². Thus the possible spatial resolution overlaps well with the resolution required for RBMP purposes. However, normally due to limitations in the quality and resolution of required input data, the practical resolution is lower. Often only average values for the whole river basin can be given. As data availability differs significantly for (priority) substances, only a few substances can be covered at present by RPA with a spatial resolution of 100 - 1500 km².

Local models are normally highly adapted to the specific situation of the target areas. The problem then is how the model can allow reasonable generalisation to larger areas (RBDs). This is strongly model dependent.

Substance Flow Analysis (SFA) investigations are limited in their regional scope as the required input data (e.g. production and consumption figures or estimates thereof) are only available from national or EU-wide statistics. In addition, regionalisation of emission factors requires an extensive compilation of analytical results and their corresponding metadata. So, when using SFAs, even regionalisation on RBD level is normally only possible using proxy parameters like population share.

In conclusion, the spatial resolution achievable will be a compromise between the size of the problem, the required information, the availability of data and the resources required. Thus it is likely that the methods used and the spatial resolution achieved will vary between substances.

III.3. Temporal scope of the inventory

The inventories aim to provide information on the yearly inputs of the PS at a certain point in time (reference period). Emissions discharges and losses are not always steady throughout the year and the impact on aquatic environment of peak inputs can be higher than the same quantity emitted at a steady state over time. However this temporal disaggregation is not targeted by the inventory since it is already addressed through the EQS and associated monitoring and compliance checking.

As emission processes, particularly diffuse ones, are strongly dependent on the hydrological situation, interpretation of the results requires a separation and discrimination of the hydrological effects from trends and changes caused by anthropogenic activities. This is especially important when evaluating and interpreting trends which are clearly dominated by hydrological variation. The offered option for PPPs is one possibility to account for these effects.

Article 5(2) of the EQS Directive states that the reference period for the first inventory is one year between 2008 and 2010. For PS covered by Regulation (EC) No 1107/2009[7] on PPPs also the average of the years 2008-2010 may be used. For the updates of the inventories, the reference period is the year before that analysis is to be completed. For PPPs again the average of the three years before completion may be used. The specific 3-year-average option for PPPs is explained in Recital 23 with the *"fact that the losses from the application of pesticides may vary considerably from one year to another because of different application rates, for instance as a result of different climatic conditions."*

Inventories of inputs of PPPs need to consider 3 - 5 years average so as to minimize the yearly variation in emission due to variation of climatic conditions involving variation of pest pressure and so significant difference in yearly use of PPPs. Choice of the years on which to calculate the average needs to consider possible changes in approved uses over the years. It could be, for example, that the approved use of a substance is currently restricted to greenhouse use only, when in previous years the substance was used on cereals. In such cases the average calculation needs to cover years with the same approved usage; separate averages should be provided for different usage periods.

[7] Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC

A similar approach is used in the regionalised path analysis where results are calculated on a yearly basis but published as 3-5 years average values. Another possibility is the calculation of inputs and adjustment of riverine loads using the long-term average hydrological conditions. Alternatively, riverine loads from any given year can be flow normalized.

Look out 	Nominally the **reference period** is the start of the RBMP cycles, providing information at the beginning of each cycle on the effects of the measures taken in the previous cycle. Given the complexity of the emission monitoring and estimation methods, the term "reference period" does not mean that only data generated during the reference period may be used. All data may be used if they are required in order to draw an adequate picture of the emission situation in the reference period. This is particularly important given that the guidance on inventory provisions had not been agreed prior to the conclusion of the period documented in the Directive. The selection of data should be justified by expert judgment and documented in the inventory.

III.4 Tiered Approach

The in depth analysis for the relevant substances can be performed with different approaches.

The approaches described in this guidance document vary in their complexity in order to account for the wide range of information and data sources available across MS. A tiered (or level) approach is presented whereby the complexity increases with each progressive rise in the tier.

Associated with a tier rise is an increase in understanding of sources and pathways, resolution and detail, all of which aids the identification of appropriate measures.

Improvements associated with higher tier approaches include; a greater discrimination of ‘true sources’, for example, the relative contribution of those sources emitting PS to sewers and UWWTPs, rather than the (lower tier) reporting of a lumped treated effluent discharge which does not allow for discrimination of the original source. Similarly, higher tier methods can discriminate original sources within the transport sector such as brake and tyre wear; greater geographical detail (from basin through to waterbody); improved temporal information (from once in a few years to annual or even seasonal); and the use of location-specific emission factors, production data (life-cycle assessment information) and detailed statistical data. Thus the different tiers support a progressively improved understanding of the emission situation and, therefore, the ability to effectively allocate financial resources.

Table 2 summarises the steps / approaches in compiling the inventory, the information required and the increase in output information which may be gained. Step 1 is the check for relevance of a substance. The criteria are described in chapter I.3.

For the relevant substances, the first two approaches of Step 2 (Table 2) must be undertaken in order to meet the requirements of the first round of reporting. It is anticipated that methodologies will generally become more sophisticated with later reporting cycles, however, MS may already choose to adopt a higher tier approach for the first round of reporting. Where methods are improved over time using higher tier approaches (tier 3 and 4), re-calculation of the more basic estimates for earlier reporting dates should be undertaken and reported. In this way, not only will the quality of the original estimate be improved but consistency in methodology over time will be maintained.

Table 2: Scheme of tiered approach for establishing an inventory, indicating complexity and information content

TIER	BUILDING BLOCKS	EXPECTED OUTPUT	RESULTS FOR THE INVENTORY
STEP 1: ASSESSMENT OF RELEVANCE			
	Information sources identified in Art. 5 of EQS directive, see section I.1	Decision of relevance	List of relevant and less relevant substances
STEP 2: APPROACHES FOR RELEVANT SUBSTANCES			
1. Point source information	• Data on point sources • Emissions factors	• Availability of data • Quality of data • Identification of gaps	• Point source emissions • Listing of identified data gaps
2. Riverine load approach	add: • River concentration • Data on discharge • In stream processes	• Riverine load • Trend information • Proportion of diffuse and point sources • Identification of gaps	• Rough estimation of total lumped diffuse emissions • Verification data for pathway and source orientated approaches • Listing of identified data gaps
3. Pathway orientated approach	add: • Land use data • Data on hydrology • Statistical data • …….. • ……..	• Quantification and proportion of pathways • Identification of hotspots • Information on adequacy of POM	• Pathway specific emissions • Additional spatial information on emissions
4. Source orientated approach	add: • Production and use data e.g. from REACH • SFA • Substance specific emission factors • …….. • ……..	• Quantification of primary sources • Complete overview about substance cycle • Information on adequacy of POM	• Source specific emissions • Total emissions to environment and proportion to surface waters

The method of deriving information for the inventory will vary depending upon a range of factors including data availability and available resources. In any given RBD different methodologies will be selected for different substances through a process of identification of relevant and less relevant substances and a subsequent focus on the most important problem substances.

Four levels or “tiers” of emission estimation methods can be distinguished:

Tier 1: Point Source Information:

This tier focuses on point source information. It uses readily available statistical data including point source information reported under E-PRTR. Based on this information, the presence or absence of known point sources can be concluded. The conclusion of absence should be backed up through the analysis of production and use information. If this confirms that the point emission of a substance is negligible, then final confirmation should be provided from the results of emission monitoring, which should be undertaken using appropriate methods. For all relevant hazardous substances this tier is mandatory, as it forms the basis of diffuse sources assessment.

Tier 2: Riverine Load Approach

It is based on concentration (both for the water and the suspended solids phase) and discharge data in rivers considering the basic processes of transport, storage or temporary storage and degradation of substances. The resulting riverine load provides information about the recent status of pollution and if long-term information is available then temporal trends too. In combination with the information gained in tier 1 it allows the allocation of observed loads to point and diffuse sources (a basic source apportionment). If the riverine load is equal to or less than the point source load calculated in tier 1, and the database, especially regarding concentration data, delivers reliable information, then the requirements for an inventory might be met. High pollutant concentrations, an increasing trend, or a high relevance of diffuse sources point to the need for a more detailed analysis using the approaches in tiers 3 and 4.

Tier 3: Pathway Oriented Approach

It uses more specific information about the land use, hydrology and basic transport processes involved. The data requirements are higher than for the lower tiers, but the level of information available for the inventory and management plans is even higher. This tier allows identification of the main sources and regional hotspots of emission and, a holistic overview of emission status, providing specific emissions (e.g. area specific loads, storm water runoff loads). It will, therefore, provide the basis for an accurate inventory. For substances following a ubiquitous emission pattern or for which efficient mitigation measures are not available it might be appropriate to enter the next tier.

Tier 4: The Source Oriented Approach (SOA)

It is based on substance-specific information on production, sales and consumption which to some extent are available through REACH. It allows the drawing of a comprehensive picture of the life cycle of a substance. The benefit of this approach is that the information gained is precise enough to implement not only end-of-pipe solutions but also source controls and precautionary measures.

IV. WORKING METHODOLOGIES

IV.1. General Description of existing methodologies

IV.1.1. Riverine load oriented approaches

Background

Riverine loads describe the mass of a contaminant transported per unit of time, typically expressed as kg or tons per year. Their calculation has value with respect to establishing a PS emissions inventory for two reasons:

- Riverine loads for any given contaminant reflect the sum of inputs to surface water from all sources upstream of the monitoring point at which they are calculated. As such they provide a check or means of verification – the sum of inputs from individual and separate sources should broadly equate to the total riverine load (provided any in-river processing is accounted for).
- Total riverine contaminant loads can be used - provided certain other information is available - to estimate and/or validate the contribution of that contaminant from diffuse sources; diffuse inputs are not readily calculable and typically require the use of estimation tools and models.

Estimation of riverine load

The load of a contaminant transported by a river is estimated by taking the product of the mean flow weighted concentration and the total river flow, expressed by the following formula (OSPAR, 2004a);

$$Ly = \frac{Q_d}{Q_{Meas}} \cdot \left(\frac{1}{n} \sum_{i=1}^{n} C_i \cdot Q_i \cdot U_f \right)$$

Ly = annual load (t/yr)
Qd = arithmetic mean of daily flow (m3/s)
Qmeas = arithmetic mean of all daily flow data with concentration measurement (m3/s)
Ci = concentration (mg/l)
Qi = measurement of daily flow (m3/s)
Uf = correction factor for the different location of flow and water quality monitoring station
n = number of data with measurements within the investigation period

Periods of high river flow typically carry a disproportionately large amount of the annual load of a contaminant. To avoid the underestimation of annual loads it is, therefore, important that water quality sampling strategies are designed to capture periods of high river flow. Sites selected for sampling should be in a region of unidirectional freshwater flow in an area where the water is well mixed and of uniform quality. Both the particulate and soluble load of a contaminant should be quantified. OSPAR, (2004) provides guidelines with respect to concentrations that are less than the limit of detection. These involve the calculation of two load estimations, one assuming that the true concentration is zero and the other assuming that the true concentration is the limit of detection. This approach derives maximum and minimum concentrations within which the true estimate will fall, providing upper and lower bounds for the load estimate. Other approaches are used al well, e.g. using 50% of the limit of quantification. The method used in load calculation has to be transparently documented and reported.

Flow normalisation

Riverine contaminant loads, and in particular certain diffuse source components, vary strongly with rainfall and hence river flow; typically the wetter the year, the higher the loading. Without the application of flow normalisation procedures, natural inter-annual variations in flow can mask or lead to misinterpretation of trends in contaminant loads. Genuine reductions in pollutant inputs attributable to the implementation of measures, for example, can be masked by the occurrence of higher annual river flow during more recent monitoring. Conversely, an apparently declining trend can be incorrectly attributed to the success of measures, but in reality reflects a drier year or years. Flow normalisation addresses this issue and can be undertaken via a variety of methods. Harmonised flow normalisation procedures are given by OSPAR, 2004a.

Estimation of diffuse loads

Riverine loads can be used to calculate diffuse and unknown inputs of PS providing point source information is available. In the most basic approach, the diffuse load can be estimated as the difference between the total load and the load discharged from point sources, as follows:

$$LDiff = Ly - Dp$$

Where, for a given contaminant, LDiff is the anthropogenic diffuse load, Ly is the total annual riverine load, and Dp is the total point source discharge. Such an approach ignores any potential in-river processes such as sedimentation and remobilisation, but provides a useful approximate means of estimating the diffuse load of a given substance.

A more detailed formulation will be necessary where in-stream processes and natural background loads are thought to be significant. The following formula is based on an approach established by OSPAR (2004b) for the calculation of diffuse nutrient loads; in-river nutrient processing is typically significant. The formulation is also applicable to the PS:

$$LDiff = Ly - Dp - LB + NP$$

Where, for a given contaminant, LB is the natural background load of the contaminant, and NP is the net outcome of in-river processes upstream of the monitoring point.

The riverine load approach provides a useful means of estimating diffuse inputs and/or validating modelled predictions. However, diffuse inputs from different sources are lumped into a single value and it is not possible, for example, to distinguish between inputs arising from agriculture and those from urban runoff.

IV.1.2. Pathway oriented approaches including hydrology-driven transfer processes

Pathway oriented approaches are well established and applied in many European RBDs for the quantification of nutrients and heavy metal inputs. Here, understanding the transformation, removal and temporal storage processes taking place between the source of emission and the receiving water body is vital.

As defined in chapter 2, inputs can be caused by point and diffuse sources. Accordingly, point source-pathways are defined by being discrete, having distinct locations and quasi-continuous discharge, e.g. the discharge of municipal waste water treatment plants and industrial plants. Diffuse source inputs influence different pathways and are discharged via different runoff components into surface waters. A differentiation of the runoff components is necessary as substance concentrations as well as the underlying processes may differ significantly for the considered substances.

The current state of knowledge in RPA identifies 13 potential pathways for inputs into surface waters. This is summarized in the general working scheme (cf figure 2). Not all potential pathways are important for all substances under consideration.

To keep track the pathways can be classified into three blocks:

1. pathways depend on point-source
2. pathways depend on diffuse non-urban sources and
3. pathways depend on diffuse urban sources.

The calculation of emissions from point sources can be straightforward, as data on effluent concentration and the amount of treated waste water are available or can be derived from statistical data with the required accuracy.

The inputs caused by diffuse sources are the result of more or less complex interactions with different interfaces, including temporal storage, transformation and losses. These processes have to be integrated into the approaches adequately.

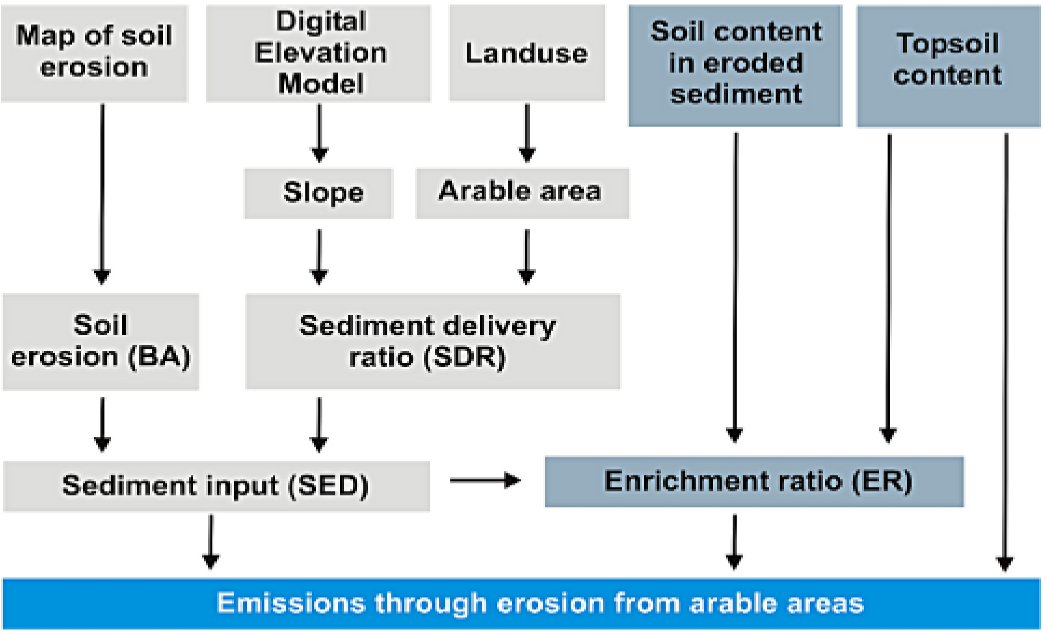


Figure 3: Input data to quantify the emissions from erosion (taken from Fuchs et al., 2010)

Pathways from agricultural diffuse sources include erosion, surface run off, tile drainage, seepage and spray drift. With regard to the transported masses and the complexity of processes involved, erosion is most suitable to illustrate the principles of pathway oriented approaches particularly as PS, including PPPs, can readily attach to soil and eroded sediment (see figure 3).

The initial process of pollutant inputs via erosion is the mobilization of top soil caused by heavy rainfall. At a river basin scale the soil loss from arable land is commonly calculated using an adapted version of the Universal Soil Loss Equation (Wischmeier, W. H., and D. D. Smith, 1960) which considers the slope, rainfall (energy input), soil characteristics, land cover and cultivation as well as active erosion protection measures. In the second step, the proportion of eroded soil entering the surface water is calculated (sediment delivery ratio). Based on a Geographical Information System (GIS)-supported sub model, individual areas within a catchment can be identified where eroded soil reaches a water body, enabling a relationship between sediment delivery and catchment characteristics to be obtained (Behrendt et al., 1999). The slope and the share of arable land have a large influence on the sediment input. During the erosion process, fine particles accumulate in the transported sediment. As pollutants are predominantly bound to finer grains, they also accumulate during the transport process. The enrichment of a substance in the erosion material is described by the enrichment ratio (EnR) which is the ratio between the substance concentration in the top soil and in the sediment reaching the water body. Beyond the initial substance concentration, the grain size distribution of the top soil and the intensity of the classification process are the most important factors influencing the sediment concentration.

Storm sewers and combined overflows are important diffuse pathways in all urbanized parts of a river basin. Up to 40 % of the total heavy metal load or 25 % of the total PAH load emitted into surface waters can be traced back to storm sewer outlet and combined sewer overflows. These pathways account for various sources including air pollution, waste water from industries and households as well as primary emissions from construction material and traffic. For the calculation of annual pollutant loads emitted to surface waters several processes including mixing, transformation and retention, taking place on urban surfaces and within sewer systems, have to be taken into account. The relevance of these processes is highly variable and depends on local boundary conditions. In general a more complex situation can be assumed in combined sewer systems where it has to be considered that a certain portion of storm water is routed to a central waste water treatment plant and that the discharges via combined sewer overflow (CSO) include a variable amount of sewage.

The calculation of pollutant load discharged via storm sewers can be based on a regionalised and area specific surface load (e.g. Cu 204 g/(ha·a)) for any pollutant under consideration. This specific surface load is derived from observed runoff concentrations and precipitation data and it is assumed that it is realised every year independent of the inter-annual variation of precipitation. Regionalisation of specific surface loads can be based on three categories of intensity of urbanisation (rural, urban, urban agglomeration).

For combined sewer systems, the overflow rate and the proportion of discharged wastewater that is mixed up with the stormwater should be estimated. The overflow rate is strictly dependent on the storage volume realised in the catchment and the hydraulic capacity of the waste water treatment plant. For example on average, combined overflows may run for approximately 200 h/a (Brombach et al 1997) and for this time the related sewage load has to be added to the specific surface load.

As illustrated for erosion and urban sewer systems, pathway oriented approaches always require process studies and input data which allow for the formulation of empirical sub models. Due to the fact that these process studies may be limited, the identification of the necessary variables, in a way that enables wide application of such models, may prove challenging. Transfer of a model application from one river basin to another always needs a cross check of the sub-model used.

IV.1.3. Source oriented approaches (SFA, SOCOPSE project)

Substance Flow Analysis (SFA), a source oriented approach, is a method of analysing the flows of a substance in a well-defined system, including through industries producing and using it, households, wastewater treatment plants and all connected media such as soil, air and water.

All the applications and uses of a substance are collated, enabling strategies to reduce the impact of the substance to be developed. Such measures are not necessarily only end-of-pipe as in other approaches but can also encompass source controls such as product substitution. SFA is applied in connection with the early recognition of potentially harmful or beneficial accumulations and depletions in stocks, as well as the prediction of future environmental loads. SFA methods, as we know them today, were first applied by Wolman in the wake of the introducing metabolism studies for cities (Wolman, 1965) .

Basic information on sources was collected during the drafting process of the EQS Directive and made available by the Commission (DG ENV, 2005).

In the SOCOPSE project [www.socopse.se] for example, SFA is used to describe current European sources, fluxes, and endpoints in the environment for selected PSs. This information is used to identify important source categories and to set priorities for emission control measures. Information to construct SFAs can be derived from different sources such as: inventories of goods and their PS concentrations; statistical data on the use of PSs in different economic sectors and; concentration of PSs in raw materials and production data. In cases where data are not available, emission factors, release rates and other statistical information can be used for estimation.

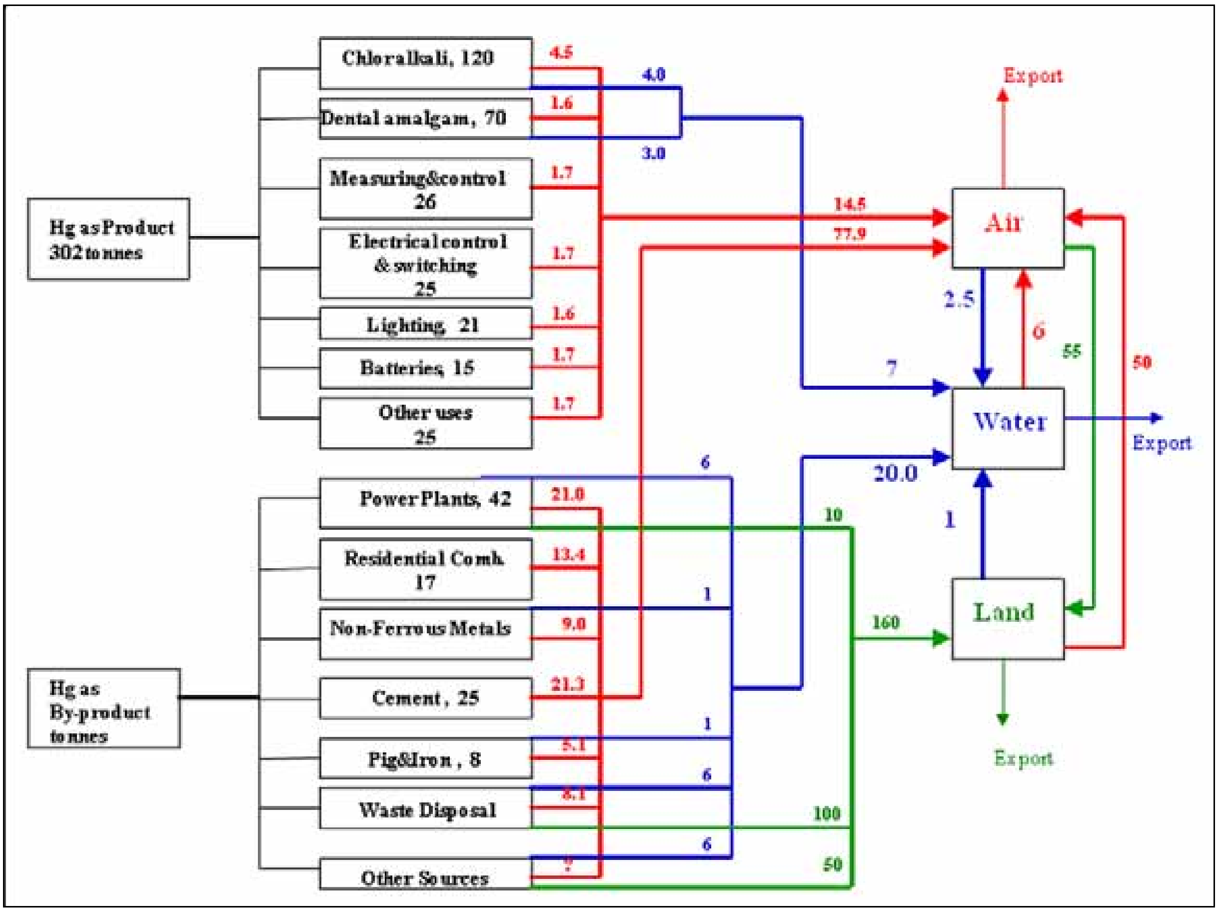


Figure 4: SFA for mercury in Europe in 2000 (numbers in tonnes/year)

Figure 4 shows an example of a SFA for mercury in Europe in 2000 from the SOCOPSE project (NILU, 2009). One advantage of the source-oriented approach is that, if all fluxes are known, it is possible to identify the most efficient emission reduction, because the SFA gives the share of the different emission sources to water, soil and air.

One drawback to SFA is that applicable data are often limited to specific spatial or temporary solutions, which influence the quality of the resulting SFA. Data sets are often only available on a country or EU level. If the perspective is limited to a river basin, proxies often have to be used to illustrate the regional situation. And even though national data may be of high quality because they were compiled accurately, downsizing to the regional level can incorporate errors. Particularly for PSs, use and emission figures can decrease steeply in the space of a few years, so that the corresponding emission factors become worthless. As a result, it is necessary for a SFA to cite information about the time and regional frame for each figure used.

IV.2. Input data needs for the different approaches: building blocks, using existing EU and international data sources

For the generation of an inventory, the EQS Directive requires the use of data obtained by implementing Articles 5 and 8 of Directive 2000/60/EC, Regulation (EC) No 166/2006 and from other available sources. The different data management systems can be operated on regional, national or international level.

Besides the data management systems based on EU-legislation, other data sources can be available from other legal national and international dataflows or based on voluntary data management systems.

Many data are generated for reasons other than fulfilling reporting obligations. For the compilation of an emissions inventory it is of crucial importance that the data are quality checked.

Special attention should be given to the identity of the chemicals concerned as discrepancies can exist between the reporting obligations. Normally for an inventory it is the total emissions of a substance / group of substances that matter, not the species which is used to assess the status, as speciation varies over time.

For example, Annex X of the WFD names brominated diphenylethers as priority substances but sets EQS only for six congeners of pentabromodiphenylether. The E-PRTR however requests emissions data for the sum of penta-, octa- and deca-BDEs. So the E-PRTR data can be used to compile the inventory of brominated diphenylethers, but cannot provide specific information about the congeners.

In the following an overview of possible data sources is provided. In Table 3 the use of data for the different assessment approaches is indicated. This indicative list of data sources should support the generation of the inventory of emissions, discharges and losses. However many data are collected through different data streams and it is of utmost importance to avoid double counting. For that, information coming from different reporting streams should not be simply "joined" but have to go through a critical compilation process to identify data common to the different streams and those that are different.

IV.2.1. Legal data flows

The following legislatively based reporting obligations are the core sources for the data needed for the inventory on emissions, discharges and losses

- Reporting under the WFD (Art. 5 and 8)
- Reporting schemes under the Urban Waste Water Treatment Directive
- Reporting under the European Pollutant Release and Transfer Register (E-PRTR).
- Reporting under the Dangerous Substances Directive

IV.2.2. Voluntary data flows

There are several other dataflow organised by Eurostat/ Organisation for Economic Cooperation and Development (OECD) where the MS are co-operating to gather the information, to develop and apply common definitions and criteria for the quality control of the data, and to verify the data and to provide the information necessary to interpret and report the submitted data.

Further, detailed reporting exercises are organized by the Contracting Parties within the frame of the existing international conventions such as Danube River Protection Convention (DRPC), OSPAR Convention, and the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM) and Stockholm Convention on Persistent Organic Pollutants (POP).

IV.2.3. WISE

The development and the update of the Water Information System for Europe (WISE) have been triggered by the need to streamline and facilitate reporting from the MS to the Commission and to improve its effectiveness. Many reporting obligations are integrated into WISE covering also other water-related Directives, in particular the UWWTD, Bathing Water Directive (BWD), Nitrate Directive (NiD), Drinking Water Directive (DWD) and other mandatory or voluntary reporting to the EU level, in particular submissions to the European Environment Agency (EEA) and EUROSTAT (see Figure 5 below).

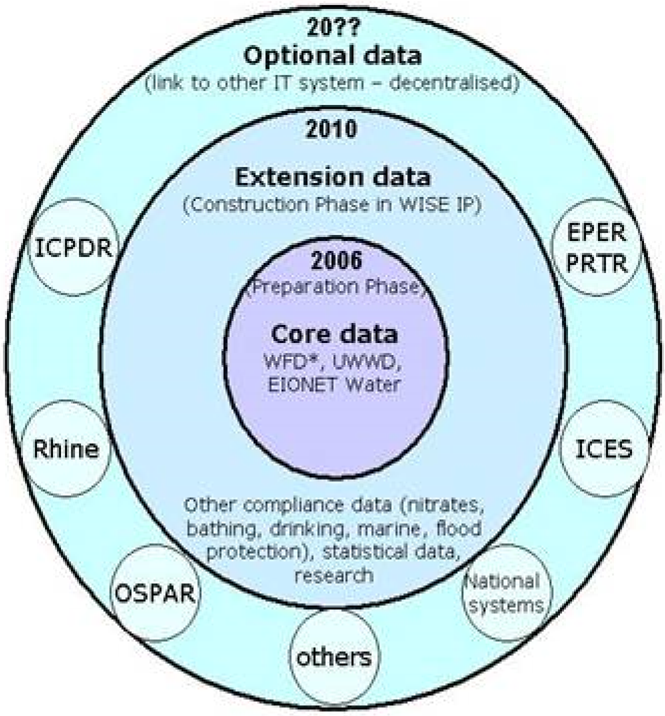


Figure 5: Concept of the Water Information System for Europe (WISE)

The Eurostat/OECD Water Statistics Joint Questionnaire on Inland Water provides national aggregates for load generation and inputs by sector – however data coverage is very poor (in particular for heavy metals and specific organic PS are not included)[8]. It is considered useful for comparison of national estimates for a few pollutants but not a feasible dataflow for the WFD / EQS emission inventory.

State of the Environment (SoE) inputs aim at collecting existing national inventories at RDB aggregation level and are potentially an important dataflow: http://rod.eionet.europa.eu/obligations/632. Data from the 1st year of reporting have been published: http://www.eea.europa.eu/data-and-maps/data/waterbase-emissions, and some compilation documents prepared by the European Topic Centre for Water (ETC/W) are available.

IV.2.4. Additional national/regional dataflows

Additional data sources which may be used for the compilation of the emission inventory are national or regional data management systems (based on legal obligations, for management purposes, for statistical duties, for subsidies or for other reasons), environmental reports or scientific data. These data can have different restrictions in spatial scale, time, coverage, availability or aggregation which have to be considered for their usage for the emission inventory. In the various MS the situation may be different, with more or other data being available from different sources. This chapter contains

[8] http://appsso.eurostat.ec.europa.eu/nui/setupModifyTableLayout.do

many types of data but due to the different approaches and situations in the MS it cannot be completely comprehensive.

Examples of types and sources of data:

- Permit data
- Wastewater and emission monitoring data
- Water quality monitoring data
- Statistical data (inhabitants, connection rates to sewer systems, tourism data, ...)
- Wastewater charges
- Subsidies data on investment and operation of water and wastewater facilities
- Case studies / research data
- Environmental reports
- Other data:
  - hydrological data
  - soil data
  - (hydro-) geological data
  - production data
  - import/export data
  - deposition data
  - agricultural data
  - substance application data

Table 3: Data sources with indication to the different estimation approaches

	Data flow / source	Point Source data	Riverine load approach	Pathway oriented approach	Source orientaded approach
EU-Legislation	2000/60/EC - WFD: Article 5 and 8	x	x	x	
EU-Legislation	Regulation (EC) No. 166/2006 - E-PRTR	x		x	
EU-Legislation	91/271/EEC - Urban Wastewater Treatment Directive	x		x	
EU-Legislation	2006/11/EC - Dangerous Substances Directive	x		x	
EU-Legislation	EC 1907/2006 - REACH				x
International data collections	POP-Convention				x
International data collections	SoE Dataflow	x	x	x	

	Data flow / source	Point Source data	Riverine load approach	Pathway oriented approach	Source orientaded approach
International data collections	OSPAR	x	x	x	
International data collections	HELCOM	x	x	x	
International data collections	International River Commissions (Danube, Rhine, Elbe, …)	x	x	x	
International data collections	OECD/EUROSTAT Joint Questionnaire on Inland Waters	x		x	
National/regional data	Permits	x	x	x	
National/regional data	Waste water and emissions monitoring data	x	x	x	
National/regional data	Water quality monitoring data		x	x	
Statistical data	inhabitants, connection rates to sewer systems, tourism, agricultural data, production data, export/import data,…	x		x	x
Spatial / physical data	Hydrological data, soil data, (hydro-) geological data, land use (e.g. CORINE Land Cover), deposition data (e.g. EMEP), substance application data,…			x	

IV.3. Proposed procedure for the compilation of the inventory

As the compilation of the inventory is a demanding task which blends the information from various sources in a structured way, an iterative approach is necessary, which also reflects longer term objectives. Due to data gaps as well lack of time, resources and funds it might not be possible to obtain the results preferred from the water management perspective in the first run, and it might therefore be an option to include tasks to improve the inventory (moving to a higher tier analysis) in the next RBMP.

Based on the discussions in chapters I. 3 and III. 1- III. 4 the following steps are recommended when planning and compiling the inventory:

1. Identification of the "relevant" substances for the RBD

The criteria developed in chapter I 3 are related either to the monitoring results of the last years or the compilation of known pressures and emissions. So this information has to be collected and compiled. As a result of this selection process a list of substances relevant for the RBD concerned is available. MS may opt for certain substances identified in one RBD also to include them in the inventories for other RBDs in their territory with the aim of compiling a national overview.

2. Identification of the information outputs required from the inventory / preliminary method selection (substance specific)

A European-wide estimate of point and diffuse substance inputs can be achieved with the methodologies proposed for the minimum expectations.

As the different methodologies however provide different levels of detail in the results, it is recommended as a second step to identify the information needs for the next RBMP tasks. So for example, when it is likely that the proportion of diffuse inputs is high in the RBD and targeted measures, especially in hot-spots, to reduce these inputs have to be implemented, additional information on location and share of different pathways is required. In such a case, the information which can be extracted from the riverine load approach is normally not sufficient. The information on the share of different diffuse pathways and a spatial resolution to identify hot spots however can be extracted from RPA compilations. For an overview of the information which can be extracted from the different methodologies refer to Table 2. On the basis of the identified needs a substance-specific preliminary method selection should be performed.

3. Survey of available information needed for the selected tiers

The next step is ta compile the information needed for the selected tiers and to check which part of it is available and can be utilised. Important data sources are described in chapter IV 2.

- Point source data can be taken from the E-PRTR system. However, evaluations of the E-PRTR indicate that it may cover only part of the relevant point source emissions. Especially low-concentration inputs from UWWTPs, together with the high volume of waste water from the urban sector, might lead to additional inputs which have to be accounted for. A combined evaluation of the substance invariant information of the UWWT Directive-reporting (size, location, technology and waste water volume) and the use of emission factors may give reasonable estimates. However the derivation of the emission factors requires high-quality concentration measurements and a careful evaluation of these results. This is an area where close cooperation between MS and scientific institutions may be useful.

- The application of the riverine load approach requires data on discharges and on average concentrations of the substances in whole water if available (in the dissolved phase and in suspended solids). This information should be available in the quality required by the Commission Directive 2009/90/EC for most substances at least at the confluence of the most important tributaries and on “border” monitoring stations. For heavy metals a problem could arise from the fact that, unlike for the organic substances, the samples have to be filtered. This may cause a significant underestimation of the transported loads.
- Pathway oriented approaches (e.g. RPA) require:
    - Substance invariant regionalized data on topology, geology, land use etc which can be taken from various maps or statistical sources. If for a RBD an RPA for nutrients already exists (e.g. a MONERIS Analysis) this is a good starting point as it already covers a great portion of the required substance invariant information.
    - Substance-specific concentrations (if possible also regionalised) at the various transfer points are required. A joint compilation of results available in several MS might help.

Source oriented approaches require data on production, consumption use and emission into different environmental media; which might be available from chemical management institutions as well as infrastructure and other statistical data. Furthermore, information on storage and transfer processes in the environment is required. Here, data collected by the authorities for the management of chemicals, PPPs or biocides, national inventories and also international information, e.g. from different OECD activities, are valuable sources of information.

4. Identification of data gaps for the selected tiers and assessment of efforts needed to close the identified data gaps

As a result of Step 3 and the data requirements for the preliminary selected tiers the data gaps will become obvious. It should be also identified which parts of the intended investigations are hampered by the missing data. If the affected parts of the input inventory only affects parts which are very likely to be of minor relevance simpler substitutes for this part can be considered.

Based on these assessments the efforts needed to close the identified data gaps or to provide the substitutes can be assessed.

5. Final decision on method selection (substance-specific) for the current inventory compilation

Steps 2-4 will form the basis for the final selection of the approaches which should be taken for the current inventory compilation. It will become clear which information required from the inventory for the next RBMP tasks will not be available from the first compilation. International coordination / exchange of experiences in an international RBD should be also part this process .

6. **Formulation of tasks for the next RBMP (substance-specific), if improvements necessary in the inventory, e.g. by use of higher-tier approaches**

The data gaps and investigations needed to improve future inventories should be known. The investigations should be included in the next RBMP. This step ensures that the information identified in Step 2 will be available by the time the next inventory is compiled.

7. **Preparation, check and refinement of the substance-specific inventories**

Finally the different approaches should be compiled and checked against each other. This cross-checking, especially against the riverine load approach, provides indications of the completeness and the plausibility of results. At the right spatial scale, source and pathway specific investigations can be compared.

8. **Presentation of the results**

The results can be presented in tables or graphs as well as in maps showing either monitored loads or area / population-specific inputs into surface waters. Information on uncertainties and estimates of errors should be also provided. Key conclusions for water-management purposes, i.e. the proportion of point and diffuse sources, identification of important sources / pathways and thus possible targets for reduction measures should be integrated into the RBMP.

Specific MS examples are given in the annexes of this guidance document.

A reporting sheet for the inventory, aiming at providing information for a pan-European overview is being developed.

IV.4. Interpretation of the results from the different approaches

IV.4.1 Interpretation

As indicated in Table 2 the different approaches provide results at a different level of detail. Furthermore the results are available at different regional scales, based on methodology and regional differentiation of input data / coefficients.

1. **Point source emissions**

These localised emissions are in general reliable; however they should be checked

- if analytical results used for the load calculation show a high percentage of measurements below LOD / LOQ. This may lead to a clear over- or underestimation of those inputs, depending on how these results are taken into account.
- if emission values resulting from the use of emission factors are derived for the installations concerned. Use of emission factors reduces the spatial resolution and may lead to over- or underestimation of emissions from specific installations, although the average for several installations may be correct.

2. Riverine load approach

These results are in summary the loads of all upstream inputs plus the net sum of loads transported from and to internal stores. Depending on the flow conditions this transport may increase or decrease the monitored loads, therefore the result should be corrected for these in-stream processes. The net difference between the observed loads and the point source emissions serves as a basic estimate of all diffuse inputs.

3. Pathway oriented approach

Pathway oriented methods, when they are adapted to the situation in the RBD district, give inputs separated into different pathways regionalised into a network of small, hydrologically connected catchments. So, in addition to the localised point source emissions also localised information on diffuse inputs is available. This allows also for the identification of hot spots.

4. Source oriented approach

Here the data depend strongly on how the underlying model covers the actual situation in the river basin. As most of the production and use data are only available at national / EU level the derivation of regional information is a comprehensive task.

The source oriented method gives information on the contribution of certain sources to the pathway specific loads, however disaggregation is difficult (see Chapter III 2).

IV.4.2 Comparison

Inter-method comparison of the results at the MS level gives valuable information on the plausibility of results.

As point source information and in-stream loads are determined by measurements they are relatively reliable and serve as reference points in the comparisons.

The results of load estimations should normally be higher than the point source emissions. If not this indicates the existence of high internal storage / degradation processes which have to be taken into account, otherwise the estimated diffuse inputs would be significantly too low.

RPA estimations are normally fitted / compared to the loads transported through a high number of gauges / monitoring stations to try to minimize the overall error which normally is within +- 30% range for the individual stations. As an example a comparison of observed vs. monitored load for Nickel in Germany is given in Figure 6.

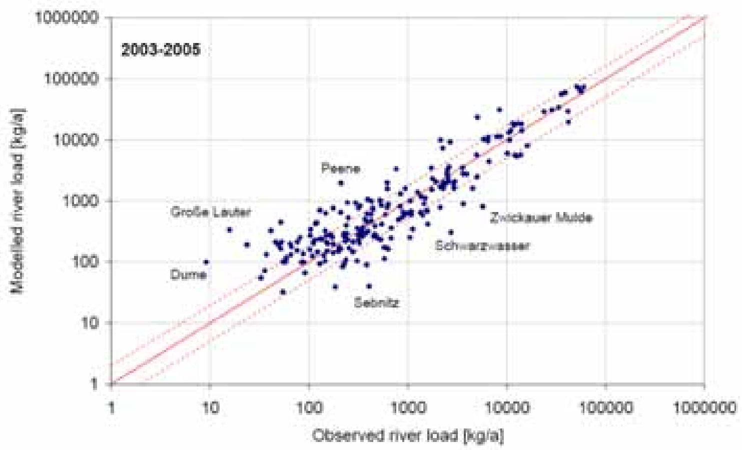
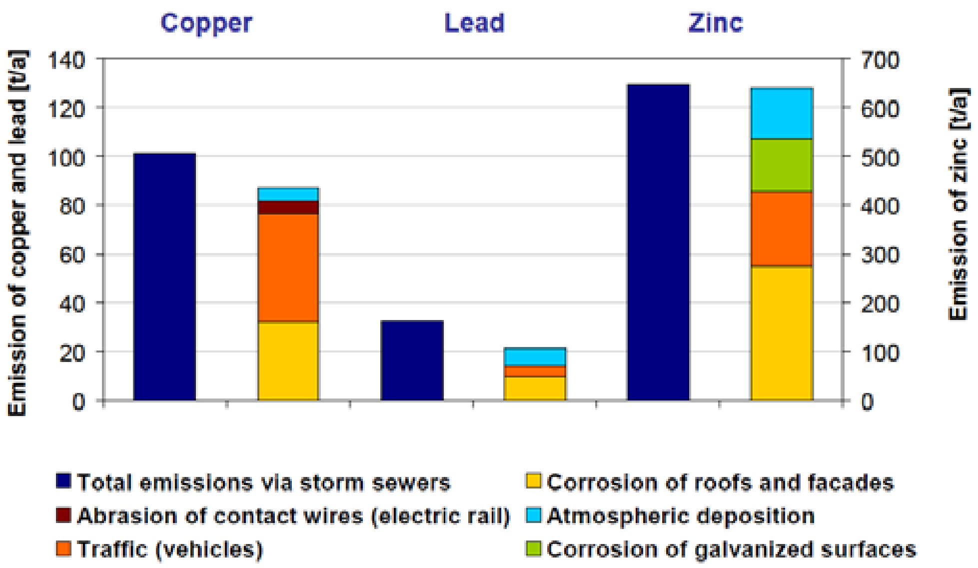


Figure 6: Comparison of calculated and observed loads of nickel using RPA for Germany (Fuchs et al. 2010)

Source based disaggregations can also be compared to the riverine loads.

A comparison of source oriented / pathway oriented results is also possible if the data situation is good and the spatial aggregation level is adequate. Figure 7 shows the comparison between a source specific emission estimation and a pathway specific estimation for the emissions via storm sewers for copper, zinc and lead for the Federal Republic of Germany. Here both results match quite well (figure taken from Fuchs et. al 2010).



Comparison of the calculated emissions from storm sewers for copper, lead and zinc with the source-specific emission approach according to HILLEN-BRAND ET AL. (2005)

Figure 7: Comparison of the calculated emissions from storm sewers for copper, lead and zinc with the source-specific emission approach according to Hillen-Brand et al. (2005)

IV.4.3 Use of results in water management processes

As the objectives of the inventories for river basin management have been defined in the proposed procedure, the results obtained should be compared with the objectives. As mentioned previously, a higher tier approach may be needed for future inventories to improve their usefulness in water management.

If measures for hot spots are planned on the basis of the inventory results, an additional round of plausibility checking should be performed to ensure that the measures are applied at a scale corresponding to the scale of the problem, which could be the result of very specific local conditions not evident from the geographical scale of the inventory.

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GLOSSARY

BWD	Bathing Water Directive
DG	Drafting Group
DRPC	Danube River Protection Convention
DSD	Dangerous Substances Directive
EC	European Commission
EEA	European Environment Agency
E-PRTR	European-Pollutant Release and Transfer Register
EQS	Environmental Quality Standard
ETC/W	European Topic Centre for Water
GIS	Geographical Information System
HELCOM	Helsinki Commission for the Protection of the Marine Environment of the Baltic Sea
ICES	International Council for the Exploration of the Sea
IPPC	Integrated Pollution Prevention and Control
LCA	Life Cycle Assessment
MS	Member State
NiD	Nitrate Directive
OECD	Organisation for Economic Cooperation and Development
OSPAR	OSlo-PARis (Convention for the Protection of Marine Environment of the North-East Atlantic)
PHS	Priority Hazardous Substance
PoM	Programme of Measures
POP	Persistent Organic Pollutant
PPP	Plant Protection Products
PS	Priority Substance
RBD	River Basin District
RBMP	River Basin Management Plan
RPA	Regionalised Pathway Analysis
SCG	Strategic Coordination Group
SCHER	Scientific Committee on Health and Environmental Risks
SFA	Substance Flow Analysis
SOA	Source Oriented Approach
SoE	State of the Environment
UWWTP	Urban Waste Water Treatment Plant
WFD	Water Framework Directive
WG E	Working Group E
WISE	Water Information System for Europe

PREPARATION OF THE GUIDANCE

Mandate for the Drafting Group

This Guidance Document was prepared under the WFD Common Implementation Strategy (CIS) by the Drafting Group (DG) on PS inventory set up in 2010 according to a mandate agreed by the Water Directors at their meeting on 27-28 May 2010 in Segovia.

The DG worked under the umbrella of the CIS Working Group E on Chemical Aspects and was co-led by Germany (Joachim Heidemeier), France (Lauriane Greaud) and DG ENV (Madalina David).

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ANNEXES: COUNTRY EXAMPLES

Austria case study fact sheet

General information

country: *Austria*

title of the project/study:

Emissions of organic and inorganic micro pollutants from Austrian urban wastewater treatment plants

type: Case Study

The Project was worked out for preparatory purposes for a national legal document (ordinance) about an emission register for surface waters.

scope:

- Information gathering: Up to this project only little information in Austria was available about organic and inorganic micro pollutants discharged from urban wastewater treatment plants.
- Selection of present priority and other Substances of national concern

duration: *2007 – 2009*

status: *finalized*

methodology used :

- Analytical analysis of influents and effluents of selected 15 Austrian urban wastewater treatment plants as a first step of the project defining the substances for an in deep assessment in a second step
- Analysis of effluents of 9 Austrian urban wastewater treamtentplant 5 times over a one year period on selected substances (result of step 1)
- Assessement of the fate of substance during wastewater treatment in two urban wastewater treatment plant with mass balance over a 2 week period.

information resources (URL):

The final report of the project is available in German language under
http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0247.pdf

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Abstract

INTRODUCTION

The focus on substances in urban wastewater management developed in the last decades from organic pollutants (BOD_5, COD) to nutrients (nitrogen and phosphorus) and within the last years to micropollutants. In the European water policy the relevance of hazardous substances is reflected by the priority (PS) and priority hazardous substances (PHS) in the Water Framework Directive (WFD) (EC, 2000). The knowledge on occurrence and fate of xenobiotics in wastewater has increased in recent years.
The development of a national emission register for surface water from significant point sources (EMREG-SW) (BGBl. II 29/2009) has been already started with the WFD implementation process in Austria. In preparation of the legal basis for this EMREG-SW a comprehensive study was carried out in the years 2007 – 2009 on Austrian urban wastewater treatment plants (UWWTP), with the aim to identify relevant substances and substance groups, which should be monitored regularly in treated urban wastewaters.

METHODOLOGY

Selection of wastewater treatment plants

In a first step the UWWTPs to be sampled had to be selected. The 638 municipal UWWTP with a treatment capacity of more than 2000 population equivalents (pe) (Überreiter et al., 2010) were categorised dependent on their size and the industrial influence. The size was selected as categorisation criteria, because different requirements regarding the treatment efficiency exist for UWWTPs with treatment capacities of less or more than 5000 pe. According to Austrian legislation UWWTPs with a capacity of more than 5000 pe have to remove nitrogen and phosphorus, whereas UWWTPs below 5000 pe have to remove phosphorus and to apply nitrification. A second size class included UWWTPs with a treatment capacity of more than 150,000 pe as these large UWWTP are treating approx 50% of the total generated load (Überreiter et al., 2010).
The second categorisation criteria was the industrial contribution to the generated load. The industrial contribution was determined based on BOD and COD data. For 420 of the 638 UWWTPs data on BOD and/or COD influent load as well as information on the connected population was available. Based on specific discharges to wastewater of 60 g BOD/(cap·d) and 110 g COD/(cap·d) the industrial/commercial contribution to the UWWTP was calculated. Based on these calculation 3 different categories were defined. Category 1 included UWWTPs with industrial/commercial contribution (in terms of BOD and or COD) of less than 25%, which are considered as domestic areas with negligible industrial influence.
The most important categories in terms of generated load are those with an industrial/commercial contribution between 25 and 75% and a treatment capacity of more than 5000 pe. For a first assessment (module 1) 15 UWWTPs were selected out of the 6 categories by considering also different treatments technologies. For this first assessment influent and effluent samples were taken.
In a second step (module 2) the substances identified as potentially relevant were monitored over one year in 9 UWWTP effluents with a 2 months frequency. Additionally 2 UWWTPs were sampled over 2 weeks in order to assess the fate of selected compounds during the treatment. For this assessment influent, effluent and sludge samples were considered.

Applied relevance criteria

The aim of the first screening of 15 UWWTP effluents was to identify substances, for which the emission to the surface waters via wastewater discharges might be relevant and to select the compounds to be subjected to a further monitoring. All substances were excluded i) which were not detectable in none of the analysed effluent samples or ii) for which the maximum measured concentration was below half the EQS. The limited number of samples and the related uncertainty should at least partially be addressed by setting the relevance criteria with half the EQS and the comparison with the maximum measured concentration.
All substances which could not be excluded in the first step were subjected to a monitoring over one year. 9 UWWTPs effluents were sampled every two months. Based on the results of this monitoring those substances are considered as relevant in wastewaters for which i) the mean concentration of all measurements (including also those from the first step) was higher than half the EQS and ii) the average concentration in at least one of the sampled UWWTPs (only second step) is higher than the EQS. The second criterion is applicable only to the substances subjected to the annual monitoring.

RESULTS AND DISCUSSION

Results of the first screening (Modul 1)

The results of the screening of UWWTP influents and effluents (Modul 1) are summarized in table 1.

Table 1: Results of the screening on the occurrence of selected xenobiotics in treated and untreated wastewater.

	Priority Substances, Priority Hazardous Substances and EU-wide regulated substances	**Other substances**
Not detected in influent and effluent	alachlor, chlorfenvinphos, endosulfane, hexachlorobenzene, hexachlorobutadiene, pentachlorophenol, pentachlorobenzene, trichlorbenzenes trifluralin, aldrin, dieldrin, endrin, isodrin, DDT, p'p'-DDT, tetrachloroethylene, tetrachloromethane, trichloroethylene	benzidine, chlordane, 1,2-dichloroethene, 2,5-dichlorophenole, 1,3-dichloro-2-propanole, heptachlor, mevinphos, omethoate, pentachloronitrobenzene, sebuthylazine
Detected in at least one influent sample but not in effluents	anthracene, 1,2-dichloroethane, naphthalene, fluoranthene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene	cyanides (easily purgeable), dimethylamine, ethylbenzene, isopropylbenzene, linear alkylbenzene sulfonates, xylene
Maximum effluent concentration below EQS/2	Atrazine, benzene, isoproturon, simazine, C_{10-13}chloroalkanes, lead*	benzylchloride, bisphenol-A, dibutyltin compounds, 2,4-dichlorophenole, phosalone, arsenic
Maximum effluent concentration above EQS/2	Pentabrominated diphenyl ethers, cadmium*, chlorpyrifos, di(2-ethylhexyl)-phthalate, diuron, mercury*, nonylphenole, nickel*, octylphenol, tributyltin compounds, indeno(1,2,3-cd)pyrene**, benzo(g,h,i)perylene**,	Ammonia**, adsorbable organic halogens, chloroacetic acid**, ethylenediaminetetraacetic acid, nitrilotriacetic acid, fluorides**, nitrite**, trichlorfon, copper, zinc,

	trichloromethane**, dichloromethane**	silver, selenium

*…total concentrations were determined **…not considered in the monitoring

According to the criteria mentioned before, the following substances were selected to be monitored in module 2 of the project over one year in two months intervals in the effluent of 9 UWWTPs: Pentabrominated diphenyl ethers, cadmium, chlorpyrifos, di(2-ethylhexyl)-phthalate, diuron, mercury, nonylphenole, nickel, octylphenol, tributyltin compounds, adsorbable organic halogens, ethylenediaminetetraacetic acid, nitrilotriacetic acid, trichlorfon, copper, zinc, selenium, sebuthylazine.

Monitoring xenobiotics in UWWTP effluents (Modul 2)

The screening (Modul 1) was performed in September, which might be beyond the application period of most Plant Protection Products (PPP). Beside the above mentioned substances PPP were measured again twice in May and in July/August (n=18) in order to confirm the observations and conclusions from the screening. The mean values of the investigated plant protection products are clearly below half the EQS and also the measured maximum concentrations are well below the EQS wherefore emissions from UWWTPs are deemed not as relevant sources for surface water contamination and are therefore not suggested to be regularly monitored.
The results of the Monitoring programme are summarized in Table 2.

Table 2: summary on the measured effluent concentrations (n=60)

	Mean [µg/l]	Median [µg/l]	Min [µg/l]	Max [µg/l]
PBDE	0,00021	0,000039	n.d.	0,0037
cadmium	0,056	0,010	n.d.	0,20
DEHP	0,51	0,22	n.d.	6,6
diuron	0,073	0,040	n.d.	0,65
nonylphenole	0,25	0,18	n.d.	1,8
AOX	110	43	2	3300
EDTA	65	43	6,5	310
NTA	45	12	n.d.	410
Cupper	7,2	4,3	1,3	56
Selenium	2,3	0,30	n.d.	32
Zinc	32	31	3,0	72
nickel	5,6	4,1	1,0	41
tributyltin compounds	0,00020	0,00010	n.d.	0,0020

n.d. … not detected

As described before mean values for each compound and UWWTP were determined and compared with the respective EQS (Fig. 1a). Beside cadmium, DEHP and nickel in at least one of the nine sampled UWWTPs the calculated mean effluent concentration exceeds the respective EQS. The mean concentration from all available effluent measurements (n=60 for each substance) exceeds half the EQS for all compounds beside DEHP, nickel and diuron (Fig. 1b). Hence comparable results are obtained by the application of the 2 criteria. For PBDE, nonylphenoles, diuron, tributyltin compounds, cadmium, AOX, EDTA, NTA, cupper, selenium and zinc the impact on surface water quality via the discharge of treated wastewater might be of relevance and those substances are suggested for a regular monitoring.

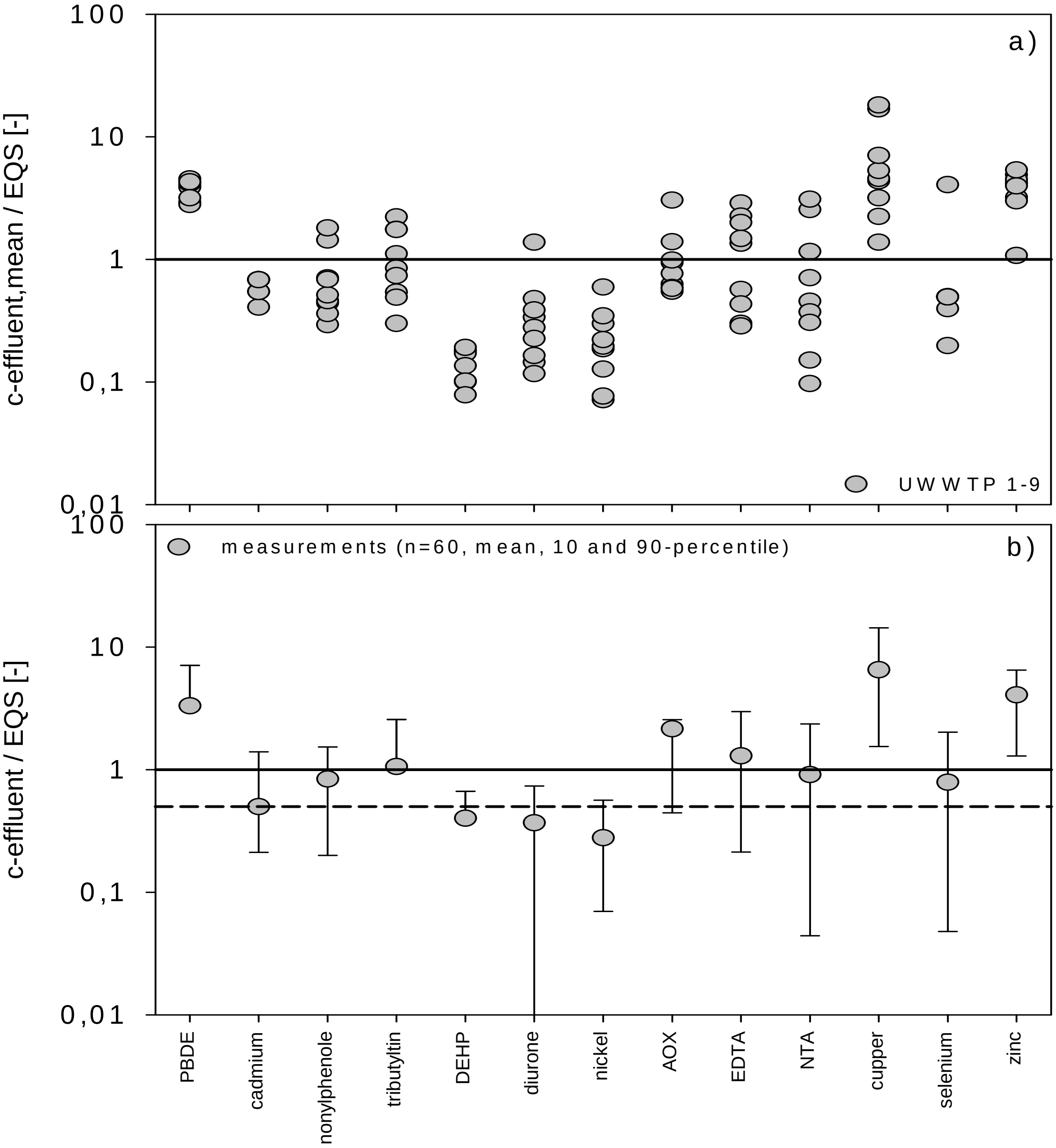

Figure 1: Ratio of mean values of each UWWTP to respective EQS (Fig. 1a); mean value of all effluent measurements compared against EQS and EQS/2 (Fig. 1b)

More details and results are available in the study report. (UBA, 2009).

CONCLUSION

As result of this study the priority substances diuron, cadmium, nonylphenole and tributyltin compounds were selected as relevant for UWWTP effluents for consideration in the Austrian EMREG-SW. Therefore these substances are included in this reporting scheme. UWWTPs with a design capacity above 10.000 pe have to measure these compounds within a six years reporting cycle at least 12 times over one year and report the annual loads in kg/a. For the relevant non priority substances there is no obligation for measurement. For UWWTP above 100.000 pe the annual emitted load can be estimated or calculated with emission factors and reported.

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Germany case study fact sheet I

country: *Germany*

title of the project/study: *German Substance Flow Analysis of Priority Substances*

type: *research projects*

scope: *A bundle of different research projects carried out by Fraunhofer ISI for SFAs for the 33 priority substances and heavy metals to access sources, pathways and measures to reduce emissions.*

duration: (start and end date): *2001 to 2007*

status: *ongoing*

methodology used : *substance flow analysis*

information resources (URL): *The final reports of the projects are available under*
http://www.umweltdaten.de/publikationen/fpdf-l/3311.pdf (report about Emissions reduction for priority and priority hazardous substances of the WFD; in English)

http://www.umweltdaten.de/publikationen/fpdf-l/3312.pdf (substance-specific data sheets for the 33 priority substances of the WFD; in German)

http://www.umweltdaten.de/publikationen/fpdf-l/2936.pdf (report about copper, zinc and lead; in German, summary in English)

contact person/organisation:

Fraunhofer ISI, Frank Marscheider-Weidemann (mw@isi.fraunhofer.de), Thomas Hillenbrand (hi@isi.fraunhofer.de)

Umweltbundesamt, Joachim Heidemeier (joachim.heidemeier@uba.de)

Abstract

The aim of the project series mentioned above was to analyse the emission situation of priority substances in Germany and to come up with suggestions for emission controls. The main focus was on the 33 substances of the WFD and additionally the heavy metals copper and zinc.
The method of SFA was applied to get information about the production, imports/exports, use and pathways to water emission of the substances. Based on this work, emission control measures under particular consideration of the situation in Germany were suggested.
The priority substances are very diverse in their use and formation, emission pathways, share of emissions into water as well as with regard to the quality and coverage of the available information. Therefore the substances were grouped together in several sets which shared some of the aspects cited (e.g. common area of application or origin, similar use/emission pathway, common data sources, comparable abatement possibilities). The groups are Heavy metals and their compounds, Polycyclic aromatic hydrocarbons, Chlorinated compounds – solvents, Chlorinated compounds – mainly intermediate products, Pesticides and Individual compounds with particular significance, see the following table.

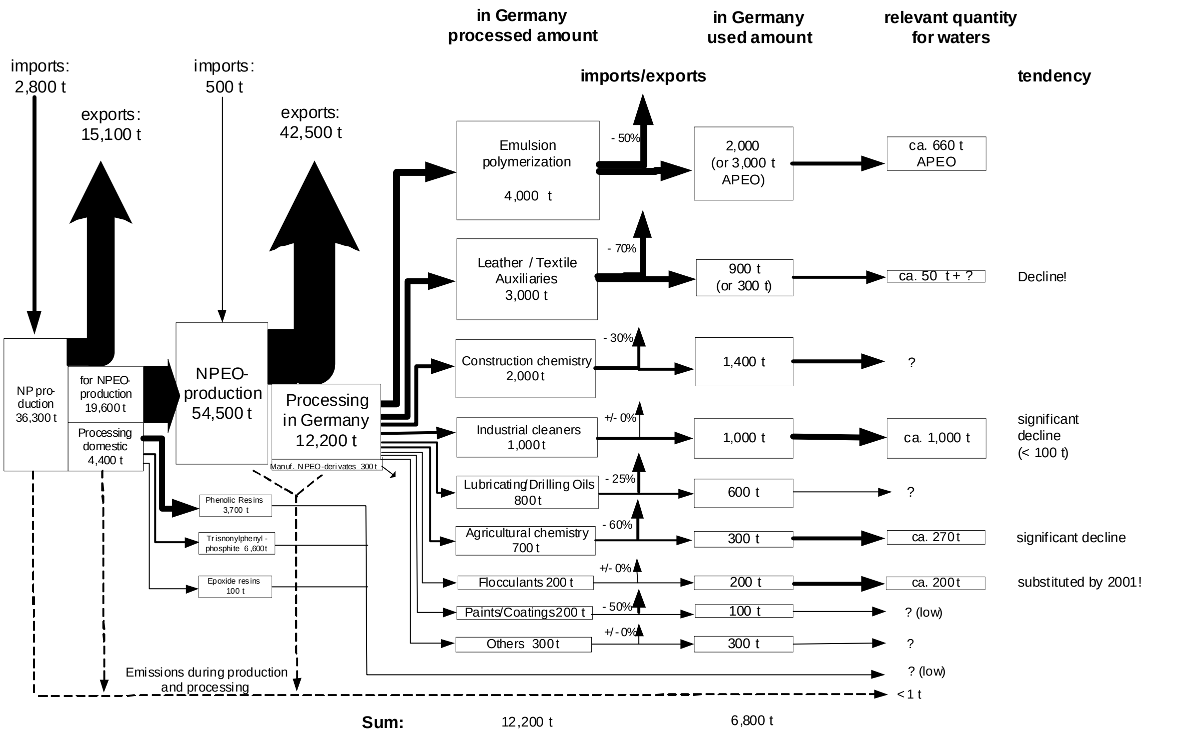
Overview of the most important uses and emission sources for the priority substances in Germany

Priority substance	Significant applications in Germany	Emissions
Lead	Storage batteries, semi finished products, alloys; construction industry, vehicles, hunting/fishing/diving sports	Heavy metals MONERIS:
Cadmium	Batteries, (stabilizers, alloys) accompanying element of Zn, fertilizer	- urban/rural areas
Nickel	Steel, Ni-alloys, batteries, Ni-plating, catalysts	- municipal/ind. sewage plants
Mercury	Chlor-alkali-electr., mercury batteries, fluorescent lamps, dental treatment (→crematoria)	- atmospheric deposition, historical pollution, …
PAH (anthracene, fluoranthene naphthalene, PAH)	PAHs are formed in combustion processes; creosote (local emission); tar oil paints (ships, corrosion prevention); anthracene, fluoranthene, naphthalene: dyes, interim product	mainly via atmospheric deposition
1,2-dichloroethane	Interim product in vinyl chloride production	emissions (air and water) from production of basic chemicals and waste treatment
Dichloromethane	industrial solvent and extracting agent, 10% as paint stripper to remove coatings	emissions from use as solvent (metal working), air emissions from open applications (atm. deposition estimated as low)
Trichloromethane (chloroform)	Interim product and solvent	emissions from use as solvent via wastewater and air pathways
Hexachlorobenzene	POP; no production, no use	emissions from use of fog-generating munitions; historical pollution of sediments/sites; by-product
Hexachlorobutadiene	no production, no use	By-product chlorine chemistry
Pentachlorobenzene	no production, no use; (source material for quintocene; prohibited since 1992)	historical pollution/sediments
Trichlorobenzene	Production; used as interim product	
Alachlor	not licensed	
Atrazine	not licensed	
Chlorfenvinphos	not licensed	
Chloropyrifos	license for 2 products until 2015 as PPP; under review as biocide	
Diuron	licensed as PPP, under review as biocide	
Endosulfane (alpha-endosulfane)	not licensed	
Hexachlorocyclohexane (HCH)	no longer permissible for licensing in EU since 2002	historical pollution one point source water direct (manufacturing inorganic basic chemicals)
Isoproturon	permitted	diffuse emissions via farming, increased by illegal/improper use, point emissions from farmyard run-offs
Simazine	prohibited	
Trifluralin	permitted i	
Benzene	large volume interim product, component of carburettor fuel (gasoline)	atmospheric deposition
Brominated diphenyl ether	flame proofing agent; since 8/2004 ban on marketing and use for penta- and octaBDPE (incl. products); decaBDPE in products	diffuse emissions DecaBDPE via imported products
C10-13-chloroalkanes	flame proofing agents, softeners; EU-	diffuse emissions via imported

Priority substance	Significant applications in Germany	Emissions
	wide restriction 2002/45/EC; no production in Germany	products, depot effect
Di(2-ethylhexyl) phthalate (DEHP)	PVC softener	emissions from PVC-processing, sewage plants, diffuse emissions via products and old products
Nonylphenols	Adhesive, varnishes; NPEO as tenside; restriction on use through 2003/53/EC	Emissions via NPEO (tenside); imported textiles; via PPP
Octylphenols	no longer produced in Germany; only very minor use	Emissions via impurities in NPEO
Pentachlorophenol	HSM/fungicide; prohibited since 1989	historical pollution, emissions via imported products, depot effect
Tributyltin compounds	Anti-fouling paints: prohibited through 782/2003 and 2002/62/EC (implementation of IMO ban);	direct emissions during anti-fouling applications; shipyards; low emissions due to impurities in mono-/dibutyltin compounds

For each priority substance a substance-specific data sheet was compiled in order to present the information and data in a compact form. These data sheets contain information on the following issues: Nomenclature and substance features, substance specific regulations, monitoring results, production and application, emission situation, approaches for emission abatement measures and literature. When possible, the findings are summarized in a figure like given for NP/NPEO below.

Figure: Fluxes for the NP / NPEO-use and resulting emissions for D (1999/2000)



Germany case study fact sheet II

General information

country: Germany

title of the project/study:

Methodological optimization of nutrient and pollutant input modelling in river basins to promote the implementation strategy for the WFD

type: research project

scope:

- assessing relevance of source
- modeling of inputs
- inventory compilation

duration: 2009 – 2011

status:

- finalized

methodology used:

- regionalized path analysis:

information resources (URL):

http://isww.iwg.kit.edu/MoRE.php

http://www.umweltdaten.de/publikationen/fpdf-l/4018.pdf

contact person/organisation:

Karlsruhe Institute of Technology, Institute for Water and River Basin Management, Department of Aquatic Environmental Engineering:

Dr. Stephan Fuchs (stephan.fuchs@kit.edu)

Abstract

Introduction

The Directives 2000/60/EC (WFD) and 2008/105/EC (on EQS) of the European Parliament and the Commission ask all Member States (MS) an inventory of emissions of priority substances for all RBDs (EU, 2000 and EP, 2008). This task requires appropriate data and approaches for the description of the current state of surface water bodies and the evaluation of appropriate measures for the reduction of emissions into the surface water bodies to achieve a good ecological state of surface water bodies and to meet the quality standards set.

Based on these requirements the proven MONERIS concept that was developed for modeling of nutrient emissions into the water bodies (Behrendt et al., 2000), was adapted as MoRE system (Modeling of Regionalized Emissions) for pollutant emissions. Besides the technical implementation, a full documentation of input data, model approaches and results as well as transparency and flexibility of the model system have been realized.

Currently, MoRE is realized for Germany's large river basins and their catchment areas outside Germany with a total area of 650,000 km². The area is divided in about 3500 analytical units based on the drainage network. The analytical units can be aggregated to different administrative units, sub-basins or river basins. Given adequate input data, MoRE can be adapted easily to any other river basin or MS. The emissions can be modeled either in individual annual steps or for user-defined periods.

The MoRE system comprises approaches for the emission pathways: municipal wastewater treatment plants, industrial direct dischargers and emissions of historic mining for pathways related to point sources and the following emission pathways related to diffuse sources: sewer systems, surface runoff, erosion, groundwater, tile drainage, direct atmospheric deposition onto water surfaces and inland navigation (Figure 1). Thus, MoRE allows a regional and pathway specific quantification for any given aggregation unit. The modeling approaches and sources of input data are described in detail in Fuchs et al. (2010).

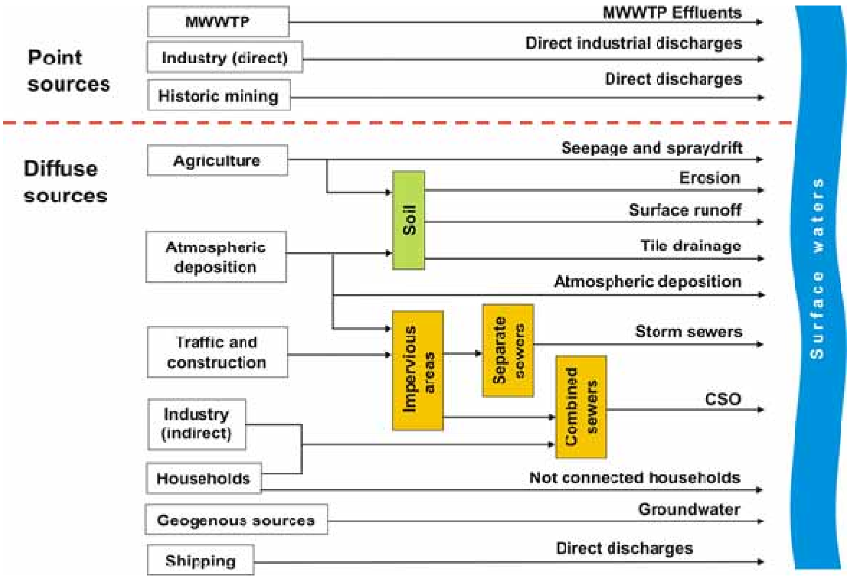


Figure 1: Sources and emission pathways considered (Fuchs et al., 2010)

Model architecture and implementation

This section describes shortly the model architecture with its components and the technical implementation of the MoRE system. Further information is available in Fuchs et al. (2011).

Model architecture

The MoRE system is based on an open source PostgreSQL database and two different graphical user interfaces (GUI): the MoRE Developer GUI and the MoRE Visualizer GUI (Figure 2). The GUIs have been developed for user interaction with the PostgreSQL database. The PostgreSQL database content can be easily read, changed and extended via the MoRE Developer GUI. The modeling can be launched via a calculation engine which is incorporated in the Developer GUI with a dynamic linkage to the PostgreSQL database. Modeling results can be visualized via a GIS-browser (MoRE Visualizer). Users can access the MoRE system either via internet on a multi-user basis or via a single user application for PC.

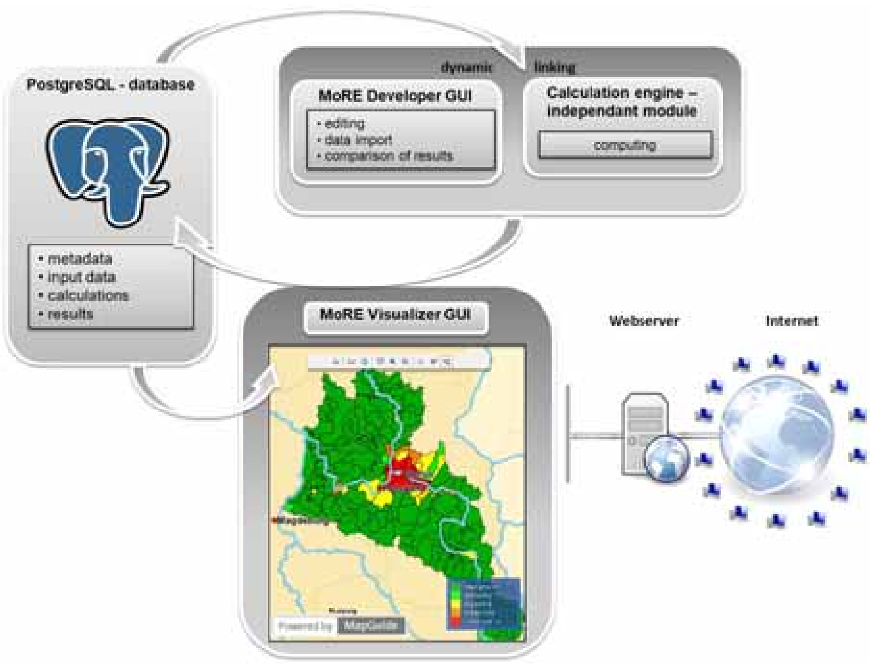


Figure 2: System architecture of MoRE

Calculation engine

One of the main goals of MoRE development was the provision of a flexible modeling tool. New modeling approaches can be integrated in a flexible way using the calculation engine and tested easily in the Developer GUI. This feature is possible because the calculation engine is integrated but unit independent of the database. That means the calculation engine does not include any equations but only the logic structure of the model and doesn't have to be adapted to changes in approaches, as long as the structure of the MoRE database will be maintained. The user does not need to have programming skills.

The database

The fundamental database contains all data and metadata for the spatial and temporal variables and for the model constants. This means, for example, that each record is assigned a unique origin and additional information like pathway specification and substance reference.
Furthermore, the empirical approaches are defined in the database. After modeling, the results can again be written to and stored in the database or exported for further analysis to MS Excel.
The MoRE database contains spatial and periodical input data. Input data is derived either from regionalized datasets like soil maps and hydrogeological maps, land use and population distribution datasets as well as from statistical data like connection rate to sewer systems, share of combined and separate sewer system, storage volume in combined sewer system. Additionally, emission factors like inhabitant specific loads and pollutant loads from impervious areas are implemented as constants. Altogether, the MoRE database contains about 300 variables, 12 million input data and 9 million results.

The graphical user interfaces

MoRE Developer

Using the MoRE Developer GUI, new input data can be added to the database and algorithms for approaches can be readjusted. Additionally, MoRE Developer owns a powerful calculation engine for calculating emissions and river loads for selected analytical units.

MoRE is modular, so that the approaches of individual pathways can be independently adjusted. Thus, alternative input data and modeling approaches can be implemented as variants of a basic variant. The results can be compared to evaluate the quality of the considered input data and approaches.

MoRE Visualizer

The MoRE Visualizer is a browser based application which works via a direct connection with the MoRE database. In addition to the MoRE Developer GUI, the MoRE Visualizer offers the opportunity of presenting and analyzing the computed data for selected aggregation units and periods.
After the selection and visualization of the data, it can also be presented as reports which can be exported to MS Excel.

Availability of MoRE

The MoRE system is Free Software. It is published under the licence AGPL V. 3 which allows free modifications, copying, redistribution and use of the software as long as the same terms also apply to the derivative works.

Exemplary results

Given the example of lead as one of the priority substances, we show exemplary model results. The total lead emissions from Germany account for 263 t/a (Fuchs et al., 2010). It turns out that erosion is the main emission pathway for lead besides sewer systems (Figure 3).

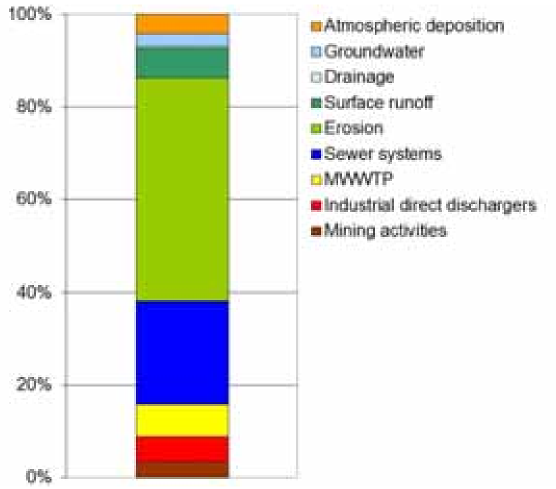


Figure 3: Relevance of the pathways for lead emissions into the RBDs of Germany in the balance period 2003-2005 (Fuchs et al., 2010)

Since MoRE generates regionalized emissions, the total emissions and the emissions for each pathway can be visualized on the level of analytical units. Using this map, one can detect pollution hotspots in river basins or administrative units (Figure 4)

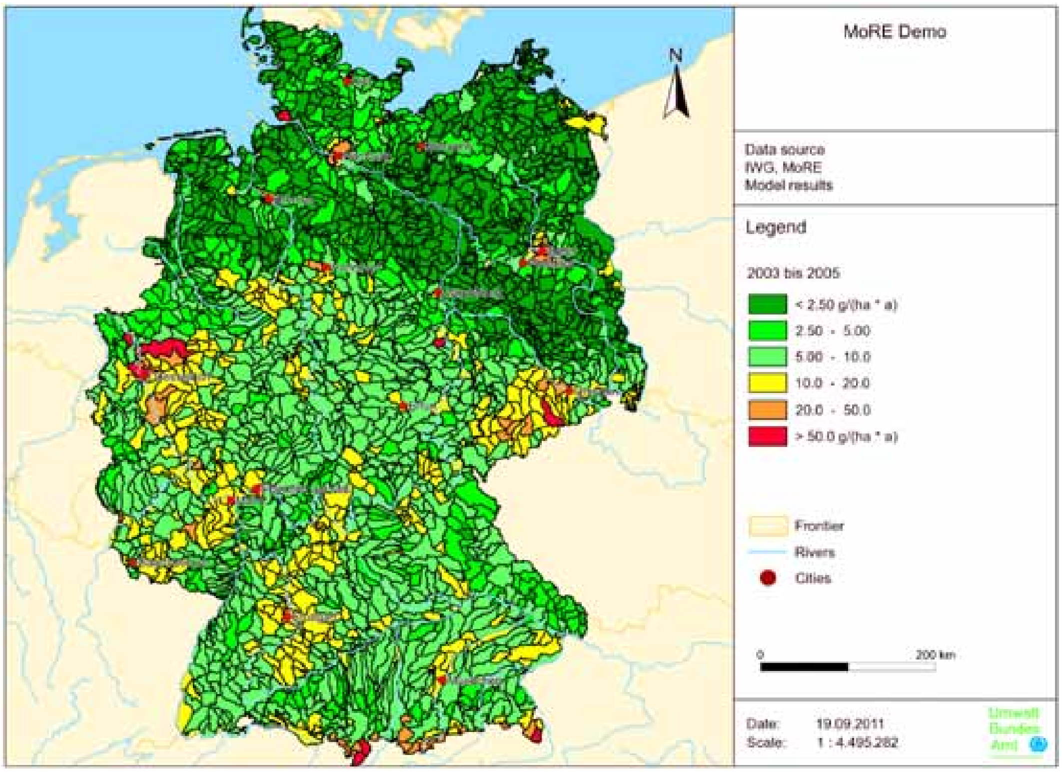


Figure 4: Specific lead emissions from the analytical units of Germany in the period 2003-2005

Conclusions

MoRE system is a flexible and transparent tool for the quantification of pollutant emissions in river basins. It allows a regional and pathway specific quantification for any given aggregation unit. Therefore, MoRE can be highly relevant for the allocation of investments or the implementation of specific measures to mitigate the overall pollutant emission into surface water bodies in order to meet the above mentioned requirements of EU water policy.

References

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Fuchs, S., Wander, R., Rogozina, T., Hilgert, S. (2011): The MoRE Handbook. Karlsruhe Institute of Technology. Institute for Water and River Basin Management. http://isww.iwg.kit.edu/MoRE.php

Belgium (Flanders) case study fact sheet

General information

country: Belgium

title of the project/study:

WEISS, the Water Emission Inventory, a planning Support System aimed at reducing the pollution of water bodies.

type:

Research project, financed by LIFE+ 08.

The result will be used for administrative practices.

scope:

- Information gathering (e.g. input loads or concentrations)

  Existing monitoring data and estimated diffuse pollution data will be used, supplemented with data from additional research.

- Modelling of inputs

  WEISS will model all the different pathways from source to surface water. Input will be monitoring data, calculated and estimated data.

- Inventory compilation

  The WEISS system will act as an emission inventory and will calculate and report gross and net emissions at a high spatial resolution.

- Assessing relevance of source

  WEISS will integrate all (relevant) emission sources and pollutants and will identify the significant emission sources.

- Decision support

  Assist authorities in their monitoring and reporting obligations. Scenario calculation and planning support.

duration: 2010-2012

status: ongoing

methodology used :

WEISS is a model-based information system handling emission data from diffuse and point sources by means of geographical calculations at a high resolution.

WEISS uses a bottom up methodology in which it combines the advantages of the pathway oriented approach (POA) and the source oriented approach (SOA).

A pure source oriented approach, like Substance Flow Analysis (SFA), analyses all the flows of a substance in a well-defined system, including through industries producing and using it, households, wastewater treatment plants and all connected media such as soil, air and water. The substance flow of WEISS focuses on the end-use of a substance and it's connection to the medium water. Therefore WEISS is less complex than SFA , and has the advantage to report the emission on a high spatial resolution.

The pathway oriented approach focuses on the processes of transport to the surface water. These processes are also part of WEISS, and moreover, WEISS can report on the proportional contribution of sources to a certain transport.

information resources (URL):
http://weiss.vmm.be

contact person/organisation:
Flemish Environment Agency, Department Water Reporting
A. Van de Maelestraat 96, BE9320 EREMBODEGEM
Mrs Greta Vos (g.vos@vmm.be)

Abstract

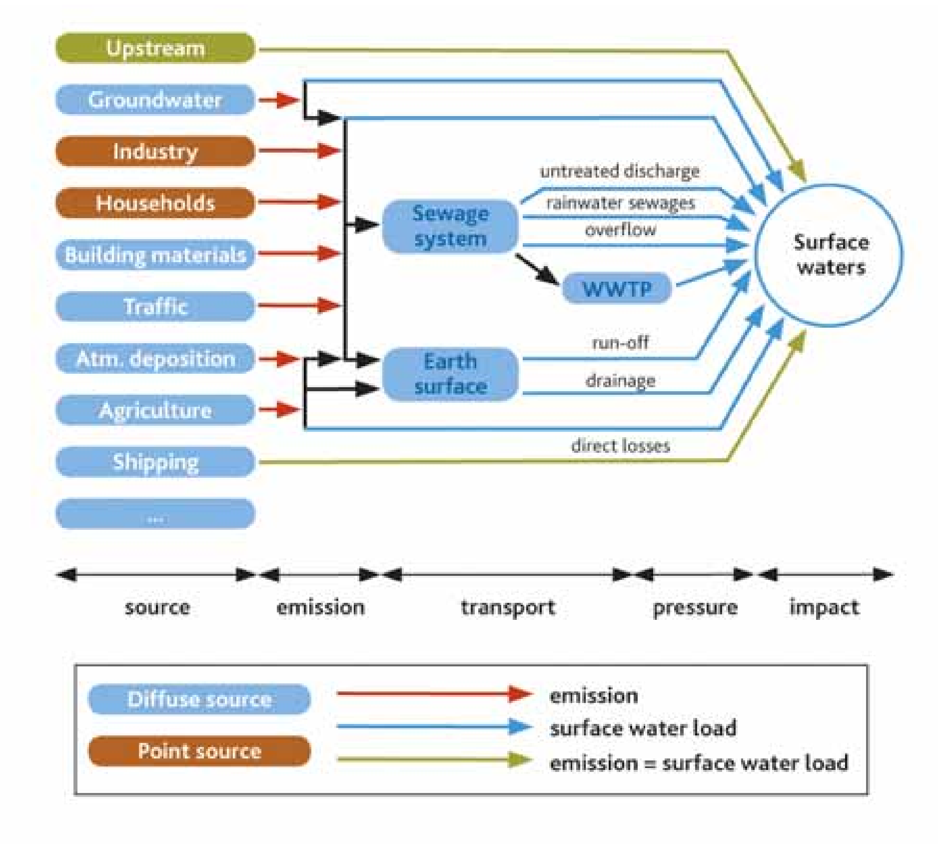
Introduction

Monitoring and reporting the water quality for the Flemish region of Belgium is the responsibility of the Flemish Environment Agency (VMM). To assist in this tasks the WEISS system is currently under development in collaboration with the Flemish Institute for Technological Research (VITO). WEISS is a LIFE+ project that will create a geographically explicit, transparent inventory of emissions towards water for the Flemish region. The project will be realised in 3 years and will be finalised by the end of 2012.

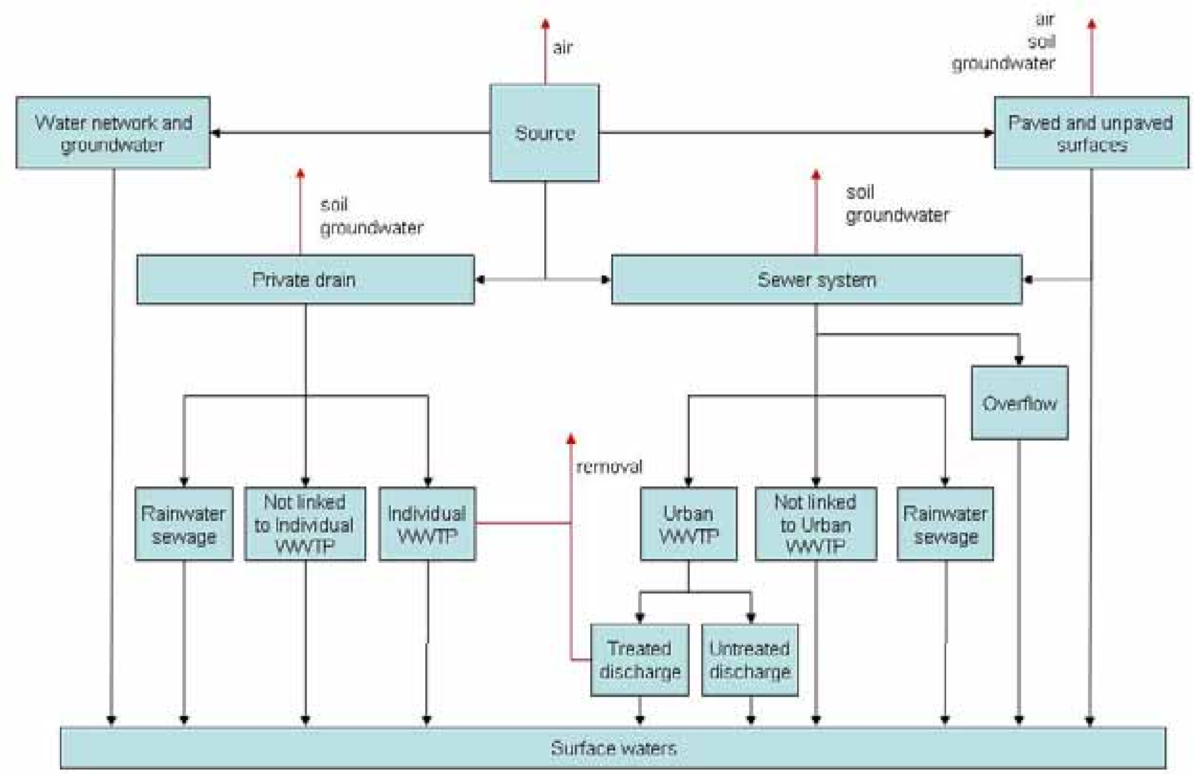
The WEISS system

The WEISS system will integrate all relevant emission sources (both diffuse and point), all transport routes, and a planning support module. This will enable calculation of pollutant loads in distinctive nodes of the pathways, as required for monitoring and reporting (e.g. WFD, E-PRTR, WISE).

Sources and pollutants addressed in WEISS are typical for regions with a high pressure on land use. Pollutants from agricultural, urban and industrial activities will be quantified, with focus on priority substances.



<u>Pathways</u>
WEISS focuses on emissions and their pathways to water bodies. In the flow scheme all the pathways considered in WEISS are represented. Reporting will be possible in each of the nodes.



Flow scheme of WEISS: different pathways from source to surface water

High geographical resolution

WEISS will operate at a high geographical resolution. A resolution of 1 ha is selected for Flanders. The sources are spatially distributed on 1ha resolution maps before calculating the path of the emissions to surface water.

The base resolution can be changed in function of the sources dealt with, the spatial detail desired, the legislative framework, the quality and quantity of the original data and computational constraints.

Bottom-up approach

WEISS will use a bottom-up approach to calculate the emissions for each source and pollutant:

1. Localise the source (EEV) on high resolution map respecting its spatial characteristics (regionalization)
2. Apply Emission Factors (EF) to each grid cell where the source is present
3. Calculate in detail the loads transported via the relevant pathways
4. Summation of the loads for reporting of emissions in entities like water bodies.

In the model this bottom-up approach consists of three consecutive steps:

1. spatial distribution of the source,
2. computation of the pathways and
3. accounting in distinctive nodes of the pathways.

For every step, specific algorithms are applied. They are implemented as part of model blocks stored in a model library. For every emission source the appropriate model blocks are selected and chained to perform the required calculations. This modular approach allows the addition of new sources and new pathways. The accounting module calculates the total pressure and source appointment for a chosen hydrological entity e.g. water body or river basin.

Adaptable

The system will be easily adaptable for use in EU MS or parts thereof and will be freely available to that effect. It will allow determination of the significant emission sources, simulate pathways from source to sink, support monitoring and reporting and assess (policy) measures aimed at reducing water pollution.

Conclusions

WEISS is a transparent emission inventory system with a generic approach that makes it easily adaptable. It uses a bottom-up approach that allows reporting at any geographical scale. The system can start small-scale or with data available at a low level, and can grow over time.

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Engelen, G., Van Esch, L., Janssen, L., Van Holderbeke, M., Provoost, J., De Cuyper, K. and Dinne, K. (2006) Kwantificering en verfijning van het aandeel van de diffuse bronnen op de emissies naar oppervlaktewater in het stedelijk (gerioleerd) gebied. Deel: emissies van metalen te wijten aan corrosie van bouwmaterialen, Report 2006/I/MS/R397, VITO, Mol.

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France case study fact sheet

country: France

title of the project: French strategy for monitoring and reduction of hazardous substances discharges to waters from industry and urban wastewater treatment plants

type**:** implementation of a national strategy through a 2 steps process:

- A survey was first carried out on a sample of industrial and urban waste water treatment plants (2876 facilities)
- Use of the outcomes for regulatory purpose (revision of discharges permits)

scope:

- Information gathering: identification of point sources of hazardous substances
- Improvement of E-PRTR reporting on hazardous substances and as the result the quality of the inventory under EQS directive
- Assess the relevance of each source and target reduction measures
- Improve the management of industrial connections to urban wastewater networks
- Contribute to achieve the 2 main objectives of the WFD as far as chemicals are concerned: good status and reduction of emissions of substances.

duration: (start and end date)

The survey started in 2002 and ended in 2008.

Following this survey, 2 ministerial notices have been published and their implementation is ongoing.

- 2009/01/05: notice on the implementation of a specific monitoring of industrial discharges of hazardous substances to waters and their reduction
- 2010/09/29: notice on the implementation of a specific monitoring of UWWTP discharges of hazardous substances to waters

status: ongoing

information resources (URL):

The results of the survey together with the notice 2009/01/05 for industrial discharges monitoring and reduction are available in french on a dedicated website http://ineris.rsde.fr/

The french strategy on micropolluants reduction is summarised in a document that can be dowloaded in french and soon in english at the following link: http://www.developpement-durable.gouv.fr/Les-micropolluants-dans-les.html

At the same link can be downloaded the notice 2010/09/29 for UWWTP discharges monitoring.

Methodology used:

Survey: monitoring of a list of 106 substances in the direct or connected discharges of 2876 plants.

Contact person/organisation:

French ministry for ecology, sustainable development, transport and housing (MEDDTL)

Lauriane Gréaud (lauriane.greaud@developpement-durable.gouv.fr): french strategy on micropolluants reduction

Marine Colin (marine.colin@developpement-durable.gouv.fr): industrial emissions

Vincent Ferstler (vincent.ferstler@developpement-durable.gouv.fr): urban wwtp emissions

Abstract

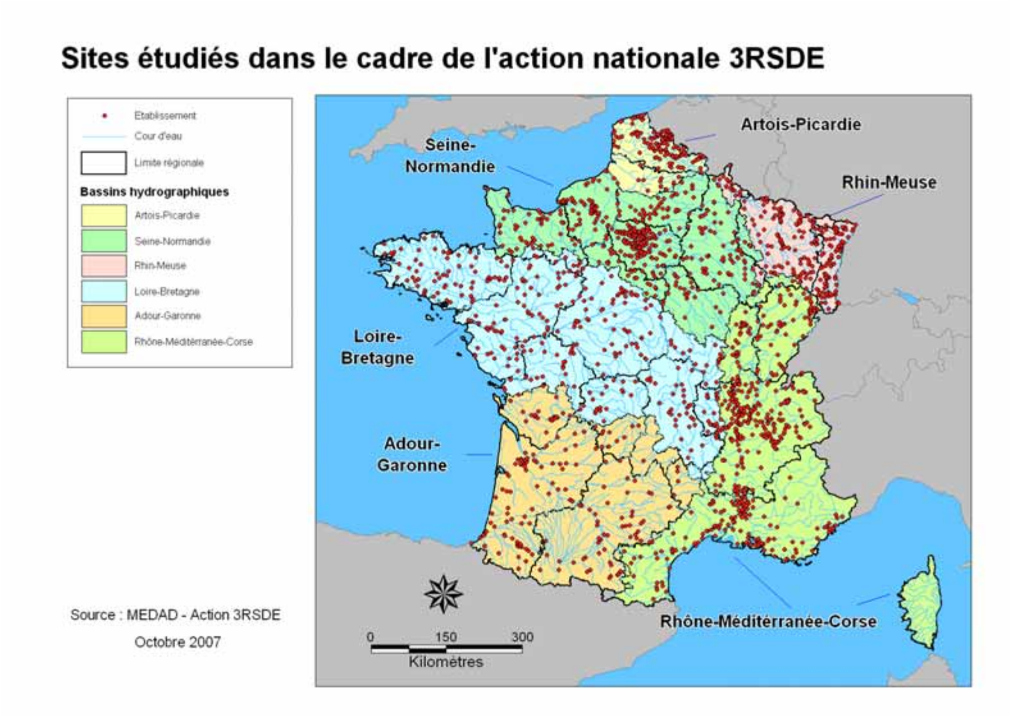
As a part of the global framework for the implementation of the WFD in France, a working programme has been initiated in 2002 which aims at reducing industrial releases of dangerous substances into the aquatic environment. This programme has 4 main steps:

1. Exploratory step: inventory of hazardous substances potentially discharged by industries and UWWTP to waters and identification of the most relevant substances to monitor
2. Improvement of knowledge and data consolidation: transitory monitoring
3. Implementation of a relevant monitoring at the site level
4. Carrying out of reduction actions

1. First step of the reduction strategy of hazardous substances point discharges: the national survey

From 2003 to 2007 took place in France a national inventory of hazardous substances in industrial and urban discharges to waters (called “action 3RSDE”). This action, initiated by the ministry in charge of sustainable development, was based on the chemical analysis of 106 chemicals in discharges from 2876 sites, mostly industrial facilities but also 167 urban wastewater treatment plants (UWWTPs) and 22 power plants. The sample of facilities involved in this action on a voluntary basis is considered representative of the French industry: chemistry, food product, paper manufacturing, surface treatment industry, metallurgy, textile, tanning, glass manufacturing, waste treatment and disposal...

Figure 1: Distribution of the 2876 facilities studied over the 6 French river basins



The list of 106 substances[9] was established considering their toxicity for aquatic ecosystems and because they were subject to EU regulations on the limitation of their discharges to water (76/464/EEC - Dangerous Substances Directive - and 2000/60/EC - Water Framework Directive). Bioassays have also been performed on 10% of the effluents measured in order to begin a study on the possible correlation between chemical and ecotoxicological impacts.

Sampling prescriptions have been determined to be significant of a normal day of activity.

The 21 laboratories in charge of sampling and analyses had to comply with the same technical and quality requirements. Nevertheless, different analytical techniques were used and the associated performances introduced uncertainties in the results. The uncertainties are of course increased for “unusual” substances (not well known on routine basis) and for the low levels of concentrations.

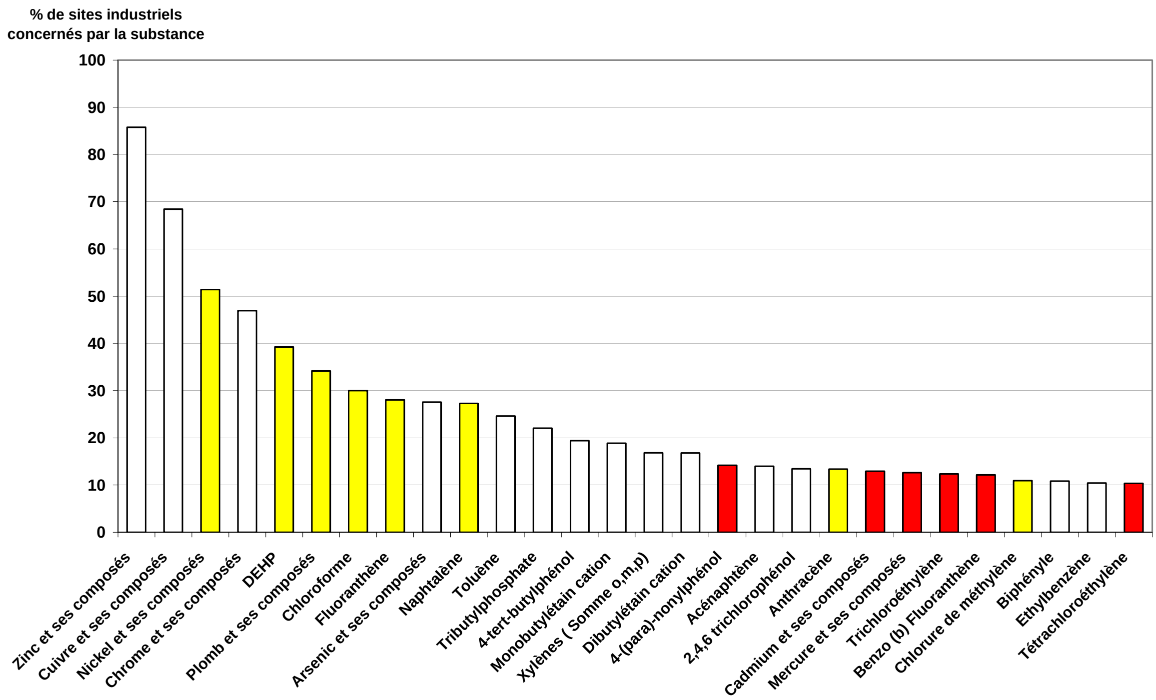
All 106 substances have been quantified at least once, some in more than 30% of the discharges (metals, PAHs, VOHCs, phtalates).

70% of the measured emissions are organic substances. Some substances are quantified in the majority of sites but for 20% of them, a main source is observed.

This action made clear that urban wastewaters are also a source of hazardous substances as most of them (81) have been quantified in at least one discharge.

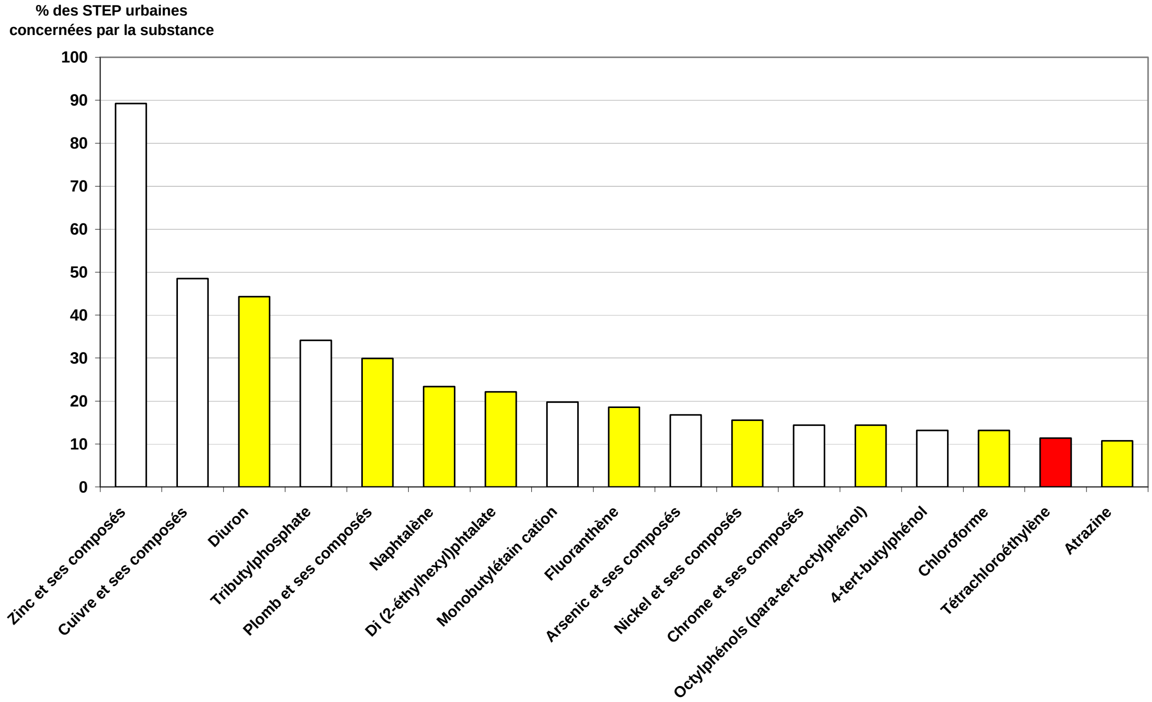
On the following figures, priority hazardous substances are identified in red and priority substances in yellow.

Figure 2: Substances quantified in more than 10% of the industrial discharges studied



[9] The complete results concerning this study can be downloaded (in French) at : http://www.ineris.fr/rsde/doc/docs%20rsde/DRC-07-82615-13836C.pdf . The list of the 106 substances can be found p. 580 to 583.

Figure 3: Substances quantified in more than 10% of the UWWTP discharges studied



The main outcomes of this inventory are:

- A great improvement of laboratories practices on these substances
- A better knowledge of hazardous substances point pollution sources, by the identification of key sectors involved
- Identification of working axes to elaborate appropriate reduction measures

In 2005, the first results of this survey, together with a similar survey carried out on surface waters, have been used to **select the substances of national concern**.

In 2008, negotiations with industrial sector representatives, on the basis of this results, lead to the elaboration of **39 sector specific lists of substances** that should be monitored in their discharges.

2. Second step : implementation of specific monitoring and reduction requirements of hazardous substances

2.1 Requirements for industry

In 2009, a notice from the ministry of sustainable development was published asking for the authorities in charge of delivering discharges permits to revise them in order to include the monitoring and, for some of them, the reduction, of relevant hazardous substances discharges for the industrial facility.

An initial monitoring has to be performed on a monthly basis, for a six month period. The list of substances to monitor depends on of the activities on site (39 sector specific lists established after the national survey).

Based on several criteria (loads, concentration, status of the water body..), some of the substances will be added to the self monitoring programme of the industry and for the ones with higher loads, a reduction action plan has to be established.

The substances entering to the self monitoring obligation have to be monitored on a quarterly basis, for 2 years minimum.

Annex 5 of the notice describes the technical requirements for chemical analysis and sampling. Limit of quantification (LoQ) that must be achieved are established for each substance.

Hazardous substances specific monitoring should be implemented in 2013 for all facilities under permit conditions.

The next step for the local authorities is to revise and ad emission limit values in the permits, according to receiving the water body's allowance (based on EQS).

2.2 Requirements for UWWTP

In 2010, a notice from the ministry was published asking for the authorities in charge of delivering discharges permits to UWWTPs, to revise them in order to include the monitoring relevant hazardous substances.

An initial monitoring has to be performed on a monthly basis during a 4 months period.

For UWWTP above 100.000 eh capacity, the list of substances to monitor is adapted from E-PRTR regulation: implementation in 2011.

For UWWTP between 10.000 and 100.000 eh capacity, the list of substances to monitor is the list of UE priority substances and substances of national concern: implementation in 2012.

Based on several criteria (see above), a regular monitoring of some substances will have to be performed (see table 1). Then, every 3 year, monitoring of a larger list has to be carried out again.

Table 1: Monitoring frequencies for UWWTP

EH	>=10.000 and t<30.000	>= 30.000 and <90.000	>= 90.000 and <360.000	>= 360.000 and <540.000	>= 540.000
Number of analysis per year	3	4	6	8	10

As for industries, this new monitoring requirement will be integrated in self monitoring requirements and permits will be revised.

Annexe 2 of the ministerial notice establishes the limit of quantification (LoQ) that laboratories must achieve for each substance. The technical requirements for chemical analysis and sampling are also described. For example, specific sampling equipment is required.

All these new requirements for industries and UWWTP also include the obligation to report the monitoring results together with the quality data through specific reporting tools. A quality check is performed by the ministry with the help of its technical agencies.

The creation of a national laboratory of reference for water (AQUAREF) has recently been supported by the ministry. This laboratory, which is a consortium of 5 structures, works at improving water monitoring results (natural or discharged waters).

Reference

LES SUBSTANCES DANGEREUSES POUR LE MILIEU AQUATIQUE DANS LES REJETS INDUSTRIELS ET URBAINS - Bilan de l'action nationale de recherche et de réduction des rejets de substances dangereuses dans l'eau par les installations classées et autres installations, L GREAUD et al, INERIS (2008)

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