1 *SUSTAIN* Version 1.2 – BMP Siting Tool

The BMP Siting Tool was developed to assist users in selecting suitable locations for different types of low impact development (LID) techniques or conventional BMPs. Site suitability is used as the dominant factor in identifying potential site locations (USEPA 1999a). The siting tool provides guidance on where to place a selected BMP on the watershed based on the site suitability criteria. The following enhancements are made to the previously publicly released version 1.0.

- Land ownership (public or private land): The user has option to limit their selection criteria to public or private land for different selected BMP types.
- Proximity to land features (i.e., roads, streams, and buildings): The user has option to specify a buffer size (i.e., less than, greater than, lower and upper limit) for the suitable locations.
- Prioritize the suitable locations by adding a weighting factor to the suitability criteria for *Slope* and *Hydrologic Soil Group*. For example, a bioretention basin is best suited in areas with hydrologic soil group A as compared to D.
- Efficient selection of appropriate sites by enhancing the code.
- An increased level of automation for siting and placement of BMPs on the map.

1.1 Data Requirements

Using GIS analysis and up to nine base data layers, the Siting Tool helps users identify suitable sites for placement of structural BMPs on the basis of suitability criteria including slope, soil type, urban land use, land ownership, roads, water table depth, stream location, and drainage area. Table 1-1 describes these nine GIS data layers that are used as the base input data for the tool.

Table 1-1. GIS Data Requirement for BMP Suitability Analysis

GIS Layer	Format	Description
DEM	Raster file	The DEM is used to calculate the drainage slope and drainage areas that are used to identify the suitable locations for BMPs.
NLCD Land Use	Raster file	The USGS Multi-Resolution Land Characteristics Consortium NLCD land use grid is used to eliminate the unsuitable areas for BMPs.
Percent Imperviousness	Raster file	The impervious grid is used to identify the suitable locations for BMPs for the given suitability criteria.
Soil	Shape file	The soil data contain the soil properties such as hydrological soil group, which are used to identify suitable locations for BMPs.
Urban Land Use	Shape file	The urban land use data contain the boundaries for the buildings and the impervious areas needed to identify suitable locations for LIDs.
Road	Shape file	The road layer is used to identify suitable locations for some BMPs that must be placed within a specific road buffer area.
Stream	Shape file	The stream layer is used to define a buffer so that certain BMP types can be placed outside the buffer to minimize the impact on streams.
Groundwater Table Depth	Shape file	The groundwater table depth layer is used to identify suitable locations for the infiltration BMPs; derived from monitoring data.
Land Ownership	Shape file	A parcel layer is used to identify the locations on the public or private land.

Table 1-2 shows the GIS data format required for the siting tool. GIS layers with different coordinate system will cause error during the spatial analysis. It is important to project all GIS data into the preferred coordinate system of the study area before starting the project. ***Project Raster*** utility under ***Data Management Tools*** of **ArcToolbox** can be used to project the GIS data from one coordinate system to another.

Table 1-2. GIS Data Format Requirement for BMP Suitability Analysis

GIS Layer	Data Type	Field Name	Field Type	Field Value / Description
DEM	Raster file	VALUE	Floating	ESRI grid
NLCD Land Use	Raster file	VALUE	Integer	ESRI grid
Land Use Lookup	Table	LUCODE	Integer	should be same as in the VALUE field in NLCD Land Use layer
		LUNAME	String	Description about the land use type
		SUITABLE	Short	1 or 0 (1 = suitable; 0 = unsuitable)
Percent Imperviousness	Raster file	VALUE	Integer	0 – 100
Soil	Shape file	MUKEY	String	Hydrological soil classification (STATSGO or SSURGO or local dataset)
Soil Lookup	Table	MUKEY	String	should be same as in the MUKEY field
		HYDGRP	String	A or B or C or D
Urban Land Use	Shape file	LU_DESC	String	Buildings or Roadways or ParkingLots
Road	Shape file	N/A	N/A	N/A
Stream	Shape file	N/A	N/A	N/A
Groundwater Table Depth	Shape file	GWDEP_FT	Double	Depth to groundwater table
Land Ownership	Shape file	OWNERSHIP	String	Public or Private

Figure 1-1 shows the interface for defining the GIS data and lookup tables needed to run the site suitability criteria. Not all the data layers are required to use the tool.

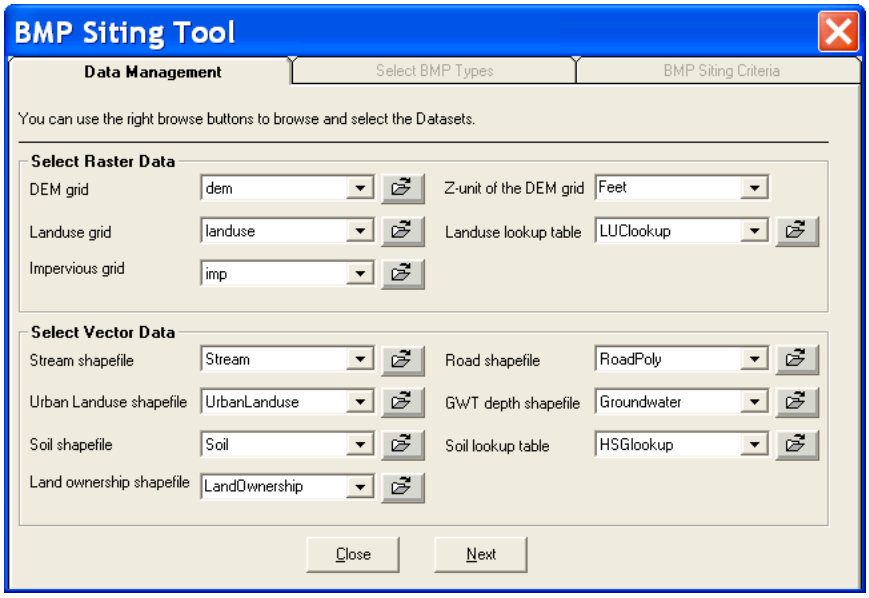

Figure 1-1. Data Management Interface for BMP Siting Tool

The analysis can be performed with at least one GIS data layer and the corresponding siting criteria. By increasing the number of input data layers (adding more constraints for the suitable locations) will certainly increase the resolution of the suitable location map. Note that it is a tool and the output is vastly correlated to the accuracy and resolution of the input data.

1.2 BMP Options

To conceptualize the physical function of BMPs with regard to their associated landscape, four categories (or types) of BMPs are presented in the Siting Tool: (1) point LID, (2) point BMP, (3) linear BMP, and (4) area BMP. Point BMPs and LID include practices that capture upstream drainage at a specific location and can use a combination of detention, infiltration, evaporation, settling, and transformation to manage flow and remove pollutants. Linear BMPs are narrow linear shapes adjacent to stream channels that provide filtration of runoff; nutrient uptake; and ancillary benefits of stream shading, wildlife habitat, and aesthetic value. Area BMPs are land-based management practices that affect impervious area, land cover, and pollutant inputs (e.g., fertilizer, pet waste). Table 1-3 shows the structural BMP options included in BMP Siting Tool and Figure 1-2 shows the interface for selecting the BMP options available in this tool.

Table 1-3. Structural BMP Options Available in BMP Siting Tool

BMP Option	BMP Type
Bioretention	Point LID
Cistern	Point LID
Constructed Wetland	Point BMP
Dry Pond	Point BMP
Grassed Swale	Linear BMP
Green Roof	Area BMP
Infiltration Basin	Point BMP
Infiltration Trench	Linear BMP
Porous Pavement	Area BMP
Rain Barrel	Point LID
Sand Filter (non-surface)	Linear BMP
Sand Filter (surface)	Point BMP
Vegetated Filterstrip	Linear BMP
Wet Pond	Point BMP

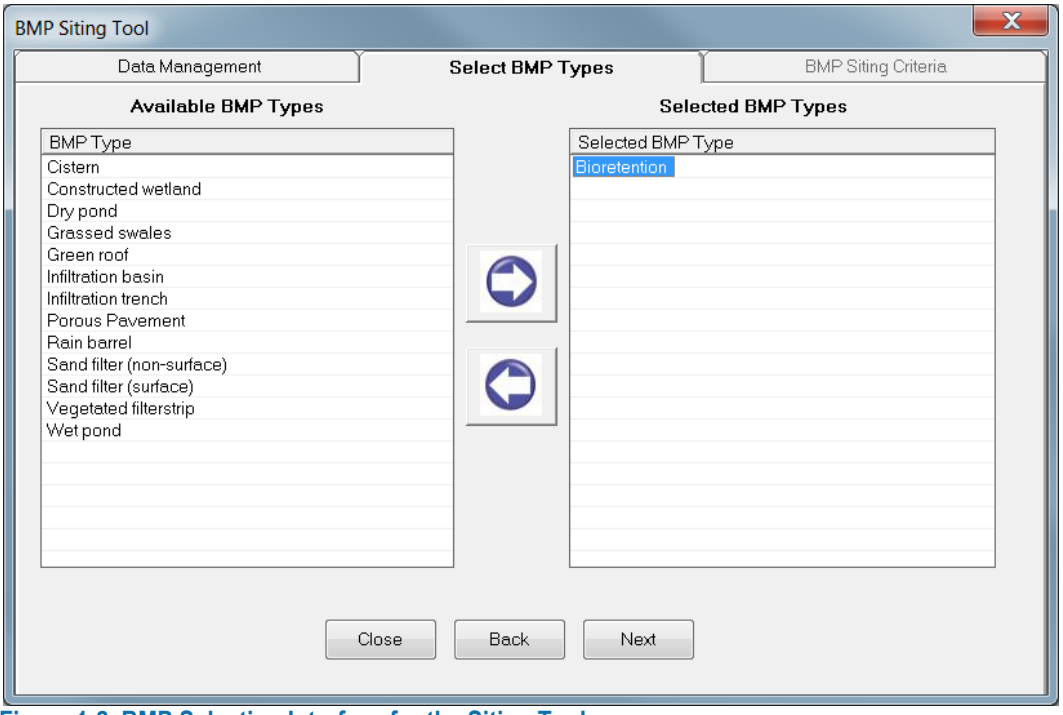

Figure 1-2. BMP Selection Interface for the Siting Tool

1.3 Site Suitability Criteria

Table 1-4 shows a site suitability criteria matrix and is populated with default criteria that the user can change to his or her preference or local knowledge. The default criteria in the tool as shown in Table 1-4 are derived from two EPA reports (USEPA 2004a, 2004b). Users can modify these criteria through the interface (Figure 1-3).

Table 1-4. Default Criteria for BMP Suitable Locations Used in BMP Siting Tool

BMP Type	Drainage Area (acre)	Drainage Slope (%)	Impervious (%)	Hydrological Soil Group	Water Table Depth (ft)	Road Buffer (ft)	Stream Buffer (ft)	Building Buffer (ft)
Bioretention	< 2	< 5%	> 0%	A–D	> 2	< 100	> 100	-
Cistern	--	--	--	--	--	--	--	< 30
Constructed Wetland	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--
Dry Pond	> 10	< 15%	> 0%	A–D	> 4	--	> 100	--
Grassed Swale	< 5	< 4%	> 0%	A–D	> 2	< 100	--	--
Green Roof	--	--	--	--	--	--	--	--
Infiltration Basin	< 10	< 15%	> 0%	A–B	> 4	--	> 100	--
Infiltration Trench	< 5	< 15%	> 0%	A–B	> 4	--	> 100	--
Porous Pavement	< 3	< 1%	> 0%	A–B	> 2	--	--	--
Rain Barrel	--	-	--	--	--	--	--	< 30
Sand Filter (non-surface)	< 2	< 10%	> 0%	A–D	> 2	--	> 100	--
Sand Filter	< 10	< 10%	> 0%	A–D	> 2	--	> 100	--

BMP Type	Drainage Area (acre)	Drainage Slope (%)	Impervious (%)	Hydrological Soil Group	Water Table Depth (ft)	Road Buffer (ft)	Stream Buffer (ft)	Building Buffer (ft)
(surface)								
Vegetated Filterstrip	--	< 10%	> 0%	A–D	> 2	< 100	--	--
Wet Pond	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--

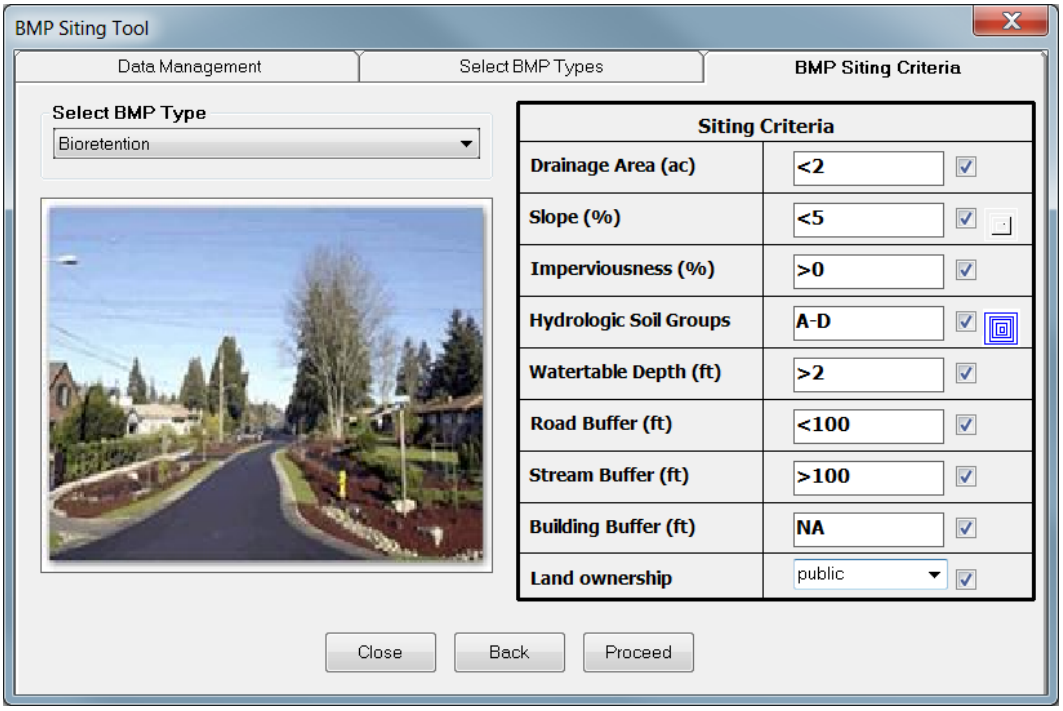

Figure 1-3. BMP Siting Criteria Interface for the Siting Tool

Figure 1-4 shows the user-specified weighting factors for hydrologic soil group criteria. The box on the right side of the criteria turns blue (Figure 1-3) when the weighting factors are defined (check box on Figure 1-4) as part of the specific criteria (i.e., slope or hydrologic soil groups).

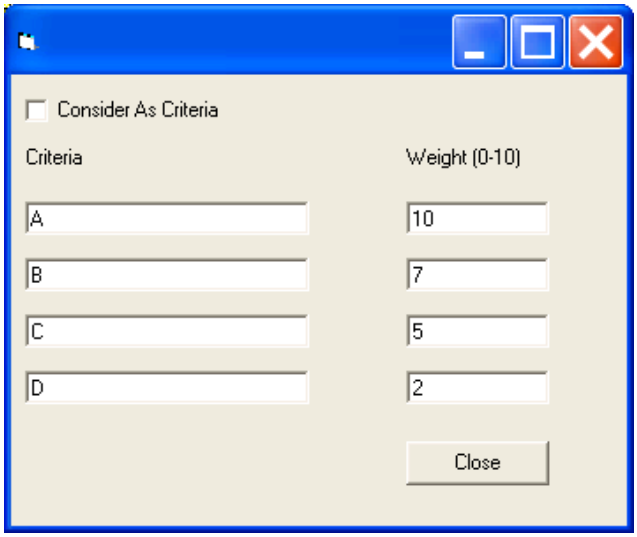

Figure 1-4. Interface for Defining Weighting Factor

2 *SUSTAIN* Version 1.2 – BMP Optimization

The data collection process for a *SUSTAIN* application is similar to most modeling projects and involves a thorough compilation and review of information available for the study area. It generally includes gathering applicable regional and site-scale GIS data layers, digital elevation model (DEM) data, stream networks, locations of BMPs, land use data, critical source information, and monitoring data for calibration and validation.

2.1 Data Requirements

Table 2-1 shows summary of typical data needs for *SUSTAIN* application.

Table 2-1. Typical Data Needs for *SUSTAIN* Application

Data	Data Type	Need	Data Source
Land use	ESRI Grid	Required for defining land use distribution	National Land Cover Dataset (NLCD) (http://seamless.usgs.gov/website/seamless/viewer.php) or locally derived
Land use lookup	DBF Table	Required for assigning land use categories and groupings	Standard National Land Cover Dataset (NLCD) land cover code for NLCD land use (http://landcover.usgs.gov/). or land cover mapping code for locally derived data
External Model	ASCII Text Files	Required for external model linkage	Time series generated by calibrated model; by land use or combination of land use, slope and hydrological soil group
Digital Elevation Data (DEM)	ESRI Grid	Required for automatic delineation of drainage areas	(http://seamless.usgs.gov/website/seamless/viewer.php) or locally derived source
Stream Network	ESRI Shape File	Required for automatic delineation of drainage areas and for placing on-stream management practices	National Hydrography Dataset (NHD) from http://nhd.usgs.gov/data.html
Precipitation	ASCII Text File	Required for internal land simulation and for estimating storm sizes for the post-processor	National Climatic Data Center (NCDC). NCDC Summary of the Day (daily data) can also be obtained from (EarthInfo Inc., http://www.earthinfo.com).
Other weather data	ASCII Text File	Required if snow melt is simulated for internal land simulation	NCDC (temperature, evaporation, and wind speed)
Pipes	Data Entry	Required if pipe/conduit is simulated	Shape and dimensions (e.g., length, width, diameter)
Stream Geometry	Data Entry	Required if stream routing is simulated	Cross-sectional geometry (shape and related dimensions)
Management Practices	Data Entry	Required	Characteristics of installed and proposed management practices (e.g., size, shape, media, design specification); dependent on type of practice
Flow	ASCII Text File	Required for calibration of internal modeling of runoff; recommended for system testing	USGS real time data (http://waterdata.usgs.gov/nwis/rt) or local sampling
Water Quality	ASCII Text File	Required for calibration of internal	USGS surface water data (http://waterdata.usgs.gov/nwis/sw) or

Data	Data Type	Need	Data Source
		modeling of water quality; recommended for testing of water quality predictions	EPA STORET data (http://www.epa.gov/storet/dw_home.html) or local sampling

2.2 Weather Data

The land simulation module of *SUSTAIN* uses the daily air temperature, evaporation, and wind speed data from the user-specified climate file. The format for climate file is consistent with that used in the SWMM, where each line in the file contains a recording station name, year, month, day, maximum temperature, minimum temperature, and optionally, the evaporation rate and wind speed. The data must be in U.S. units: temperature in degrees F, evaporation in in./day, and wind speed in mi/hr, all separated by one or more spaces.

An excerpt from the climate file format might look as follows:

```
ST93738   2007   1   1   43   32   0.12   13.9
ST93738   2007   1   2   45   23   0.04   5.84
ST93738   2007   1   3   54   24   0.07   4.21
```

The precipitation data is input in a separate file where each line of the file contains the station ID, year, month, day, hour, minute, and non-zero precipitation reading, all separated by one or more spaces.

An excerpt from the precipitation file format might look as follows:

```
ST448903   2007   1   1   00   00   0.12
ST448903   2007   1   1   01   00   0.04
ST448903   2007   1   2   16   00   0.07
```

The precipitation data type in any one of these three formats: (1) intensity, where the value is an average rate (in./hr) over the recording interval; (2) interval volume, where the value is the volume of rain that fell in the recording interval (in.); or (3) cumulative volume, where the value represents the cumulative rainfall that has occurred since the start of the last series of non-zero values (in.).

2.3 External Watershed Model Time Series

The externally generated time series represent hydrology and water quality at the landscape level. The external option in *SUSTAIN* allows importation of the hydrograph and pollutograph for each land use category (or combination of land use, slope, and hydrologic soil group) from a calibrated external watershed model such as HSPF or LSPC. It uses the sub-hourly (1min – 60min) flow and pollutant loading data from the user-specified time series file. The format for the time series file is consistent with that output from the HSPF or LSPC, where each line in the file contains a watershed id (dummy value not used in *SUSTAIN*), year, month, day, hour, minute, flow volume (in.-acre), groundwater recharge volume (in.-acre), and the loads for each pollutant per unit area (acre). The data must be in U.S. units separated by space or tab delimiters.

An excerpt from the external time series file format might look as follows:

```
TT-----------------------------------------------------------------------------------
TT LSPC -- Loading Simulation Program, C++
TT Version 4.1
TT
TT Designed and maintained by:
TT     Tetra Tech, Inc.
TT     10306 Eaton Place, Suite 340
```

```
TT     Fairfax, VA 22030
TT     (703) 385-6000
TT-----------------------------------------------------------------------------------------
TT LSPC MODEL OUTPUT FILE
TT Time interval: 60 min      Output option: timestep
TT Label
TT SURO     surface outflow volume (in-acre/timestep)
TT AGWI     groundwater recharge volume (in-acre/timestep)

TT SOSED    sediments load from land (tons/timestep)
TT SOQUAL   surface flux of QUAL from the PLS_TP (lb/timestep)
TT
TT WATERSHED_1002 Area:    1.000 (acres)
TT Date/time                                  Values
TT
1002    1987    1       1       0       0       1.26E-05        0.00E+00        2.96E-10        0.00E+00
1002    1987    1       1       1       0       0.00E+00        0.00E+00        0.00E+00        0.00E+00
```

Note that Date/time is the keyword used to differentiate the comments and data sections. Anything up to one line below that keyword is considered as comments and ignored while reading the file. There is no specific character for the comment line. The second line below the keyword is the start of data section and there should be no gaps and comments in between the data lines. The number and order of the pollutants must be same as defined in the pollutant definition table on the *SUSTAIN* interface.

2.4 External Point Source Time Series

The point source time series represent hydrology and water quality. *SUSTAIN* allows importation of the hydrograph and pollutograph for each node (BMP or junction). It uses the sub-hourly (1min – 60min) flow and pollutant loading data from the user-specified time series file. The format for the time series file is consistent with the external watershed model time series, where each line in the file contains a point source id (dummy value not used in *SUSTAIN*), year, month, day, hour, minute, flow volume (in.-acre), and the loads for each pollutant. The data must be in U.S. units separated by space or tab delimiters.

An excerpt from the external time series file format might look as follows:

```
TT-----------------------------------------------------------------------------------------
TT LSPC -- Loading Simulation Program, C++
TT Version 4.1
TT
TT Designed and maintained by:
TT     Tetra Tech, Inc.
TT     10306 Eaton Place, Suite 340
TT     Fairfax, VA 22030
TT     (703) 385-6000
TT-----------------------------------------------------------------------------------------
TT LSPC MODEL OUTPUT FILE
TT Time interval: 60 min
TT Label
TT FLOW         point source flow volume (in-acre/timestep)
TT SED          sediments load from point source (tons/timestep)
TT TP           total phsphorus load from point source (lb/timestep)
TT
TT POINTSOURCE IDENTIFIER:      1000
```

TT Date/time						Values		
TT								
1000	1987	1	1	0	0	1.00E-02	0.00E+00	0.00E+00
1000	1987	1	1	1	0	0.00E+00	0.00E+00	0.00E+00

Note that Date/time is the keyword used to differentiate the comments and data sections. Anything up to one line below that keyword is considered as comments and ignored while reading the file. There is no specific character for the comment line. The second line below the keyword is the start of data section and there should be no gaps and comments in between the data lines. The number and order of the pollutants must be same as defined in the pollutant definition table on the *SUSTAIN* interface.

3 References

USEPA (U.S. Environmental Protection Agency). (1999a). *Preliminary data summary of urban storm water best management practices*. EPA 821/R-99/012. U.S. Environmental Protection Agency, Office of Water. Washington, DC.

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USEPA (U.S. Environmental Protection Agency). (2004b). *The Use of Best Management Practices (BMPs) in Urban Watersheds*. EPA/600/R-04/184. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.