



Opti-Tool: Stormwater Nutrient Management Optimization Tool

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What is Opti-Tool?

Stormwater Nutrient Management Optimization Tool (Opti-Tool) is a spreadsheet-based tool that provides both a planning level and an implementation level analysis to assist stormwater managers in developing technically sound and economically feasible management plans to address stormwater impacts and reduce excessive nutrient loadings. A comparison between these two options is shown in Figure 1. The planning level analysis uses BMP performance curves and Excel Solver to identify an optimal solution. The implementation level analysis calls the SUSTAIN (System for Urban Stormwater Treatment and Analysis Integration) dynamic link library to estimate BMP performance and retrieve optimization results to provide cost-effective BMP sizing strategies.

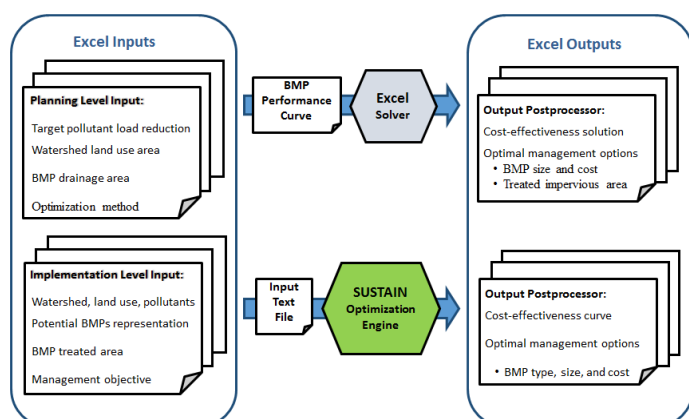


Figure 1. Comparison between Planning Level Analysis and Implementation Level Analysis in Opti-Tool

The **Planning Level Analysis** can provide maximum possible load reduction for all feasible BMP opportunities or cost-effective single solution that meets the numeric target. This analysis can be performed at the watershed and/or site scale, represents aggregated BMPs, and does not allow BMP to BMP routing.

The **Implementation Level Analysis** can provide optimal combination of different BMP types, sizes and cost-effective solutions for a range of load reduction targets. Similar to the Planning Level Analysis, the Implementation Level Analysis can be performed at the watershed and/or site scale. However, the Implementation Level Analysis allows for aggregated and/or distributed BMP representation, and allows for simple to complex routing network. Figure 2 shows the main interface for launching both options.

Software Requirements

The software requirements for Opti-Tool are as follows:

- Microsoft Excel 2013
- Activate Solver
 - 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*.
- Change security settings to 'enable macros'
 - 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.

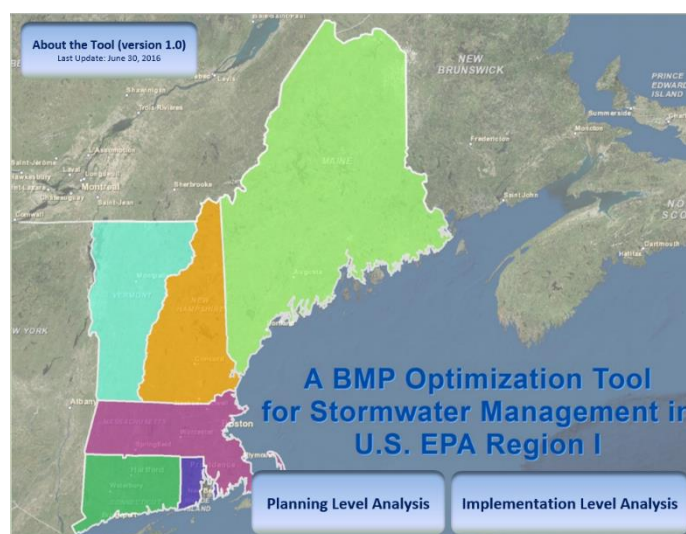


Figure 2. Opti-Tool's main interface

Regional Specific Data

Multiple datasets used in Opti-tool were customized for EPA Region 1.

1. Boston Logan Airport weather station was selected as a representative station after comparing weather stations from major urban areas across the New England states.
2. Local stormwater monitoring data were used to calibrate the buildup and washoff processes on the impervious cover. The calibrated SWMM model was used to develop long-term pollutant runoff time series for typical land uses (Table 1) in the region.
3. BMP monitoring data collected by University of New Hampshire Stormwater Center (UNHSC) was utilized to calibrate flow and pollutant loss mechanisms in variety of structural BMPs.

- Regionally calibrated BMPs along with regionally developed hourly runoff timeseries were used to develop performance curves for a variety of structural BMPs.
- Charles River Watershed Association and the UNHSC provided the BMP cost estimates.

Table 1. Hydrologic Response Unit types in Opti-Tool

Land Use Type
Agriculture Impervious
Forest Impervious
Highway Impervious
Industrial Impervious
Commercial Impervious
High Density Residential Impervious
Medium Density Residential Impervious
Low Density Residential Impervious
Open Land Impervious
Agriculture Pervious
Forest Pervious
Developed Pervious A
Developed Pervious B
Developed Pervious C
Developed Pervious C/D
Developed Pervious D

Planning Level Analysis

The Planning Level Analysis provides decision-makers with a comprehensive overview of stormwater management opportunities in a given watershed. The Planning Level Analysis provides two different optimization approaches; BMP Storage Capacity and BMP Drainage Area.

The **BMP Storage Capacity** evaluates the BMP performance for a design criterion (e.g., capture 1 inch of stormwater from the impervious drainage area), evaluates the changes in water quality benefits as the BMP sizes area changed, and identifies the most cost-effective BMP storage capacity that meets the target pollutant load reduction.

The **BMP Drainage Area** determines how much impervious drainage area would require treatment if specified BMP design capacities were selected, identifies the extent of impervious area to be treated that can provide the target pollutant load reduction. In the BMP Drainage Area approach, both the BMP storage capacity and BMP cost are fixed.

The required information is separated into four different sections, see Figure 3. The user is only responsible for providing or selecting the cells highlighted in yellow. The first portion, Management Objective, requires the user to select a pollutant of interest and the target load reduction (%) for the selected pollutant. The pollutant options are Total Phosphorus (TP), Total Nitrogen (TN), Total

Suspended Solids (TSS), and Zinc (Zn). The second portion, Optimization Target, references the optimization analysis of interest, either BMP Storage Capacity or BMP Drainage Area. The third portion, Watershed Information, provides a link to another table where the total land use area distribution across the watershed is defined. The list of land use types available are shown in Table 1. The fourth portion, BMP Information, also provides a link to another table where the drainage areas to each selected BMP are defined. The list of available BMPs are shown in Table 2.

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 3. Planning Level Analysis – input interface

Table 2. Structural BMP types in Opti-Tool

BMP Types
Bio-filtration
Enhanced Bio-filtration with Internal Storage Reservoir
Dry Pond
Grass Swale
Gravel Wetland
Infiltration Basin
Infiltration Chamber
Infiltration Trench
Porous Pavement
Sand Filter
Wet Pond

After the required information is entered, the user can run a scenario of interest; design criteria or optimization scenario, see Figure 4.

5. Optimal Solution						
BMP Type	Design Storage Capacity (ft³)	BMP Cost (\$)	Treated Impervious Area (ac)	CSM (in/yr)	Load Reduction (lbs)	Treated Runoff Depth (in)
Biofiltration with OR		\$				
Bioretention	101,647	\$ 3,142,920	70.00	1,449	64.77	0.43
Dry Pond	-	\$ -	-	-	-	-
Grass Swale*	-	\$ -	-	-	-	-
Gravel Wetland	152,478	\$ 2,877,922	70.00	1,519	62.32	0.50
Infiltration Basin	152,463	\$ 1,902,738	70.00	-	106.51	0.60
Infiltration Chambers*	-	\$ -	-	-	-	-
Infiltration Trench	152,449	\$ 3,868,181	70.00	-	100.20	0.60
Porous Pavement*	-	\$ -	-	-	-	-
Sand Filter	101,640	\$ 3,048,826	70.00	1,995	41.06	0.40
Wet Pond	139,190	\$ 1,882,960	70.00	1,960	51.53	0.55

Note: Only fill in the yellow highlighted cells.
* Place holder for future option (not implemented)

[Run Single Scenario](#)
[Run Optimize Scenario](#)
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Figure 4. Planning Level Analysis – run 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. The Run Optimize Scenario analysis will begin the performance optimization process using the Excel Solver.

The Planning Level Analysis calculates the BMP storage capacity (ft³), BMP cost (\$), treated impervious area (ac), annual operation and maintenance hours (hr), and pollutant load reduction (lbs) from the selected BMP defined in the fourth step, see Figure 4.

Implementation Level Analysis

The Implementation Level Analysis allows users to enter the required information through a series of customized forms and tables. The user must complete the steps in a sequential order because the provided information builds off each other during the process. The steps are tabled in order on the Implementation Level Analysis interface, see Figure 5. Two steps are defined as optional: Load Watershed Map, and Add Stream/Conduit. Opti-Tool will not allow a user to proceed if information from a previous step has not been provided.

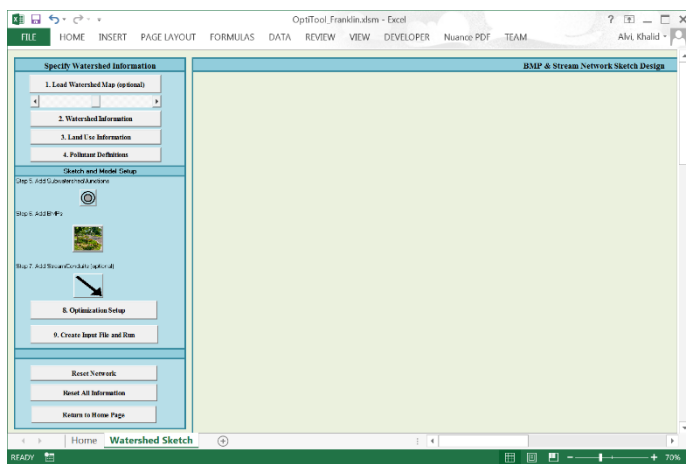


Figure 5. Implementation Level Analysis – main interface

Step 1 – Load Watershed Map (optional): The Load Watershed Map button provides the option to load a jpg image into the BMP & Stream Network Design box. The scroll bar below the Load Watershed Map button changes the transparency of the image. The map serves as a background image to guide the user while building the BMP routing network.

Step 2 – Watershed Information: The Watershed Information button activates the Key Information form. The key information form requires the user to define the number of subwatersheds, land uses, BMPs, and pollutants modeled in the study area, see Figure 6.

Figure 6. Key Information form

The user has the option to select Default Land Uses on key information form. If selected, the Default Land Uses button will ask for a pathway to the folder location of the 15 default land use timeseries files, then it will define the land use definitions (step 3). Also, 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 define the pollutant definitions (step 4).

Step 3 – Land Use Information*: The Land Use Information button activates the Add Land Use Definition form. The Add Land Use Definition form requires the user to define the land use name, select impervious or pervious, and provide the timeseries file location. Save **must be** selected after inputting each individual land use information.

**If the Default Land Uses option was selected in step 2, then all the information will already be completed, skip the step 3.*

Step 4 – Pollutant Definition*: The Pollutant Definitions button activates the Pollutant Definition form. The Pollutant Definition form requires the user to define the pollutant name and the pollutant multiplier. The pollutant multiplier is used to convert the units used in the timeseries file into the required units of pound per hour in Opti-Tool. The pollutants must be defined in the same order as they appear in the land use timeseries files. Save **must be** selected after inputting each individual pollutant information.

**If the Default Pollutant Values option was selected in step 2, then all the information will already be completed, skip the step 4.*

General Naming Practices

As a general rule, do not use special characters or spaces in any of the user-defined component names such as Land Use Definitions, Pollutant Definitions, Subwatersheds/Junctions, BMPs and Conduits, including paths for time series files, input files, and output files. The use of an underscore (“_”) is acceptable.

Step 5 – Add Subwatershed Junctions: The Add Subwatershed Junctions button will insert a junction symbol on the map. By selecting on the inserted junction symbol, the form will prompt the user to provide a junction name, downstream junction, and total subwatershed drainage area (acres). The defined land use types from step 3 will appear in the Land Use Distribution list. The sum of the land use distribution must be equal to the subwatershed total drainage area.

Step 6 – Add BMPs: The Add BMPs button will insert a BMP symbol on the map. By selecting on the inserted BMP symbol, the BMP form (Figure 7) will prompt the user to provide BMP details. The required BMP information will be depending upon which BMP type is selected; the available BMP types are provided in Table 2.

Figure 7. BMP Information form

The user has the option of using the default design parameters available in the Opti-Tool by selecting the *Default Parameters* button or the option of inputting site specific BMP design information. The default design parameters for the BMPs are based on the BMP calibration performed using the UNHSC BMP monitoring data and BMP design specification from those monitoring sites. BMP costs are defined on a physical storage volume basis using the following cost function:

$$\text{Cost} = \text{Storage Volume Cost} * \text{Storage Volume}$$

Storage volume cost (Table 3) could include a cost adjustment factor (Table 4) based on the site conditions in which the BMP would be installed (i.e., development type).

Table 3. BMP storage volume cost

BMP Type	Cost (\$/ft ³)- 2016 dollar
Bio-filtration	\$15.46
Enhanced Bio-filtration with Internal Storage Reservoir	\$15.61
Dry Pond	\$6.8
Gravel Wetland	\$8.78
Infiltration Basin	\$6.24
Infiltration Chamber	\$67.85
Infiltration Trench	\$12.49
Porous Pavement (Porous Asphalt Pavement)	\$5.32
Porous Pavement (Pervious Concrete)	\$18.07
Sand Filter	\$17.94
Wet Pond	\$6.8

Table 4. Cost adjustment factors (default values)

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

Step 7 – Add Streams/Conduits (optional): The stream/conduit provides a means to define the routing between subwatersheds and BMPs in the model building process. The Add Streams/ Conduits button will insert a stream/conduit symbol on the map. The Stream/ Conduit Properties form allows a user to specifying an upstream and downstream node. The user also has the option to define the cross section geometry, see Table 5.

Table 5. Cross section geometry options in Opti-Tool

Cross Section Geometry
Dummy
Circular
Filled Circular
Rectangle Closed
Rectangle Open
Trapezoidal
Triangular
Parabolic
Rectangular Triangular

Step 8 – Optimization Setup: The Optimization Setup button activates the Management Objectives form. The form requires the user to select an assessment method, assessment point, evaluation factor, evaluation type, and provide factor values. Two analysis methods are available when defining management objectives: (1) No Optimization, and (2) Cost-Effectiveness Curve. The No Optimization method simulates the baseline condition with existing BMPs on the ground. The Cost-Effectiveness Curve method simulates the full spectrum of trade-offs between cost and load reduction associated with selected management strategies. 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.

Step 9 – Create Input File and Run: The Create Input File and Run button activates the SUSTAIN Input File Creation and Model Run screen, see Figure 8. This screen asks for the simulation start and end date, a pre-development land use type, the location where the model input file and model output should be saved, and file path for SUSTAIN model executable. After providing the required input, the Create Input File creates a text file used by the SUSTAIN optimization engine. The Run Simulation executes the SUSTAIN model.

SUSTAIN Input File Creation and Model Run

1. Time Period
Simulation Start Date (01/01/1992)
Simulation End Date (12/31/2014)

2. Select a Pre-Development Land Use
The selected land use will be used to run an alternative baseline scenario.

3. Create Simulation Input File
All the watershed information (including BMPs) will be compiled into the SUSTAIN input file and BMP estimation results will be written into the output folder.
Input File Path
Output Folder Path

4. Run Simulation
SUSTAIN model executable

Figure 8. SUSTAIN Input File Creation and Model Run screen

Implementation Level – Model Output

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 provides the user an opportunity to have a meaningful interaction with the simulation results. Implementation level analysis yields a graph of all solutions, and identification of the “best” solutions in a cost versus percent reduction graph, see Figure 9.

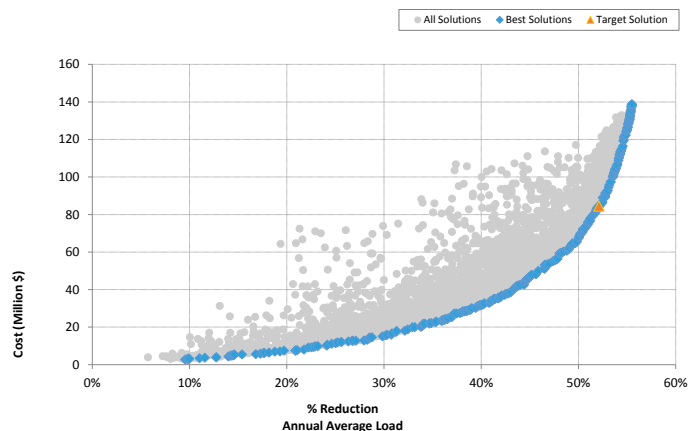


Figure 9. Cost-effectiveness curve in Opti-Tool

The View Results option allows the user to provide a target reduction value (Table 6), and Opti-Tool searches for the most cost-effective solution on the curve and provides the total cost of that solution (“target solution”, Figure 9). It also provides a table of the BMP information for the selected solution. The BMP information includes: BMP Type, BMP Area (ft²), BMP Storage Depth (ft), Treated Impervious Area (ac), Annual Maintenance (hours), and Cost(\$).

Table 6. Selected solution on the cost-effectiveness curve

Target Reduction (%)		Solution Total Cost (Million \$)	Solution Reduction (%)			
52.1%		84.53	52.10%			
BMP ID	BMP Type	BMP Area (ft²)	BMP Storage Depth (ft)	Treated Impervious Area (ac)	Annual Maintenance (hours)	Cost (\$)
BMP1	INFILTRATIONBASIN	690000	2.0005	653.85	NOT ASSESSED	17,226,706
BMP2	INFILTRATIONBASIN	580000	2.0005	586.58	NOT ASSESSED	14,480,419
BMP3	INFILTRATIONBASIN	76000	2.0005	62.92	NOT ASSESSED	1,897,434
BMP4	BIORETENTION	432	1.768	0.22	4.55	23,616
BMP5	BIORETENTION	52360	1.768	33.12	685.58	2,862,341
BMP6	BIORETENTION	600000	1.768	495.3	10252.71	32,799,936
BMP7	BIORETENTION	60000	1.768	95.02	1987.61	3,279,994
BMP8	ENHANCEDBIORETENTION	100800	2.28	89.08	NOT ASSESSED	7,175,105
BMP9	SUBSURFACEGRAVELWETLAND	85200	3.2	107.58	2334.49	4,787,558

Benefits of Opti- Tool

The core functionalities of Opti-Tool include:

- Accessible to all users with Microsoft Excel 2013 software;
- Represents regional precipitation conditions;
- Incorporates best available information on stormwater urban runoff nutrient quality;
- Incorporates best available information for estimating long-term cumulative nutrient load and runoff volume reduction performances for 11 categories of structural stormwater controls;
- Uses information which is being shared with other regional tool developers to promote the use of consistent and high quality data;
- Incorporates representative stormwater control units cost information with scaling function to account for specific conditions and development density;
- Includes flexibility to conduct either watershed planning level or site specific design-level analyses;
- Performs optimization analyses to determine most cost-effective selection of structural stormwater controls for achieving pollutant loading and runoff flow related reduction targets; and
- Provides calibrated SWMM HRU model and a utility tool that converts the SWMM output into the required format for the Opti-Tool.

Where Can I go for More Information?

Contact Person: Mark Voorhees (voorhees.mark@epa.gov)

References

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