PROPER DECISION SUPPORT SYSTEM

USER GUIDE

DELIVERABLE 3.4

CEDR PROPER PROJECT

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Executive summary

This report is the fourth deliverable of WP3 (Sustainable assessment of measures and treatment systems for road runoff) of the CEDR PROPER project. It directly compliments PROPER Deliverable 3.3 (the PROPER decision support system; DSS) and PROPER Deliverable 3.5 (PROPER DSS technical manual) by describing each of the four components of the MS Excel-based PROPER DSS tool:

- Site criteria: which enables the user to perform an initial screening of the suitability of 12 different SUDS/BMPs based on site specific data
- Performance matrix: provides the opportunity for the user to use criteria/indicator weightings and default grades to determine the relative performances of 12 SUDS/BMPs against specific criteria/indicators; alternatively the user has the opportunity to enter their own weightings and/or grades
- Results overview: this page of the DSS displays the results of the performance criteria analysis in both numerical and graphical representations
- Alternative treatments: which enables the user to comparatively assess the performances of non-specified sustainable treatment systems or proprietary products in a consistent manner.

The descriptions of each of the components are accompanied by a series of 'screen shots' of appropriate pages of the DSS tool together with supporting text on how to use it, effectively providing the user with a step-by-step guide to implementing the PROPER DSS. Users wishing to understand the scientific and technical rationale underpinning the grades allocated within the performance matrix or to modify the allocated grades to suit local conditions are referred to the PROPER DSS technical manual for a full description of the approaches used to develop and allocate grades per indicator for the different SUDS/BMPs.

Acknowledgements
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1. Introduction

This User Guide supports the Excel based Decision Support System (DSS) (PROPER Deliverable 3.3) which has been designed for the PROPER project with the aim of comparatively assessing the performances of different SUDS/BMPs with regard to their ability to reduce the impacts of highway runoff. The DSS identifies the criteria and individual indicators which are important in determining the overall performance of each SUDS/BMP and allocates grades of between 1 and 5 based on a comprehensive assessment of the appropriate performance characteristics. The procedures by which the performance criteria grades are derived are fully described in the Technical Guide which is available as PROPER Deliverable 3.5. The Excel based DSS tool can be operated using the pre-entered default values (for criteria and indicator weightings; and performance grades) or the user is allowed to enter their own weightings and grades (as described in Section 2.2.2).

The PROPER DSS tool consists of four separate components which are identified below together with brief descriptions of their role and purpose. The front page of the tool allows the user to access pdf versions of both this User Guide and the Technical Manual, which are both important components of the PROPER Decision Support Tool.

- Site Criteria (see Section 2.1):

This component within the DSS enables the user to perform an initial site screening operation to establish the prevailing site conditions which may influence the suitability of a particular SUDs/BMP to be installed and may influence its ability to efficiently reduce the impact of the incoming highway runoff. The site screening characteristics incorporated into the DSS include the existence of sensitive groundwater zones, soil type, groundwater depth, the effective contributing drainage area and the traffic volume on the highway draining to the treatment system. The determination of the parameters associated with the site screening characteristics reliance has been based on the existing UK recommendations. These are consistent with those adopted by several other European countries but there are others, particularly with regard to the identification of groundwater protection zones, for which they may appear to be either too conservative or too lenient. However, by referring to the definitions provided in Chapter 2 of this User Guide it is possible for users to select comparable conditions which are the most pertinent to their situation.

- Performance Matrix (see Section 2.2):

This component of the DSS contains the Excel database which incorporates the performance grades (default or user selected) allocated to a set of six controlling criteria (and sub-indicators) which enable the SUDs/BMPs to be prioritised in terms of their preferential ability to reduce the impact of highway runoff in a particular location.

- Results Overview (see Section 2.3)

This component allows the user to see the relative overall scores achieved by the different treatment systems together with a bar chart representation of these scores. In addition, a colour allocation identifies the suitability of the treatment system according to the previously entered site characteristics.

- Alternative treatment (see Section 2.4):

This component of the DSS enables the user to input the site characteristics and performance grades to assess the performance of a non-specified treatment system, such as a manufactured proprietary treatment device or a different sustainable treatment system.

1.1. Advantages of the PROPER DSS

The PROPER DSS contains data for 12 different SUDS/BMPs and allows the user to utilise an extensive database in a consistent way to identify the single most preferred treatment option, to prepare a shortlist or ranking of the different treatment options, and/or to distinguish between acceptable and unacceptable treatment possibilities. There is also the option to assess the abilities of additional non-specified treatment systems. Through the provision of a 'bigger picture" in relation to the merits of different treatment options, the PROPER DSS is able to facilitate pertinent discussions thereby increasing the transparency of the decision-making process and contributing to making it fully auditable.

1.2. The performance matrix

The performance matrix uses multi-criteria analysis to assess how a range of possible solutions performs in relation to a range of criteria and/or indicators. In the PROPER DSS, the solutions are SUDS/BMPs and the criteria include 'Technical', 'Environmental', 'Operation and Maintenance', 'Socio-environmental awareness', 'Economic' and 'Legal and highway planning' aspects' with the indicators providing more detailed discriminators for each of the criteria (e.g. 'flood control', 'pollution control' and 'adaptability to highway widening and climate change' for the Technical criterion). The performance matrix incorporates weightings which reflect the relative importance of each criterion/indicator in the highway environment enabling a multi-criteria analysis to sort the different SUDS/BMP options into an order of preference according to their ability to meet the required treatment performance. It is important to point out that the generated results are not directly comparable in terms of the values produced i.e. the performance matrix can predict which option is most preferable, but cannot identify how much better one option one is compared to another. The PROPER DSS has been designed specifically for individual, "stand-alone" SUDS/BMPs located within the highway environment for the treatment of highway runoff and would not be appropriate for other catchment types such as a mixed urban land use catchment or an intensive residential area.

2. Components of the DSS

2.1. Site screening characteristics

The site screening characteristic component of the PROPER DSS enables an initial identification regarding the suitability of an individual SUDS/BMP for use in a particular highway environment. According to the level of suitability, the background to the SUDS/BMP name is coloured either 'green', 'amber' or 'red' and this is carried forward to the Performance Matrix and the Results Overview. Red indicates that the identified treatment system is definitely not recommended. Amber indicates that the identified treatment system should only be used under advisement and that a full site survey should be conducted before proceeding with the installation. Green indicates that the SUDS/BMP conforms to the requirements posed by a specific set of site characteristics. In comparing the different site screening characteristics, the order applied within the DSS is that red takes priority over amber which in turn takes priority over green i.e. failure to fully comply with one of the site screening characteristics results in the award of a red category. Further details of the site screening guidelines applied within the PROPER DSS are described in Sections 2.1.1 to 2.1.5 and Section 2.1.6 guides the user through the use of the 'Site Criteria' screen.

2.1.1. Presence of a sensitive groundwater below the proposed site

The identification of what comprises a sensitive groundwater can be described in terms of the definitions allocated to different categories of groundwater protection zone, as defined below:

Zone I (most sensitive): is based principally on biological decay criteria and is designed to protect against the transmission of toxic chemicals and water-borne disease. It is defined by a 50-day travel time to any point below the water table from the source and, additionally, as a minimum 50 m radius from the source.

Zone II is defined by a 400-day travel time or 25 percent of the source catchment area, whichever is larger. The travel time is derived from consideration of the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants.

Zone III is defined as the area needed to support the protected yield from long-term groundwater recharge (effective rainfall). In areas where the aquifer is confined beneath impermeable strata, this source catchment may be located some distance from the abstraction.

If the site is not situated above a sensitive groundwater or is situated above a groundwater classified as Source Zone III, infiltration from a SUDS/BMP is considered to be permissible and a green colour will be allocated within the DSS although this will be subject to the appropriate depth existing to groundwater (see Section 2.1.2) and the infiltration properties of the underlying soil (see Section 2.1.3).

If the site is situated above a sensitive groundwater, classified as Source Zone I, infiltration from a SUDS/BMP is not recommended and all infiltration systems will be outlined in 'red' in the DSS. This negative screening outcome is designed to act as a warning to persuade developers, planners, designers etc. to consider alternative or upgraded drainage systems that do not involve infiltration. In addition, a full environmental impact assessment should be conducted based on the attenuation, adsorption and purification capabilities provided by the soil type and depth with a multiple treatment system (e.g. incorporating filtration, front-end sedimentation and tertiary treatment) potentially being required prior to any discharge to ground.

If the site is situated above a sensitive groundwater, classified as Source Zone ll, infiltration may be permitted under advisement and following site investigations. This is recognised by colouring all infiltration systems with a background 'amber' colour in the DSS. This will still be subject to the appropriate depth existing to groundwater (see Section 2.1.2) and the infiltration properties of the underlying soil (see Section 2.1.3).

The definitions of groundwater protection zones used in the PROPER DSS are based on those developed by the UK Environment Agency with similar approaches also having been adopted in other European countries. It is considered that the applied tripartite zonal structure has wide recognition and generic merit, but it is also acknowledged that alternative national approaches, in terms of the detailed methodological assessment, also exist. Where such differences occur, it is recommended that the user selects the condition of groundwater sensitivity identified in the DSS which is most relevant to their situation given the existence of alternative designation structures and influencing criteria.

2.1.2. Depth to groundwater

The depth of soil between the base of the treatment system and the groundwater level (together with its infiltration characteristics; see Section 2.1.3) will influence the extent to which the discharged waters from infiltration systems can be naturally purified before they reach the groundwater. This site characteristic does not influence the applicability of non-infiltration treatment systems such as detention basins, extended detention basins, retention ponds and constructed wetlands, all of which are allocated a green colour in the DSS. Table 1 identifies how different depths to groundwater influence the applicability of infiltration systems through the award of red, amber or green colourations in the DSS. The critical depth is clearly that extending to 0.6 m below the base of the infiltration system (awarded a red colour) with depths in excess of 1.5 m being acceptable (awarded a green colour). For intermediate depths (0.6 - 1.0 m), the allocation of an amber colour indicates that an infiltration treatment system should only be used under advisement and that a full site survey should be conducted before proceeding with the installation.

Table 1. Treatment system suitability according to depth above groundwater

Depth to groundwater below base of treatment system	Treatment systems allowed or not allowed
<0.6 m	Allowed: CW, DB, EDB, RP (green colour) Not allowed: FD, FS, IB, IT, PS, PS+, SO, SW (red colour)
0.6 – 1.0 m	Allowed: CW, DB; EDB; RP (green colour) Allowed subject to conditions: FD, FS, IB, IT, PS, PS+, SO, SW (amber colour)
1.0 -1.5 m	All allowed: (green colour)
>1.5 m	All allowed: (green colour)

Key: CW = constructed wetland; DB = detention basin; EDB = extended detention basin; FD = filter drain; FS = filter strip; IB = infiltration basin; IT = infiltration trench; PS = porous surfacing (without storage); PS+ = porous surfacing (with storage); RP = retention pond; SO = soakaway; SW = swale.

Although depth to the groundwater table is widely accepted as the operational criterion for infiltration systems, it is acknowledged that in some European countries the piezometric depth is used as the benchmark unit. As only groundwater table levels are permitted in the DSS, it is recommended that users adapt their piezometric measurements to derive a corresponding groundwater depth which can then be matched against one of the depth ranges shown in Table 1.

2.1.3. Soil infiltration characteristics

The ability of infiltration based treatment systems to perform well is influenced by the infiltration characteristics of the underlying soil. The soil properties which describe this characteristic include the soil hydraulic conductivity, the soil infiltration rate and/or the nature of the soil. The emphasis in the PROPER DSS tool is placed on soil type as this is the parameter which will be most readily available to users of the tool. The relationships between the soil hydraulic conductivities/infiltration rates and the different types of soil are as defined by the following cut-off values:

- soil hydraulic conductivities $<10^{-5}$ m/s equivalent to infiltration rates <5 mm/hr are characteristic of clay and silt soil types.

- soil hydraulic conductivities $>10^{-5}$ m/s equivalent to infiltration rates >5 mm/hr are characteristic of loam, sand and gravel soil types.

Based on these categories, loam, sand and gravel can be grouped together as being supportive to infiltration whereas clay and silt will present resistance to efficient infiltration. The PROPER DSS tool combines the soil infiltration capability with the different depths to groundwater to identify the suitability of a SUDS/BMP in a particular set of sub-surface conditions. The outcomes, which are incorporated in the PROPER DSS are shown in Table 2.

Table 2. Treatment system suitability according to soil type and depth above groundwater

Water table	Soil type	Outcome
< 0.6 m	Loam; sand; gravel	Allowed: CW, DB, EDB, RP (green colour) Not allowed: FD, FS, IB, IT, PS, PS+, SO, SW (red colour)
0.6 – 1.0 m	Loam; sand; gravel	Allowed CW; DB; EDB; RP (green colour) Allowed subject to conditions: FD, FS, IB, IT, PS, PS+, SO, SW (amber colour)
1.0 – 1.5 m	Loam; sand; gravel	All allowed: (green colour)
>1.5 m	Loam; sand; gravel	All allowed: (green colour)
< 0.6 m	Clay; silt	Allowed: CW, DB, EDB, RP (green colour) Not allowed: FD, FS, IB, IT, PS, PS+, SO, SW (red colour)
0.6 – 1.0 m	Clay; silt	Allowed: CW; DB; EDB; RP (green colour) Not allowed: FD, FS, IB, IT, PS, PS+, SO, SW (red colour)
1.0 – 1.5 m	Clay; silt	Allowed: CW; DB; EDB; FS; RP; SW (green colour) Not allowed: FD, IB, IT, PS, PS+, SO (red colour)
>1.5 m	Clay; silt	Allowed: CW; DB; EDB; FS; RP; SW; (green colour) Not allowed: FD, IT, IB, PS, PS+, SO (red colour)

Key: CW = constructed wetland; DB = detention basin; EDB = extended detention basin; FD = filter drain; FS = filter strip; IB = infiltration basin; IT = infiltration trench; PS = porous surfacing (without storage); PS+ = porous surfacing (with storage); RP = retention pond; SO = soakaway; SW = swale.

2.1.4. Effective contributing drainage area

The ‘effective contributing drainage area’ provides an indication of the probable level of pollution expected to be discharged from the highway surface. Although this can influence the suitability for using a particular SUDS/BMP, it does not totally jeopardise its use and therefore failure to conform to stipulated requirements merits the award of an amber colouration

indicating that the identified SUDS/BMP should be used under advisement and is not forbidden altogether.

The effective contributing drainage area is the proportion of catchment area which contributes to surface runoff during a storm event, and is therefore an important physical factor in deciding which SUDS/BMP options are feasible. In urban developments, detention basins and constructed wetlands require a significant drainage area (normally greater than 8 ha) to ensure effective operation and to counter drying-out and vegetation wilting effects caused by prolonged dry periods. A lower limit of suitability (6 to 7 ha) is set by the orifice size for extended detention basins and a similar limit might be adopted to maintain water level capacity in retention ponds. In contrast, infiltration and grass filter facilities are generally only applicable on sites less than 2 to 3 ha due to flow velocity constraints (as well as space and cost) and because they have low storage volume/storm runoff (Vs:Rv) ratios. However, filter strips can normally be fitted into any urban catchment size even though their individual contributing drainage area will be restricted and thus they have not been allocated any maximum value in the current DSS methodology. The same reasoning applies to filter drains and both types of porous surfacing. By comparison, infiltration basins operate most effectively within an operating range of 1.5 to 8 ha.

The working limits for effective contributing drainage areas in respect to individual SUDS/BMPs when utilised in urban areas are shown in Table 3. However, in the context of the highway environment, these areas are expected to be considerably less because of the reduced drainage areas combined with the fact that they will possess a higher percentage of impervious surface compared to general urban areas. The drainage area limits associated with the treatment of urban runoff are compared with those expected for highway runoff in Table 3. Based on the values in the final column of Table 3, the PROPER DSS tool uses the data shown in Table 4 to identify how the size of the effective contributing area of a highway surface can influence the preferred type of treatment system.

Table 3. Comparison of the effective contributing drainage areas associated with the treatment of highway runoff compared with those required for urban runoff

Treatment system	Drainage area (ha) for urban areas	Drainage area (ha) for predominantly highway areas
PS	N/A	N/A
PS+	N/A	N/A
FS	N/A	N/A
FD	N/A	N/A
SW	<2	<1
SO	<2	<1
IT	<2	<1
IB	<5	<2.5
DB	>6	>3
RP	>6	>3
EDB	>8	>4
CW	>8	>4

Key: N/A indicates the drainage area has no effect
CW = constructed wetland; DB = detention basin; EDB = extended detention basin; FD = filter drain; FS = filter strip; IB = infiltration basin; IT = infiltration trench; PS = porous surfacing (without storage); PS+ = porous surfacing (with storage); RP = retention pond; SO = soakaway; SW = swale.

Table 4. Treatment system suitability according to size of effective contributing highway drainage area.

Contributing highway drainage area (m^2)	Outcome
<10,000	Recommended: FD, FS, IB, IT, PS, PS+, SO, SW, (green colour) Not recommended: CW, DB, EDB, RP (amber colour)
10,000 - 30,000	Recommended: FD, FS, IB, PS, PS+ (green colour) Not recommended: CW, DB, EDB, IT, RP, SO, SW (amber colour)
30,000 – 40,000	Recommended: DB, FD, FS, PS, PS+, RP (green colour) Not recommended: CW, EDB, IT, IB, SO, SW (amber colour)
>40,000	Recommended: CW, FS, FD, PS, PS+, DB, EDB, RP, (green colour) Not recommended: SW, SO, IT, IB (amber colour)

Key: CW = constructed wetland; DB = detention basin; EDB = extended detention basin; FD = filter drain; FS = filter strip; IB = infiltration basin; IT = infiltration trench; PS = porous surfacing (without storage); PS+ = porous surfacing (with storage); RP = retention pond; SO = soakaway; SW = swale.

The information contained in Tables 3 and 4 has been derived from the following references:

Deliverable 3.2 of the PROPER project. Sustainable assessment of measures and treatment systems for road runoffs: Survey of guidelines

CIRIA Report C753. 2015. The SuDS Manual, Construction Industry Research and Information Association, London, UK. ISBN:978-0-86017-760-9.

Design Manual for Roads and Bridges. 2006. Volume 4, Geotechnics and Drainage; Section 2, Drainage, The Stationary Office, London, UK.

Ellis, J.B., Shutes, R.B.E. and Revitt, D.M. 2003. Guidance Manual for Constructed Wetlands. R&D Technical Report P2-159/TR2. Environment Agency, Bristol UK. ISBN 1 844 321185

Revitt, D.M., Ellis, J.B and Scholes, L. 2003. Review of the Use of Stormwater BMPs in Europe. Report D5.1. EU RTD 5th Framework Programme, Adaptive Decision Support System (ADSS) for the Integration of Stormwater Source Control into Sustainable Urban

Water Management Strategy. Middlesex University, London. (www.leesu.fr/daywater/REPORT/D5-1.pdf).

2.1.5. Annual average daily traffic (AADT)

Although it is not universally recognised as a predictor for the expected pollution load arising from a highway surface, AADT is probably still the most widely used parameter for this purpose. The ranges of AADT proposed for use in the PROPER DSS tool are <50,000 vehicles/day, 50,000-100,000 vehicles/day, 100,000-150,000 vehicles/day and >150,000 vehicles/day. These ranges are indicative of low/medium, medium, medium/high and high traffic usage on highways and therefore on associated pollution potential impacts. Table 5 provides identification of treatment systems according to their suitability for treating the pollutant loads associated with the different ranges of AADT values.

Table 5. Treatment system suitability according to annual average daily traffic on the highway providing runoff.

AADT	Outcome
<50,000	All treatment systems recommended (all green)
50,000 – 100,000	Recommended: CW, DB, EDB, FS, IB, IT, RP, SO, SW, (green colour) Not recommended: FD, PS, PS+ (amber colour)
100,000 – 150,000	Recommended: CW, DB, EDB, FS, IB, RP, SW, (green colour) Not recommended: FD, PS, PS+, SO; IT (amber colour)
>150,000	Recommended: CW, IB (green colour) Not recommended: DB, EDB, FD, FS, IT, PS, PS+, RP, SO, SW, (amber colour)

Key: CW = constructed wetland; DB = detention basin; EDB = extended detention basin; FD = filter drain; FS = filter strip; IB = infiltration basin; IT = infiltration trench; PS = porous surfacing (without storage); PS+ = porous surfacing (with storage); RP = retention pond; SO = soakaway; SW = swale.

2.1.6. Using the 'Site Criteria' screen

A screen shot of the 'Site Criteria' screen is shown in Figure 1. By following the blue arrow, a user is directed to the table showing the five site screening characteristics with the selected choices outlined in blue. The selection can be changed by clicking on the appropriate highlighted box when a drop down menu will appear showing the options available. Clicking on the required option changes the value or definition in each of the highlighted boxes. In the example shown in Figure 1, the site is identified as being in a loam soil area above a sensitive groundwater (categorised as Source Zone I) at a depth of between 0.6 m and 1.0 m below the treatment system. The effective contributing drainage area is less than 10,000 m^2 with a vehicle flow rate on the highway of between 50,000 and 100,000 vehicles/day. The results produced by this combination of site criteria are shown in the column at the bottom of the page (Figure 1) indicating that all treatment systems are identified as being unsuitable for use (red background colour) except for retention ponds, detention basins, extended detention basins and constructed wetlands which are considered suitable subject to advisement (amber background colour).

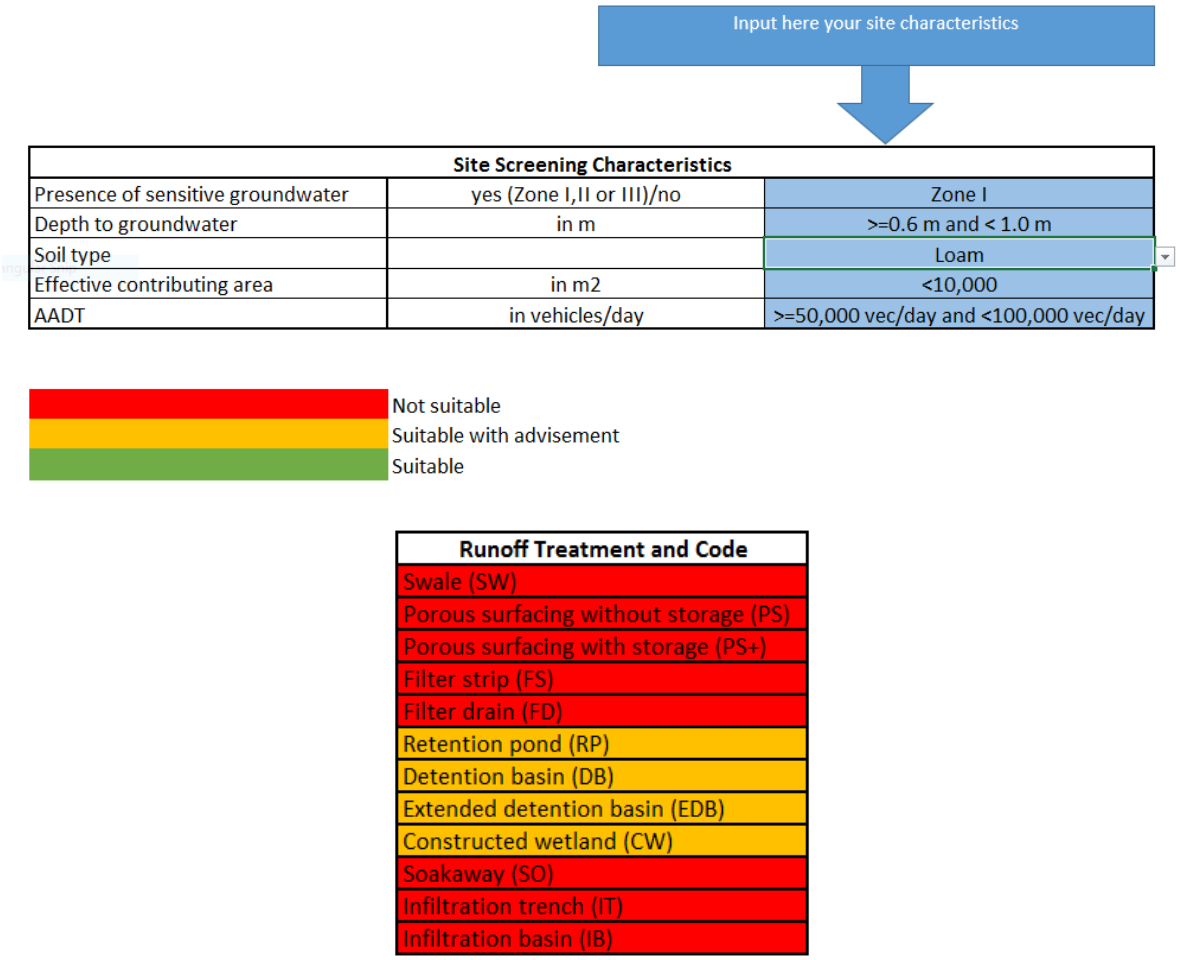


Figure 1. Screen shot of the 'Site Criteria' page in the PROPER DSS corresponding to (a) the presence of sensitive groundwater (Source Zone I), (b) a groundwater depth of between 0.6 m and 1.0 m, (c) a loam type soil, (d) an effective contributing drainage area less than 10,000 m^2 and (e) an AADT of between 50,000 and 100,000 vehicles/day.

Figure 2 identifies the results produced by a different combination of site criteria where the predominant soil type is gravel and the treatment system is to be situated greater than 1.5 m above a non-sensitive groundwater. The effective contributing drainage area is greater than 40,000 m^2 and the annual average daily traffic is less than 50,000 vehicles/day. These site conditions are indicated to be able to support all treatment systems (green background colour) although swales, soakaways, infiltration trenches and infiltration basins are only recommended for use with advisement (amber background colour).

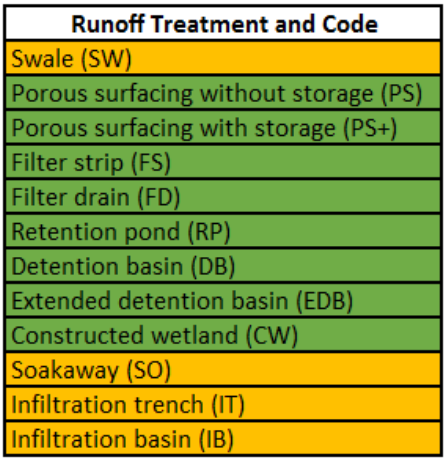
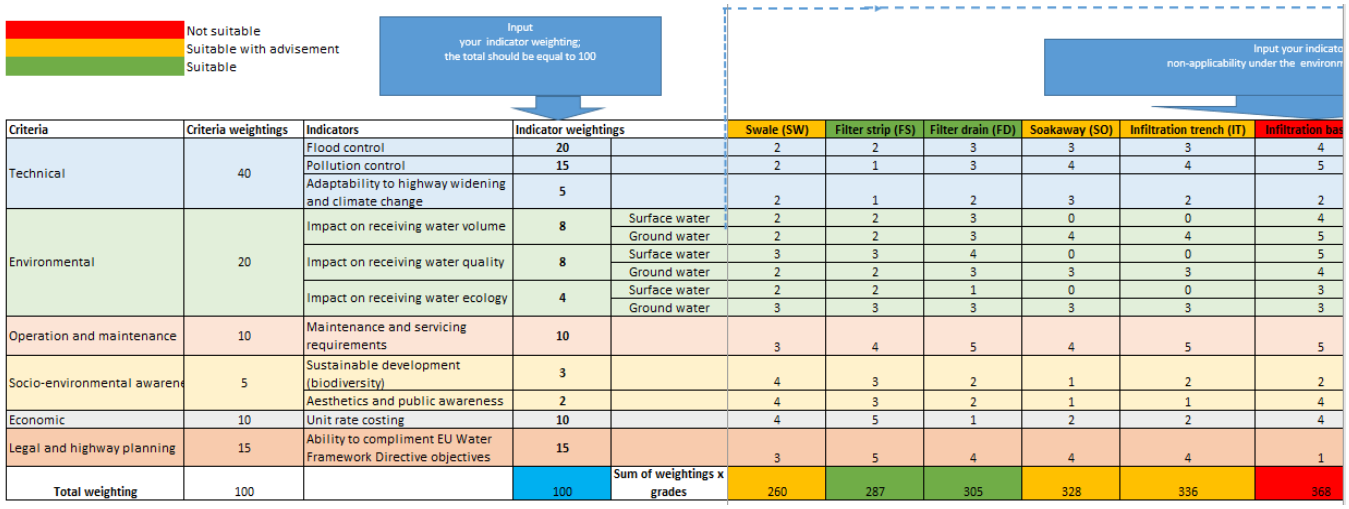


Figure 2. Screen shot of the 'Site Criteria' page in the PROPER DSS corresponding to (a) the presence of a non-sensitive groundwater, (b) a groundwater depth of greater than 1.5 m, (c) a gravelly soil, (d) an effective contributing drainage area greater than 40,000 m^2 and (e) an AADT of less than 50,000 vehicles/day.

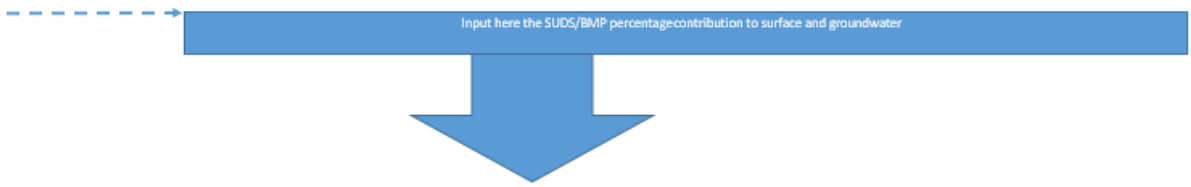
2.2. Performance matrix

Separate screen shots of two parts of the 'Performance matrix' page of the PROPER DSS tool are shown in Figure 3. Figure 3a shows part of the performance matrix and Figure 3b shows part of the procedure for identifying the contributions which different SUDS/BMPs make to surface waters and groundwater.



Criteria	Criteria weightings	Indicators	Indicator weightings		Swale (SW)	Filter strip (FS)	Filter drain (FD)	Soakaway (SO)	Infiltration trench (IT)	Infiltration bas
Technical	40	Flood control	20		2	2	3	3	3	4
		Pollution control	15		2	1	3	4	4	5
		Adaptability to highway widening and climate change	5		2	1	2	3	2	2
Environmental	20	Impact on receiving water volume	8	Surface water	2	2	3	0	0	4
				Ground water	2	2	3	4	4	5
		Impact on receiving water quality	8	Surface water	3	3	4	0	0	5
				Ground water	2	2	3	3	3	4
		Impact on receiving water ecology	4	Surface water	2	2	1	0	0	3
				Ground water	3	3	3	3	3	3
Operation and maintenance	10	Maintenance and servicing requirements	10		3	4	5	4	5	5
Socio-environmental awarene	5	Sustainable development (biodiversity)	3		4	3	2	1	2	2
		Aesthetics and public awareness	2		4	3	2	1	1	4
Economic	10	Unit rate costing	10		4	5	1	2	2	4
Legal and highway planning	15	Ability to compliment EU Water Framework Directive objectives	15		3	5	4	4	4	1
Total weighting	100		100	Sum of weightings x grades	260	287	305	328	336	368

(a)



		Swale	Filter strip	Filter drain	Soakaway	Infiltration trench	Infiltration basin	Retention pon	Detention basin	Extended detention basin	Cor
Contribution to	Surface wate	75	75	50	0	0	25	100	100	100	
	Groundwater	25	25	50	100	100	75	0	0	0	

(b)

Figure 3. Screen shots of the 'Performance matrix' page of the PROPER DSS tool showing (a) part of the performance matrix and (b) part of the table for allocating the percentage contributions made by different SUDS/BMPs to surface waters and groundwater.

Figure 3a shows part of the structure of the Excel based performance matrix in which the initial column identifies the six criteria against which the performances of the SUDS/BMPs are assessed. The default criteria weightings are shown in the second column. The third column identifies the indicators which describe in more detail the factors which are able to influence the performances of the SUDS/BMPs. The weightings for the indicators follow in the fourth column. The weightings which are applied reflect the importance placed on each criterion or indicator in terms of contributing to the overall assessment of the treatment systems. It is important that the sum of the weightings of both the criteria and the indicators equals 100%. The criteria and indicators used in the PROPER DSS tool together with their default weightings are also reproduced in Table 6. The fifth column in Figure 3a is only relevant to the 'Environmental' criterion and the three associated indicators and enables the contributions that individual SUDS/BMPs make to either surface water or groundwater or both to be allocated (see also Figure 3b) and incorporated in the performance matrix calculation. The 12 subsequent columns identify the individual SUDS/BMPs which have been incorporated in the

performance matrix with the rows below containing the default grade values which have been assigned for each of the indicators. The explanations for the allocations of the default grade values are fully described in the Technical Manual which accompanies the PROPER DSS tool.

Table 6. The criteria and indicators used in the performance matrix together with the default weightings applied in the PROPER DSS tool

Criteria	Weighting	Indicator	Weighting
Technical	40	Flood control	20
		Pollution control	15
		Adaptability to highway widening and climate change	5
Environmental	20	Impact on receiving waterbody volume	8
		Impact on receiving waterbody quality	8
		Impact on receiving waterbody ecology	4
Operation and Maintenance	10	Maintenance and servicing requirements	10
Socio-environmental awareness	5	Sustainable development (biodiversity)	3
		Aesthetics & public awareness	2
Economic	10	Unit rate costing	10
Legal & highway planning	15	Acceptability to highway authorities /discharge and pollution control regulations	15

As mentioned previously the indicators associated with the ‘Environmental’ criterion require further refinement to differentiate between the impacts imposed by the different treatment systems on surface waters and groundwaters. This is achieved by identifying the relative amounts by which each treatment system is expected to discharge to either surface waters or groundwaters or to both. The relative discharge distributions expected to each receiving water are reproduced in Table 7 (using a combination of literature values and expert judgement). The screen shot in Figure 3b shows part of the performance matrix which identifies the default percentage contributions to surface waters and groundwaters for the different SUDS/BMPs.

Table 7. Identification of the percentage contributions to surface waters and groundwaters for the different SUDS/BMPs.

SUDS/BMPs	Discharge distribution processes	Percentage contribution to surface water	Percentage contribution to groundwater
Swale	Discharge mainly to surface waters although some infiltration is possible	75	25
Filter strip	Discharge mainly to surface waters although some infiltration is possible	75	25
Filter drain	Typically permit discharge to both surface waters and groundwaters	50	50
Soakaway	Discharge entirely to ground	0	100
Infiltration trench	Discharge entirely to ground	0	100
Detention basin	Discharge predominantly to surface waters, especially when base is sealed	100	0
Retention pond	Discharge predominantly to surface waters	100	0
Constructed wetland	Discharge predominantly to surface waters, especially when base is sealed	100	0
Infiltration basin	Discharge mainly to groundwaters although overflow to surface waters possible	25	75
Porous surfacing (with or without sub-structure storage)	Different designs are possible allowing 3 different options; discharge to surface only, discharge to ground only or discharge to both	50	50
Extended detention basin	Discharge predominantly to surface waters, especially when base is sealed	100	0

The percentage distributions in Table 7 can subsequently be used to subdivide the weightings allocated to the 3 indicators which contribute to the 'Environmental' criterion according to whether surface waters or groundwaters are the main receptor of discharged waters. The resulting distributed weightings are shown in Table 8. The performance matrix in the PROPER DSS automatically calculates these weightings and applies them to the grade values to derive a summed total for each SUDS/BMP. This enables the generation of an order of preference for SUDS/BMP applications which best meet the requirements of the identified highway environment (see Section 2.3). The PROPER DSS tool may be operated using default weightings and grades or with weightings and grades introduced by the user to suit their specific requirements.

Table 8. Allocated weightings to the three Environmental indicators depending on whether discharge is to surface waters and/or groundwaters.

	Distributed weightings					
	Impact on receiving water volume (8)		Impact on receiving water quality (8)		Impact on receiving water ecology (4)	
	Surface water	Groundwater	Surface water	Groundwater	Surface water	Groundwater
Swale	6	2	6	2	3	1
Filter strip	6	2	6	2	3	1
Filter drain	4	4	4	4	2	2
Soakaway	0	8	0	8	0	4
Infiltration trench	0	8	0	8	0	4
Detention basin	8	0	8	0	4	0
Retention pond	8	0	8	0	4	0
Constructed wetland	8	0	8	0	4	0
Infiltration basin	2	6	2	6	1	3
Porous surfacing (with or without sub-structure storage)	4	4	4	4	2	2
Extended detention basin	8	0	8	0	4	0

2.2.1. Operation of the PROPER DSS using default values

Following completion of the 'Site Criteria' page, the background to the SUDS/BMP headings in the 'Performance Matrix' page are automatically updated with the colour appropriate to either their non-suitability (red), suitability with advisement (amber) or full suitability (green). The default grades for each SUDS/BMP are automatically multiplied by the indicator weightings and summed to produce an overall total for each treatment system. These summed totals are compared graphically in the 'Results Overview' page (see Section 2.3).

The default grades are between 1 and 5 except for some of the indicators within the Environmental criterion where a '0' value appears for those SUDS/BMPs which do not discharge to either surface water or groundwater. Thus '0' consistently appears against surface water for soakaways and infiltration trenches as these only discharge to groundwater (Figure 3b). Similarly, ''0' consistently appears against groundwater for retention ponds, detention basins, extended detention basins and constructed wetlands as these predominantly discharge to surface waters (Figure 3b).

2.2.2. Operation of the PROPER DSS using user derived values

It is possible for the user to change the following values in the performance matrix:

- the criteria and indicator weightings
- the grade values corresponding to the indicators and SUDS/BMPs
- within the Environmental criterion, the percentage discharge which individual SUDS/BMPs direct to either surface waters or groundwaters

a) Criteria and indicator weightings

If the user does not wish to use the default weightings, it is recommended that the criteria and indicator weights be allocated following discussions with a range of stakeholders to ensure that a range of concerns/priorities are considered. If a consensus on weightings cannot be reached, it is possible to repeatedly run the PROPER DSS using different weightings which reflect differing views to ascertain the effect that this uncertainty has on the generated SUDS/BMP order of preference.

The weightings have to be changed in the 'Indicator weighting' column whereupon the associated criterion weighting will also be adjusted. It is essential that the sum of the weighting values for both the criteria and the indicators is equal to 100%. If it is desired that an indicator is not to be considered within the DSS, then a weighting of 0% can be allocated.

b) Grade values in the performance matrix

The grades in the performance matrix can be changed using values within the range of 1 to 5. However, before doing this it is important to consult the Technical Manual (PROPER Deliverable 3.5) to clearly understand how the default grades have been established for each indicator. This will facilitate the selection of a grade value that is more appropriate for the highway catchment area/ specific circumstances under consideration. As the default grade values are altered, the revised summed totals for each SUDs/BMP will automatically be calculated and the results displayed on the 'Results overview' page. The Technical Manual can be accessed through the link on the PROPER DSS tool home page.

As explained in Section 2.2.1 above, there are also '0' values in the Environmental criterion of the performance matrix corresponding to those SUDS/BMPs which do not discharge to either surface water or groundwater. A '0' consistently appears against surface water for soakaways and infiltration trenches as these only discharge to groundwater. Similarly, '0' consistently appears against groundwater for retention ponds, detention basins, extended detention basins and constructed wetlands as these predominantly discharge to surface waters. This '0' value is locked and cannot be changed by users of the PROPER DSS tool.

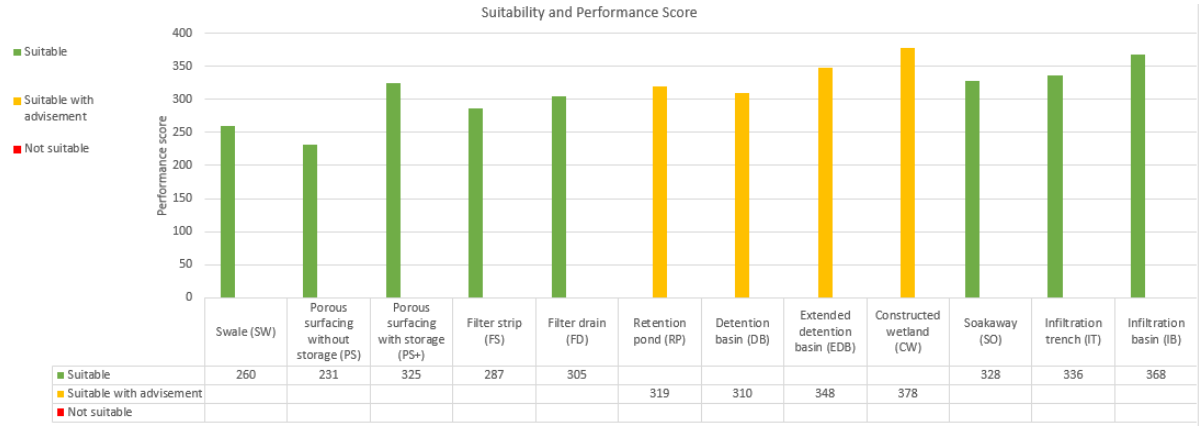
c) Percentage discharges to surface waters or groundwaters for the indicators associated with the Environmental criteria

If required the default percentage contributions (which are shaded in green) made by SUDS/BMPs to surface and groundwaters can be amended subject to the combined total equalling 100% (this is automatically actioned when a value on the top row is changed). This situation may arise where users believe that for a particular design of SUDS/BMP that they propose to install, the percentage discharge contributions to surface waters and groundwaters differ to the default values presented in the PROPER DSS tool. Where 0% or 100% contributions are indicated, it is not possible to change the percentage contributions as, in the former case, the grade value in the performance matrix is 0.

Where the percentage contributions to surface waters and groundwaters is amended, the revised summed totals for each SUDS/BMP will automatically be calculated and the results displayed on the 'Results overview' page.

2.3. Results overview

The ‘Results overview’ page allows an immediate comparison of the predicted performance and suitability of the different SUDS/BMPs through the presentation of a coloured bar chart accompanied by a list of the plotted values. In the example shown in Figure 4, the three treatment systems achieving the highest performance scores are constructed wetlands, infiltration basins and extended detention basins but only infiltration basins (represented by a green colouration) fully satisfy the site criteria conditions.



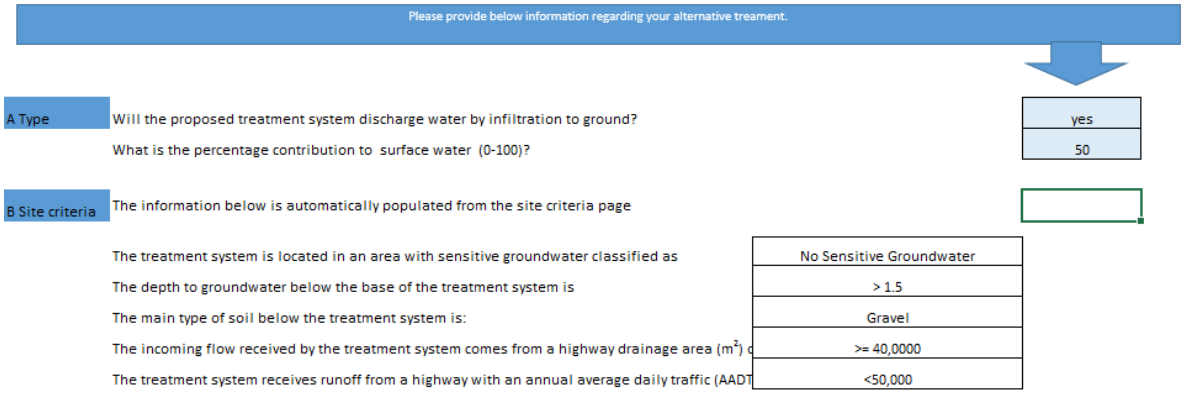
	Swale (SW)	Porous surfacing without storage (PS)	Porous surfacing with storage (PS+)	Filter strip (FS)	Filter drain (FD)	Retention pond (RP)	Detention basin (DB)	Extended detention basin (EDB)	Constructed wetland (CW)	Soakaway (SO)	Infiltration trench (IT)	Infiltration basin (IB)
Suitable	260	231	325	287	305					328	336	368
Suitable with advisement						319	310	348	378			
Not suitable												

Figure 4. Screen shot of the ‘Results overview’ page of the PROPER DSS tool.

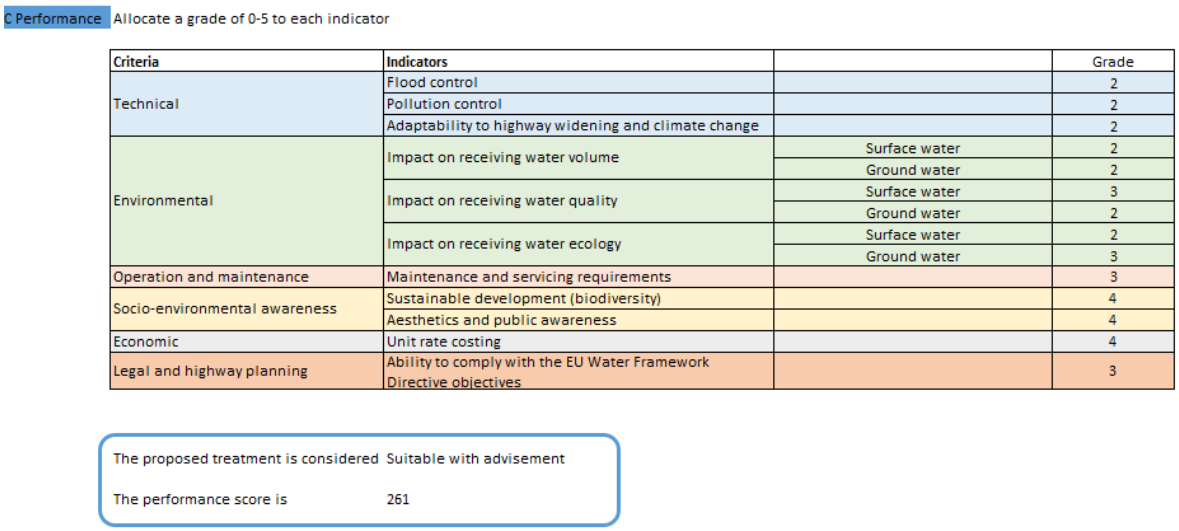
2.4. Alternative treatments

The performance matrix described in Section 2.2 provides the user of the PROPER DSS tool with the ability to assess the suitability of twelve different SUDS/BMPs. However, it is appreciated that these may not include the treatment systems that all users wish to evaluate. Therefore the ‘Alternative treatment’ page has been included in the PROPER DSS tool to offer users the opportunity to investigate the performances of other sustainable treatment systems and/or manufactured proprietary treatment systems by inputting the relevant site characteristics and performance grades.

The ‘Alternative treatment’ page is divided into 3 parts (A, B and C). Parts A and B deal with the site conditions and are shown below as a screen shot in Figure 5a. Part C addresses the contents of the performance matrix and the derived result as shown in the screen shot found in Figure 5b.



(a)



(b)

Figure 5. Screen shots of the 'Alternative treatment' page of the PROPER DSS tool showing (a) part of the selection screen for entry of site criteria and (b) part of the performance matrix for entering performance grades for the alternative treatment.

a) Site conditions (parts A and B)

In Part A (Figure 5a), the user is asked two questions which relate to whether the treatment system discharges to ground and the percentage of discharged water which is directed to surface water. The first question has a straightforward yes or no response, either of which can be selected from a drop down menu. The percentage value required by the second question has to be entered manually and must be consistent with the response to the first question. Thus, if there is no discharge to ground the percentage contribution to surface water must be 100%. If there is discharge to ground the percentage contribution to surface water cannot be 100%. The percentage discharges selected to either surface waters or groundwaters will be automatically used in the 'Environmental' criterion component of the performance matrix to calculate the overall performance score for the alternative treatment system.

The responses shown in Part B (Figure 5a) are automatically carried forward from the 'Site criteria' page of the PROPER DSS tool and determine the suitability for use of the alternative treatment system.

The PROPER DSS tool uses a flow chart procedure to determine the effect of site conditions on the proposed treatment system by addressing the following questions and allocating appropriate colour codes (RED indicates not suitable; AMBER indicates suitable with advisement; GREEN indicates suitable):

1) Will the proposed treatment system discharge water by infiltration to ground?
   If YES: proceed to the following questions (i) to (v)
   If NO: proceed to Question 2)

   (i) Will the treatment system be located in an area with sensitive groundwater?
   If YES: allocate AMBER colour code
   If NO: allocate GREEN colour code

   (ii) What will be the depth to groundwater below the base of the treatment system?
   If < 0.6 m: allocate RED colour code
   If 0.6 – 1.0 m: allocate AMBER colour code
   If 1.0-1.5 m: allocate GREEN colour code
   If >1.5 m: allocate GREEN colour code

   (iii) What is the main type of soil below the treatment system?
   If loam, sand or gravel: allocate GREEN colour code
   If clay or silt: allocate RED colour code

   (iv) What is the highway drainage area delivering flow to the proposed treatment system?
   If < 10,000 m2: allocate GREEN colour code
   If >10,000 m2: allocate AMBER colour code

   (v) What is the annual average daily traffic (AADT) for the highway delivering runoff to the proposed treatment system?
   If < 100,000 vehicles /day: allocate GREEN colour code
   If >100,000 vehicles /day: allocate AMBER colour code

2) The following responses refer to non-infiltrating treatment systems

   (i) What is the highway drainage area delivering flow to the proposed treatment system?
   If < 30,000 m2: allocate AMBER colour code
   If >30,000 m2: allocate GREEN colour code

   (ii) What is the annual average daily traffic (AADT) for the highway delivering runoff to the proposed treatment system?
   If < 150,000 vehicles /day: allocate GREEN colour code
   If >150,000 vehicles /day: allocate AMBER colour code

b) Performance matrix (part C)

In Part C (Figure 5b), the user is invited to enter a grade of 0 to 5 against each indicator for the alternative treatment system. The use of ‘0’ is only appropriate against the Environmental criteria where a 0% discharge to either surface waters or groundwaters has been selected. It is recommended that grades in the range 1 to 5 are chosen after fully consulting the Technical Manual in order to conduct a comparison of the alternative treatment with the SUDS/BMPs for which grades have been established for each indicator. This will facilitate the selection of grade values that are appropriate for the alternative treatment under consideration. When the

grade values are fully populated, the summed total performance score will be automatically calculated and the results displayed at the bottom of the 'Alternative treatment' page together with the predicted suitability for use. To gauge the relevance of the overall performance score obtained for the alternative treatment, it is recommended that this is compared with the results obtained for the 12 different SUDS/BMPs (incorporated in the performance matrix) under identical site criteria conditions.