Opti-Tool for Stormwater and Nutrient Management

User's Guide

Prepared for:
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Table of Contents

1. Introduction

Evaluation of best management practices (BMPs) is a critical component to develop and implement sound and robust stormwater management plans to meet permit requirements based on Total Maximum Daily Loads (TMDL). Modeling tools provide an attractive means to quantify the benefit and cost of potential BMPs options and facilitate the decision making process. Opti-Tool (Stormwater Management Optimization Tool), developed by Tetra Tech for USEPA Region 1 is such a spreadsheet-based optimization tool that provides both a planning level and implementation level analysis. The planning level analysis provides decision-makers a comprehensive overview of stormwater management opportunities in a given watershed. The implementation level analysis calls the SUSTAIN (System for Urban Stormwater Treatment and Analysis Integration) module to estimate BMP performance and retrieve optimization results to provide cost-effective BMP sizing strategies. The tool helps planners determine the best mix of BMPS to provide the greatest benefit for achieving water resources goals while balancing costs.

USEPA Region 1 needed a customized BMP tool to support the municipal stormwater managers and their consultants who are involved in the decision making process, and are responsible for demonstrating progress and compliance with TMDL related permit requirements. It was envisioned that Opti-Tool would have the following features:

- Spreadsheet format that is widely available
- No dependency on ArcGIS software
- Access to key processes from SUSTAIN
- General assumptions for operation that would be based on the considerable work already done in the Charles River watershed
- Capability to evaluate stormwater management scenarios in terms of feasibility based on watershed conditions, cost and achieving specified environmental targets, while also summarizing by quantification other important environmental benefits associated with the scenario
- Flexibility to reflect site specific information (e.g., loading, BMP performance, and cost) in analyses

The core functionalities of Opti-Tool fulfill the above requirements. As illustrated in Figure 1, Microsoft Excel was selected as the platform for the tool development. The *Planning Level Analysis* allows users to find the optimal solution via Excel Solver using the BMP performance curves for estimating the pollutant load reductions. The *Implementation Level Analysis* allows users to interact with the SUSTAIN module through a series of customized forms and tables.

This document provides guidance on how to use Opti-Tool.

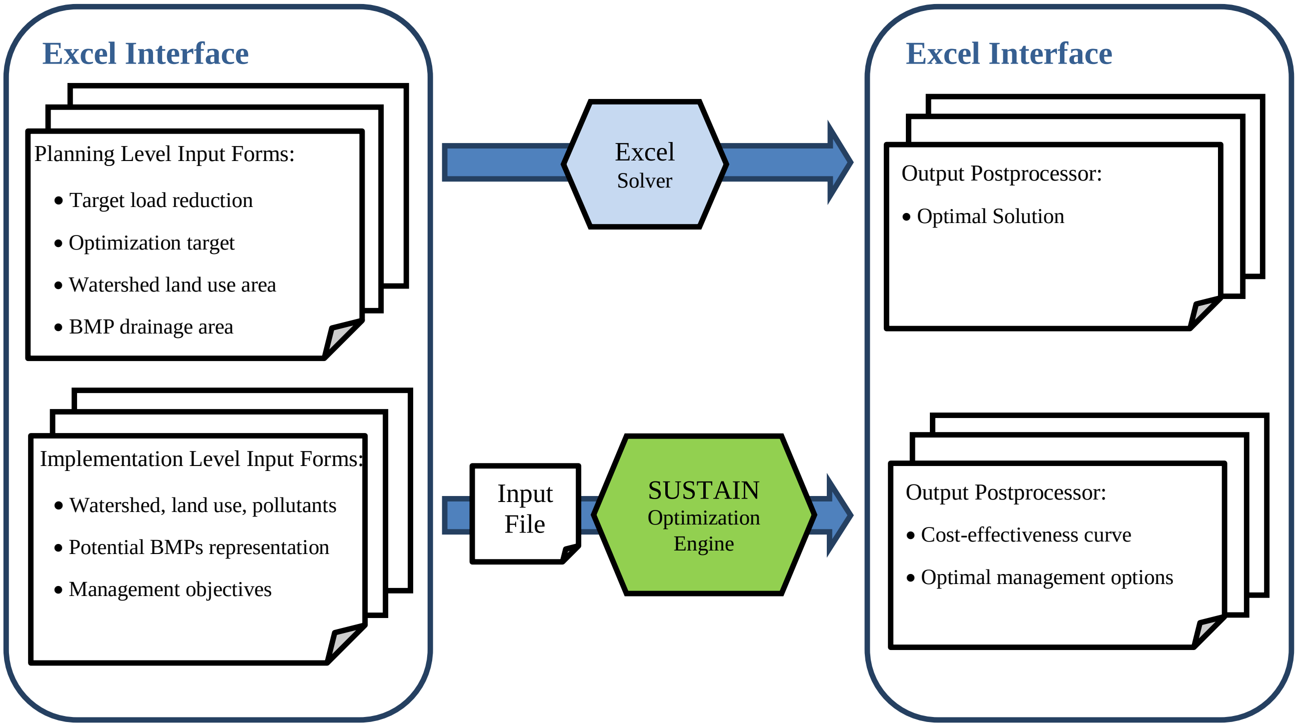


Figure 1. The Opti-Tool conceptual design

2. Getting Started

2.1 Software Requirement

The minimum software requirements for running Opti-Tool are as follows:

- Microsoft Excel 2013
    - Security settings should be changed to 'enable macros'
    - Activate 'Solver'

Enable Macros

Microsoft Excel 2013
Click the File Button and go to *Options.* On the left-hand menu select *Trust Center* and click the button for *Trust Center Settings*. On the left-hand menu select *Macro Settings*. Select the *Enable All Macros* option.

Activate Solver

Microsoft Excel 2013
Click the File Button and go to *Options.* On the left-hand menu select *Add-Ins*, in the Manage box, select the *Excel Add-ins* and then click *Go*. In the Add-Ins available box, select the *Solver Add-in* check box, and then click *Ok*.

2.2 Installation

The contents of the file *OPTI-TOOL.zip* should be saved on the C:\ drive. You will see the following files and folders under the installation folder (C:\OPTI-TOOL\).

- Opti-Tool_v1.xlsm
- Documents
    - Opti-Tool User Guide.pdf
    - SUSTAIN Application Guidance.pdf
    - SUSTAIN Data Needs.pdf

    - Technical Memos.pdf
- <u>SUSTAIN</u>
    - SUSTAINOPT.dll
    - SUSTAINOPT.exe
    - SUSTAINOPT.readme
- <u>Timeseries</u>
    - AgImp.txt
    - AgPervBSoil.txt
    - ComImp.txt
    - ForImp.txt
    - ForPervBSoil.txt
    - HDRImp.txt
    - HWYImp.txt
    - LDRImp.txt
    - MDRImp.txt
    - OPNImp.txt
    - PervASoil.txt
    - PervBSoil.txt
    - PervCDSoil.txt
    - PervCSoil.txt
    - PervDSoil.txt
- <u>Future Climate Timeseries</u>
    - ComImp.txt
    - HDRImp.txt
    - LDRImp.txt

2.3 Prepare Your Data

The following is a list of the input information required to set up a SUSTAIN model for Implementation Level Analysis. The information that users will need to provide is listed below in Table 1.

Table 1. Summary of data requirements for building an input file for SUSTAIN model. Data/Information is to be provided by Users of the Opti-Tool via (1) external generation, and (2) selections from Opti-Tool menus.

User Guide Section	**Data/Information Required**	**Page**
2.4 External Generation of Land Use Time Series Files	From other sources such as watershed simulation models or from continuous observations, provide a time series file for flow, nutrient, and sediment, on a unit area basis (one acre), and specific for each individual land use type. File format should be consistent with the format shown in Figure 2.	8-9
4.3 Land Use Distribution	Enter name of each land use, define it as impervious or pervious, and enter the time series file path; see Figure 9.	18
4.4 Pollutant Factors (Definitions)	The order of each pollutant represented in the time series files is important. Define pollutants in the same order as they appear in the externally generated land use time series files; see Figure 10. Note: SUSTAIN assumes all pollutants in the externally generated time series are defined in lbs./time step.	18-19
3.2 Optimization Target (Planning Level)	Enter storage capacity (gal.) for each BMP type (prior to tool's optimization for BMP Drainage Area); see Figure 6	12
3.4 BMP Information	Enter BMP drainage area (acres) for single or multiple land use types; Enter infiltration rate (in./hr.) for infiltration BMPs; see Tables 3, 4, 5.	14-15
4.1 Watershed Map (optional)	Provide & load Jpg image of watershed map (optional)	17
4.2 Watershed Information	Enter number of subbasins, land uses, BMPs, and pollutants; see Fig. 8 and Table 2.	14 17-18
4.5.2 Junction Inputs	Enter a junction name, downstream junction, and total subbasin drainage area (acres); see Fig. 11.	20-21
4.6.1 BMP Surface Dimensions	Enter BMP surface dimensions, including maximum length (ft.), maximum width (ft.), and weir/orifice properties (ft.); see Fig. 13. Specify BMP location (subbasin), drainage area (acres) and downstream BMP connection	21-22
4.6.3 Substrate properties	Enter depth of soil column (ft.), soil porosity (0-1), and a soil column infiltration rate (in/yr), and vegetative parameter (0.1-1.0); see Fig. 15.	23
4.7.1 Conduit Cross-Section	Enter choices on cross-sectional geometry (from Table 9) and Stream/Conduit Properties input form; see Fig. 17.	26-27
4.7.2 Conduit Properties	Enter length (ft.), Manning's Roughness coefficient, head loss coefficients; Enter invert elevations (ft); see Fig 18. Specify an initial flow rate (cfs) (optional).	27-28

User Guide Section	Data/Information Required	Page
5.1 Input File	Enter simulation start & end dates (within the dates of the land use time series files); see Fig 22.	31
6.1 System Output	Define output folder (model will generate output files under the “user-defined output folder”); See Table 11.	32-33

For the Planning Level Analysis, the user needs to provide the total land use area distribution within the entire drainage area to the assessment point, and the BMP drainage area for single or multiple land use types.

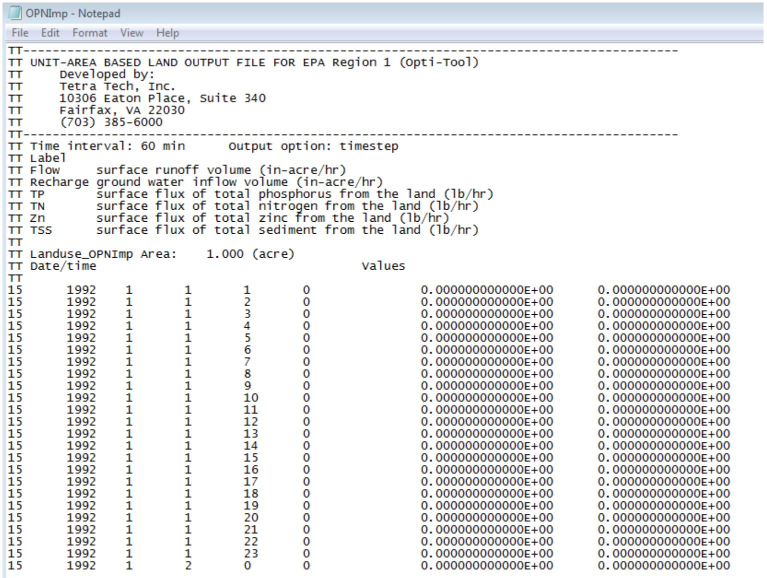
2.4 External Generation of Land Use Time Series

The system does not currently simulate flow, nutrient, and sediment time series internally. It requires that this information be obtained as time series from other sources such as watershed simulation models or from continuous observations. A user can use the default time series as input, or a user can use the default time series as a template and overwrite the file with the desired time series. The time series should be on a unit-area basis (one acre) and specific for each individual land use type. File format should be consistent with the format shown in Figure 2.

The default time series are long-term (1992 – 2014) pollutant runoff time series (provided with the Opti-Tool) updated to reflect more recent loading rate estimations for New England region. The methodology for developing these timeseries for flow, TP, TN, TSS, and Zn is summarized in a technical memo included in the installation package under the Documents folder (Technical Memo 3).

Time Series File Generation

Some suggested modeling applications that are commonly used include LSPC, HSPF and SWMM; however, any hydrology model capable of generating hourly time series of runoff and pollutant loads can be used as long as the files are formatted consistent with Figure 2.



```
OPNImp - Notepad
File  Edit  Format  View  Help
TT---------------------------------------------------------------------------------------
TT UNIT-AREA BASED LAND OUTPUT FILE FOR EPA Region 1 (Opti-Tool)
TT     Developed by:
TT     Tetra Tech, Inc.
TT     10306 Eaton Place, Suite 340
TT     Fairfax, VA 22030
TT     (703) 385-6000
TT---------------------------------------------------------------------------------------
TT Time interval: 60 min      Output option: timestep
TT Label
TT Flow     surface runoff volume (in-acre/hr)
TT Recharge ground water inflow volume (in-acre/hr)
TT TP       surface flux of total phosphorus from the land (lb/hr)
TT TN       surface flux of total nitrogen from the land (lb/hr)
TT Zn       surface flux of total zinc from the land (lb/hr)
TT TSS      surface flux of total sediment from the land (lb/hr)
TT
TT Landuse_OPNImp Area:    1.000 (acre)
TT Date/time                                 Values
TT
15      1992    1       1       1       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       2       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       3       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       4       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       5       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       6       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       7       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       8       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       9       0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       10      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       11      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       12      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       13      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       14      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       15      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       16      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       17      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       18      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       19      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       20      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       21      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       22      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       1       23      0               0.000000000000E+00      0.000000000000E+00
15      1992    1       2       0       0               0.000000000000E+00      0.000000000000E+00
```

Figure 2. Example of a time series as input for the SUSTAIN model in Opti-Tool.

2.5 Interface Introduction

Figure 3 (below) shows the Opti-Tool *Home* screen that appears when the model spreadsheet is first opened. Opti-Tool includes supplemental documentation internally, which acts like an embedded user's guide and is accessible under *About the Tool* button on the upper left-hand side of the *Home* screen.

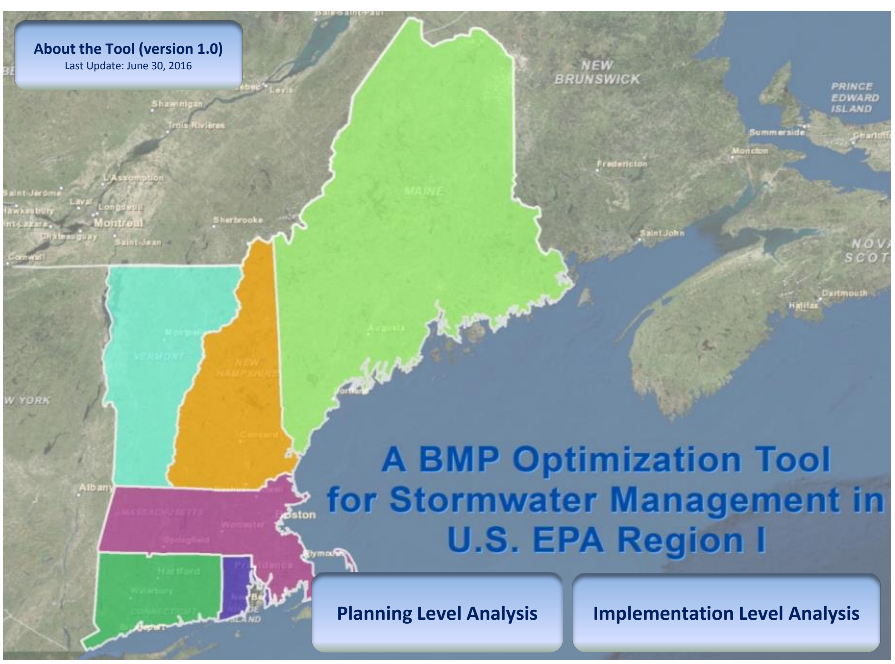
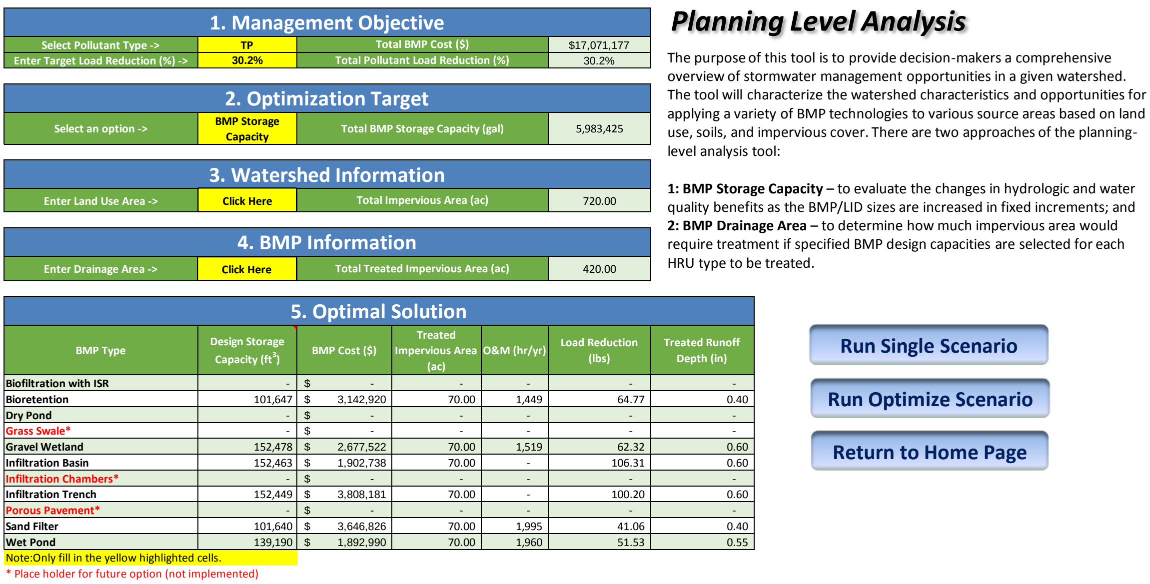


Figure 3. The Opti-Tool *Home* screen

Figure 4 (below) shows the screen that appears when *Planning Level Analysis* is selected. The user needs to define the yellow cells, and the *Run Single Scenario* or *Optimize* options will populate the remaining cells on that worksheet. The details are outlined in Section 3, *Building a Planning Level Analysis Project*



1. Management Objective			
Select Pollutant Type ->	TP	Total BMP Cost ($)	$17,071,177
Enter Target Load Reduction (%) ->	30.2%	Total Pollutant Load Reduction (%)	30.2%

2. Optimization Target			
Select an option ->	BMP Storage Capacity	Total BMP Storage Capacity (gal)	5,983,425

3. Watershed Information			
Enter Land Use Area ->	Click Here	Total Impervious Area (ac)	720.00

4. BMP Information			
Enter Drainage Area ->	Click Here	Total Treated Impervious Area (ac)	420.00

5. Optimal Solution

BMP Type	Design Storage Capacity (ft^3)	BMP Cost ($)	Treated Impervious Area (ac)	O&M (hr/yr)	Load Reduction (lbs)	Treated Runoff Depth (in)
Biofiltration with ISR	-	$ -	-	-	-	-
Bioretention	101,647	$ 3,142,920	70.00	1,449	64.77	0.40
Dry Pond	-	$ -	-	-	-	-
Grass Swale*	-	$ -	-	-	-	-
Gravel Wetland	152,478	$ 2,677,522	70.00	1,519	62.32	0.60
Infiltration Basin	152,463	$ 1,902,738	70.00	-	106.31	0.60
Infiltration Chambers*	-	$ -	-	-	-	-
Infiltration Trench	152,449	$ 3,808,181	70.00	-	100.20	0.60
Porous Pavement*	-	$ -	-	-	-	-
Sand Filter	101,640	$ 3,646,826	70.00	1,995	41.06	0.40
Wet Pond	139,190	$ 1,892,990	70.00	1,960	51.53	0.55

Note:Only fill in the yellow highlighted cells.

* Place holder for future option (not implemented)

Planning Level Analysis

The purpose of this tool is to provide decision-makers a comprehensive overview of stormwater management opportunities in a given watershed. The tool will characterize the watershed characteristics and opportunities for applying a variety of BMP technologies to various source areas based on land use, soils, and impervious cover. There are two approaches of the planning-level analysis tool:

1: BMP Storage Capacity – to evaluate the changes in hydrologic and water quality benefits as the BMP/LID sizes are increased in fixed increments; and
2: BMP Drainage Area – to determine how much impervious area would require treatment if specified BMP design capacities are selected for each HRU type to be treated.

Run Single Scenario

Run Optimize Scenario

Return to Home Page

Figure 4. The Opti-Tool *Planning Level Analysis* screen

Figure 5 (below) shows the screen that appears when *Implementation Level Analysis* is selected. Graphic forms are provided in a stepwise sequential format for each model step to logically guide the user to enter and define the required inputs.

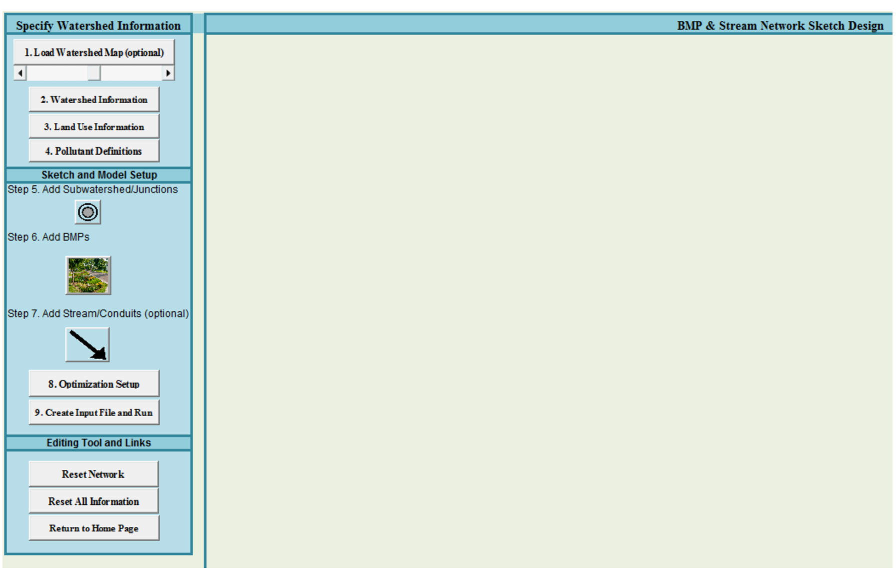


Figure 5. The Opti-Tool 'Watershed Sketch' screen

The steps for building a new model are outlined from top to bottom on the left-hand side of the *Watershed Sketch* screen, and are listed in the stepwise sequential order in which they should occur. The details of each step are outlined in Section 4, *Building an Implementation Level Analysis Project*.

3. Building a Planning Level Analysis Project

This section outlines the process of building a scenario for the planning level analysis tool and follows the model steps outlined on the 'Planning Level Analysis' screen. The purpose of this tool is to provide decision-makers with a comprehensive overview of stormwater management opportunities in a given watershed. The tool will characterize the watershed characteristics and opportunities for applying a variety of BMP technologies to various source areas based on land use, soils, and impervious cover.

The user can choose one of two approaches in planning-level analysis tool: (1) BMP Storage Capacity to evaluate the changes in water quality benefits as the BMP/LID sizes are changed. In this case, the objective function is to identify the most cost-effective BMP storage capacity that meets the target load reduction; (2) BMP Drainage Area to determine how much impervious drainage area would require treatment if specified BMP design capacities were selected. In this approach, both BMP storage capacity and BMP cost are fixed. The objective function, in this case, is to identify the extent of impervious area to be treated that can provide the target pollutant load reduction.

Building a project requires the user to select a pollutant type from the pull-down list, provide a target load reduction percentage, select an optimization target, enter watershed land use area, and enter BMP drainage area. The user is only required to fill in yellow highlighted cells shown in Figure 6. Each step of the process is detailed in the sections below.

1. Management Objective			
Select Pollutant Type ->	TP	Total BMP Cost ($)	$17,071,177
Enter Target Load Reduction (%) ->	30.2%	Total Pollutant Load Reduction (%)	30.2%

2. Optimization Target			
Select an option ->	BMP Storage Capacity	Total BMP Storage Capacity (gal)	5,983,425

3. Watershed Information			
Enter Land Use Area ->	Click Here	Total Impervious Area (ac)	720.00

4. BMP Information			
Enter Drainage Area ->	Click Here	Total Treated Impervious Area (ac)	420.00

Figure 6. *Planning Level Analysis* form

Save Often

It is recommended that you save the spreadsheet before creating an input file and also before running a simulation. In fact, it is good computing practice to save your work often throughout the process.

3.1 Management Objective

The user must select a pollutant type from the four available pollutants: TP, TN, TSS, and Zn, and enter the target load reduction percentage ranging from 0-100%.

3.2 Optimization Target

The optimization targets are based on the two approaches of the planning-level analysis tool. The first option, *BMP Storage Capacity*, provides the optimal BMP storage capacity by evaluating the most cost-effective changes in water quality benefits as the BMP/LID sizes are change. The second option, *BMP Drainage Area*, determines how much impervious area would require treatment to get the target load reduction. It is the user's responsibility to provide the storage capacity for each BMP type before the tool can optimize for *BMP Drainage Area*. The *BMP Storage Capacity* approach provides the BMP storage capacity, but if the user wants to change the BMP storage capacity, they can provide new values according to BMP type in the Design Storage Capacity (ft^3) column of 5. Optimal Solution.

3.3 Watershed Information

The *Click Here* link for *Watershed Information* will navigate the user to a table for the user to provide the total land use area distribution within the entire drainage area to the assessment point, shown below in Table 2. The user is responsible for filling in only the yellow highlighted cells. The selection of land use type is limited to the number of land use types available in the new MA/US EPA Region 1 MS4 permit, and includes both impervious and pervious areas.

Table 2. Watershed Information – Land Use Area

Landuse Type	Impervious/Pervious	Total Area (ac)
Agriculture Impervious	Impervious	10
Forest Impervious	Impervious	10
Highway Impervious	Impervious	100
Industrial Impervious	Impervious	100
Commercial Impervious	Impervious	100
High Density Residential Impervious	Impervious	100
Medium Density Residential Impervious	Impervious	100
Low Density Residential Impervious	Impervious	100
Open Land Impervious	Impervious	100
Agriculture Pervious	Pervious	100
Forest Pervious	Pervious	100
Developed Pervious A	Pervious	100
Developed Pervious B	Pervious	100
Developed Pervious C	Pervious	100
Developed Pervious C/D	Pervious	100
Developed Pervious D	Pervious	100
	TOTAL Area (ac)	1420
* Note:Only fill in the yellow highlighted cells.		

3.4 BMP Information

The *Click Here* link for *BMP Information* will navigate to a table for the user to provide the BMP drainage area for single or multiple land use types, see Table 3 below. The user must provide the infiltration rate for infiltration system BMPs (infiltration chamber, infiltration trench, and infiltration basin), see Table 4 below. The user is responsible for filling in only the yellow highlighted cells.

Table 3. BMP Information – Drainage Area

Landuse Type	Impervious/ Pervious	Biofiltration with ISR (ac)	Bioretention (ac)	Dry Pond (ac)	Grass Swale* (ac)	Gravel Wetland (ac)	Infiltration Basin (ac)	Infiltration Chambers* (ac)	Infiltration Trench (ac)	Porous Pavement* (ac)	Sand Filter (ac)	Wet Pond (ac)	Total (ac)
Agriculture Impervious	Impervious	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest Impervious	Impervious	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Highway Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
Industrial Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
Commercial Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
High Density Residential Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
Medium Density Residential Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
Low Density Residential Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
Open Land Impervious	Impervious	0.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00	10.00	70.00
	TOTAL Area (ac)	0.00	70.00	70.00	0.00	70.00	70.00	0.00	70.00	0.00	70.00	70.00	490.00
						Select BMP Infiltration Rate (in/hr) ->	0.52	0.52	0.52				
Note:Only fill in the yellow highlighted cells.													
* Place holder for future option (not implemented)													

Table 4. Infiltration Rates for infiltration BMP types in Opti-Tool

Infiltration Rate (in/hr)
0.17
0.27
0.52
1.02
2.41
8.27

3.5 Run Single Scenario

The *Run Single Scenario* analysis can estimate the *BMP Storage Capacity* for any given runoff treatment depth from the BMP impervious drainage areas. The user can enter a runoff depth (inches) between 0-2, see Figure 7 below. Based on the runoff depth (inches), Opti-tool calculates the BMP storage capacity (ft^3), BMP cost ($), treated impervious area (ac), annual operation and maintenance hours (hr), and pollutant load reduction (lbs). The list of BMP types available in Opti-Tool are shown in Table 5 below.

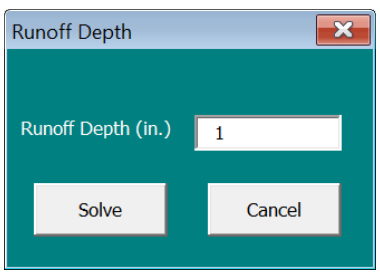


Figure 7. Run Single Scenario - Runoff Depth

Table 5. BMP Types in Opti-Tool

BMP Type
Biofiltration with Internal Storage Reservoir
Bioretention
Dry Pond
Grass Swale
Gravel Wetland
Infiltration Basin
Infiltration Chambers
Infiltration Trench
Porous Pavement
Sand Filter
Wet Pond

3.6 Run Optimize

The *Run Optimize* button will begin the performance optimization process. The optimization analyses are performed through Excel Solver. The *BMP Storage Capacity* option searches through possible BMP/LID design capacities to identify the most cost-effective BMP/LID size for meeting a user-specified control reduction target. The *BMP Drainage Area* option varies the amount of contributing impervious areas and identifies the optimal sizes of impervious areas need to be treated for each BMP combination in the watershed to meet the overall control target. After the Solver has completed, a message box will appear to inform the user of the status of the solution in terms of whether a solution was found, or if the run stopped at maximum iterations, or if a solution is not feasible. Table 6 below will be populated with information based on the optimal solution. The user has the option to select the maximum run time for the Solver to use for searching the optimal solution.

Table 6. Optimal Solution

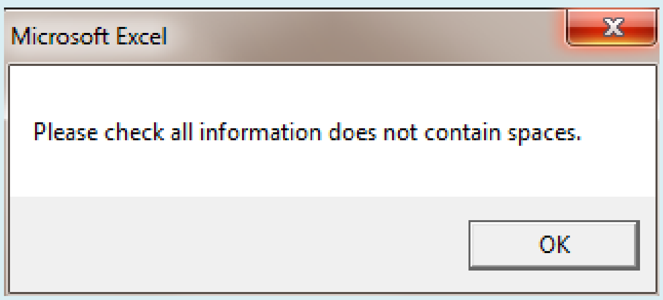
5. Optimal Solution						
BMP Type	Design Storage Capacity (ft^3)	BMP Cost ($)	Treated Impervious Area (ac)	O&M (hr/yr)	Load Reduction (lbs)	Treated Runoff Depth (in)
Biofiltration with ISR	-	$ -	-	-	-	-
Bioretention	101,647	$ 3,142,920	70.00	1,449	64.77	0.40
Dry Pond	-	$ -	-	-	-	-
Grass Swale*	-	$ -	-	-	-	-
Gravel Wetland	152,478	$ 2,677,522	70.00	1,519	62.32	0.60
Infiltration Basin	152,463	$ 1,902,738	70.00	-	106.31	0.60
Infiltration Chambers*	-	$ -	-	-	-	-
Infiltration Trench	152,449	$ 3,808,181	70.00	-	100.20	0.60
Porous Pavement*	-	$ -	-	-	-	-
Sand Filter	101,640	$ 3,646,826	70.00	1,995	41.06	0.40
Wet Pond	139,190	$ 1,892,990	70.00	1,960	51.53	0.55

4. Building an Implementation Level Analysis Project

This section outlines the process of building a simulation input file for the SUSTAIN model. The sections are organized similar to the model steps outline on the *Watershed Sketch* screen. A demonstration is available is Section 8 (pp. 36-54)

General Naming Practices

As a general rule, <u>do not</u> use special characters or spaces in any of the user-defined component names such as Land Use Definitions, Pollutant Definitions, Subbasins/Junctions, BMPs and Conduits, including paths for time series files, input files, and output files. The use of an underscore ("_") is acceptable. The error message below will appear if any user-defined component names contain spaces.



4.1 Load Watershed Map (optional)

The *Load Watershed Map (optional)* button provides the option to load a jpg image into the *BMP & Stream Network Design* box. The scroll bar below the *Load Watershed Map (optional)* button changes the transparency of the image loaded into the *BMP & Stream Network Design* box. The map serves as a background image to guide the user while building the BMP routing network.

4.2 Watershed Information

The *Watershed Information* button activates the *Key Information* form, see Figure 8 below. The user must define the number of subbasins (Section 4.5), land uses (Section 4.3), BMPs (Section 4.6), and pollutants (Section 4.4). On this form, the user has the option to select *Default Pollutant Values*, the four default pollutants are TP, TN, TSS, and Zn. If selected, the *Default Pollutant Values* button will populate the number of pollutants box with 4, and defines the pollutant definition (see Section 4.4).

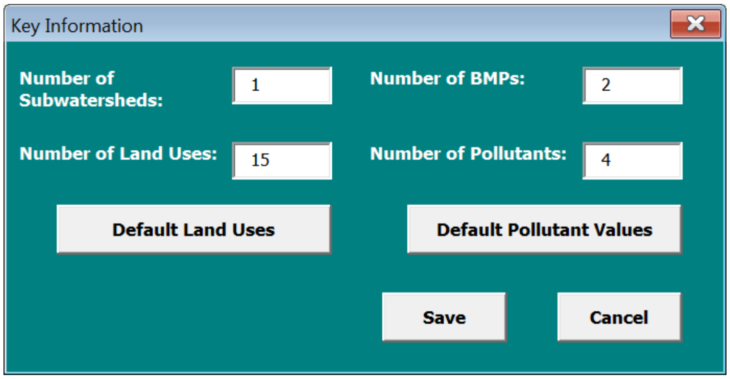


Figure 8. The Opti-Tool *Key Information* form

4.3 Land Use Information

The system does not simulate the flow, nutrient, and sediment time series. However, the tool provides a long term hourly time series of runoff flow and quality based on climatic data for Boston, Massachusetts (1992 - 2014). Based on precipitation data analyses, these time series are considered to be representative of precipitation patterns and stormwater quality for the New England region. However, the Opti-Tool provides the user with the option to use time series from other sources (e.g., watershed simulation models or from observations). See Section 2.4 for further details and file format. The time series should be unit-area-based (one acre) and specific for each individual land use type that exists within the study area. For each land use, the user must name the land use, define if it is impervious or pervious, and provide the time series file path, see Figure 9 below. *Save* must be selected after inputting each individual land use information. The user can change from one land use ID to another by selecting the drop down box.

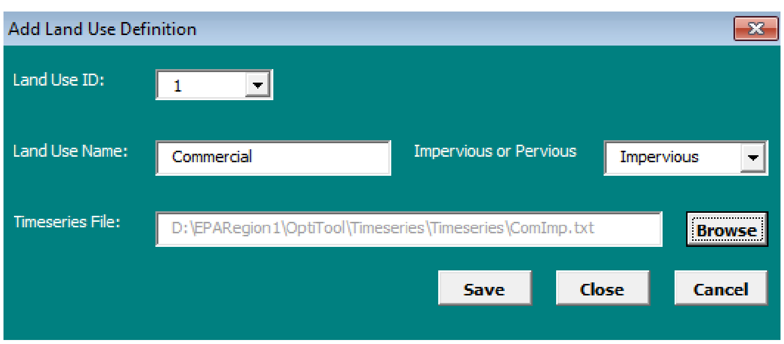


Figure 9. Defining land use categories

4.4 Pollutant Definitions

The user can include other pollutants besides TP, TN, TSS, and Zn. Pollutants should be defined in the same order as they appear in the externally generated land use time series files. Surface flow is always required as the first factor in the land use time series files and <u>should not</u> be defined by the user as a pollutant. If the user selected *Default Parameter Values* (See Section 4.2, pp. 17-18), then the pollutant definition form will be automatically populated, see Figure 10 below.

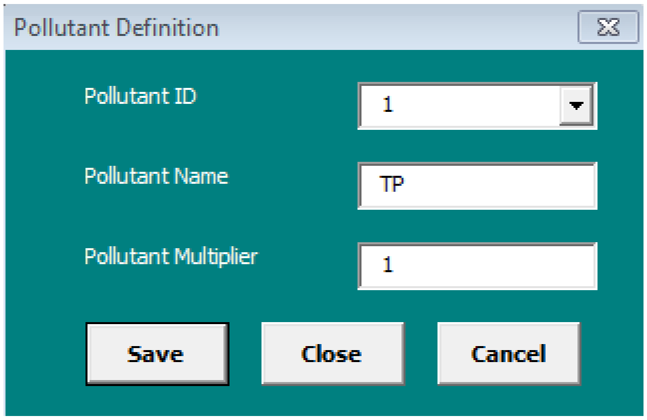


Figure 10. Defining a pollutant factor

Pollutant loading data from the land use time series files is expected in units of pounds per hour. Use the pollutant multiplier to convert the units used in the time series files into the required units of pounds per hour. Also, the pollutant multiplier can be used as a scaling factor to adjust the hourly pollutant loads to be higher or lower than the default time series. For example, if the user has determined that the loading rate for a particular source area is approximately 25% higher than the rate represented by the default time series then the user can apply a pollutant multiplier of 1.25 for that source area.

Pollutant Multiplier

The user can specify a *Pollutant Multiplier* as a way to convert their data to the required units. For example a multiplier of 2,000 converts Total Suspended Solids (TSS) data from units of <u>tons per hour</u> to <u>pounds per hour</u> (1 ton = 2,000 pounds). If pollutant units are already specified as pounds per hour, enter a multiplier of 1.

4.5 Subbasin Definitions

A subbasin is a section of land that, either because of topography or conveyance systems (sewer or storm drain network), will drain to a single point. Each subbasin in the watershed, will have a unique drainage area size and distribution of land use types (see Section 4.5.2 and Figure 12), effectiveness impervious cover (i.e., directly connected impervious cover) and pervious cover by hydrologic soil group (HSG). A group of subbasins can be connected via streams or conduits (see Section 4.7, pp 26-28) and in aggregate make up a watershed.

4.5.1 Example Basin

Figure 11 below shows an example watershed study area that is comprised of five subbasins. In this example, the subbasins are connected by streams represented by the line segments with arrows. Subbasin 1, 3 and 4 contain best management practices (BMPs) that treat a portion of the land area represented by the dotted lines. At the bottom of subbasin 5 is the watershed outlet represented by the star.

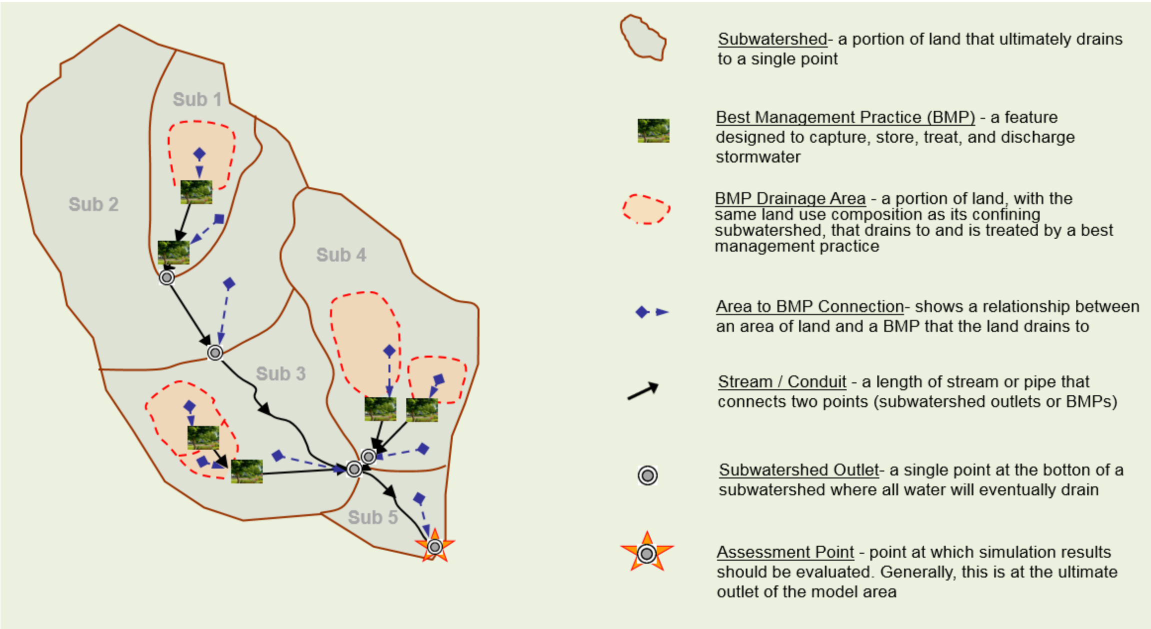


Figure 11. Example basin

4.5.2 Junction Inputs

For each subbasin in the watershed, the user will enter a junction name, downstream junction, and total subbasin drainage area (acres). The user will select the “Add Subwatershed/Junction” button on the left side of the screen and then click on the insert junction symbol in the map to access the input form shown in Figure 12. The specifications of this connection will be detailed later during the *Streams & Conduits* step (see Section 4.7). At least one subbasin must be connected to the *OUTLET*. This represents the terminating point in the routing network which is usually an assessment point for evaluating the management objective.

All defined land uses will appear in the *Land Use Distribution* list, although not all land uses are required for every subbasin. If a specific land use is not needed, enter 0 for the area. The same land use category can be used multiple times within a subbasin. The sum of the land use distribution should equal the subbasin total drainage area. An example subbasin input form is presented below as Figure 12.

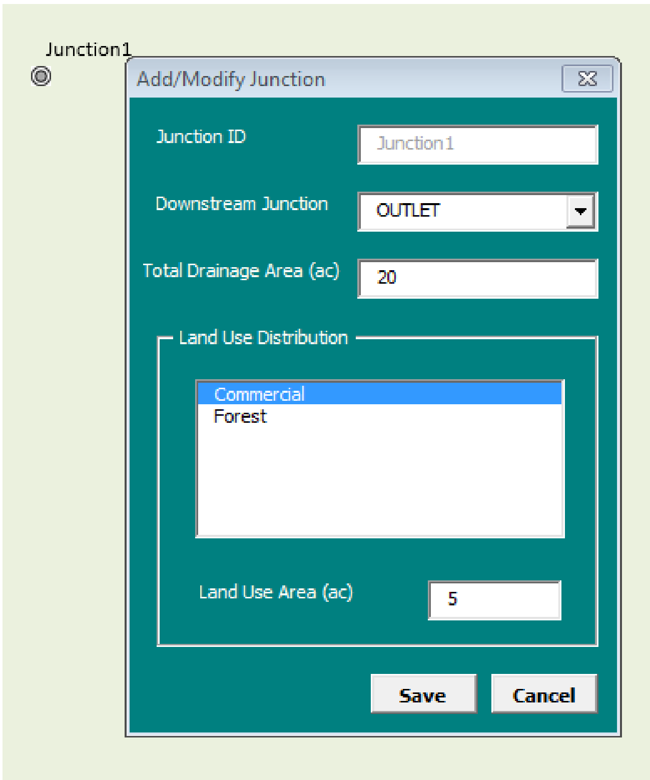


Figure 12. Example subbasin input form showing the land use distribution

4.6 Best Management Practices (BMPs)

A list of BMPs available in Opti-tool are shown in Table 5 (above, p.15). The default design specifications and default parameters for the BMPs are based on the BMP calibration performed using the UNHSC BMP monitoring data (Tetra Tech, 2010) and BMP design parameters for TN performance calibration (Technical Memo 10).

4.6.1 Surface Dimensions

The user has the option of using the default design parameters available in the Opti-Tool by selecting the Default Parameter button or the option of inputting site specific BMP design information. BMP surface dimensions include parameters such as the maximum length, maximum width, and weir/orifice properties. The BMP location (subbasin), drainage area and downstream BMP connection are also specified by the user on this form. An example BMP input form is presented below as Figure 13.

A list of BMP types is provided allowing the user to select from the range of available BMPs as shown in Table 5 (above p. 15). The required inputs will change depending on what BMP type is selected.

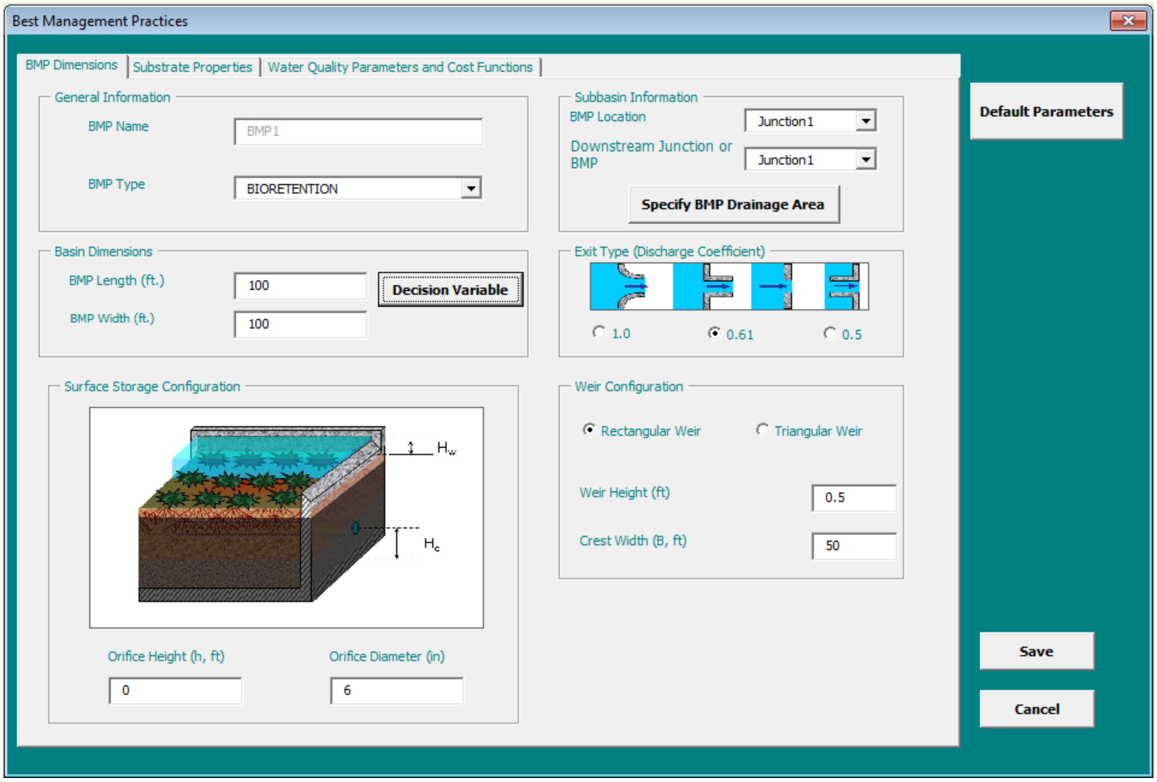


Figure 13. Example of the BMP surface dimension input form

4.6.2 Decision Variables

On the previous BMP input form (Figure 13 above), there is a button labeled *Decision Variable*. Rather than specifying a fixed BMP dimension, the user can select, upper and lower bounds, allowing the dimension to change during the optimization. After clicking on a *Decision Variable* button the user will be presented with the *Decision Variable* form, see Figure 14 below. The length of the BMP footprint is a decision variable, the width is always fixed.

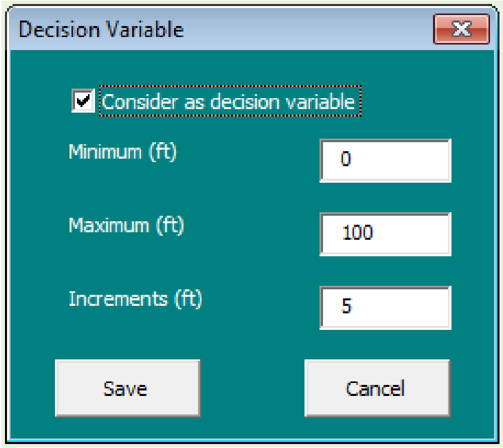


Figure 14. Example decision variable window

4.6.3 Substrate Properties

For soil properties the user is asked to define the depth of soil column, soil porosity, and a soil column infiltration rate, as shown in Figure 15 below. Alternatively, the user can select the default parameters by selecting Default Parameter button. The Holtan-Lopez empirical infiltration model is used to simulate water transfer through the soil layer. The user is required to define the vegetative parameter A (0.1-1.0) for this method.

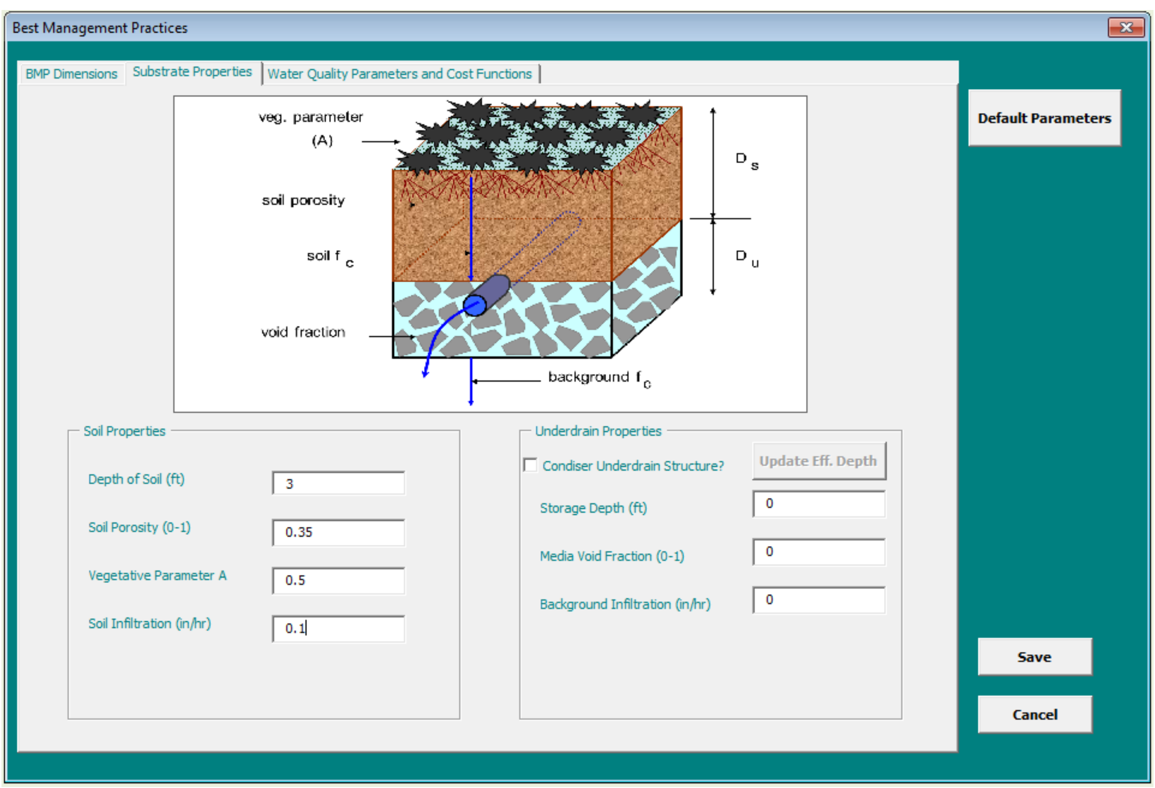


Figure 15. Example of the BMP substrate properties input form

BMPs can also be simulated with an optional underdrain structure. The user is asked to define the depth of underdrain storage, the media void fraction (0.0 to 1.0), and a background infiltration rate for the underlying native soil.

Underdrain Simulation
If no underdrain structure is modeled, the soil layer infiltration rate is also assumed to be the background infiltration rate. The user should verify that the specified soil saturated infiltration rate is representative of native soil properties.

4.6.4 Default BMP Parameters

The user has the option to populate the surface dimensions and substrate properties with default parameters based on the BMP type by selecting the "Default" button. The default parameters are specific BMP design configurations used for calibrating the BMP cumulative performance using UNHSC BMP monitoring data, and are used to develop long term cumulative BMP performance curves.

4.6.5 Water Quality Parameters and Cost Function

General pollutant loss through a BMP is modeled in two parts (1) first-order decay in the surface storage compartment and soil column, and (2) filtration through the substrate as a percent removed. Filtration is associated with the underdrain layer and only occurs when modeling with an underdrain is selected. Users should specify a pollutant decay rate for each pollutant factor. The *Default Pollutants* can only be selected if the user selected *Default Pollutant* (see Section 4.2, pp. 17-18), and it populates decay and underdrain removal rates based on the BMP type.

BMP costs are defined on a storage volume basis using the following cost function:

Cost = *Storage Volume Cost* * *Storage Volume*

Where: *Storage Volume Cost* = unit cost of ($/ft^3)
Storage Volume = unit volume of (ft^3)

Storage Volume Cost could include a cost adjustment factor based on the site conditions in which the BMP would be installed (i.e., "BMP development type").

The proposed BMP cost estimates for Opti-Tool were provided by EPA-Region 1 (Technical Memo 5). Table 7 below includes the BMP Type options in Opti-Tool and the associated *Storage Volume Cost* ($/ft^3). The unit cost represents the 2016 dollar amount

($) per cubic feet. The storage volume cost can be adjusted based on the BMP development type (Table 8 below). The cost adjustment factor increases according to implementation difficulty level. The cost adjustment factors are direct a multiplier to the storage volume cost.

The storage volume cost ($/ft³) is populated based on the BMP type. By default, Opti-Tool assumes *New BMP in Undeveloped Area* as the BMP development type with a cost adjustment factor of 1. The user has the option to adjust the storage volume cost ($/ft³) by changing the BMP development type (Figure 16 below). If the users determines the cost adjustment factor options are not representative of their development type, users are able to provide an alternative cost adjustment factor. The cost adjustment factor is the only mechanism to change the storage volume cost ($/ft³).

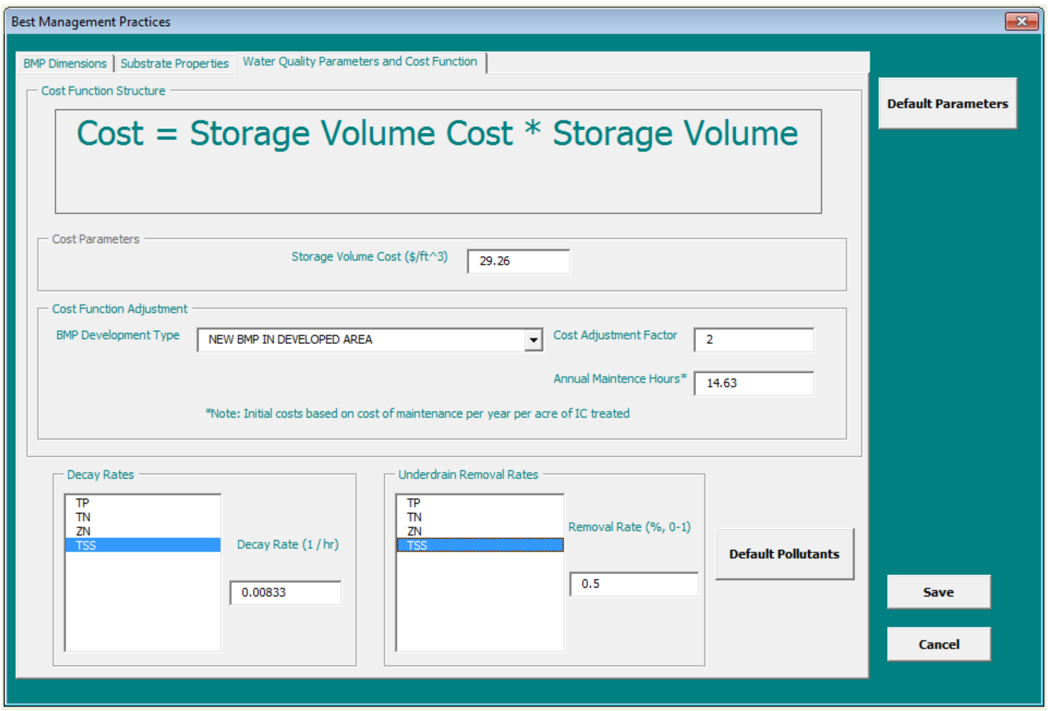


Figure 16 Example of the BMP water quality parameters and cost function input form

Table 7. Storage Volume Cost

BMP Type	Cost ($/ft³) – 2016 dollar
Bioretention	$ 15.46
Dry Pond	$ 6.8
Enhanced Bioretention	$ 15.61
Infiltration Basin	$ 6.24
Infiltration Chamber	$ 67.85
Infiltration Trench	$ 12.49

BMP Type	Cost ($/ft^3) – 2016 dollar
Porous Pavement (Porous Asphalt Pavement)	$ 5.32
Porous Pavement (Pervious Concrete)	$ 18.07
Sand Filter	$ 17.94
Subsurface Gravel Wetland	$ 8.78
Wet Pond	$ 6.8

Table 8. Cost Adjustment Factor

BMP Development Type	Cost Adjustment Factor
New BMP in Undeveloped Area	1.0
New BMP in Partially Developed Area	1.5
New BMP in Developed Area	2.0
Difficult Installation in Highly Urban Settings	3.0

4.7 Streams and Conduits

Streams and conduits provide a means to link the subbasins and BMPs defined during previous steps in the model building process. The user will select the arrow symbol below the "Step 7. Add Stream/Conduits (optional)" button on the left side of the screen and then click on the insert stream/conduit symbol in the map to access the input form shown in Figure 17. A connection is created by specifying an upstream and downstream node (subbasin or BMP) for each conduit, see Figure 17 below. All connections, by default, will be set as *Dummy* connections, which have no specific geometry unless the user specifies a conduit with another geometry. The conduits are optional in Opti-Tool and *Dummy* conduits will be the default setting if no routing is desired between two nodes (BMP or subbasin).

4.7.1 Conduit Cross-Section

The conduit cross-section allows the user to specify the cross-sectional geometry of each stream or conduit in the routing network. Eight unique cross-sections are available, and are consistent with those used in SUSTAIN, see Table 9 below.

Table 9. Cross Section Geometry Options in Opti-Tool

Cross Section Geometry
Dummy
Circular
Filled Circular

Cross Section Geometry
Rectangle Closed
Rectangle Open
Trapezoidal
Triangular
Parabolic
Rectangular Triangular

At the bottom on the Stream/Conduit Properties form there are drop-down boxes for specifying the upstream and downstream nodes that the segment is connecting. These lists will be automatically populated with the subbasin and the BMPs defined in previous steps.

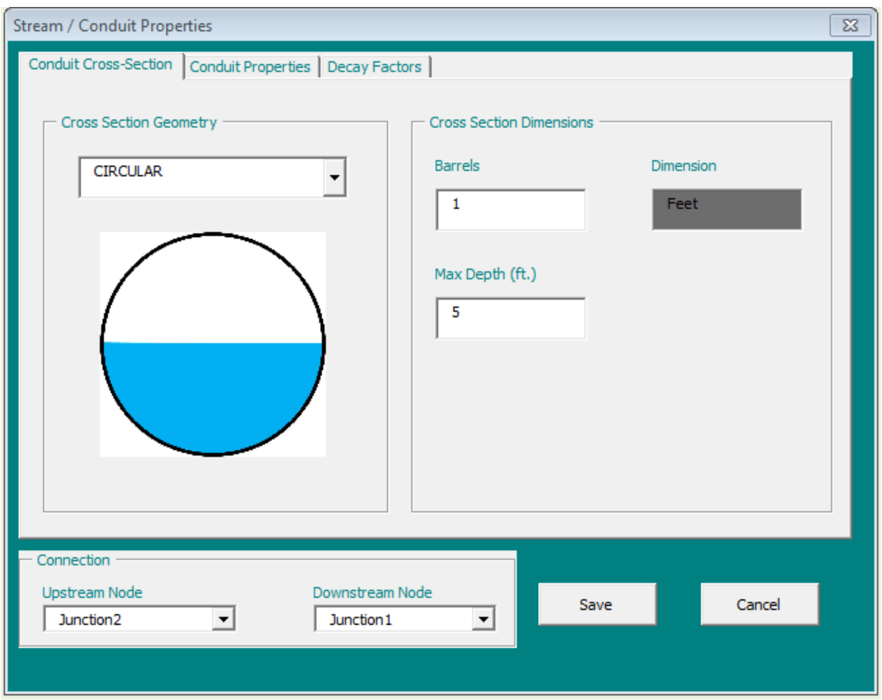


Figure 17 Conduit cross-section input form

4.7.2 Conduit Properties

Conduit properties include parameters related to the length of segment. Users should enter the conduit length (ft.), Manning's Roughness coefficient, and head loss coefficients at the entrance, exit and along conduit length, see Figure 18 below. Invert elevations at the conduit entrance and exit should be entered with the units of feet (ft). Optionally, the user can specify an initial flow rate in cubic feet per second (cfs) in the conduit.

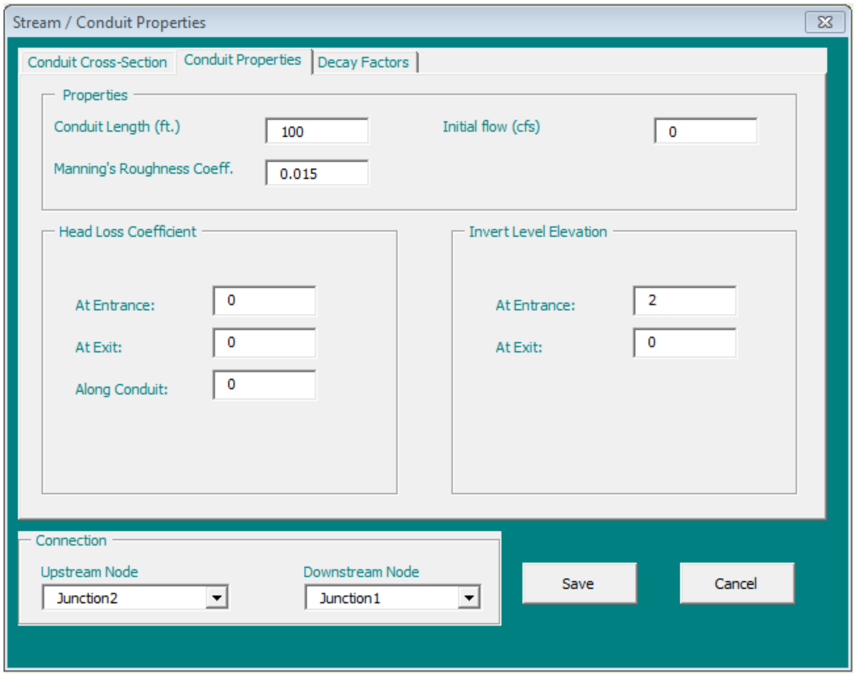


Figure 18 Conduit properties input form

4.7.3 Decay Rates

Depending on the system, it may be necessary to model in-stream pollutant decay. This can help account for pollutant settling or other removal factors that occur during transport. Users should specify a pollutant decay rate for each pollutant factor using the form shown in Figure 19 below.

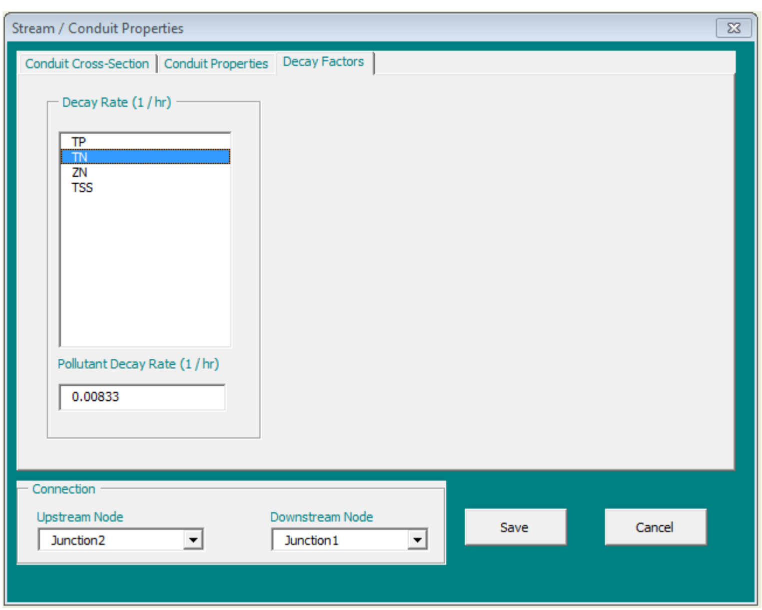


Figure 19 Example of the water quality decay factor input form

4.8 Define Management Objectives

Management objectives are defined as flow or water quality targets that the user is interested in achieving with the help of a combination of BMPs and associated decision variables defined during the previous steps. These objectives can be assessed at any node in the model network including BMP outlets, stream outlets, and even at the watershed outlet. Any node that is associated with a management objective is called an Assessment Point. A summary of the available evaluation factors and types is presented below as Table 10.

Table 10. Summary of Management Objective Evaluation Factors & Types

Evaluation Factor	Evaluation Type	Abbreviation Code	Units
Flow	Annual Average Flow Volume	AAFV	ft^3 / year
	Peak Discharge Flow	PDF	ft^3 / second
	Flow Exceeding Frequency	FEF	# of Exceedances
Water Quality	Annual Average Load	AAL	pounds / year
	Annual Average Concentration	AAC	mg / L
	Maximum Moving Average Concentration	MAC	mg / L

4.8.1 Assessment Methods

Two analysis methods are available when defining management objectives (1) No Optimization, and (2) Cost-Effectiveness Curve. The No Optimization method provides a solution of the trade-off between cost and management intensity. The Cost-Effectiveness Curve method provides a means to visualize the full spectrum of trade-offs between cost and management intensity. This latter method is ideal for larger study areas with many possible management options and also for long-range phased implementation planning. A baseline simulation is created which represents the developed condition without any BMPs. The results from the simulations are compiled together to form the cost-effectiveness curve.

The Management Objective form requires the user to specify the assessment method, assessment point, evaluation factor, and evaluation type, see Figure 20 below. Factor value 1 should remain -99 unless the evaluation type is maximum number of days or threshold (cfs). Factor value 2 should remain -99 unless the evaluation type is minimum inter-exceedance time (hr).

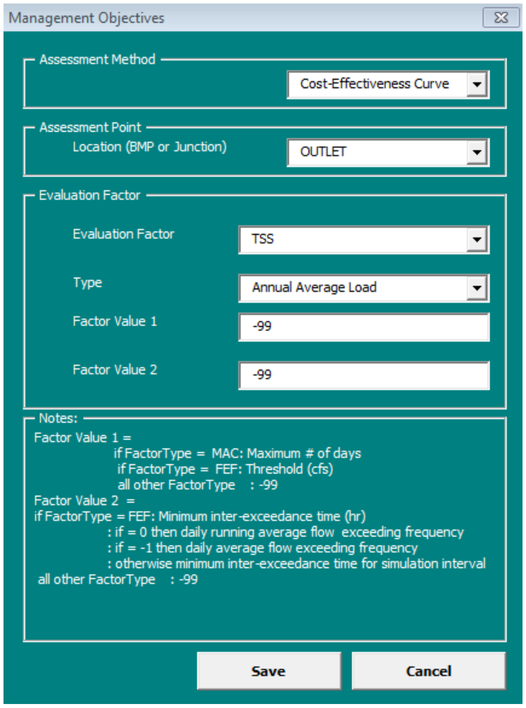


Figure 20 Example cost-effectiveness curve input form

4.8.2 Optimization Settings

Additional optimization settings are available for the cost-effective curve assessment method. The optimization settings allow users to set: (1) an approximate maximum number of runs for the optimization, and (2) a cost factor ($) that each successive solution must improve by in order to continue searching, see Figure 21 below.

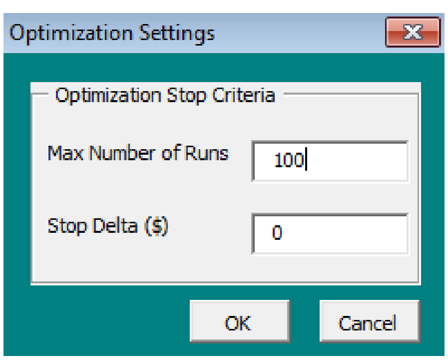


Figure 21 Example of the additional optimization settings

5. SUSTAIN Input File Creation and Model Run

After completing all the required model input steps, the *SUSTAIN Input File Creation and Model Run* screen should appear similar to the screen shown in Figure 22 below.

5.1 Create Input File

Steps 1-3 on the *SUSTAIN Input File Creation and Model Run* screen ask for simulation start and end dates that should be within the dates of the land use time series files. A location for the model input file and output files is also required. A pre-development land use is used to generate the *Pre-Development* model scenario (see output description under Section 6.1, pp. 32-33).

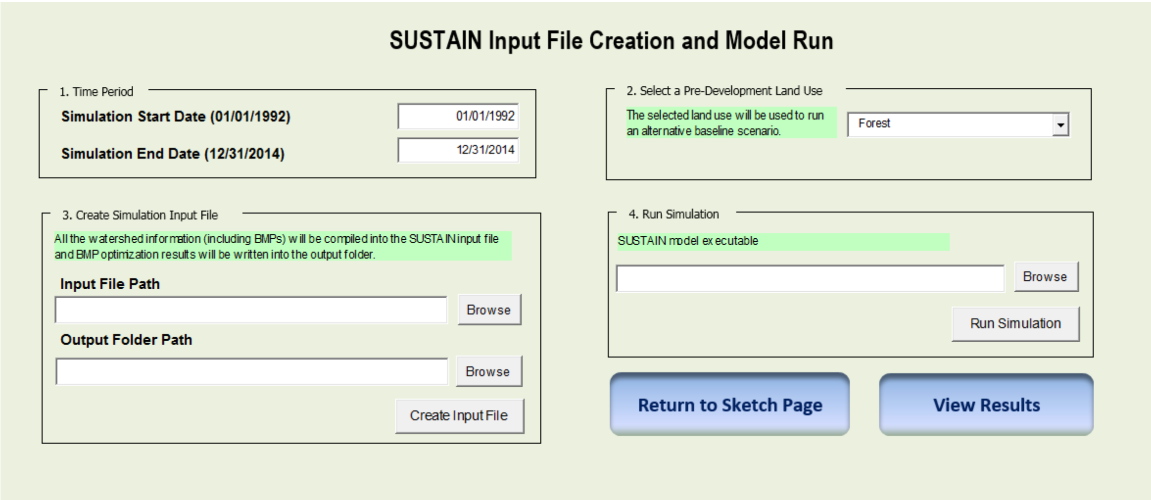


Figure 22 Example of the *SUSTAIN Input File Creation and Model* Run screen

After entering all the required inputs click *Create Input File*. This step takes all model inputs and formats them into a single input file (text file) used by the SUSTAIN engine to perform simulations.

5.2 Run Simulation

Steps 4 on the *SUSTAIN Input File Creation and Model Run* screen ask for the location of SUSTAIN executable. Once an input file is successfully created, click *Run Simulation* to execute the model in SUSTAIN.

6. System Output and Cost-Effective Curve

During the simulation run, a number of output files will be generated that represent scenarios of (1) pre-development conditions, (2) post-development without BMPs, and (3) post-development (initial conditions) with existing BMPs. The Cost-Effectiveness Curve references these output files and provides the user an opportunity to have a meaningful interaction with the simulation results.

6.1 System Output

The BMP and optimization model will generate output files under the user-defined output folder, as listed in Table 11 below.

Table 11. List of system output files and description of contents

Init_*.out	These are simulated flow and water quality time series output files for the existing or current scenario without having the optimization run. There will be one output file for each assessment point.
Init_Eval.out	This file has simulated and target values for each user-defined evaluation factor for the current scenario for each assessment point.
Init_FDC.out	This file has simulated flow rates (cfs) at the assessment point for the existing or current scenario without having the optimization run.
PostDev_*.out	These are simulated flow and water quality time series output files for the post-development without BMP scenario. There will be one PostDev output file for each assessment point.
PostDev_Eval.out	This file has simulated and target values for each user-defined evaluation factor for the post-development without BMP scenario for each assessment point.
PostDev_FDC.out	This file has simulated flow rates (cfs) at the assessment point for the post-development without BMP scenario.
PreDev_*.out	These are simulated flow and water quality time series output files for the pre-development scenario. There will be one PreDev output file for each assessment point.
PreDev_Eval.out	This file has simulated and target values for each user-defined evaluation factor for the pre-development scenario for each assessment point.

PreDev_FDC.out	This file has simulated flow rates (cfs) at the assessment point for the pre-development scenario.
AllSolutions.out	This file has optimization results for user-defined decision variables and evaluation factors for all the simulated optimization scenarios (iterations).
BestSolutions.out	This file has optimization results for user-defined decision variables and evaluation factors for the best optimization scenarios (best solution from each generation).
Best#_*.out	These are simulated flow and water quality time series output files for the user defined target reduction solution scenarios for each assessment point.
Best#_Eval.out	This file has simulated and target values for each user-defined target reduction solution for each assessment point.
Best#_FDC.out	This file has simulated flow rates (cfs) for the user defined target reduction solution scenario at the assessment point

Various Scenarios

Best Solutions: the near optimal solutions identified during the optimization run.

Pre-Development: the condition prior to development, it is represented using the land use time series specified as pre-development land use type, most commonly used land use type is forest.

Post-Development: developed condition (mix of land uses) without any BMPs.

Existing: developed condition with any existing BMPs, and would be identical to post-development condition if no existing BMPs.

6.2 View Results

After the simulation has run successfully, select *View Results* on the *SUSTAIN Input File Creation and Model Run* screen as shown in Figure 23 below. The result screen is divided into two parts depending on the user's selection of (1) cost-effective curve and the (2) flow duration curve.

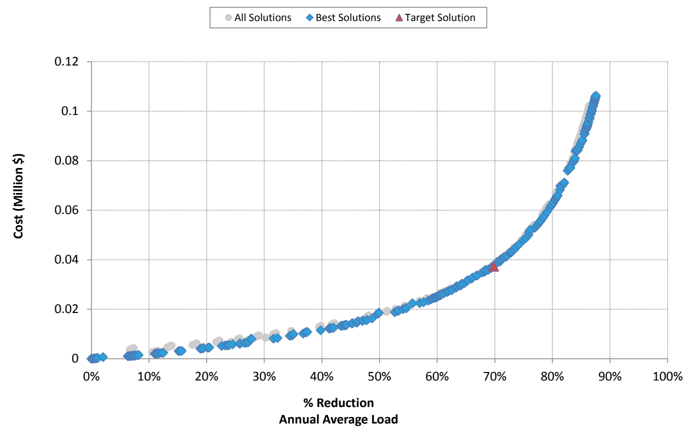


Figure 23 Cost –effectiveness curve results

6.2.1 Cost-Effectiveness Curve

The cost-effectiveness curve is an interactive plot showing the target solution. The user provides the target reduction, and Opti-Tool searches for the closest solution. The solution cost and reduction percentage are provided to the right of the user-defined target reduction, and the decision variables are provided for the selected solution (red diamond).

6.2.2 Flow Duration Curve

The flow duration curve is a graph showing percent of time that flow is equaled or exceeded for target solution. The user runs the target simulation and selects *Refresh FDC.* The flow duration curve plots the post-development (blue), predevelopment (green), and BMP scenario conditions (red), see Figure 24 below.

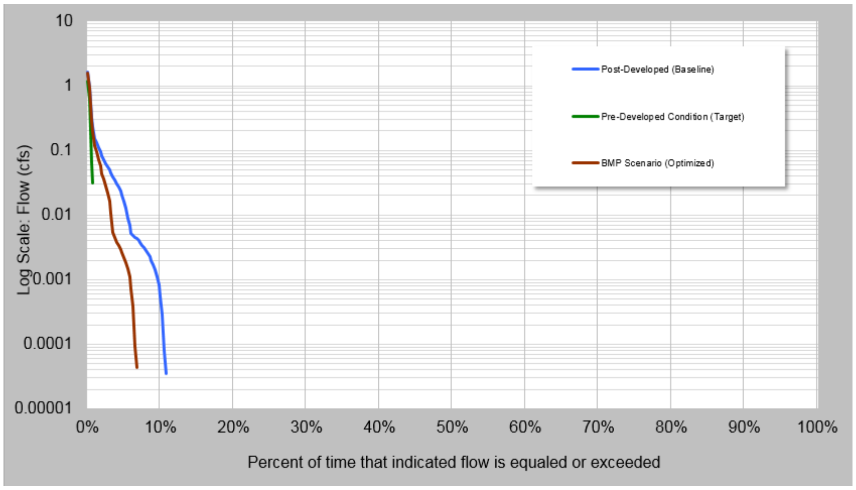


Figure 24 Flow duration curve

7. Appendix A – SUSTAIN Overview

Established urban areas and newly developing areas must find cost-effective means to manage excessive stormwater runoff, and meet water quality goals for nutrients and other pollutants. SUSTAIN can be applied to analyze the overall performance of multiple BMPs and find an optimal solution for their implementation. SUSTAIN is a decision support tool to evaluate optimal BMP locations based on cost optimization in urban and developing watersheds (USEPA, 2009). The key questions that can be addressed by SUSTAIN are:

1. What is the effectiveness of BMPs in reducing runoff and pollutant loading?
2. What are the most cost-effective solutions for meeting water quality and quantity objectives?
3. Where, what type of, and how big should BMPs be?

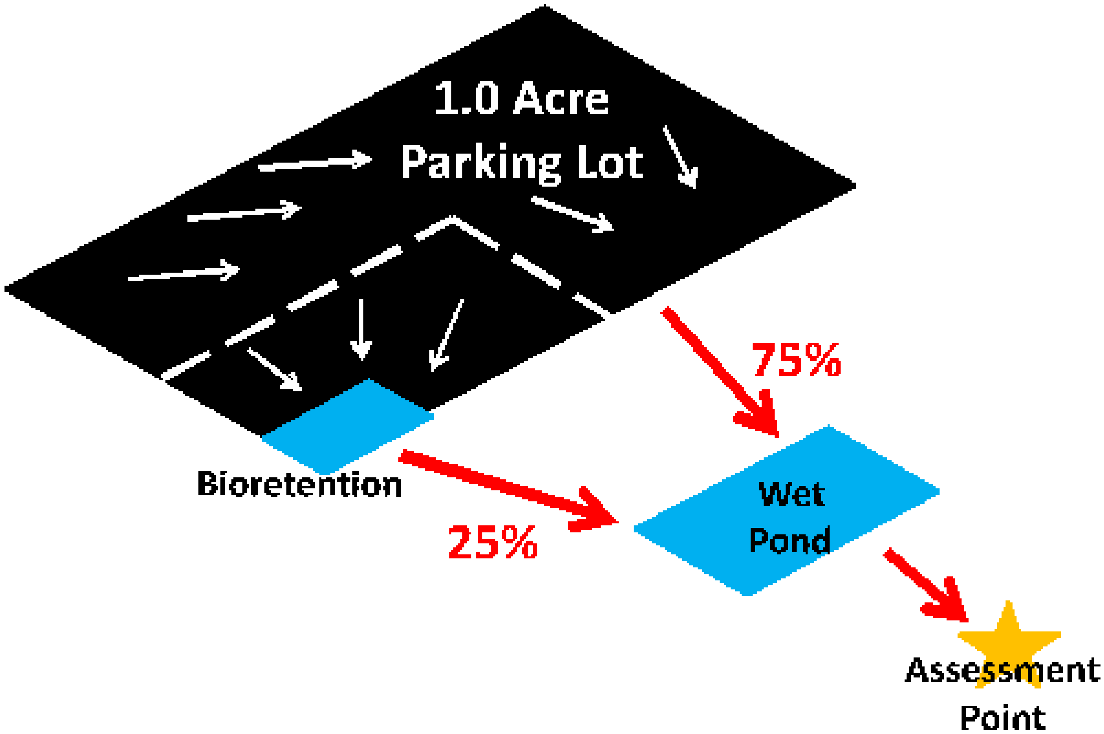
The user should refer to the following documents for more background information.

- SUSTAIN—A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality (Shoemaker, et. al., 2009)
- Report on Enhanced Framework (SUSTAIN) and Field Applications to Placement of BMPs in Urban Watersheds (Shoemaker, et. al., 2012)
- Stormwater Management for TMDLs in an Arid Climate: A Case Study Application of SUSTAIN in Albuquerque, New Mexico (Shoemaker, et. al., 2013)

The potential users of this system include local and county government water resource engineers/planners, state and federal regulatory reviewers, public concerned citizen/stakeholder groups, private industry, consultants, and academics.

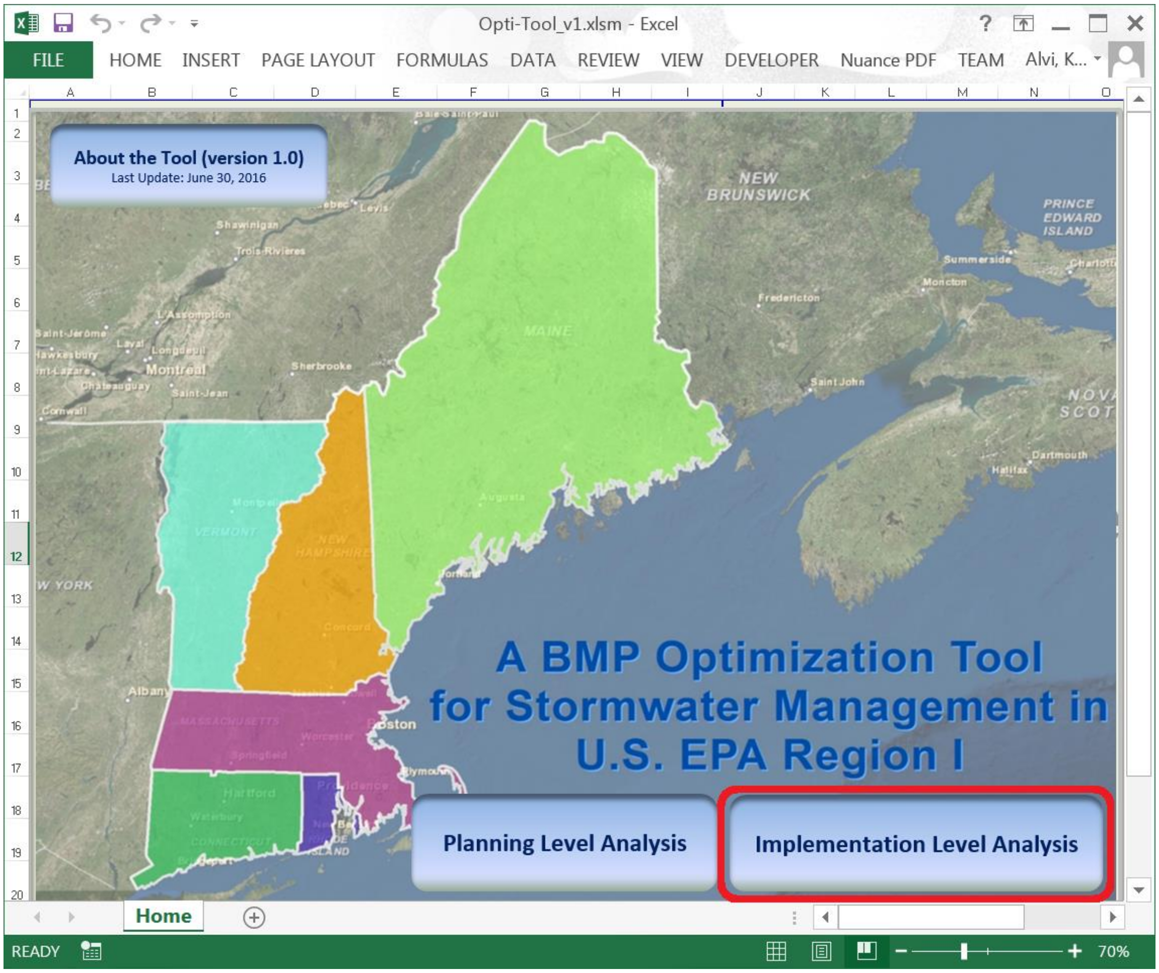
8. Appendix B – Opti-Tool Demonstration

This example models a 1.0 acre commercial impervious parking lot with 0.25 acres draining to a Bioretention BMP and 0.75 acres draining to a Wet Pond. Outflow from the Bioretention BMP is then directed to the Wet Pond. An assessment point is set at the outlet of the Wet Pond. The goal of this case study is to achieve a target TP load reduction from the site.

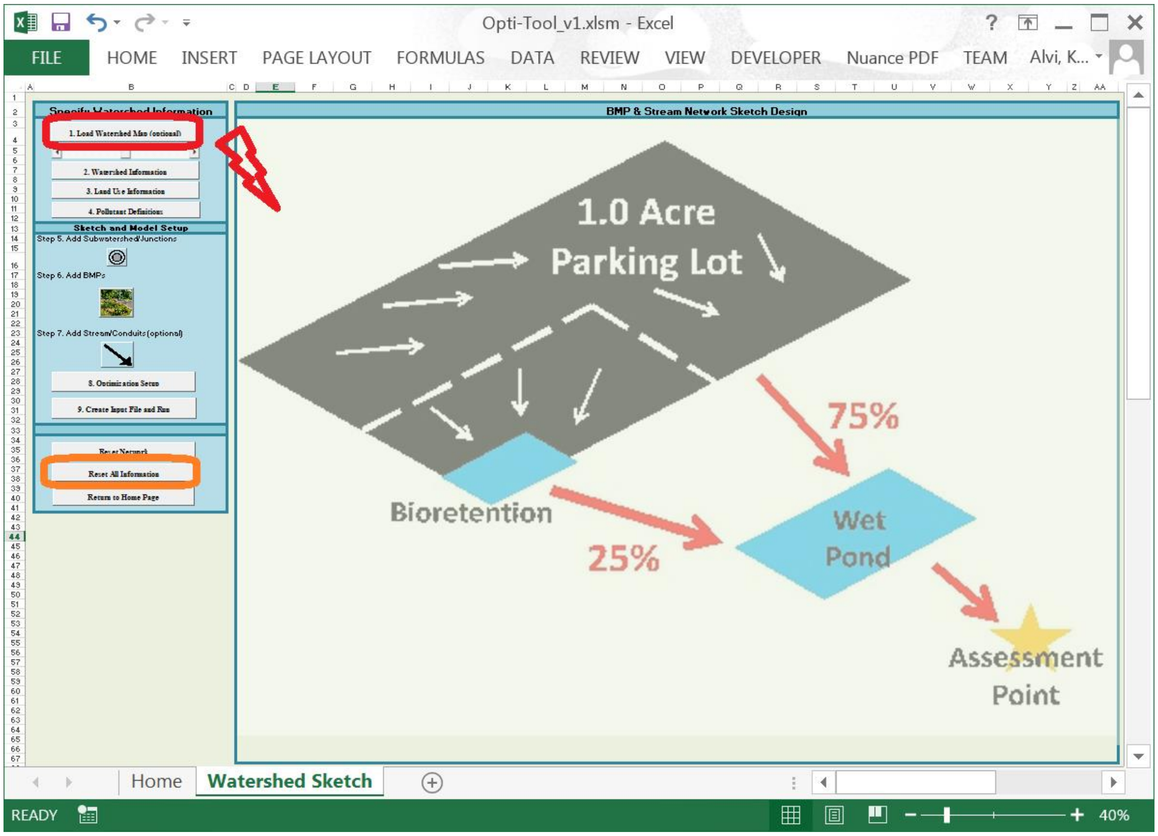


8.1 New Model Setup

From the *Home* screen, begin by selecting *Implementation Level Analysis*.

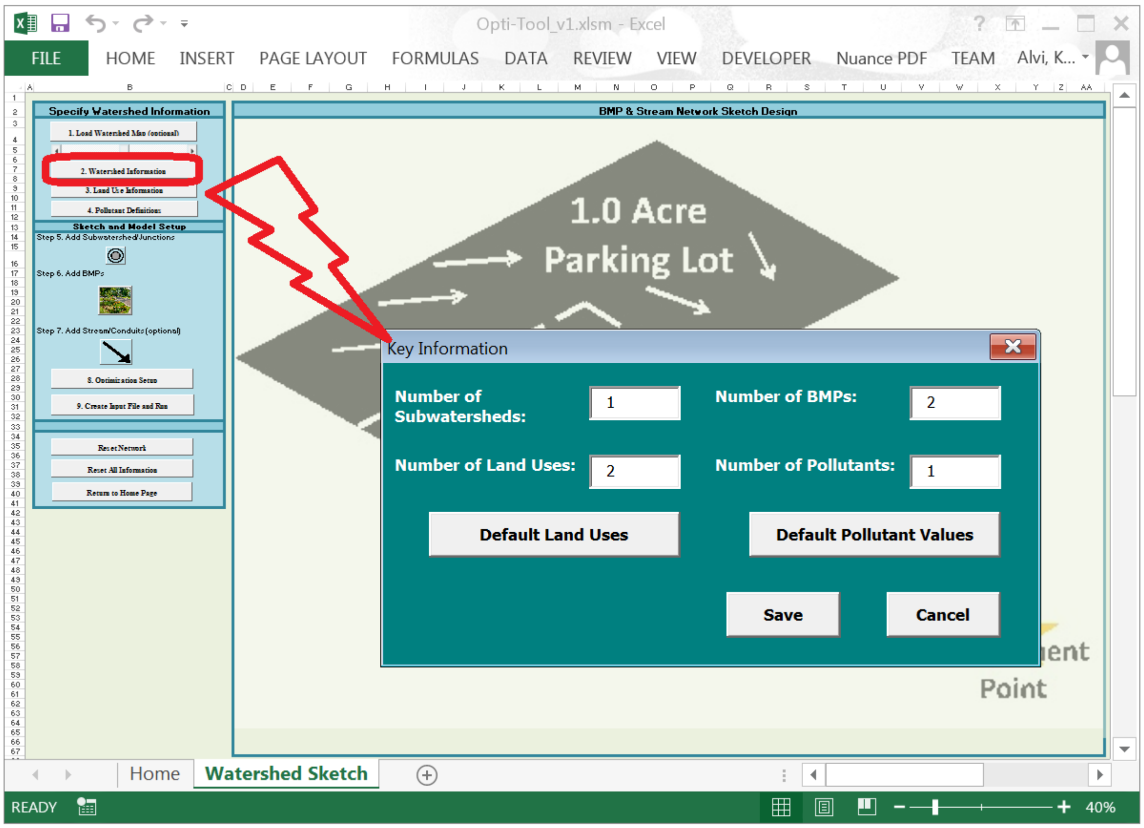


Add watershed map or project schematic as background image to help define BMP network and place BMPs on the input screen.



8.2 Watershed Information

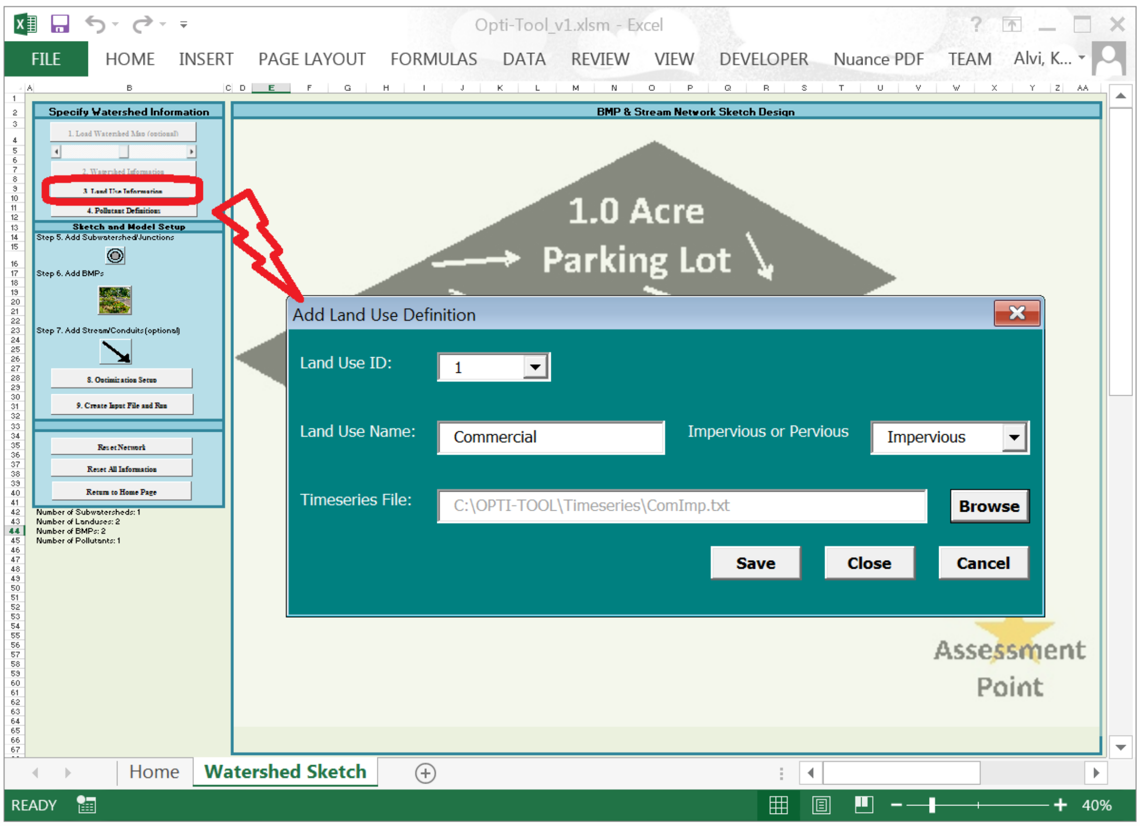
To start a new project, from the left menu, click on *Reset All Information* button, then select the *Watershed Information* button. On the *Key Information* form, enter 1 for the number of subbasins, 2 for the number of BMPs, 2 for the number of land uses, and 1 for number of pollutants. Click *Save*.



8.3 Land Use Categories

From the left menu, click the *Land Use Information* button. On the *Add Land Use Definition* form, enter *Commercial* as the Land Use Name, *Impervious* as the impervious/pervious option, and *Browse* to the location of the commercial land use time series (ComImp.txt). Click *Save*. Change the *Land Use ID* to 2, enter Forest as the Land Use Name, *Pervious* as the impervious/pervious option, and *Browse* to the location of the forest land use time series (ForPervBSoil.txt). Click *Save*. Click *Close*.

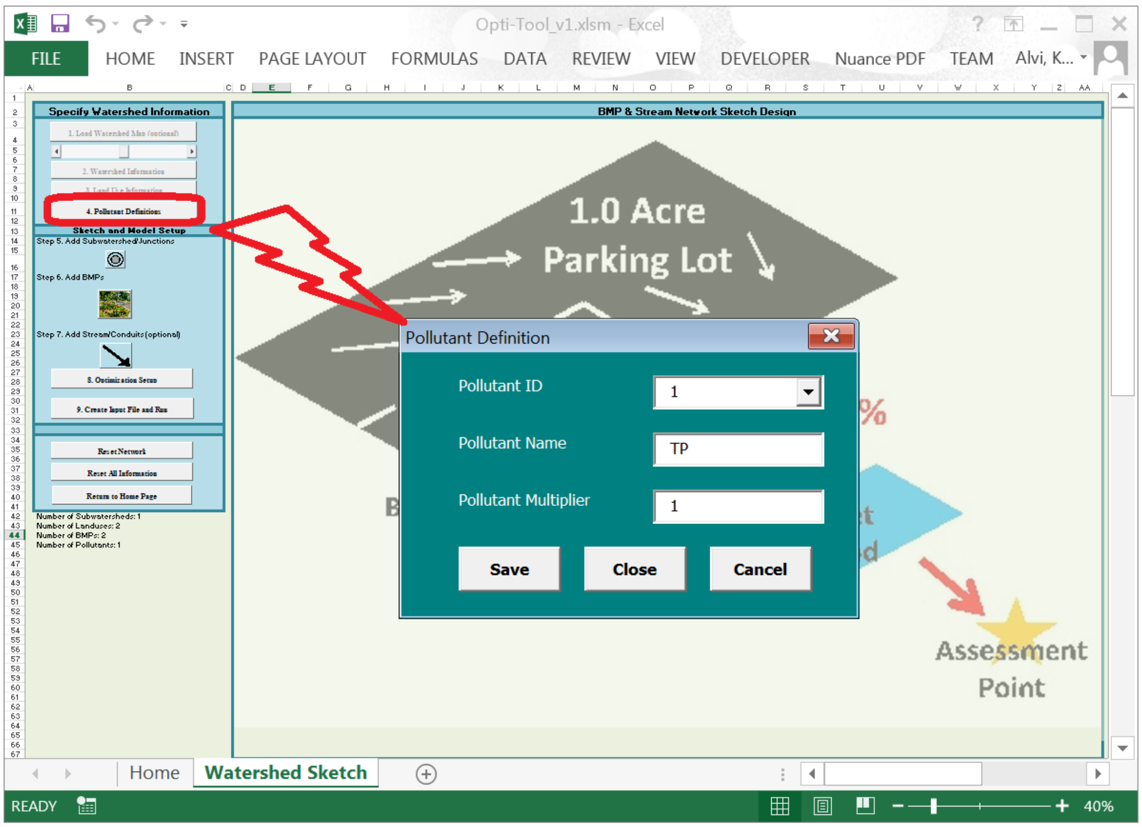
Note: *Save* must be selected after inputting each individual land use information.



8.4 Pollutant Definition

From the menu, click the *Pollutant Definitions* button to begin entering the pollutant definitions. Click *Save*. Click *Close*.

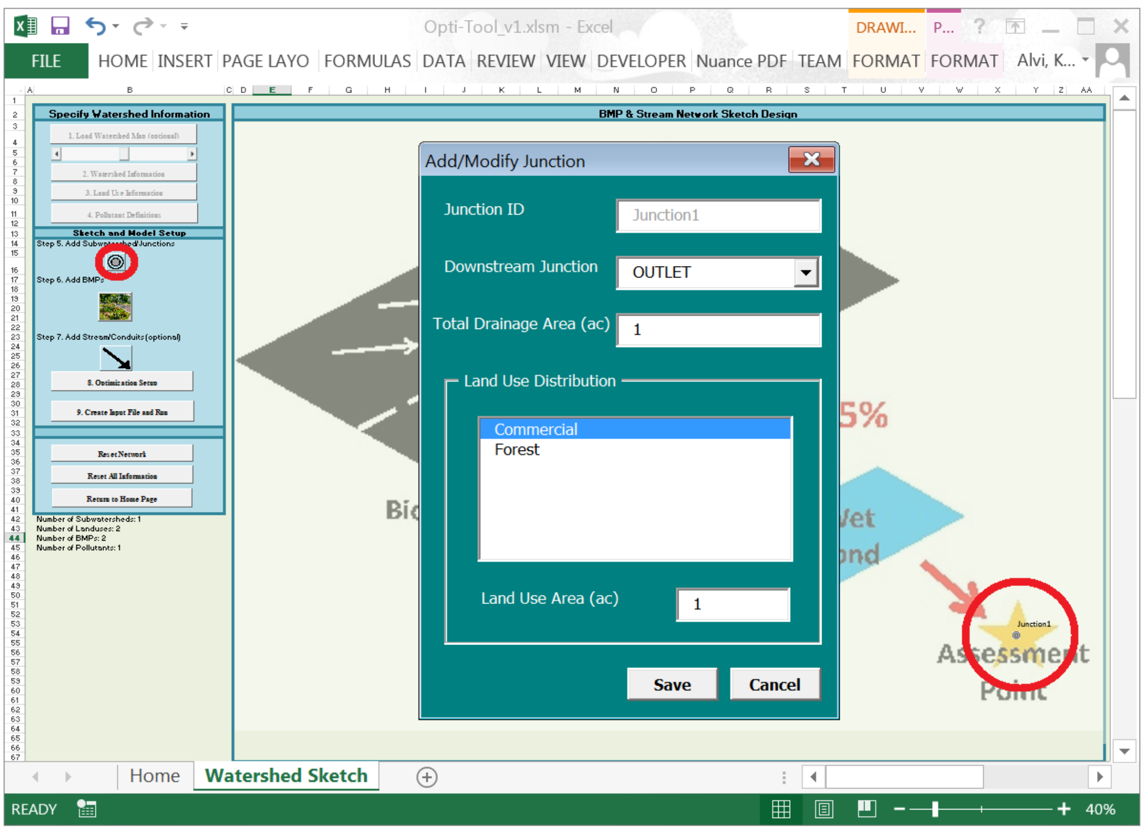
Note: Each pollutant has a Pollutant ID, Pollutant Name, and a Pollutant Multiplier. The multiplier is a unit conversion factor. SUSTAIN assumes all pollutants in the time series are defined in lbs. / timestep. The multiplier could also be used as a scaling factor to proportionally increase or decrease the pollutant loading represented in the time series.



8.5 Subbasin/Junction

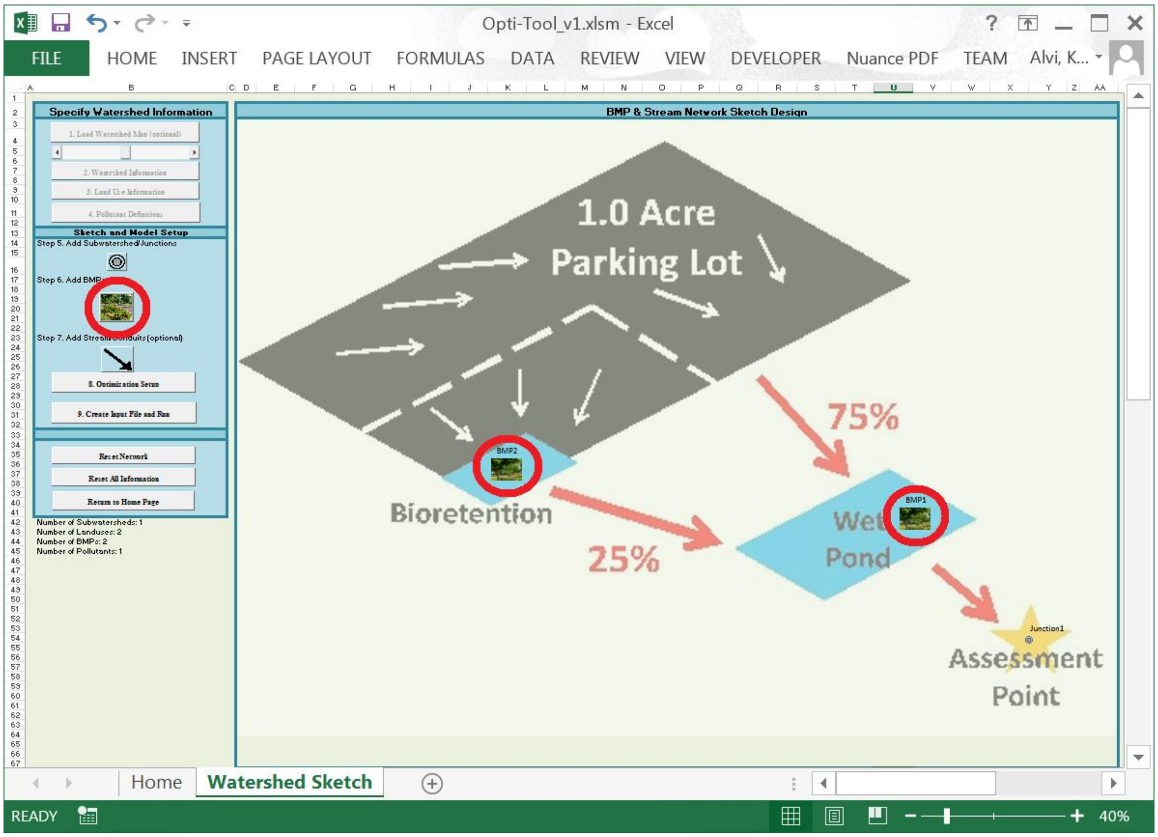
From the menu, click the  button to create a new subbasin. Junction1 will appear within *BMP & Stream Network Sketch Design*. Click *Junction1* within the *BMP & Stream Network Sketch Design* to add junction information. Each land use type is shown in the list box. Enter 1 acres of commercial land use as shown below, and 0 acres of forest land use. Click *Save*.

Note: Each subbasin will have a Junction ID, Downstream Junction, and Total Drainage Area (acres). Each land use defined in the Land Use Information step will appear in the *Land Use Distribution* list box. The sum of the Land Use Area (acres) must equal the Total Drainage Area (acres).



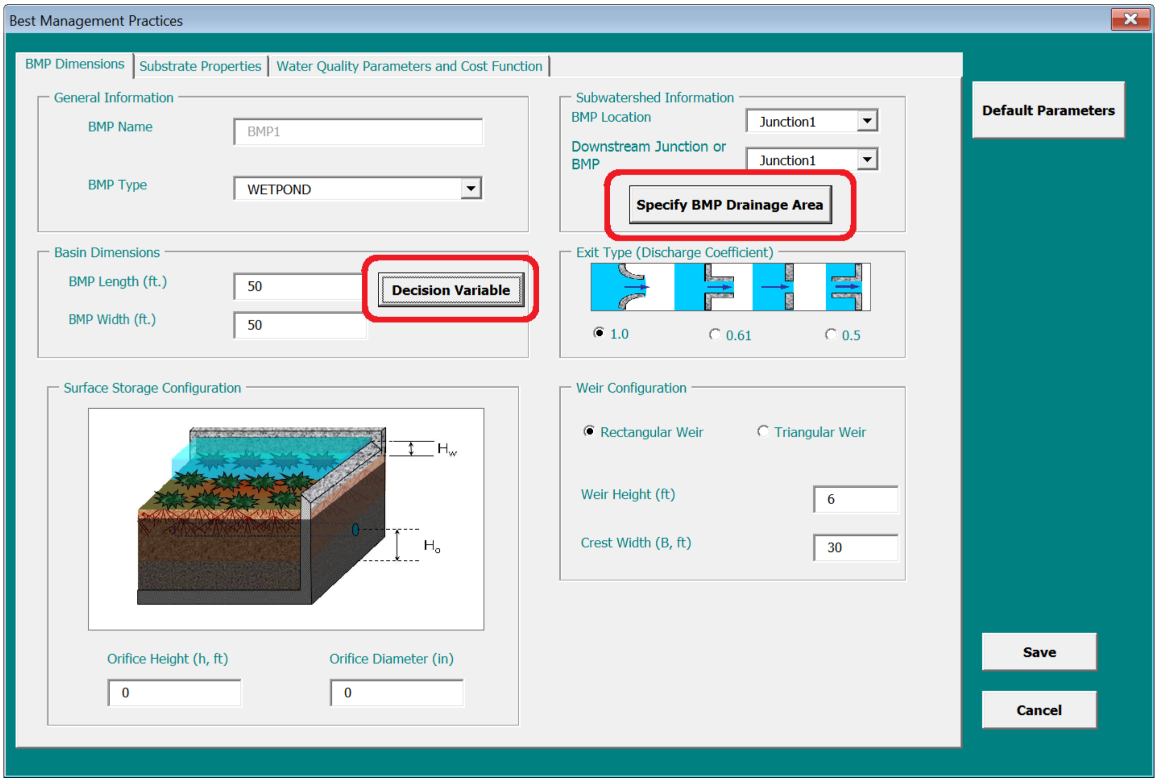
8.6 Best Management Practice

From the left menu, click the button to create a new BMP. BMP1 will appear within *BMP & Stream Network Sketch Design*. Click *BMP1* within the *BMP & Stream Network Sketch Design* to add BMP information. A message box will appear, click *Yes*.

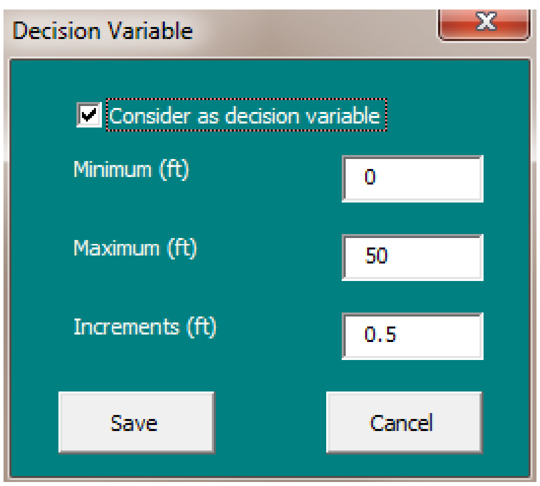


8.6.1 Wet Pond

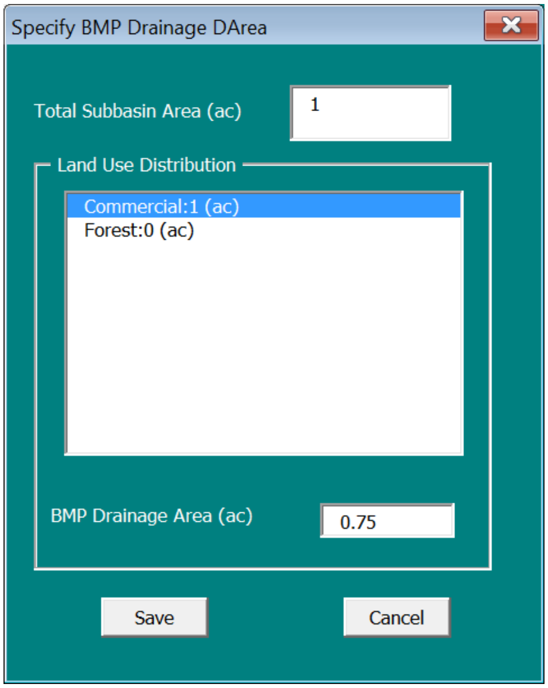
Defining a BMP starts on the *BMP Dimensions* tab. Add information as shown below to the General Information, Subbasin Location, Basin Dimensions, Exit Type (Discharge Coefficient), Surface Storage Configuration, and Weir Configuration boxes. Note that upon selecting a BMP type, the tool automatically assigns the default parameters specific to BMP design specification used for calibrating these BMPs for Region 1.



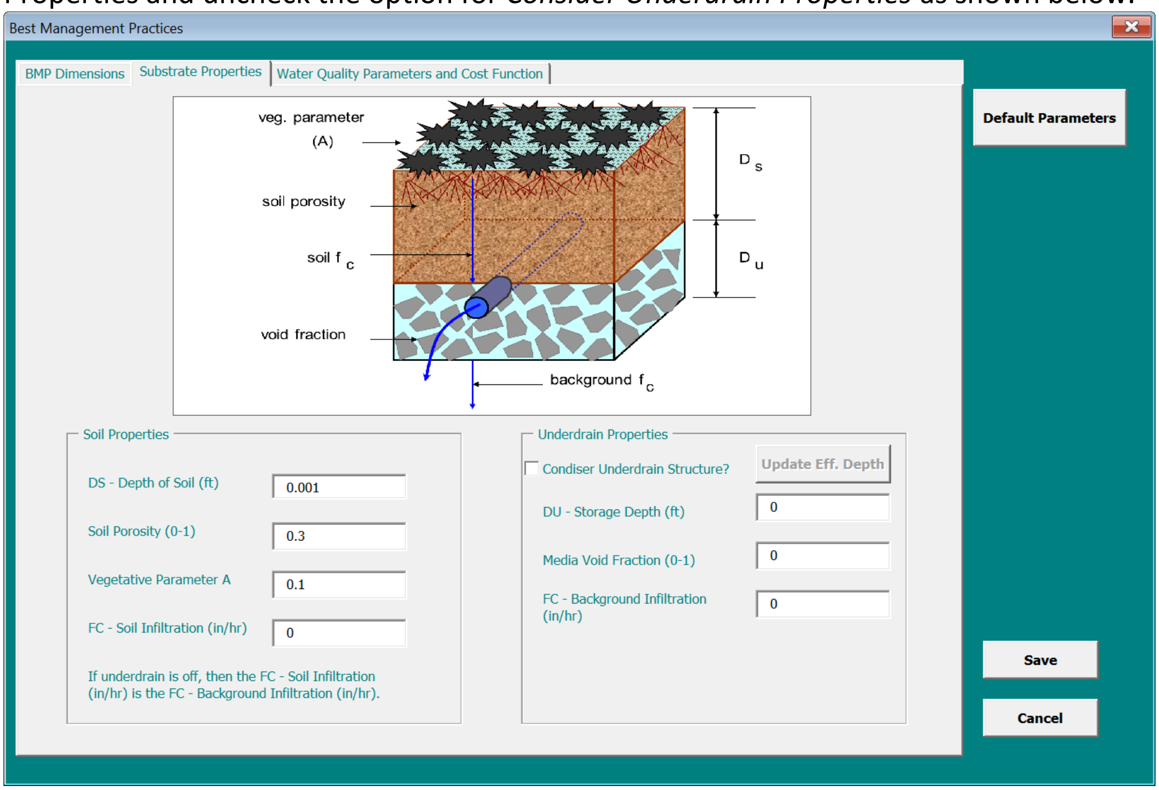
Define the BMP length as a decision variable by clicking on the *Decision Variable* button in the *Basin Dimensions* box and filling in the information as shown below



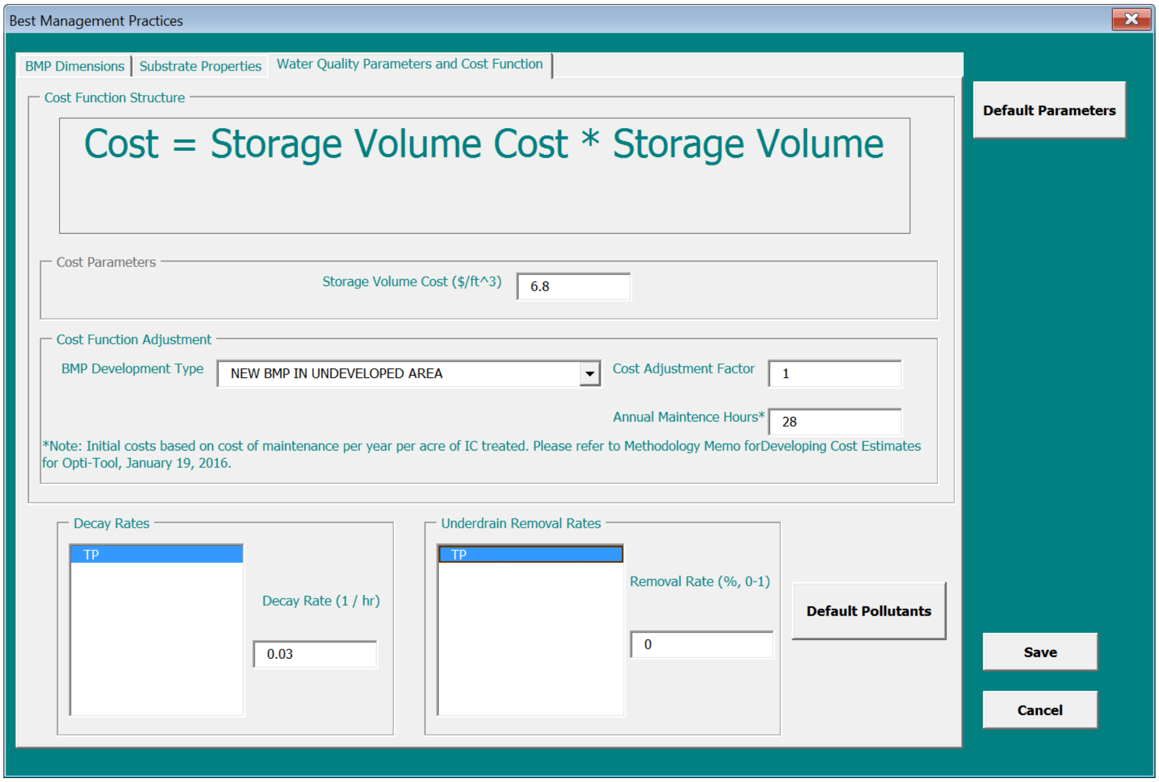
Click on the *Specify BMP Drainage Area* button. Add information as shown below. Click *Save*.



Click on the *Substrate Properties* tab. Continue filling out the information in the Soil Properties and uncheck the option for *Consider Underdrain Properties* as shown below.



Next, click on the *Water Quality Parameters and Cost Function* tab. Click *Default Pollutants* to populate decay rates and underdrain removal rates for each pollutant. Click *Save*

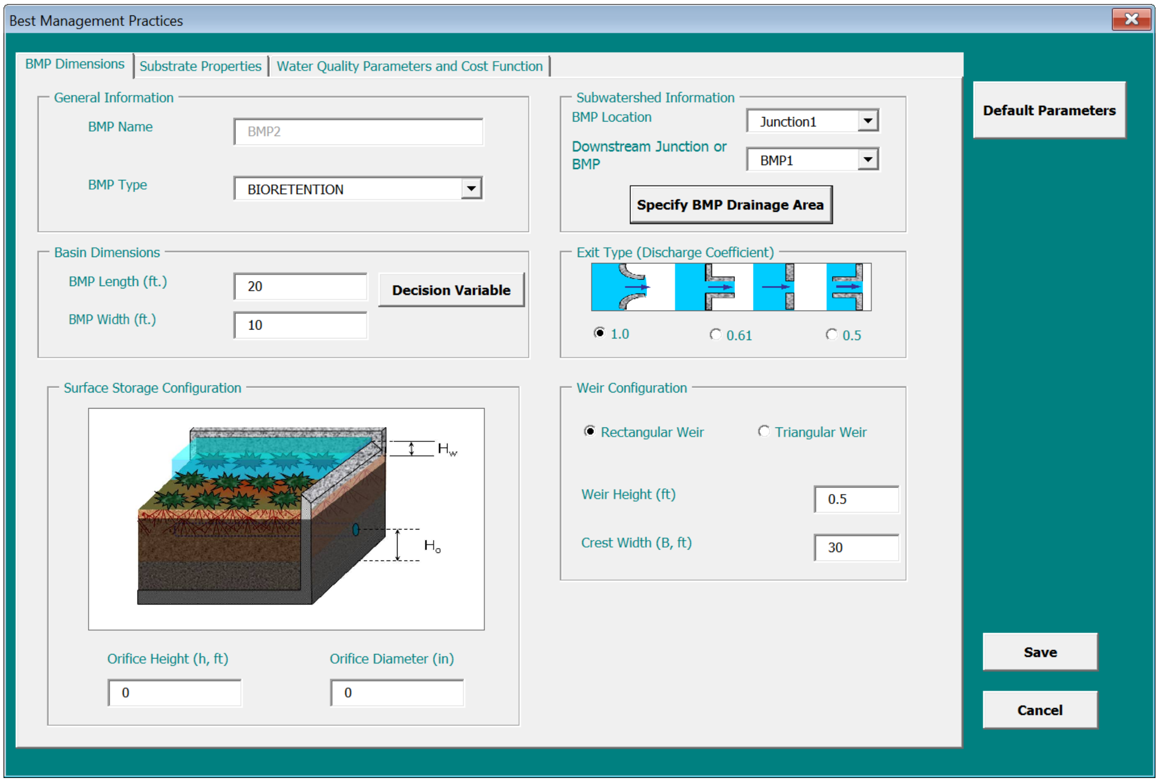


Note: Decay rates are specified with units of hr^{-1} and apply to pollutants in the soil column. Underdrain removal rates are specified as a percentage and apply only to pollutants flowing out of the underdrain once it has filled.

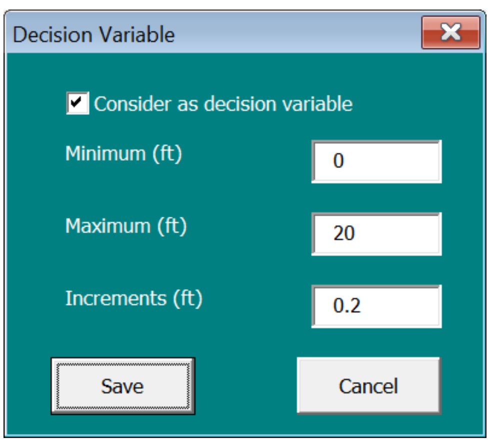
8.6.2 Bioretention

From the left menu, click the  button to create a new BMP. BMP2 will appear within *BMP & Stream Network Sketch Design*. Click *BMP2* within the *BMP & Stream Network Sketch Design* to add BMP information. A message box will appear, click *Yes*.

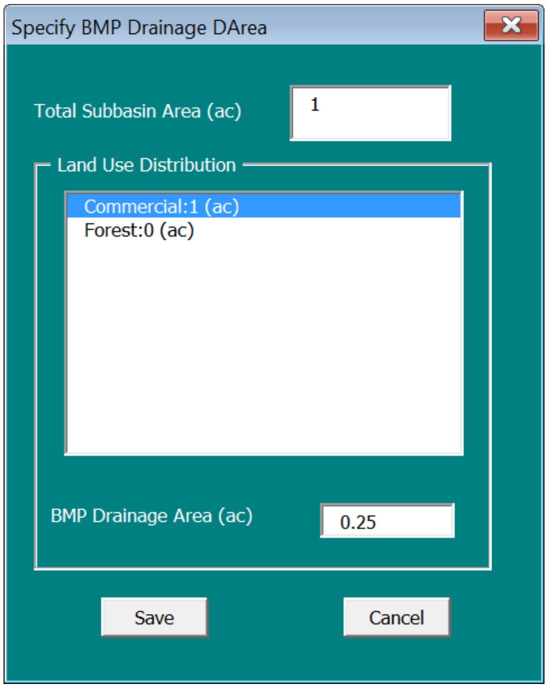
Defining a BMP starts on the *BMP Dimensions* tab. Add information as shown below to the General Information, Subbasin Location, Basin Dimensions, Exit Type (Discharge Coefficient), Surface Storage Configuration, and Weir Configuration boxes. Define the BMP length as a decision variable by clicking on the *Decision Variable* button in the *Basin Dimensions* box and filling in the information as shown below.



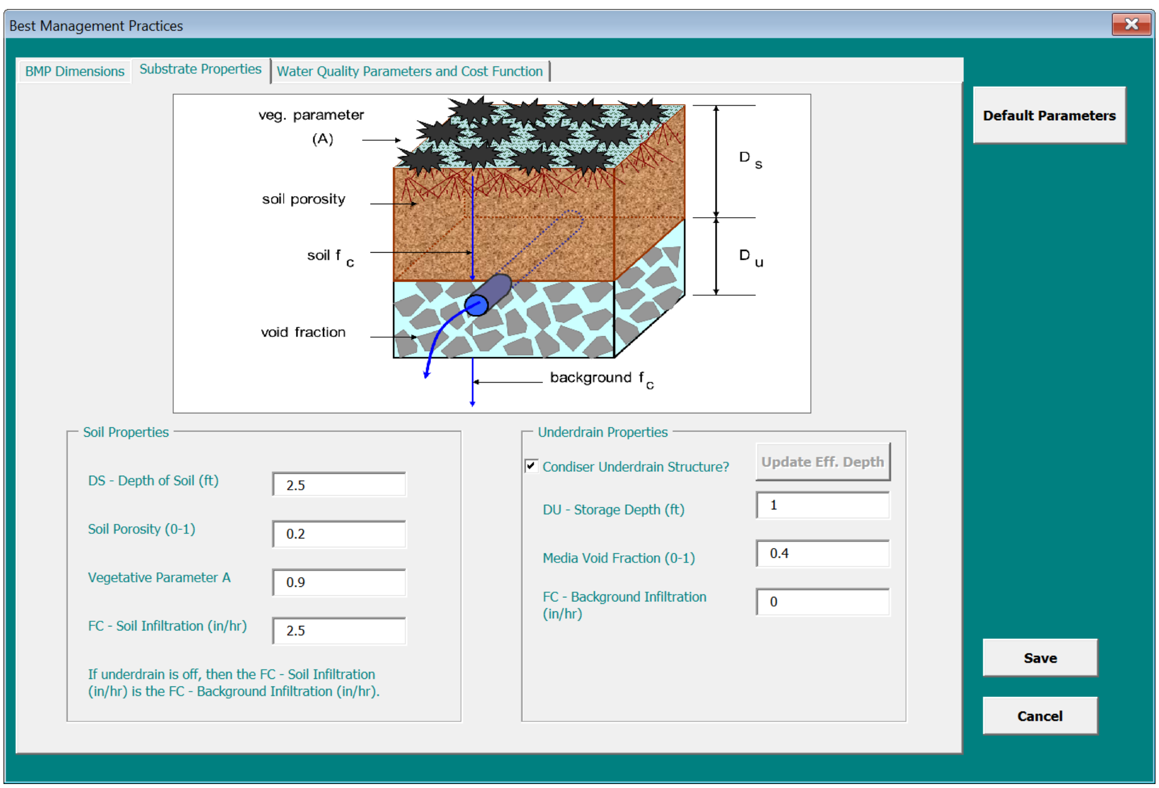
Click on the *Decision Variable* button. Add information as shown below. Click *Save*.



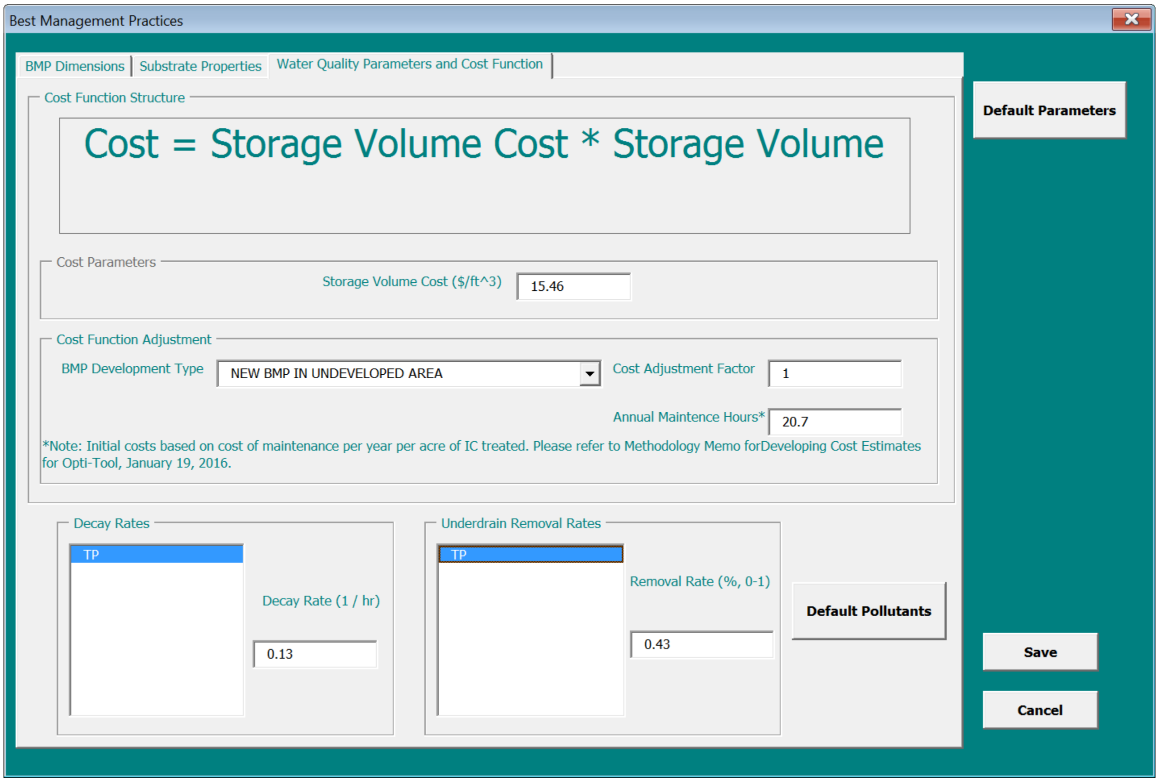
Click on the *Specify BMP Drainage Area* button. Add information as shown below. Click *Save*.



Click on the *Substrate Properties* tab. Continue filling out the information in the Soil Properties and Underdrain Properties as shown below.

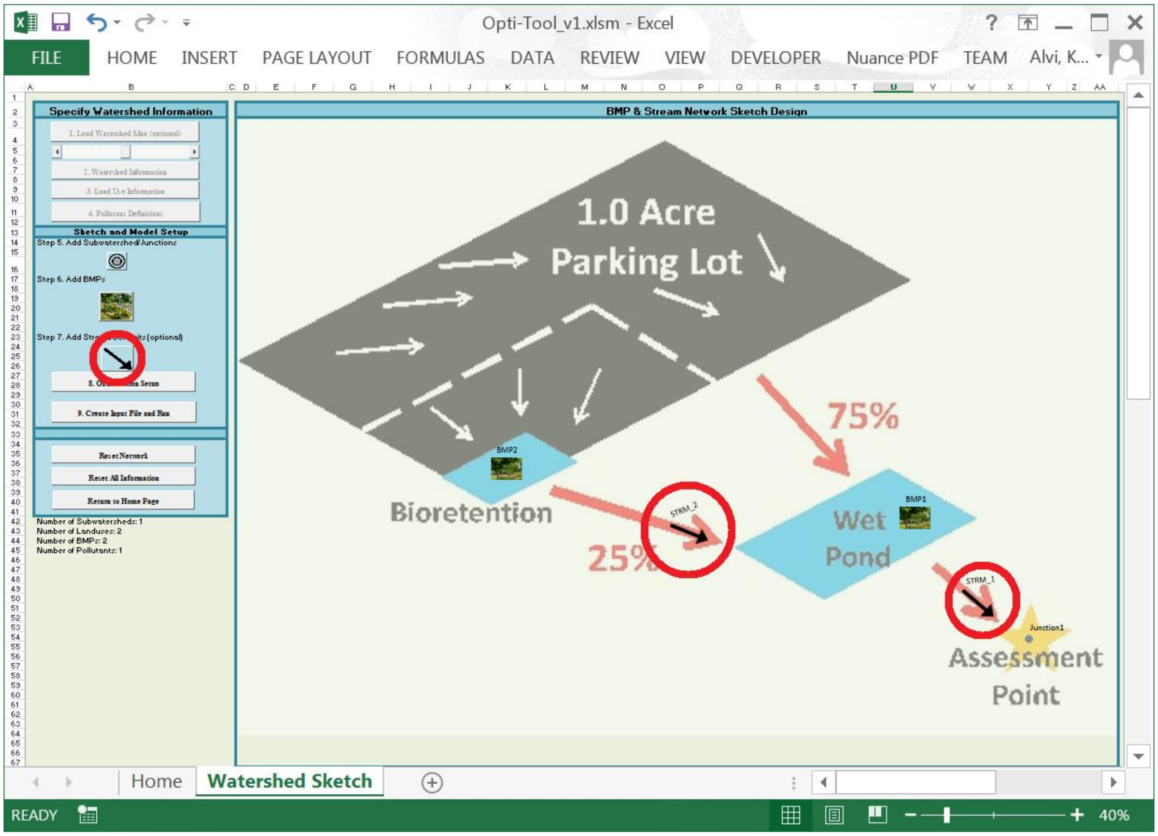


Next, click on the *Water Quality Parameters and Cost Function* tab. Click *Default Pollutants* to populate decay rates and underdrain removal rates for each pollutant. Click *Save*

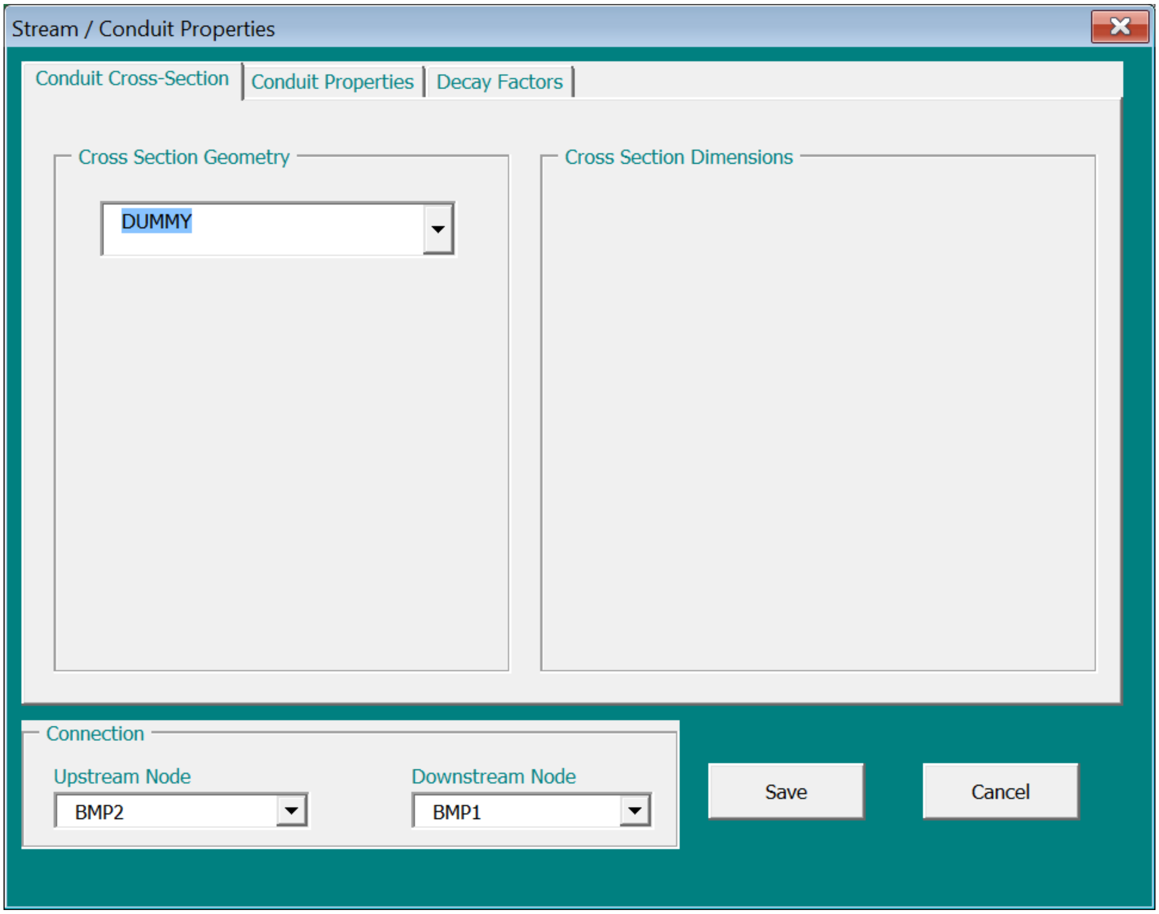


8.7 Stream and Conduits (Optional)

From the left menu, click the ↘ button to add a new stream/conduit. *STRM1* will appear within *BMP & Stream Network Sketch Design*. Click *STRM1* within the *BMP & Stream Network Sketch Design* to add Conveyance information. A message box will appear, click *Yes*.



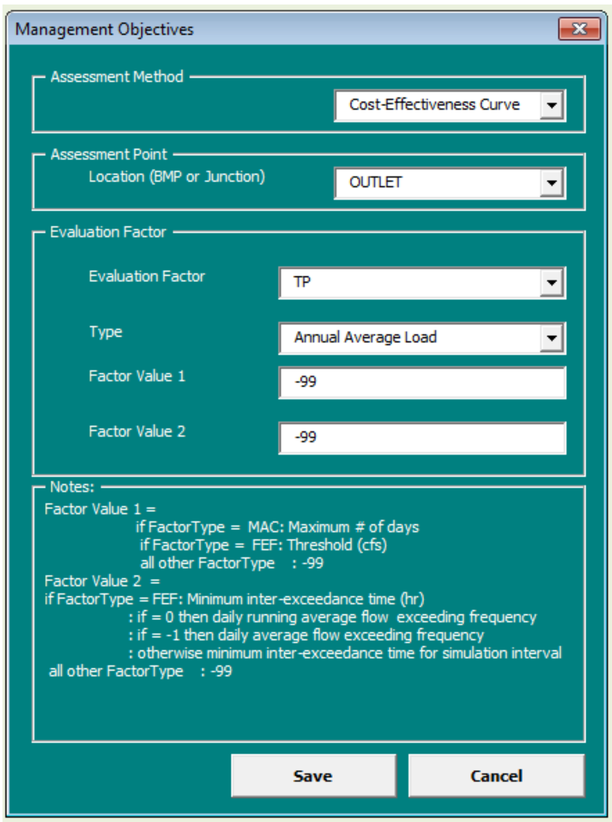
Defining a conveyance starts on the *Conduit Cross-Section* tab. Add information to the Cross Section Geometry, Cross Section Dimensions, and Connection boxes. Define a *DUMMY* connection in this example as shown below. Click *Save*.



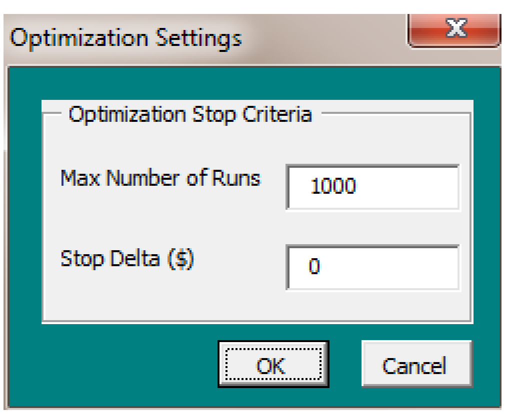
Note: Adding a dummy connection is optional since the BMP already has the routing information. The conveyance system is needed only if you want to simulate the transport mechanism in stream or conduit.

8.8 Objectives

From the left menu, click the *Optimization Setup* button to begin defining the optimization objective. For this example a cost-effectiveness curve will be developed. Click *Save*.

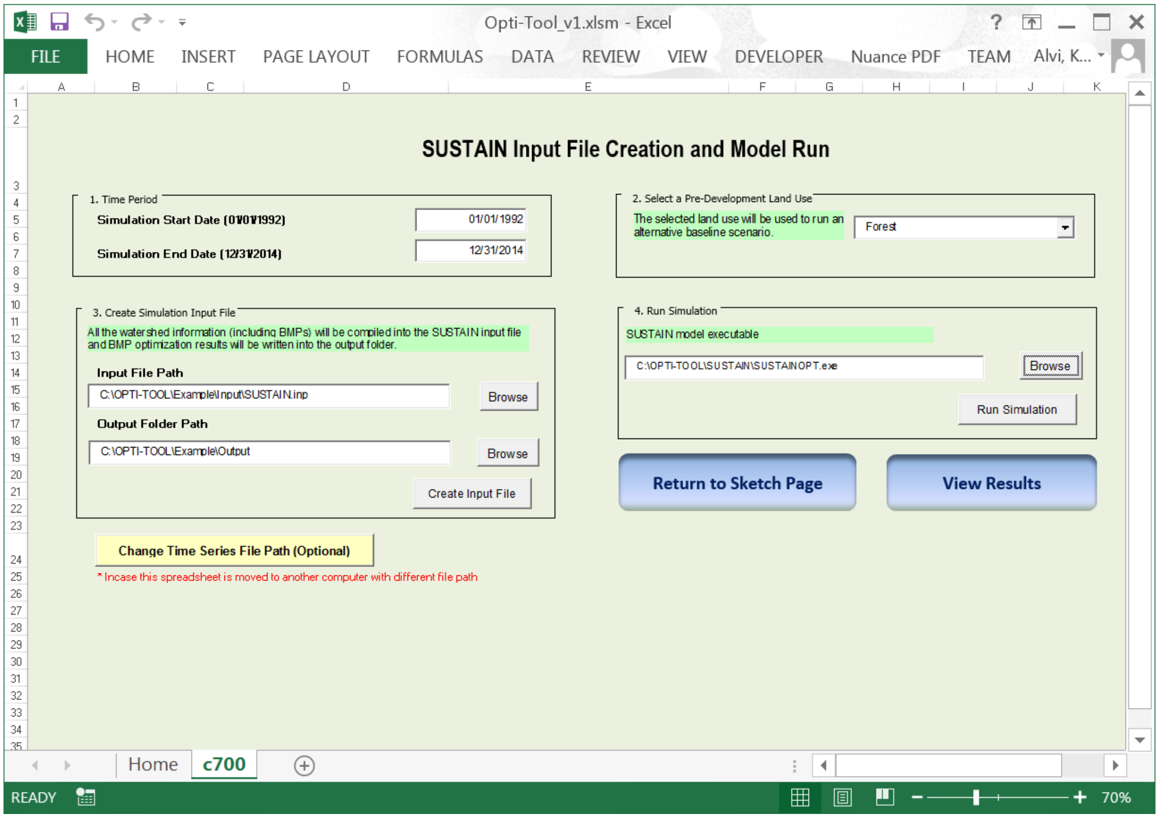


Next, the *Optimization Settings* form will appear, complete the form as shown below. The options allow the user to set a maximum number of runs and a cost improvement required of each successive solution to continue the optimization. Click *OK*.



8.9 Create Input File and Run

From the left menu, click the *Create Input File and Run* button. Once Simulation Time Period, Select a Pre-Development Land Use, Create a Simulation Input File, and Run Simulation boxes are filled in, click *Create Input File*. After the input file is successfully created, click the *Run Simulation* button.



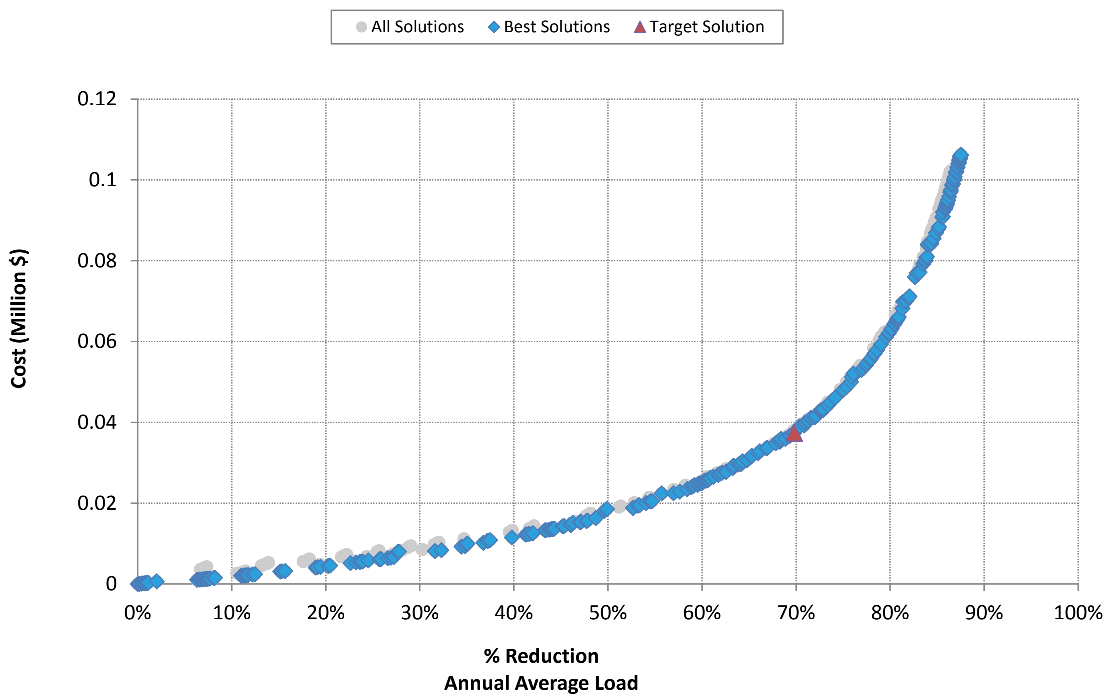
8.10 View Results

After the simulation has completed, click the *View Results* button.

The cost-effectiveness curve plots the solutions from the simulation. The user provides their target reduction in the *Target Reduction (%)* cell as shown below. Opti-Tool searches for the closest solution to the user input *Target Reduction (%).* The curve is an interactive plot showing the target solution (diamond) and the associated decision variables (surface area, storage depth, treated impervious area, annual maintenance hours, and BMP cost). These values represent the selected combination of BMP decision variables for the solution selected on the curve (Note: A value of zero indicates the BMP was not required for the selected solution, although it may be used for other solutions).

Target Reduction (%)	Solution Total Cost (Million $)	Solution Reduction (%)
70.0%	0.04	69.80%

BMP ID	BMP Type	BMP Area (ft^2)	BMP Storage Depth (ft)	System Storage Capacity(ft^3)	Treated Impervious Area (ac)	Runoff Depth (in)	Annual Maintenance (hours)	Cost ($)
BMP1	WETPOND	875.00	6.00	5250.26	0.75	1.93	21.00	35,701.79
BMP2	BIORETENTION	78.00	1.40	109.20	0.25	0.12	5.18	1,688.23



9. References

Shoemaker, L., J. Riverson, K. Alvi, J. X. Zhen, R. Murphy, B. Wood. 2013. *Stormwater Management for TMDLs in an Arid Climate: A Case Study Application of SUSTAIN in Albuquerque, New Mexico*. EPA/600/R-13/004. U.S. Environmental Protection Agency, Water Supply and Water Resources Division, National Risk Management Research Laboratory, Cincinnati, OH.

Shoemaker, L., J. Riverson, K. Alvi, J. X. Zhen, and R. Murphy. 2012. *Report on Enhanced Framework (SUSTAIN) and Field Applications to Placement of BMPs in Urban Watersheds*. EPA/600/R-11/144. U.S. Environmental Protection Agency, Washington, DC.

Shoemaker, L., J. Riverson, K. Alvi, J. X. Zhen, S. Paul, and T. Rafi. 2009. *SUSTAIN—A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality*. EPA/600/R-09/095. U.S. Environmental Protection Agency, Washington, DC.

Technical Memo 3. *Update of long-term runoff time series for various land uses in New England*. Prepared for: U.S. EPA Region 1, Boston, MA. Prepared by: Tetra Tech, Inc. Fairfax, VA.

Technical Memo 5. *Methodology for developing cost estimates for Opti-Tool*. Prepared by: U.S. EPA Region 1, Boston, MA.

Technical Memo 9.1. *Buildup and Washoff Calibration Approach and SW Nutrient EMC Data Analyses*. Prepared for: U.S. EPA Region 1, Boston, MA. Prepared by: Tetra Tech, Inc. Fairfax, VA.

Technical Memo 9.2. *Buildup and Washoff Calibration Results and Long-term Continuous Hourly Timeseries*. Prepared for: U.S. EPA Region 1, Boston, MA. Prepared by: Tetra Tech, Inc. Fairfax, VA.

Technical Memo 10. *BMP performance calibration approach sensitivity analysis*. Prepared for: U.S. EPA Region 1, Boston, MA. Prepared by: Tetra Tech, Inc. Fairfax, VA.

Tetra Tech, Inc. 2010. *Stormwater Best Management Practices (BMP) Performance Analysis*. Prepared for: U.S. EPA Region 1, Boston, MA. Prepared by: Tetra Tech, Inc. Fairfax, VA.