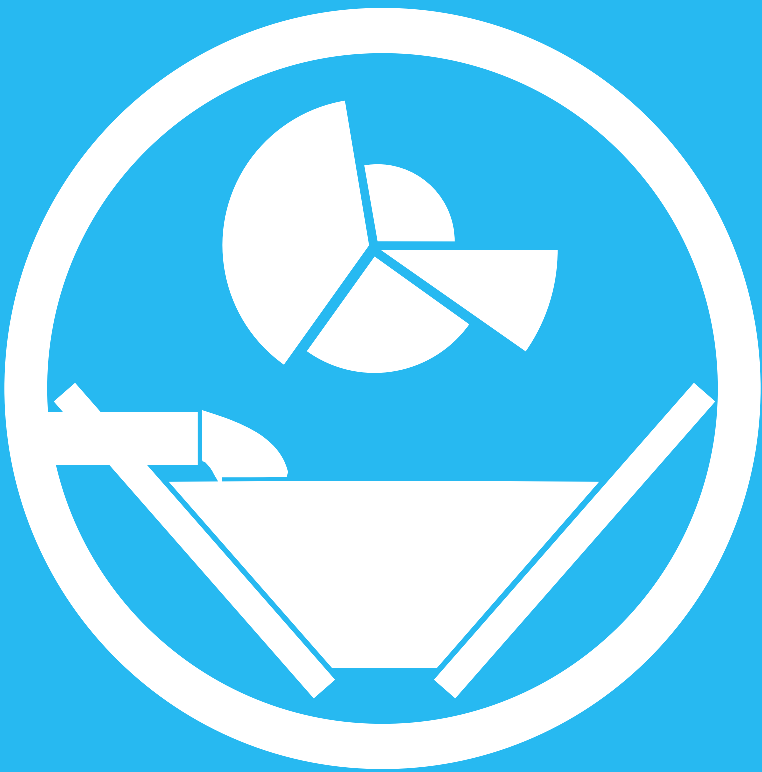
Report on Management and Decision Assessment Tools



E²STORMED PROJECT
Improvement of energy efficiency in the water cycle by the use of innovative storm water management in smart Mediterranean cities
www.e2stormed.eu

Abertay University

L'Europe en Méditerranée
Europe in the Mediterranean

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1. Decision Support Tool Review

1.1. Introduction

The development of a Decision Support Tool (DST) is one of the key outputs of the E²STORMED Project, and will enable partner countries to assess the effectiveness of stormwater management techniques, and importantly energy efficiencies for both new and retrofit developments. This output is described in the E²STORMED Management Manual as a:

"Decision Support Tool (DST) to improve energy efficiency in the urban water cycle in smart MED cities by the use of innovative storm water management systems. The DST shall allow local authorities to take better informed decisions".

The development of the DST seeks to combine the assessment of different stormwater designs with energy efficiency as a key parameter. The DST is intended to include common variables which feature in existing (stormwater) decision support tools such as hydraulic performance, treatment efficiency, construction and operations costs, etc.

The E²STORMED Project application document proposed that the project should:

"Link knowledge from EU programmes both within the Med region and outside…and….contribute to a long term improvement in energy efficiency while at the same time enhancing the lives of citizens in the region".

Specifically, reference was made to the stormwater decision support tool *Comparing the Flexibility of Alternative Solutions* (COFAS) developed within the EU FP6 Project *SWITCH: Managing Water for the City of the Future*. The COFAS tool is described as a *"multi-criteria assessment and flexibility assessment of the future uncertainties associated with urban drainage systems*".

The E²STORMED Project Application document proposed that the COFAS tool be adapted and enhanced with energy efficiency indicators for use in MED regions.

To meet these requirements, an initial review of the COFAS tool was undertaken to:

- Define decision criteria for drainage systems, for instance outflow maximum discharge and concentration of Nitrogen. Each criterion has a weight and a utility function, which describe what values of the criterion are "good" or "bad" (from 0 to 1).
- Define different drainage system options. In each option, the value for each criterion is introduced.
- Compute the utility value for each criterion and scenario. With these results, different graphs are obtained and different indicators are computed to prioritize between the proposed drainage system options.

This review identified that the COFAS tool provided a suitable basis to develop a DST for the needs of the E²STORMED Project, and importantly, that energy efficiency data could be incorporated within the tool.

1.2. Decision Support Tool Specification

1.2.1. Outline from Lead Partner

Following the initial review of the COFAS tool, Polytechnic University of Valencia (UPV) produced more detailed guidance on the required functionality of the DST.

This proposed that the DST should be able to:

1. *Define different drainage system scenarios, each one with different drainage structures (an explanation should be included of each type of drainage infrastructure).*
2. *Compute and represent for each scenario the variation of economic costs, energy consumed, CO_2 emissions and water consumed during a period.*
3. *Use these results for developing decision criteria based on energy efficiency, economic costs and proper water management.*
4. *Use these criteria with other social and environmental criteria in order to compute results and display graphics to support the decision-making process (this part could be made directly with COFAS software or similar).*

UPV highlighted that the most difficult part of the tool was estimating the relationship between each drainage system infrastructure and the variation of costs, electricity and water consumption with time. In order to make this estimation, the benefits and costs of each drainage system were separated into seven groups:

1. Drainage system infrastructure construction and maintenance.
2. Wastewater treatment (combined systems).
3. Stormwater treatment (separated systems).
4. Water supply savings.
5. Flood protection benefits.
6. Buildings insulation benefits.
7. Ecosystem services.

In addition, UPV identified that additional general data about the urban water and electricity supply, independent of the drainage system options, will be required.

2. Review of Existing Decision Support Tools

2.1. Existing Decision Making Tools: Overview

The availability and suitability of a number of water related decision support tools (DST) available in the public realm (and written in the English Language) was investigated. Two main sources of reference were used:

1. SWITCH Project decision making software, including COFAS (SWITCH, 2013).
2. USEPA green infrastructure modeling tools (USEPA, 2013a).

The SWITCH website includes four stormwater decision tools whilst the USEPA site includes fourteen. An initial review of the tools available was made to identify those which were applicable to the general parameters of the E^{2}STORMED DST. This first pass identified three tools from the USEPA website and two from the SWITCH Project website which were in general accordance with the DST specification (Table 2.1).

The evaluation of these tools against the proposed DST specification (Section 1.2, above) is provided in the following sub-sections.

Table 2.1. Decision tools shortlisted for further investigation.

Source	Tool
USEPA	Virginia Runoff Reduction Method
USEPA	Water Environment Research Foundation (WERF) BMP and LID Whole Life Cost Models
USEPA	EPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) Model
SWITCH	Comparing the Flexibility of Alternative Solutions (COFAS)
SWITCH	Selection Tool for Natural Wastewater Treatment Systems (SETNAWWAT)

2.1.1. Virginia Runoff Reduction Method

Table 2.2. Virginia Runoff Reduction Method: Compatibility with DST Criteria.

Compatibility with DST Criteria						
Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
✗	✗	✓	✗	✓[1]	✗	✗

[1] *Limited benefit; the tools outputs for volume calculation must then be applied to hydraulic models and programs to calculate peak discharges for various design storms.*

The Virginia Runoff Reduction Method (Virginia Department of Conservation and Recreation, 2013) is an Excel based tool which is designed to help users design combinations of a range of (but not all) SUDS for a particular site in order to meet quality and quantity standards. The tool comprises two spreadsheets, one for new developments and the other for redevelopment.

The tool uses Total Phosphorus (TP) as the target pollutant for compliance with Water Quality criteria. Total Nitrogen (TN) is also calculated and SUDS designs address TN removal, as well as the removal of other stormwater pollutants.

Asides from assessing the effectiveness of treatment train designs for a site, the tool also promotes the use of environmental site design (ESD), a method to maximise forest and open space cover (i.e. minimising impervious cover). Multiple sites can be incorporated within the design so that catchment based assessments of proposed schemes can be made.

Tool last updated: March 2011.

Table 2.3 Virginia Runoff Reduction Method: Summary.

Scale	User Input	Output	SUDS / Techniques
Site / Catchment	Annual Precipitation Land Cover Distribution Soil Type Distribution SUDS	Runoff Volume Reduction (ft3 /design storm) Phosphorus Load Reduction (lb/yr) Nitrogen Load Reduction (lb/yr)	Green Roof Downspout Disconnection Permeable Pavement Grass Channel Dry Swale Bioretention Infiltration Extended Detention Pond Sheet-flow to Filter Wet Swale Constructed Wetland Wet Pond

Potential for Incorporation within the E^{2}STORMED DST

The Virginia Runoff Reduction tool has a simple and well laid out user interface (Figure 2.1). Colour coded cells are used to indicate user input cells, calculation cells and constant values cells; this enables the user to easily understand how the tool works and is of particular use to non-technical or less experienced users.

The flexibility for assessment of multiple treatment trains is of particular use to the development of the DST; the user can define separate drainage areas. Techniques can be defined, and there is a detailed range of type and configurations of SUDS available (Figure 2.2). Not all SUDS techniques are included however this could be further developed to include all relevant techniques (and combinations).

The tool could be either incorporated within the DST or could be used to provide an initial drainage design prior to use of the DST.

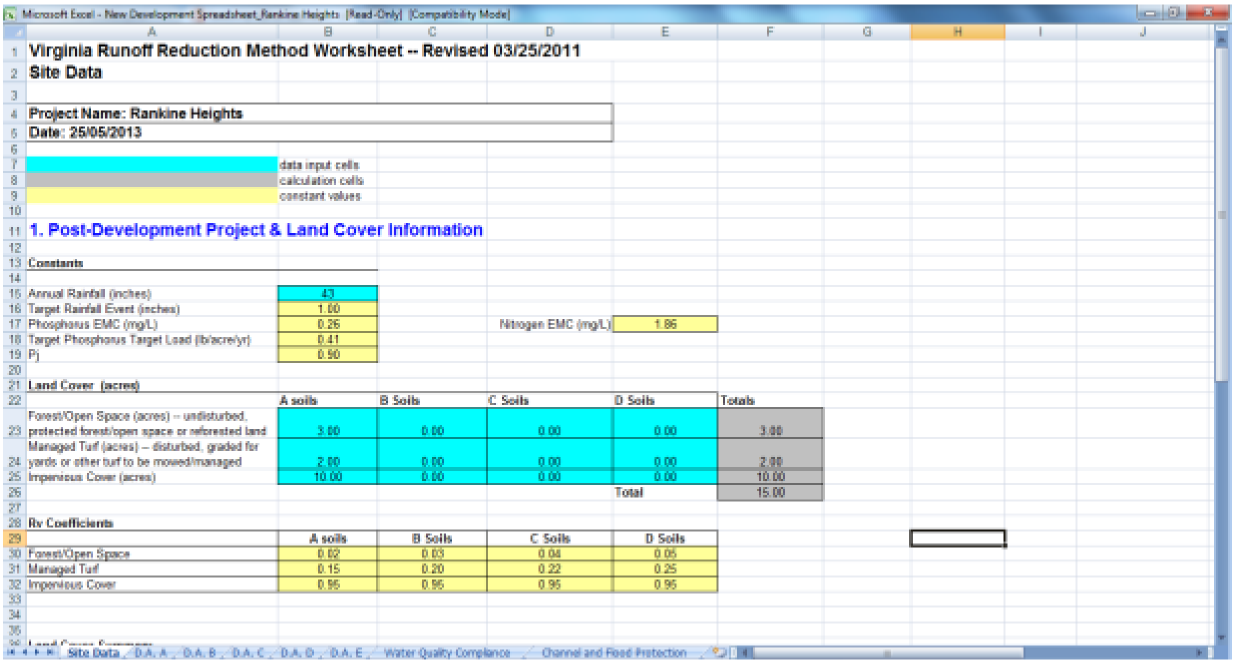


Figure 2.1 User Interface

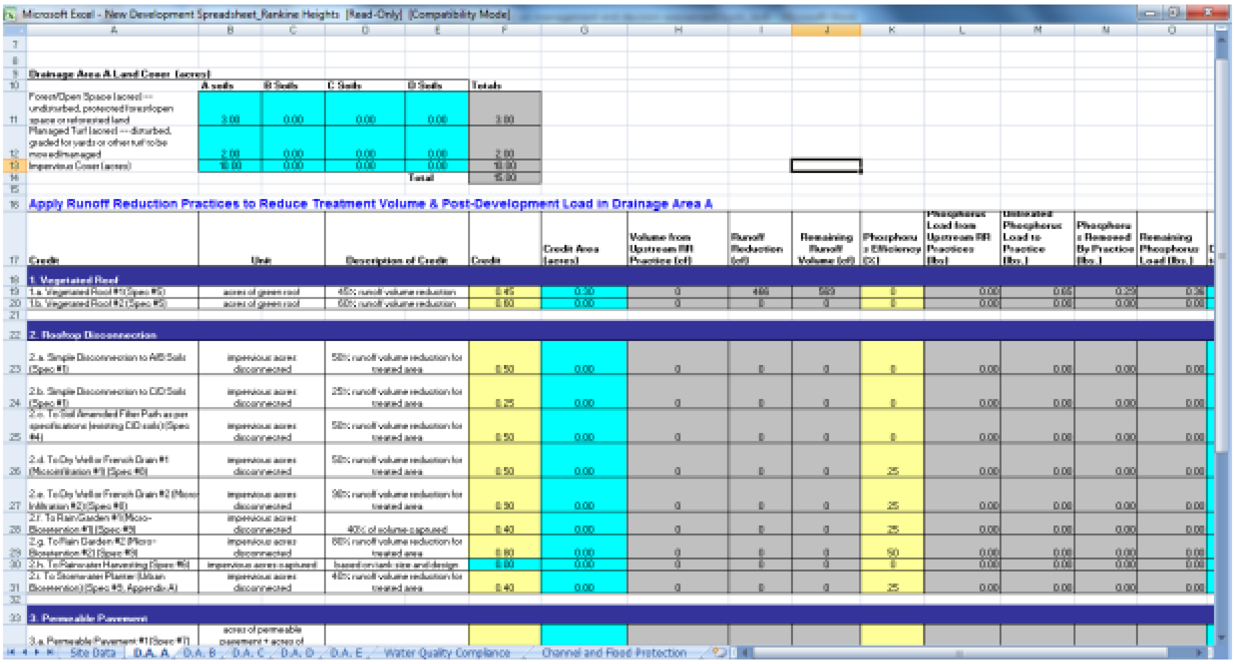
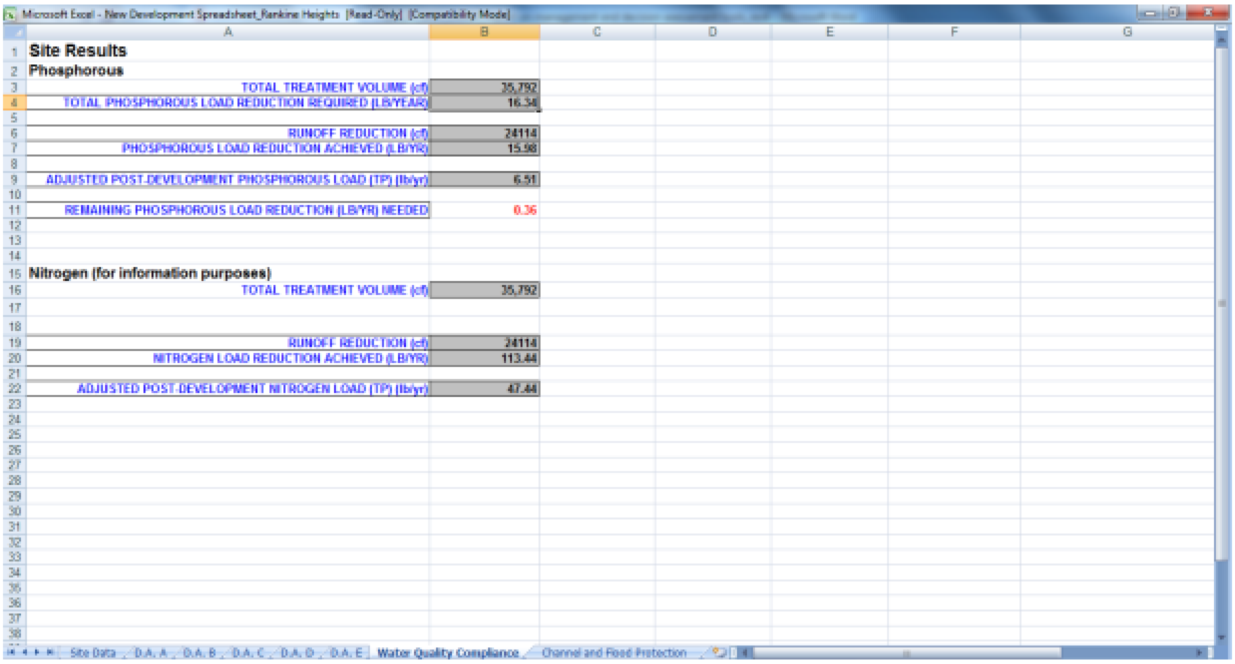


Figure 2.2 User defined catchment areas and choice of techniques for assembling treatment trains.

The key design of the tool is to match the level of pollution within the catchment with combinations of SUDS (treatment). This information is clearly shown in the *Water Quality Compliance* worksheet (Figure 2.3) which summarises the pollutant removal effectiveness of the treatment train so that the user can further refine the treatment train to suit. Similarly the *Channel and Flood Protection* worksheet (Figure 2.4) summarises the water quantity (flood reduction) benefits of the proposed scheme. This manner of input and output is intuitive to the user and it is anticipated that this functionality could be adopted and further refined to include energy use and efficiencies within the DST.

The volumetric calculations and water quality criteria refer to US targets and the relevant European equivalents would need to be used.

Whilst the general layout and functionality of the tool is clear it could be further improved by using clearer descriptions (and ensuring that these are common European English terms) and by reducing the number of acronyms used.

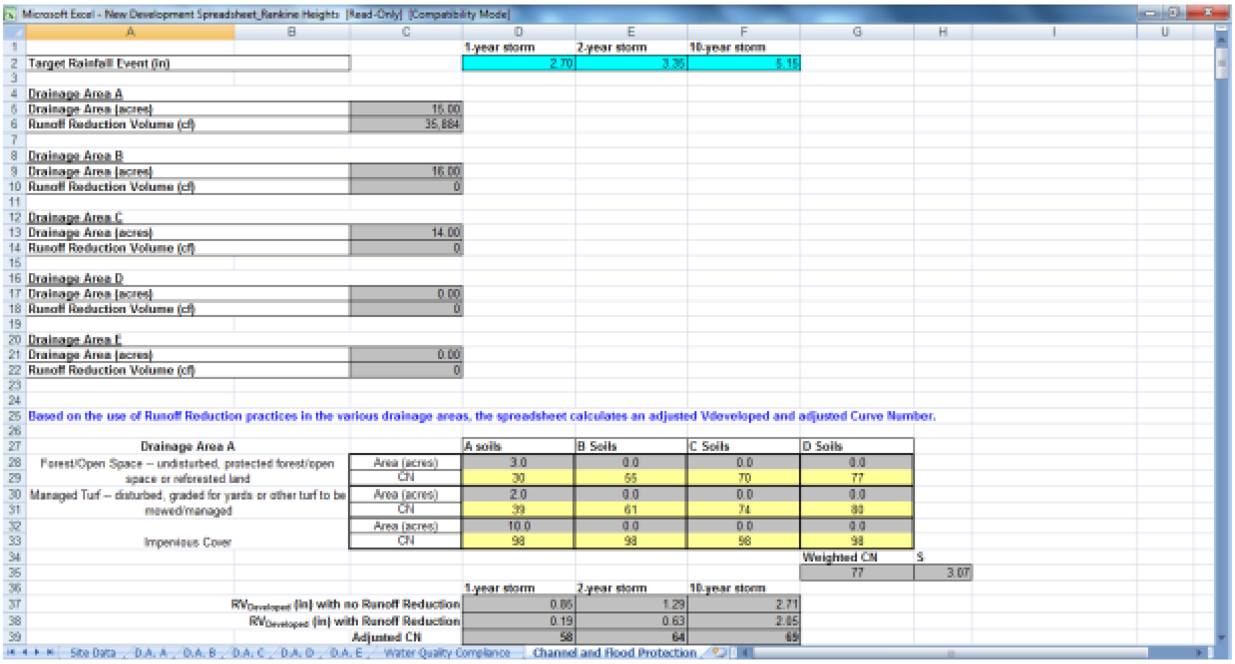


Microsoft Excel - New Development Spreadsheet_Rankine Heights [Read-Only] [Compatibility Mode]

	A	B
1	**Site Results**	
2	**Phosphorous**	
3	TOTAL TREATMENT VOLUME (cf)	35,792
4	TOTAL PHOSPHOROUS LOAD REDUCTION REQUIRED (LB/YEAR)	16.34
6	RUNOFF REDUCTION (cf)	24114
7	PHOSPHOROUS LOAD REDUCTION ACHIEVED (LB/YR)	15.98
9	ADJUSTED POST-DEVELOPMENT PHOSPHOROUS LOAD (TP) (lb/yr)	6.51
11	REMAINING PHOSPHOROUS LOAD REDUCTION (LB/YR) NEEDED	0.36
15	**Nitrogen (for information purposes)**	
16	TOTAL TREATMENT VOLUME (cf)	35,792
19	RUNOFF REDUCTION (cf)	24114
20	NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	113.44
22	ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TP) (lb/yr)	47.44

Site Data / D.A. A / D.A. B / D.A. C / D.A. D / D.A. E / Water Quality Compliance / Channel and Flood Protection

Figure 2.3 Water Quality Compliance worksheet clearly displays the effectiveness of the chosen treatment train to meet water quality criteria.



Microsoft Excel - New Development Spreadsheet_Rankine Heights [Read-Only] [Compatibility Mode]

	A	C	D	E	F	G	H
1			1-year storm	2-year storm	10-year storm		
2	Target Rainfall Event (in)		2.70	3.36	5.15		
4	Drainage Area A						
5	Drainage Area (acres)	15.00					
6	Runoff Reduction Volume (cf)	35,884					
8	Drainage Area B						
9	Drainage Area (acres)	16.00					
10	Runoff Reduction Volume (cf)	0					
12	Drainage Area C						
13	Drainage Area (acres)	14.00					
14	Runoff Reduction Volume (cf)	0					
16	Drainage Area D						
17	Drainage Area (acres)	0.00					
18	Runoff Reduction Volume (cf)	0					
20	Drainage Area E						
21	Drainage Area (acres)	0.00					
22	Runoff Reduction Volume (cf)	0					
25	Based on the use of Runoff Reduction practices in the various drainage areas, the spreadsheet calculates an adjusted Vdeveloped and adjusted Curve Number.						
27	Drainage Area A		A soils	B Soils	C Soils	D Soils	
28	Forest/Open Space -- undisturbed, protected forest/open	Area (acres)	3.0	0.0	0.0	0.0	
29	space or reforested land	CN	30	55	70	77	
30	Managed Turf -- disturbed, graded for yards or other turf to be	Area (acres)	2.0	0.0	0.0	0.0	
31	mowed/managed	CN	39	61	74	80	
32		Area (acres)	10.0	0.0	0.0	0.0	
33	Impervious Cover	CN	98	98	98	98	
34						Weighted CN	S
35						77	3.07
36			1-year storm	2-year storm	10-year storm		
37	$RV_{Developed}$ (in) with no Runoff Reduction		0.86	1.29	2.71		
38	$RV_{Developed}$ (in) with Runoff Reduction		0.19	0.63	2.05		
39	Adjusted CN		58	64	65		

Site Data / D.A. A / D.A. B / D.A. C / D.A. D / D.A. E / Water Quality Compliance / Channel and Flood Protection

Figure 2.4 Channel and Flood Protection worksheet

2.1.2. Water Environment Research Foundation (WERF) BMP and LID Whole Life Cost Models

Table 2.4 WERF BMP and LID Whole Life Cost Models: Compatibility with DST Criteria.

Compatibility with DST Criteria						
Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
✓	✗	✓	✗	✗	✗	✗

The WERF BMP and LID[2] Whole Life Cost Model (WERF, 2009a) is a series of Excel spreadsheets, each of which is specific to one SUDS technique. It provides detailed analysis of capital costs, maintenance and whole life costs for a number of (although not all) common SUDS techniques. Cost models are based primarily on green infrastructure and there is limited provision for proprietary devices (only cisterns). Costs are derived by inputting specific details including design, maintenance hydraulic design. Output cost data is in $US.

The tool provides cost data for construction and maintenance and has a flexible interface; the latter allows the user to specify levels of maintenance. Cost data is provided for some basic maintenance activities however detailed information (activity, frequency & cost) must be input by the user; this would require detailed local datasets and operational specifications.

Tool last updated: 2009.

Table 2.5 WERF BMP and LID Whole Life Cost Models: Summary.

Scale	User Input	Output	SUDS / Techniques
Plot / Site / Catchment	Drainage Area SUDS Characteristics Capital Costs Maintenance Costs	Whole Life Costs Present Value Graphs	Green Roof (extensive) Planters Permeable Pavement Rain Gardens Retention Ponds Swales Cisterns Bioretention Extended Detention Basins

[2] *BMP: (Best Management Practices) & LID (Low Impact Developments) American terms for SUDS on site/regional and source scale respectively.*

Potential for Incorporation within the E^{2}STORMED DST

The spreadsheets permit the user to calculate either a generic assessment or a site specific assessment (Figure 2.5); this could be a particularly useful inclusion within the DST. The generic assessment provides a quick estimate of benefits and requires the user to enter basic information, such as system size, drainage area, and system type; this would be useful for feasibility and/or planning assessment. The site specific assessment requires the user to input more detailed information to gain more accurate cost data and is appropriate for use at the detailed design stage.

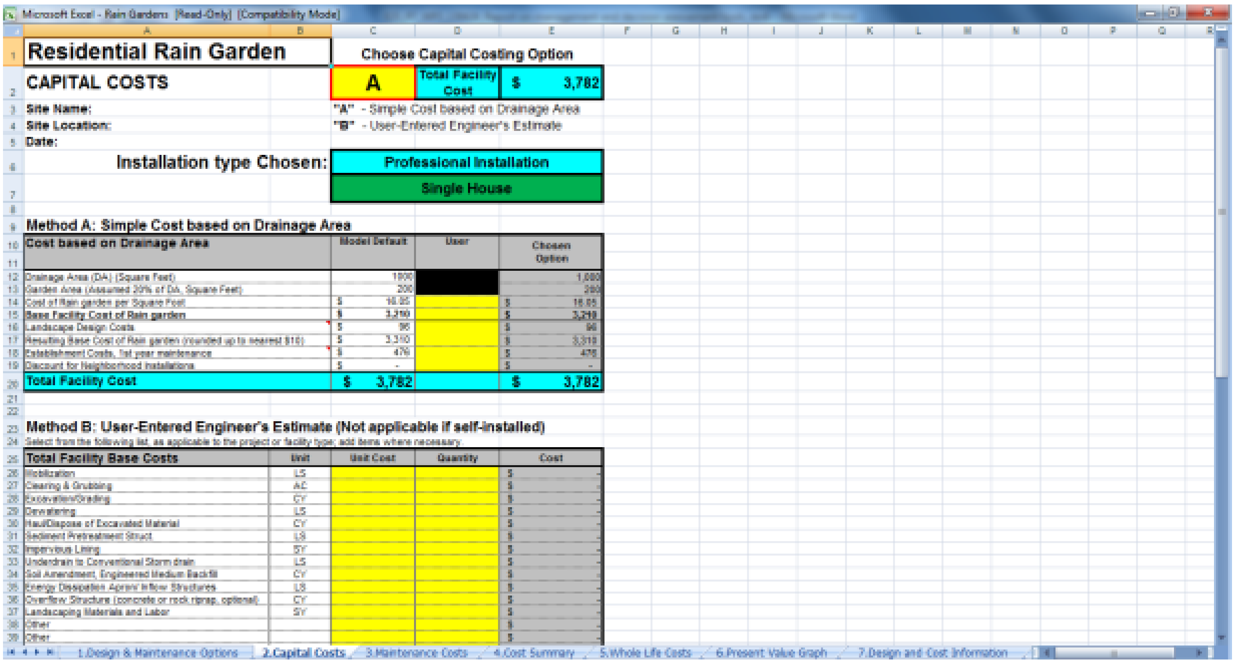


Figure 2.5 Deriving the schemes capital cost; quick estimate (method A) or detailed calculation (Method B)

The WERF tool dataset does not provide detailed information for all construction and operation costs; whilst they cover the top line items, to obtain detailed costings the user must enter their own data. The Users Guide (WERF, 2009b) acknowledges that:

The accuracy of the cost data is limited to those sources identified in the reference section of the spreadsheet...in order to determine if the cost estimates generated by the tool are appropriate for an application, the user should refer to the references and review the original source information. The amount of data available, the specificity of the elements included in a cited cost, the geographic region of the country where a cited project is located, and the scale of the cited projects may make the estimates in the cost tool inappropriate for some user's specific needs.

This may limit the appropriateness for inclusion in the DST as it is anticipated that a more detailed and expansive cost database would be required. However the process in which the tool calculates the whole life costs and calculates the net present value (and displays as numerical and graphical outputs) would be beneficial to include in the DST.

The spreadsheets are designed as a standalone assessment tool and there is no way to link different combinations of SUDS to assess cost savings for construction and operation of treatment trains.

Constructing more than one SUDS for a scheme typically lends to economies, whether of scale, set up costs, etc. However, using the WERF tool would likely result in an over-estimation of the WLC, albeit this is acknowledged to be more preferable than under-estimation. This could limit the value of the tool as a basis for the DST to estimate realistic costs for proposed schemes, unless the tool is further developed.

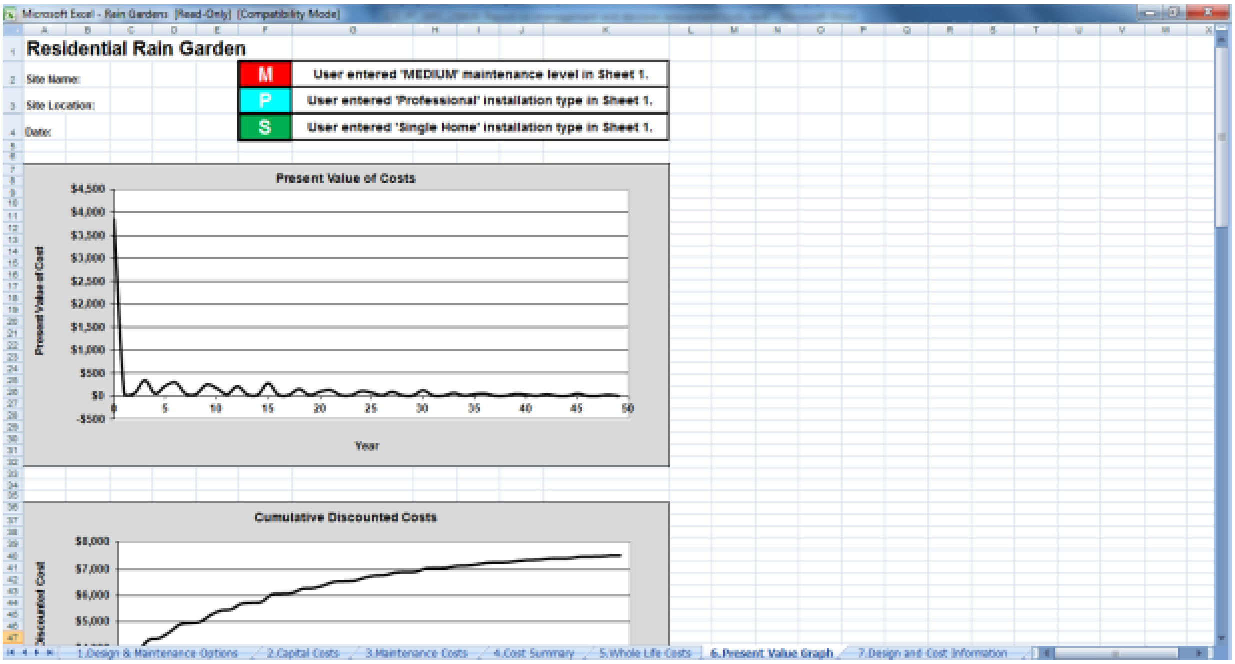


Figure 2.6 Present value and cumulative discount costs for a raingarden shown in graphical format.

2.1.3. EPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) Model

Table 2.6 SUSTAIN Model: Compatibility with DST Criteria.

Compatibility with DST Criteria						
Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
✓	×	✓	×	✓	×	×

The SUSTAIN Model (USEPA, 2013b) is a decision support system to facilitate selection and placement of SUDS at strategic locations in urban watersheds. The tool allows the user to optimise combinations of SUDS on a plot, site or catchment scale. It provides specific information on:

- Effectiveness of SUDS to reduce pollution within runoff.

- The most cost effective techniques to meet water quality and quantity objectives.
- Type, location and size of particular SUDS for a location.
- Cost estimates for SUDS construction (using a pre-determined dataset or the user can input their own values).

The tool provides information for most SUDS techniques but does not cover proprietary systems.

SUSTAIN is a bespoke software and requires the use of additional specialised GIS software. Consequently this review of the tool has been based on available literature.

Tool last updated: January 2013.

Table 2.7 SUSTAIN Model: Summary.

Scale	User Input	Output	SUDS / Techniques
Plot / Site / Catchment	Varies	Cost estimation SUDS treatment train optimisation Flow and pollutant removal efficiencies	Bioretention Constructed Wetland Dry Pond Grassed Swale Green Roof Infiltration Basin Infiltration Trench Porous Pavement Rain Barrel Sand Filter (non-surface) Sand Filter (surface) Vegetated Filter strip Wet Pond

Potential for Incorporation within the E^{2}STORMED DST

The SUSTAIN tool is an extensive software package contains a number of features which may be applicable to the development of the DST. It could be used as the initial step to design the drainage network prior to application of the DST.

GIS is used in conjunction with the tool to identify the best location and use of SUDS for the developable area; this can be on a plot, site or catchment scale (Figure 2.7). This could be included into the DST as a quick selection tool to match suitable techniques to land areas/uses.

SUSTAIN also has other modules including a simulation module, which models the hydraulic and pollutant removal efficiencies of the treatment train, and these may be useful options for the DST development, however may it would depend upon the proposed functionality of the tool. It is unlikely given the duration of the project that the development of a detailed DST covering all areas in detail is feasible.

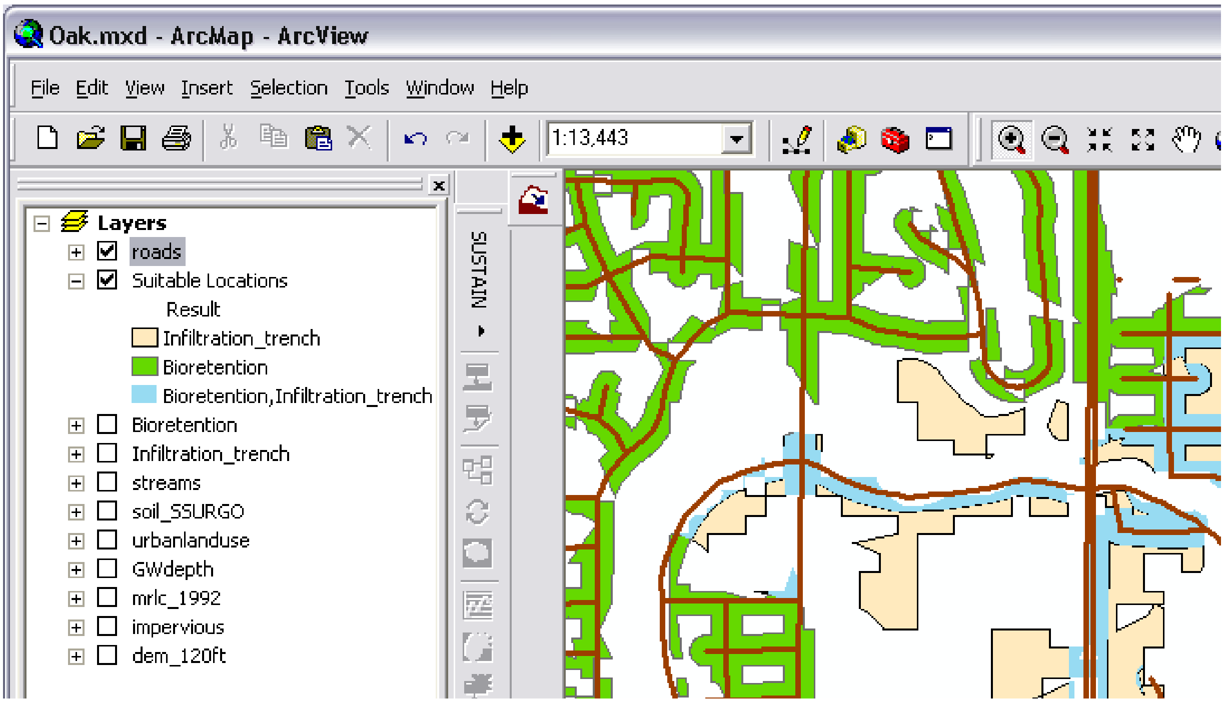


Figure 2.7 BMP (SUDS) Siting tool to optimise the use of specific techniques within the catchment.

2.1.4. Comparing the Flexibility of Alternative Solutions (COFAS)

Table 2.8 COFAS: Compatibility with DST Criteria.

Compatibility with DST Criteria						
Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
✓	✓	✓	×	×	×	×

The COFAS Tool is a decision support tool which allows that comparison of a range of stormwater techniques over a range of scales. According to Peters *et al*. (2010) COFAS assesses the flexibility of different stormwater drainage designs incorporating future changes / drivers may have on the system:

"*These different future change drivers…may affect the design and operation of urban stormwater management systems*".

Such changes include increase / decrease in population, change of impermeable surface area, effects of global warming, etc. and their inclusion allows decisions to be made regarding long term investment in infrastructure.

COFAS compares different scenarios using a range of criteria and ranks them in order of preference. The user can generate their design options within the tool.

Tool last updated: January 2010.

Table 2.9 COFAS Tool: Summary.

Scale	User Input	Output	SUDS / Techniques
Plot / Site	Peak and average loads for NH4, COD, P	Runoff Volume peak flow	User defined criteria, can include grey infrastructure

Potential for Incorporation within the E^2STORMED DST

COFAS allows the user to compare the homogeneity of different drainage systems with user defined criteria; this offers a great deal of flexibility and meets the objectives of the DST.

The user interface of the tool is not particularly intuitive, or user friendly (Figure 2.8). Conversely the information output is very good and can be shown in range of formats including numerical, bar chart, or sector diagrams (Figure 2.9). The output option is deemed as advantageous as it could assist communication of the order of preference of the flexibility/adaptability of options to stakeholders.

COFAS provides only a comparison of options and does not include cost information or match the other DST criteria.

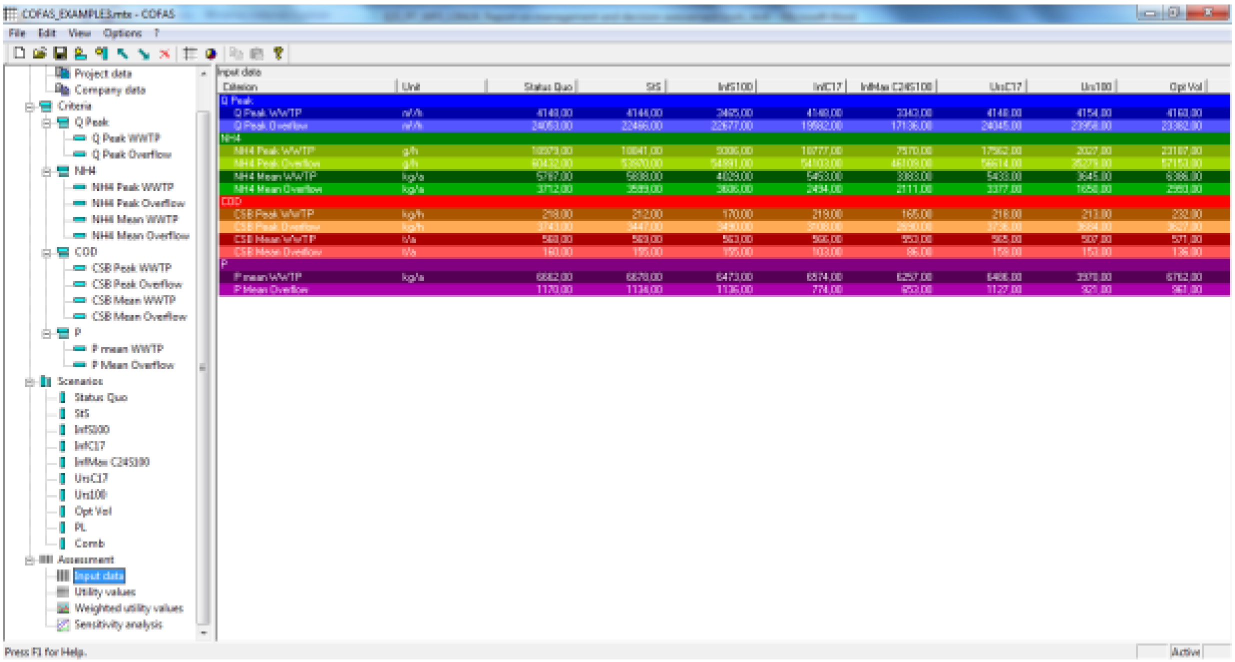


Figure 2.8 COFAS User interface

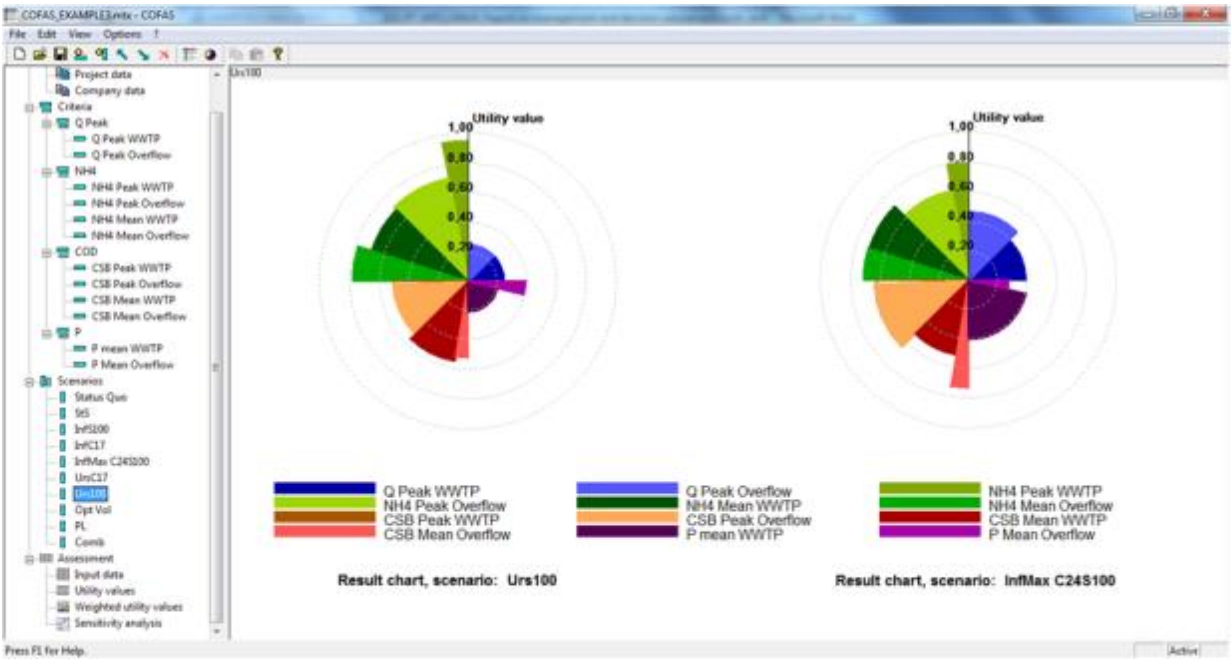


Figure 2.9 Sector diagram output showing the least preferable (left) and most preferable (right) options.

2.1.5. Selection Tool for Natural Wastewater Treatment Systems (SETNAWWAT)

Table 2.10 SETNAWWAT: Compatibility with DST Criteria.

Compatibility with DST Criteria						
Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
✓	✓	×	×	×	×	×

SETNAWWAT is an Excel based tool which evaluates treatment trains for wastewater using a defined set of criteria ranging from technical, economic and social criteria and ranks them in the order of preference.

The model is a non-technical tool which does not require the user to have specialised knowledge of wastewater design to use. It contains a list of pre-defined treatment trains for simplicity, and there is also the option for users to create their own.

The installation files were not available to freely download – these must be requested from the developer.

Table 2.11 SETNAWWAT Tool: Summary.

Scale	User Input	Output	SUDS / Techniques
Plot / Site	Extensive, includes: demographic data, hydro-meteorological data, wastewater characteristics, technical and economic data, topographic data, and socio-cultural aspects.	Effluent quality: BOD, TN, TP, SS, FC, Construction and O&M costs Land requirement	Most widely used natural system units for wastewater treatment, including: Constructed Wetlands Anaerobic Ponds Facultative Ponds Maturation Ponds Facultative aerated lagoons Primary Treatment Sedimentation Tank

Potential for Incorporation within the E^{2}STORMED DST

The SETNAWWAT tool does not assess surface water systems; however it is a highly flexible user driven tool which could provide a basis for the development of the DST.

The tool has been designed so that the user, in addition to designing the treatment train, can define the assessment criteria, and the level of importance (weighting) of each. This produces detailed and specific comparisons of the treatment train options.

3. Developing the DST: Conclusions

The decision support tools reviewed within this report all offered a range of benefits for water asset decision making and planning. All tools were surface water decision tools except SENAWATT which is for wastewater. A summary of the tools reviewed is provided in Table 3.1.

The review provides a basis on which to make recommendations for the E^{2}STORMED DST development, and it has also identified a number of challenges; these are discussed in the following sections.

Table 3.1 Summary of Tool Compatibility with DST Criteria.

	Drainage system infrastructure construction and maintenance	Wastewater treatment (combined systems)	Stormwater treatment (separated systems)	Water supply savings	Flood protection benefits	Buildings insulation benefits	Environmental services
Virginia Runoff Reduction Method	×	×	✓	×	✓	×	×
WERF BMP and LID Whole Life Cost Models	✓	×	✓	×	×	×	×
EPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN)	✓	×	✓	×	✓	×	×
Comparing the Flexibility of Alternative Solutions (COFAS)	✓	✓	✓	×	×	×	×
Selection Tool for Natural Wastewater Treatment Systems (SETNAWWAT)	✓	✓	×	×	×	×	×

3.1. User Interface

E^{2}STORMED aims to embed knowledge and understanding of best practice in water management combined with energy use and efficiencies, and for some partner countries these areas may be regarded as new technologies and challenges. The DST is intended to provide support to decision makers within Local Authorities and it is realistic to assume that the users will be of mixed skill and knowledge levels; consequently it is important that the user interface is simple and easy to understand so that the DST is used in practice.

The Virginia Runoff Reduction Method illustrates the use of a simple and intuitive interface, and the DST could adopt a similar approach. In order to minimise resistance to adoption of the DST it is important that the use of jargon and acronyms is limited, and information is presented in a manner which is easily understood.

3.2. Scale

The tools reviewed all worked on different scales (plot / site / catchment). Treatment trains can vary from a single plot basis (e.g. green roof and soakaway) to extensive large scale systems which cover many hectares. The development of the DST should ensure that it can provide assessment and guidance for the selection of standalone and multiple asset treatment trains at plot, site and a regional level; this will provide the Local Authority users with a flexible tool suitable for all catchments.

The WERF and SUSTAIN tools both offer the user the flexibility for design at all scales however only SUSTAIN allow comparison of treatment trains; this is an essential function of the DST.

3.3. Incorporating Energy Use and Efficiency Criteria within the Model

None of the decision tools reviewed included energy use and efficiency criteria. Other sources for energy efficiency assessment, at plot (building) level and on a larger scale will need to be investigated and incorporated within the proposed DST.

One source which could be used for this purpose is the assessment of SUDS is the 'SUDS for Roads Whole Life Costs and Whole Life Carbon Toolkit'; this is a recent tool (2012) and includes both costing and carbon data for a wide range of SUDS techniques.

3.4. Cost Data

There will be variation between regions and nations regarding costs and it is not realistic to assume that individual cost models could be prepared for each partner country within the duration of the project. A more appropriate method for the DST cost models could be to use a single, comprehensive dataset, with the functionality for the user to review (similar to the WERF tool) and amend with their own local data for variations in costs, including land cost, labour rates, etc..

Cost data used within the model should also include detail of the payback period for water and energy efficiency measures; this may be particularly important where single households (as opposed larger municipal, commercial or industrial units) are being developed so that the developer and other stakeholders have clear understanding of the impact on the marketable value of the units.

It may also be pertinent to consider the level of detail required; whether the DST is to provide outline or detailed design (and costs) similar to that included within the WERF tool.

3.5. Compatibility

The DST should be a freely available and developable guidance tool which does not restrict user access to calculations sheets, source code or datasets; this will ensure that the tool is adopted for use and provides opportunity for further refinement to meet specific national or organisational needs.

Most of the reviewed models use Microsoft Excel (and Excel Visual Basic for Applications, VBA) which lends to usability and means that the tool can be easily adapted and further developed.

It is also important that the DST is a standalone tool and does not require the use of other software to function. This does not preclude the use of other software applications to support the DST, but any such functionality should either incorporate freeware or freely accessible cloud based tools.

3.6. FLEXIBILITY

SETNAWWAT provides the user with a range of predefined treatment trains and also the functionality to create new treatment train combinations. This type of flexibility may be useful for the DST, providing a quick start for common combinations of techniques, for example in plot soakaways and porous driveways to manage runoff at source, or the use of green roof types and /or rain water harvesting units for commercial and municipal buildings. This, combined with a 'treatment train assembler' would allow the user to quickly assemble SUDS to build a treatment train which the DST could then analyse and produce energy and other benefits.

The decision tools reviewed offered a varied range of SUDS techniques which could be assembled into treatment trains however no single tool offered the full complement of SUDS techniques. One area that was deficient in almost all tools was proprietary SUDS devices. The DST should as a minimum contain information and datasets for all established SUDS techniques, preferably in accordance with CIRIA C697 *The SUDS Manual*. There should also be functionality to include proprietary devices; this would likely require detailed input given the wide range and effectiveness of existing devices and the current deficit in available guidance. This would allow the user to update the DST should new devices come to market.

The DST should also take into account whether the proposed scheme is a new development or a retrofit (redevelopment). The latter will influence which SUDS techniques can be used, energy efficiencies achieved, costs, etc. New developments commonly offer more flexibility to the designer than redevelopment and retrofit projects, which due to existing conditions often reduce the types of SUDS techniques which can be used.

Using green roofs as an example; retrofit (e.g. Benaguasil) may restrict the roof type specified based upon existing structural conditions of the building. In many retrofit examples, green roofs tend to be extensive sedum based systems as they are lighter and thus easier to incorporate. However this roof type will have different hydraulic, treatment and energy benefits than semi-intensive or intensive roofs which could be specified for a new build.

3.7. OUTPUTS

Information produced by the DST should be available in a number of output formats to ensure stakeholders understand and engage with the recommendations. The COFAS tool illustrates how a number of output techniques can be produced, yielding numerical, graphical and diagrammatic outputs. Permitting the user to define the output type (in addition to the treatment train) would ensure that the most suitable means to communicate the information from the tool is used.

Providing a choice of information output types would be useful, particularly where there are many different users who may require simple or more detailed outputs. The consultation stage of any design process typically involves discussion with technical and non-technical stakeholders and it is important that information is clearly and simply communicated.

Whilst the development of the tool is predominantly based on energy savings and efficiencies in the water cycle this should not be irrespective of cost. The development of the tool should include a means to compare multiple criteria so that comparisons of the energy efficiency and other benefits of different drainage techniques (and combinations) can be easily compared.

Typically, decision analysis within organisations is carried out using a range of techniques, the Department for Communities and Local Government identify common analysis processes include:

- Cost effectiveness analysis (CEA): a process which assesses similar options (based upon cost) to achieve a known objective which cannot be given a monetary value.
- Cost benefit analysis (CBA): a process which allows the comparison of different options including those which do not have traditional (monetary) market values by assigning values using appropriate mechanisms, for example willingness to pay. This process permits comparison of such things as environmental and social benefits.

Both CEA and CBA are recognised as effective tools for the decision making however they are not effective to assess disparate options particularly when monetary values cannot be easily or realistically assigned; subsequently these processes have limited use when considering the range of criteria specified for the E2STORMED decision support tool.

Use of an alternative assessment process is required so that complex information and designs can be assessed in a fair and transparent manner. Multiple criteria analysis (MCA) is an established process which can be used to assist decision makers when comparing different complex options. It should be noted that MCA is not intended to make decisions, rather to guide decision makers to make the most appropriate choice.

MCA techniques can be used to identify a single preferred plan, to rank options, as short-listing tools to select options for more detailed assessment, or to differentiate acceptable and unacceptable plans. MCA techniques generally include the use of weighted and scored matrices, and hence require the establishment of measurable criteria, whether qualitative or quantitative, to assess the extent to which objectives may be fulfilled (Environment Agency, 2013).

There are many MCA techniques available and their suitability for specific applications has been the subject of much debate (Department for Communities and Local Government, 2009). The MCA process involves a number of steps which is summarised in Figure 3.1.

The decision support tools reviewed in this document incorporate mechanisms to assess the suitability of the selected options. In particular, Peters et al. (2010) identify the unitary value (UV) form of multicriteria analysis as the most appropriate mechanism for assessing multiple drainage design options for the COFAS tool.

Based upon this existing review it may be advantageous to adopt the unitary value MCA process for the E2STORMED decision support tool to provide an aggregated value for benefits, particularly (but not limited to) energy efficiency and costs (including both capital and operational expenditure). Whilst it could be argued that hydraulic efficiency should also be a key criterion it is more likely that any treatment train that does not satisfy volumetric requirements would be discounted before applying a MCA.

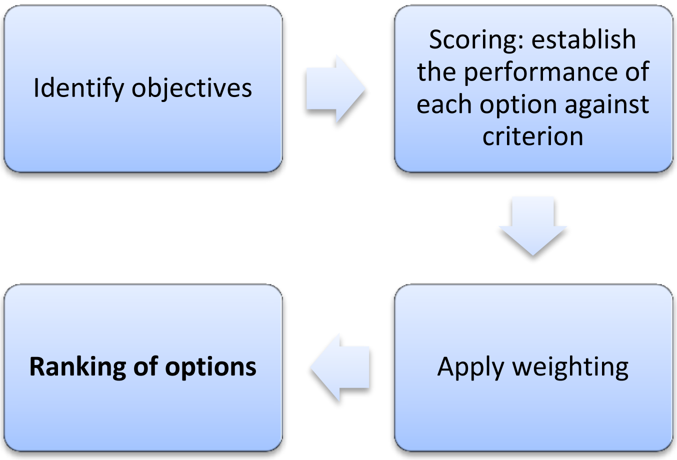


Figure 3.1 *Multicriteria analysis process overview*

3.8. Complexity

The scope of the DST is to provide guidance on the design of water infrastructure to minimise energy use and increase efficiencies. The review of existing support tools has highlighted that there are tools which offer guidance on one specific area, for example the WERF model yields whole life cost information, and those which purport to cover a range of design and assessment modules such as the SUSTAIN tool.

The exact outputs of the DST should be considered carefully and consider the main goal of understanding energy use and efficiencies in the water cycle. There are a number of powerful but complex stormwater (and other water resource) software packages available which can create detailed hydraulic models which can be simulated under a range of rainfall conditions however a balance of outputs should be made ensuring that the DST does not become unwieldy and deter users.

The DST must cover the key functionality as proposed within the initial scope issued by UPV. The review has highlighted that the water volume and cost criteria are reasonably well covered but there are considerably less examples of water decision tools which provide information of environmental services, building insulation benefits, water supply savings, and even flood protection benefits. In such examples advice should be sought from energy and other relevant specialists.

3.9. UNDERSTANDING COMPLEX BENEFITS

Whilst there are many examples of single (standalone) SUDS in use, it is recognized that to deliver water quality and quantity benefits, a series of SUDS (a treatment train), is best used. Treatment trains can incorporate a number of different SUDS techniques and in different sequences, to meet the needs of each site.

Comparing the potential benefits between two treatment trains may not be simple (unless comparing two standalone SUDS techniques). It is possible to calculate some benefits, for example the hydraulic design will provide detail of runoff volumes removed from the sewer, reduction of flood risk, etc.

Similarly, understanding the complex benefits for criteria such as energy efficiency and pollutant removal is significantly more challenging. Taking pollutant removal efficiency within SUDS as an example, there are studies and guidance available on the pollutant removal effectiveness of most SUDS techniques but these are predominantly standalone techniques and there is no current means to quantify the actual performance when two or more techniques are used within a treatment train. Jefferies *et al* (2009) investigated the pollutant removal benefits of using different combinations of SUDS techniques to achieve water quality criteria in treatment trains in Scotland. The output was the *SUDS Treatment Train Assessment Tool* (STTAT) which indicated the suitability of different treatment train combinations to different catchment conditions. STTAT provides guidance, but not a definitive answer to the problem, ranking the suitability of treatment trains. The development of STTAT followed a logical path, based upon informed assumptions from literature (and experience of the authors), and not on performance data and cannot be considered as definitive tool.

Development of the DST will need to overcome the challenge of quantifying complex benefits and the current lack of data in this area; this is applicable to treatment, energy and cost.

It is also important that proposed schemes are realistic, and importantly *survivable* and *efficient.* It is possible that schemes appear to satisfy criteria at the design stage, however the actual techniques used, how they are detailed, and their sequence within the treatment train can make a great difference to the ongoing operational (OPEX) costs and can reduce the operational life of the scheme.

REFERENCES

Department for Communities and Local Government, 2009. *Multi-criteria analysis: a manual.* [Online]
Available at: www.communities.gov.uk

Environment Agency, 2013. *Multi Criteria Analysis (MCA).* [Online]
Available at: http://www.environment-agency.gov.uk/research/policy/32929.aspx

Jefferies, C. y otros, 2009. Sustainable Urban Drainage Systems (SUDS) treatment train assessment tool. *Water Science & Technology,* 60(5), pp. 1233-40.

Peters et al., 2010. *Deliverable 2.1.4: Assessing future uncertainties associated with urban drainage using flexible systems – the COFAS method and tool.* [Online]
Available at: http://www.switchurbanwater.eu/outputs/pdfs/W2-1_GEN_MAN_D2.1.4_Assessing_future_uncertainties_urban_drainage_COFAS.pdf

SWITCH, 2013. *Stormwater: Exploring the options.* [Online]
Available at: http://www.switchurbanwater.eu/res_software.php#24

USEPA, 2013a. *Green Infrastructure Modelling Tools.* [Online]
Available at: http://water.epa.gov/infrastructure/greeninfrastructure/gi_modelingtools.cfm

USEPA, 2013b. *SUSTAIN. System for Urban Stormwater Treatment and Analysis IntegratioN Model. United States Enviromental Protection Agency..* [Online]
Available at: http://www.epa.gov/nrmrl/wswrd/wq/models/sustain/
[Accessed 18 6 2013].

Virginia Department of Conservation and Recreation, 2013. *Runoff Reduction Method.* [Online]
Available at: http://www.dcr.virginia.gov/other/deq/laws_and_regulations/lr2f.shtml

WERF, 2009a. *BMP and LID Whole Life Cost Models: Version 2.0. Water Environment Research Federation.* [Online]
Available at: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

WERF, 2009b. *SW2R08. User's Guide to the BMP and LID Whole Life Cost Models. Version 2.0. Water Environmental Research Federation.* [Online]
Available at: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

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