SOUTH ORANGE COUNTY HYDROLOGY MODEL

GUIDANCE DOCUMENT

San Diego Region

March 23, 2012

A COOPERATIVE PROJECT OF THE COUNTY OF ORANGE, THE CITIES OF ORANGE COUNTY, AND THE ORANGE COUNTY FLOOD CONTROL DISTRICT

South Orange County of OrangeHydrology Model

Guidance Document

Produced by:
Clear Creek Solutions, Inc.
www.clearcreeksolutions.com

March 23, 2012

To download the South Orange County Hydrology Model (SOHM)
and the electronic version of this document,
please go to www.clearcreeksolutions.com/downloads

If you have questions about SOHM or its use, please contact:
Clear Creek Solutions, Inc.
360-943-0304 (8 AM – 5 PM Pacific Time)

By clicking on the "Accept" Button when installing the South Orange County Hydrology Model (SOHM) Software or by using the SOHM Software following installation, you, your employer, client and associates (collectively, "End User") are consenting to be bound by the following terms and conditions. If you or User do not desire to be bound by the following conditions, click the "Decline" Button, and do not continue the installation process or use of the SOHM Software.

The SOHM Software is being provided to End User pursuant to a sublicense of a governmental licensee of Clear Creek Solutions, Inc. Pursuant to the terms and conditions of this Agreement, End User is permitted to use the SOHM Software solely for purposes authorized by participating municipal, county or special district member agencies of signatory programs which are organized on a county-wide basis for implementation of stormwater discharge permits issued by the California Regional Water Quality Control Board, under the National Pollutant Discharge Elimination System. The End User is not permitted to use the SOHM Software for any other purpose than as described above.

End User shall not copy, distribute, alter, or modify the SOHM Software.

The SOHM incorporates data on soils, climate and geographical features to support its intended uses of identifying site-appropriate modeling parameters, incorporating user-defined inputs into long-term hydrologic simulation models of areas within the County of Orange, and assisting design of facilities for flow duration control as described in the accompanying documentation. These data may not be adequate for other purposes such as those requiring precise location, measurement or description of geographical features, or engineering analyses other than those described in the documentation.

This program and accompanying documentation are provided 'as-is' without warranty of any kind. The entire risk regarding the performance and results of this program is assumed by End User. Clear Creek Solutions Inc. and the governmental licensee or sublicensees disclaim all warranties, either expressed or implied, including but not limited to implied warranties of program and accompanying documentation. In no event shall Clear Creek Solutions Inc, or authorized representatives be liable for any damages whatsoever (including without limitation to damages for loss of business profits, loss of business information, business interruption, and the like) arising out of the use of, or inability to use this program even if Clear Creek Solutions Inc., has been advised of the possibility of such damages.

The South Orange County Hydrology Model (SOHM) is a tool for analyzing the hydromodification effects of land development projects and sizing solutions to mitigate the increased runoff from these projects. This section of the guidance documentation provides background information on the definition and effects of hydromodification and relevant findings from technical analyses conducted in response to regulatory requirements. It also summarizes the current Hydromodification Management Standard and general design approach for hydromodification control facilities, which led to the development of the SOHM.

Effects of Hydromodification

Urbanization of a watershed modifies natural watershed and stream processes by altering the terrain, modifying the vegetation and soil characteristics, introducing pavement and buildings, installing drainage and flood control infrastructure, and altering the condition of stream channels through straightening, deepening, and armoring. These changes affect hydrologic characteristics in the watershed (rainfall interception, infiltration, runoff and stream flows), and affect the supply and transport of sediment in the stream system. The change in runoff characteristics from a watershed caused by changes in land use conditions is called *hydrograph modification*, or simply hydromodification.

As the total area of impervious surfaces increases in previously undeveloped areas, infiltration of rainfall decreases, causing more water to run off the surface as overland flow at a faster rate. Storms that previously didn't produce runoff under rural conditions can produce erosive flows. The increase in the volume of runoff and the length of time that erosive flows occur ultimately intensify sediment transport, causing changes in sediment transport characteristics and the hydraulic geometry (width, depth, slope) of channels. The larger runoff durations and volumes and the intensified erosion of streams can impair the beneficial uses of the stream channels.

Regulatory Context

The California Regional Water Quality Control Board (Water Board) requires stormwater programs to address the increases in runoff rate and volume from new and redevelopment projects where those increases could cause increased erosion of receiving streams. The Phase 1 municipal stormwater permit for the San Diego Region of Orange County contains requirements to develop and implement hydromodification management plans (HMPs) and to implement associated management measures.

Development of the South Orange County Hydrology Model

The concept of designing a flow duration control facility is relatively new and, as described above, requires the use of a continuous simulation hydrologic model. To facilitate this design approach, Clear Creek Solutions (CCS) has created a user-friendly, automated modeling and flow duration control facility sizing software tool adapted from its Western Washington Hydrology Model (WWHM). The WWHM was developed in 2001 for the Washington State Department of Ecology to support Ecology's *Stormwater*

Management Manual for Western Washington[1] and assist project proponents in complying with the Western Washington hydromodification control requirements. The SOHM is adapted from WWHM Version 4, but has been modified to represent Orange County hydrology and enhanced to be able to size other types of control measures and Low Impact Development (LID) techniques for flow reduction as well.

SOHM is a useful tool in the design process, but must be used in conjunction with local design guidance to ensure compliance for specific projects. The reader should refer to Appendix C and local stormwater program guidance for additional information and suggestions for using the SOHM.

Acknowledgements

The following individuals are acknowledged for their contributions to the development of SOHM and guidance documentation:

- Doug Beyerlein, Joe Brascher, Gary Maxfield, and Shanon White of Clear Creek Solutions, Inc., for development of WWHM, BAHM, and SOHM and preparation of the SOHM guidance documentation.
- Daniel Apt, Scott Taylor, and Remi Candaele of RBF Consulting for providing SOHM meteorological data, maps, and technical specifications.

[1] Washington State Department of Ecology. 2001. Stormwater Management Manual for Western Washington. Volume III: Hydrologic Analysis and Flow Control Design/BMPs. Publication No. 99-13. Olympia, WA.

TABLE OF CONTENTS

TABLES

APPENDICES

INTRODUCTION TO SOHM

SOHM is the South Orange County Hydrology Model. SOHM is based on the WWHM (Western Washington Hydrology Model) stormwater modeling platform. WWHM was originally developed for the Washington State Department of Ecology. More information about WWHM can be found at www.clearcreeksolutions.com. More information can be found about the Washington State Department of Ecology's stormwater management program and manual at www.ecy.wa.gov/programs/wq/stormwater/manual.html.

Clear Creek Solutions is responsible for SOHM and the SOHM guidance documentation.

This guidance documentation is organized so as to provide the user an example of a standard application using SOHM (described in *Quick Start*) followed by descriptions of the different components and options available in SOHM. The *Tips and Tricks* section presents some ideas of how to incorporate LID (Low Impact Development) facilities and practices into the SOHM analysis. **Appendices A** and **B** provide a full list of the HSPF parameter values used in SOHM. **Appendix C** contains additional guidance and recommendations by the stormwater programs that have sponsored the SOHM development.

*Throughout the guidance documentation notes using this font (sans-serif italic) alert the user to actions or design decisions for which guidance must be consulted that is external to the SOHM software, either provided in **Appendix C** of this guidance documentation or by the local municipal permitting agency.*

Purpose

The purpose of SOHM is to size hydromodification management or flow control facilities to mitigate the effects of increased runoff (peak discharge, duration, and volume) from proposed land use changes that impact natural streams, wetlands, and other water courses.

SOHM provides:

- A uniform methodology for South Orange County.
- A more accurate methodology than single-event design storms.
- An easy-to-use software package.

SOHM is based on:

- Continuous simulation hydrology (HSPF).
- Actual long-term recorded precipitation data.
- Measured pan evaporation data.
- Existing vegetation (for predevelopment conditions).
- Regional HSPF parameters.

Computer Requirements

- Windows 2000/XP/Vista/7 with 300 MB uncompressed hard drive space.
- Internet access (only required for downloading SOHM, not required for executing SOHM).
- Pentium 3 or faster processor (desirable).
- Color monitor (desirable).

Before Starting the Program

- Knowledge of the site location and/or street address.
- Knowledge of the actual distribution of existing site soil by category (A, B, C, or D).
- Knowledge of the actual distribution of existing and proposed site land cover by category (scrub, open brush, or gravel).
- Knowledge of the actual distribution of existing and proposed site topography by category (flat, moderate, steep, or very steep).
- Knowledge of the planned distribution of the proposed development (buildings, streets, sidewalks, parking, lawn areas) overlying the soil categories.

SOHM OVERVIEW

The SOHM software architecture and methodology is the same as that developed for BAHM (Bay Area Hydrology Model), SDHM (San Diego Hydrology Model), and WWHM and uses HSPF as its computational engine.[2] Like BAHM, SDHM, and WWHM, SOHM is a tool that generates flow duration curves for the pre- and post-project condition and then sizes a flow duration control pond/basin or vault and outlet structure to match the predevelopment curve. The software package consists of a user-friendly graphical interface with screens for input of predevelopment and post-project conditions; an engine that automatically loads appropriate parameters and meteorological data and runs continuous simulations of site runoff to generate flow duration curves; a module for sizing or checking the control measure to achieve the hydromodification control standard; and a reporting module.

The HSPF hydrology parameter values used in SOHM are based on best professional judgment using our experience with calibrated watersheds in other parts of California. SOHM uses the Orange County long-term 15-minute precipitation data records selected to represent South Orange County rainfall patterns.

HSPF is the U.S. Geological Survey and U.S. Environmental Protection Agency continuous simulation hydrology software package maintained by AQUA TERRA Consultants. The HSPF continuous simulation hydrology model is preferred over single-event hydrology models because of its ability to compute and keep track of all of the individual components of the hydrologic cycle including surface runoff, interflow, groundwater, soil moisture, and evapotranspiration. HSPF, since its introduction in 1980, has become the industry standard for hydrologic modeling.

One of the major advantages of continuous simulation hydrologic modeling is the ability to accurately determine soil moisture conditions immediately prior to storm events. Single-event hydrologic models have to make assumptions about the antecedent soil moisture conditions – assumptions which are often not accurate or appropriate. This is an important distinction because antecedent soil moisture conditions play a major role in determining the amount and timing of runoff.

Not all continuous simulation hydrologic models handle the calculation of soil moisture conditions in the same level of detail. HSPF uses a potential evapotranspiration time series to compute actual evapotranspiration each time step. HSPF uses parameter values to determine the proportion of the actual evapotranspiration from interception storage, upper soil layer storage, lower soil zone layer storage, groundwater storage, and base flow. Other continuous simulation hydrologic models, SWMM included, use a much more simplified approach to determining soil moisture. Such simplified approaches do not accurately reflect the seasonal and daily variability of the actual evapotranspiration and its effects on soil moisture.

[2] SOHM is based on WWHM Version 4.

SOHM computes stormwater runoff for a site selected by the user. SOHM runs HSPF in the background to generate a 15-minute runoff time series from the available rain gage data over a number of years. Stormwater runoff is computed for both predevelopment and post-project land use conditions. Then, another part of the SOHM routes the post-project stormwater runoff through a stormwater control facility of the user's choice.

SOHM uses the predevelopment peak flood values from a partial duration series of individual peak events to compute the predevelopment 2-year through 25-year flood frequency values[3]. The post-project runoff 2-year through 25-year flood frequency values are computed at the outlet of the proposed stormwater facility. The model routes the post-project runoff through the stormwater facility. As with the predevelopment peak flow values, partial duration post-project flow values are selected by the model to compute the developed 2-year through 25-year flood frequency.

The predevelopment 2-year peak flow is multiplied by a percentage (10 percent) to set the lower limit of the erosive flows, in accordance with the current HMP performance criteria. The predevelopment 10-year peak flow is the upper limit. A comparison of the predevelopment and post-project flow duration curves is conducted for 100 flow levels between the lower limit and the upper limit. The model counts the number of 15-minute intervals that predevelopment flows exceed each of the flow levels during the entire simulation period. The model does the same analysis for the post-project mitigated flows. Low impact development (LID)/best management practices (BMPs) have been recognized as opportunities to reduce and/or eliminate stormwater runoff at the source before it becomes a problem. They include compost-amended soils, bioretention, permeable pavement, green roofs, rain gardens, and vegetated swales. All of these approaches reduce stormwater runoff. SOHM can be used to determine the magnitude of the reduction from each of these practices and the amount of stormwater detention storage still required to meet HMP requirements.

[3] The actual flood frequency calculations are made using the Cunnane flood frequency equation.

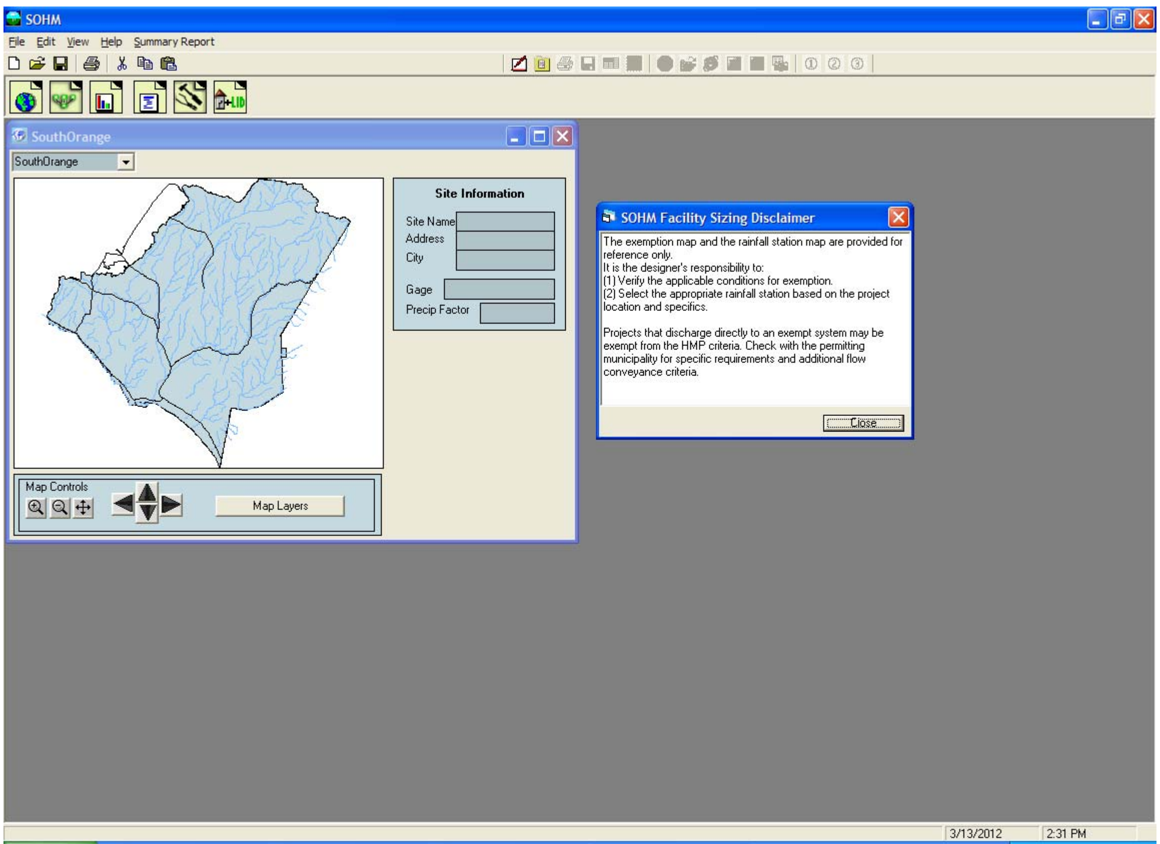
QUICK START

Quick Start very briefly describes the steps to quickly size a stormwater detention pond using SOHM. New users should read the descriptions of the SOHM screens, elements, and analysis tools before going through the steps described below.

1. Open SOHM.

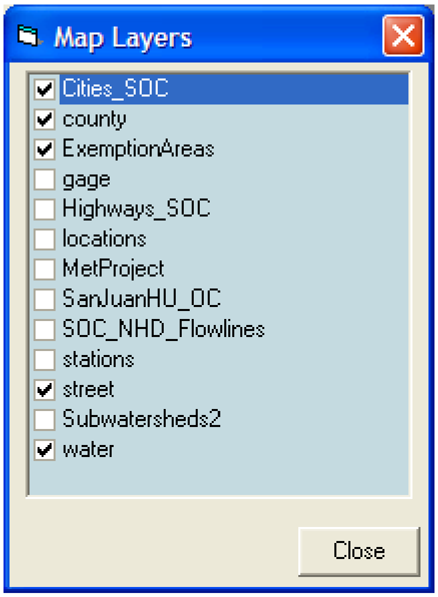
SOHM will open with a disclaimer. The disclaimer states that it is the user responsibility to:

(1) Verify the applicable conditions for HMP exemption, and
(2) Select the appropriate rainfall station gage based on the project location.



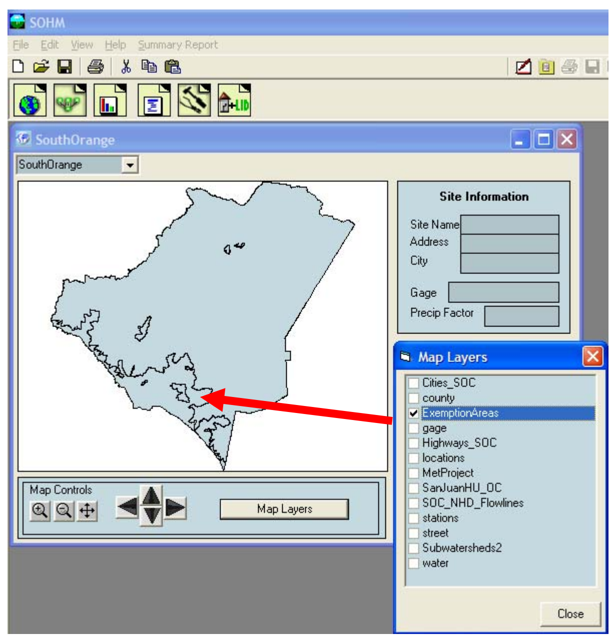
Projects that discharge directly to an exempt system as defined by Section 4.3 of the HMP are exempt from the HMP criteria. Projects however that discharge to an exempt system but not directly to the exempt system must discharge runoff directly to an engineered conveyance system that extends to the exempt system in order to qualify for the HMP criteria exemption. Such engineered systems can include existing storm drain systems, existing hardened conveyance channels, or stable engineered unlined conveyance channels that are part of the MS4 but that are not receiving waters. To qualify for the exemption, the existing hardened or rehabilitated conveyance system must continue uninterrupted to the exempt system. The engineered conveyance system cannot discharge to an unlined, non-engineered channel segment prior to discharge to the exempt system. Additionally, the project proponent must demonstrate that the engineered conveyance system has the capacity to convey the 10-year ultimate condition flow through the conveyance system. The 10-year flow should be calculated based upon single-event hydrologic criteria as detailed in the Orange County Hydrology Manual.

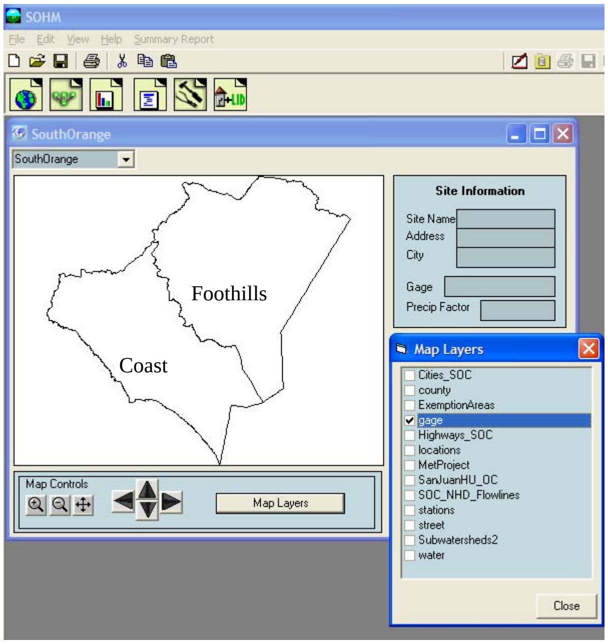
Users can view different SOHM map layers by clicking on the “Map Layer” button.



Selection of the Exemption Areas layer (with the other layers turned off) identifies the portion of South Orange County where projects that discharge directly to an exempt system as defined by Section 4.3 of the HMP are exempt from the HMP criteria (see above for more details).

Other layers identify other features in South Orange County.





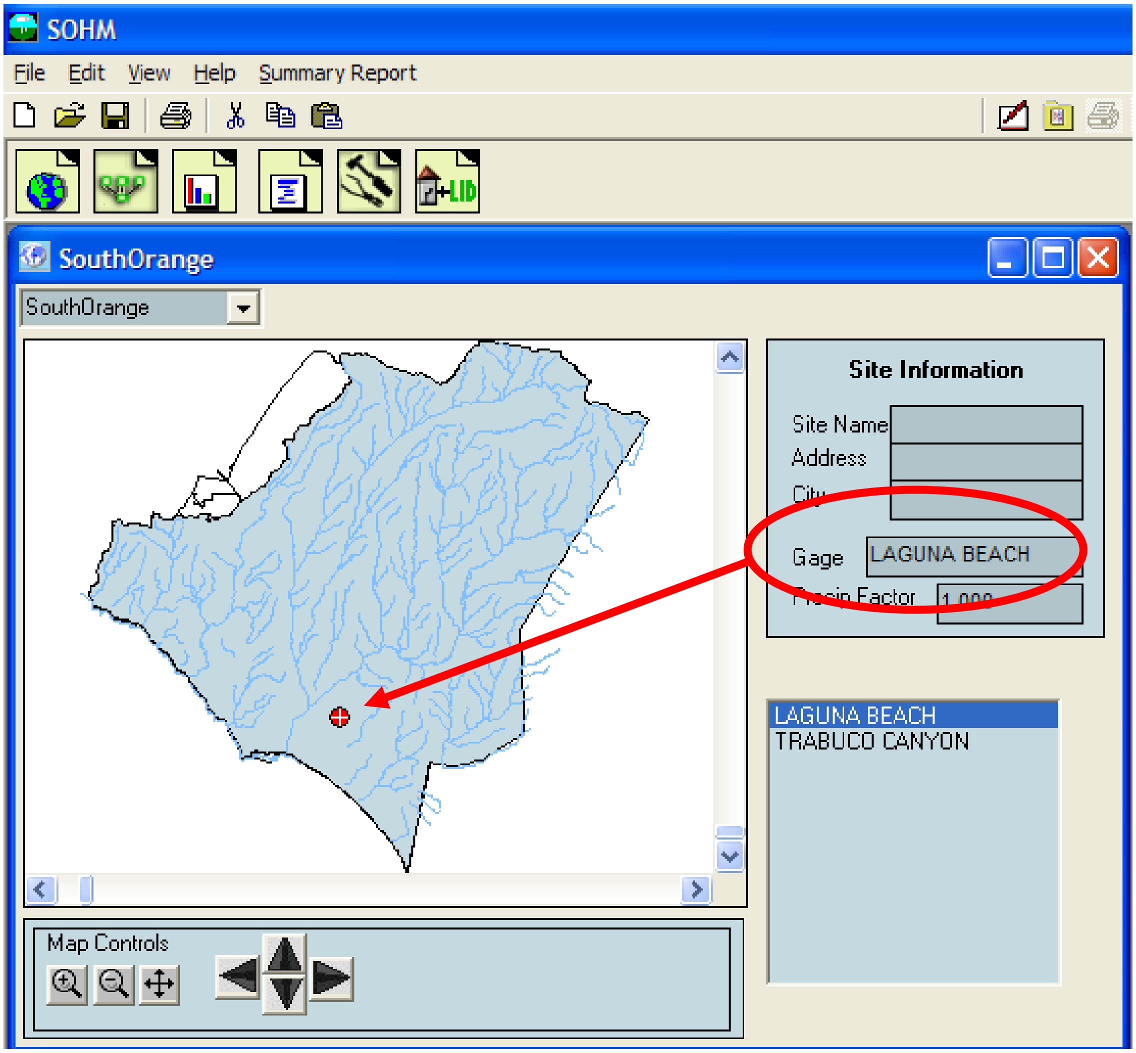
The gage layer identifies the portion of South Orange County that the coastal region and the portion that is the foothill region.

The Laguna Beach precipitation gage should be used for projects located in the coastal portion of the county and Trabuco Canyon for the foothills.

Contact the local reviewing agency for direction if unsure of which precipitation gage to use.

2. Select the project site location.

Locate the project site on the map. Use the map controls to magnify a portion of the map, if needed. Select the project site by left clicking on the map location. A red square will be placed on the map identifying the project site.

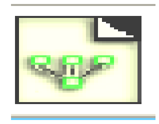


The user then selects the appropriate rain gage record for the project site. South Orange County has two long-term 15-minute precipitation records: Laguna Beach for the coastal portion of the county and Trabuco Canyon for the foothills. Check with the reviewing agency to determine the appropriate precipitation gage for the project site.

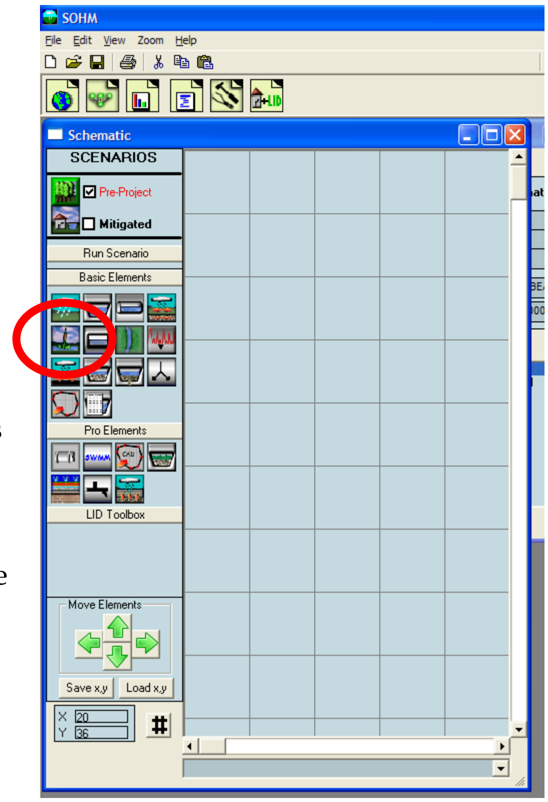
For this example we will use the Laguna Beach rain gage. With the mouse click on the name of the rain gage you want to use. SOHM will then load that precipitation and confirm the gage location in the gage name box.

The site name, address, and city information is optional. It is not used by SOHM, but will be included in the project report summary.

3. Use the tool bar (immediately above the map) to move to the Scenario Editor. Click on the General Project Information button.



The General Project Information button will bring up the Schematic Editor.



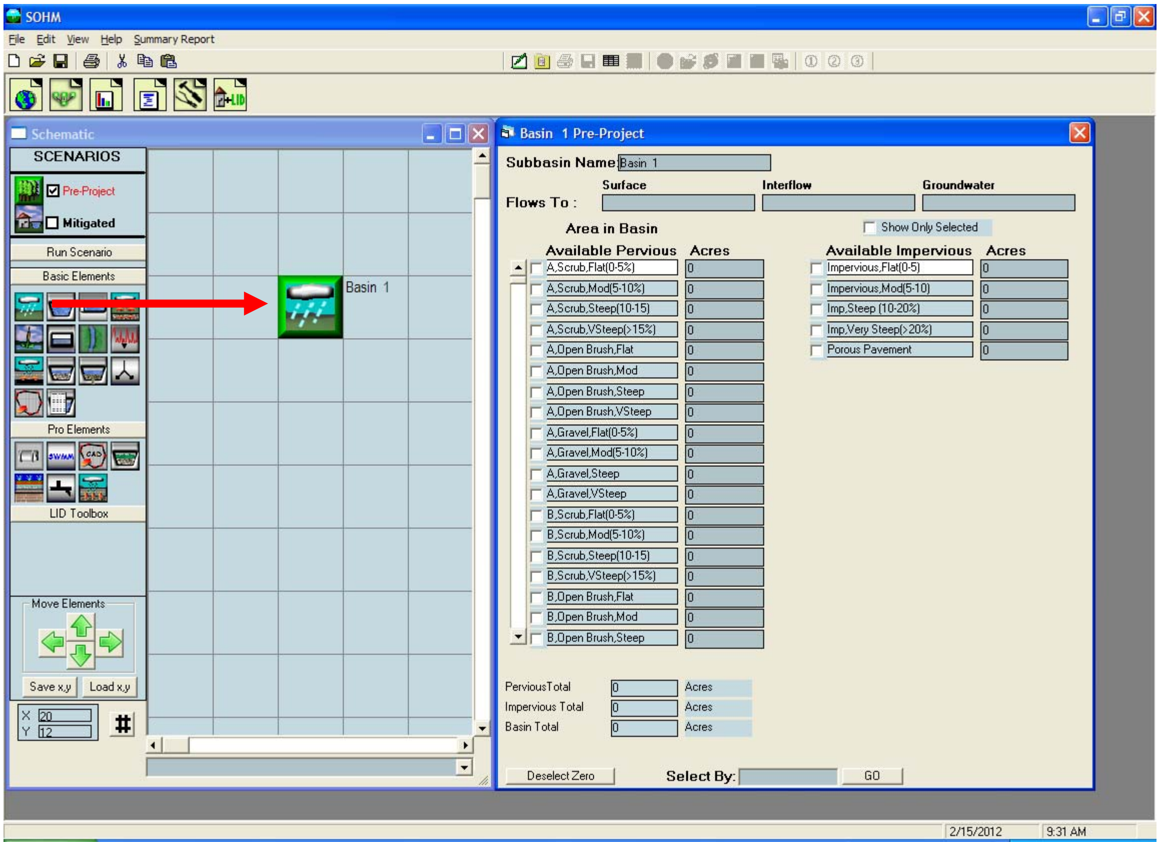
The schematic editor screen contains two scenarios: Pre-Project (Predevelopment) and Mitigated.

Set up first the Predevelopment scenario and then the Mitigated scenario.

Check the Predevelopment scenario box.

Left click on the Basin element under the Elements heading. The Basin element represents the project drainage area. It is the upper left element.

Select any grid cell (preferably near the top of the grid) and left click on that grid. The basin will appear in that grid cell.



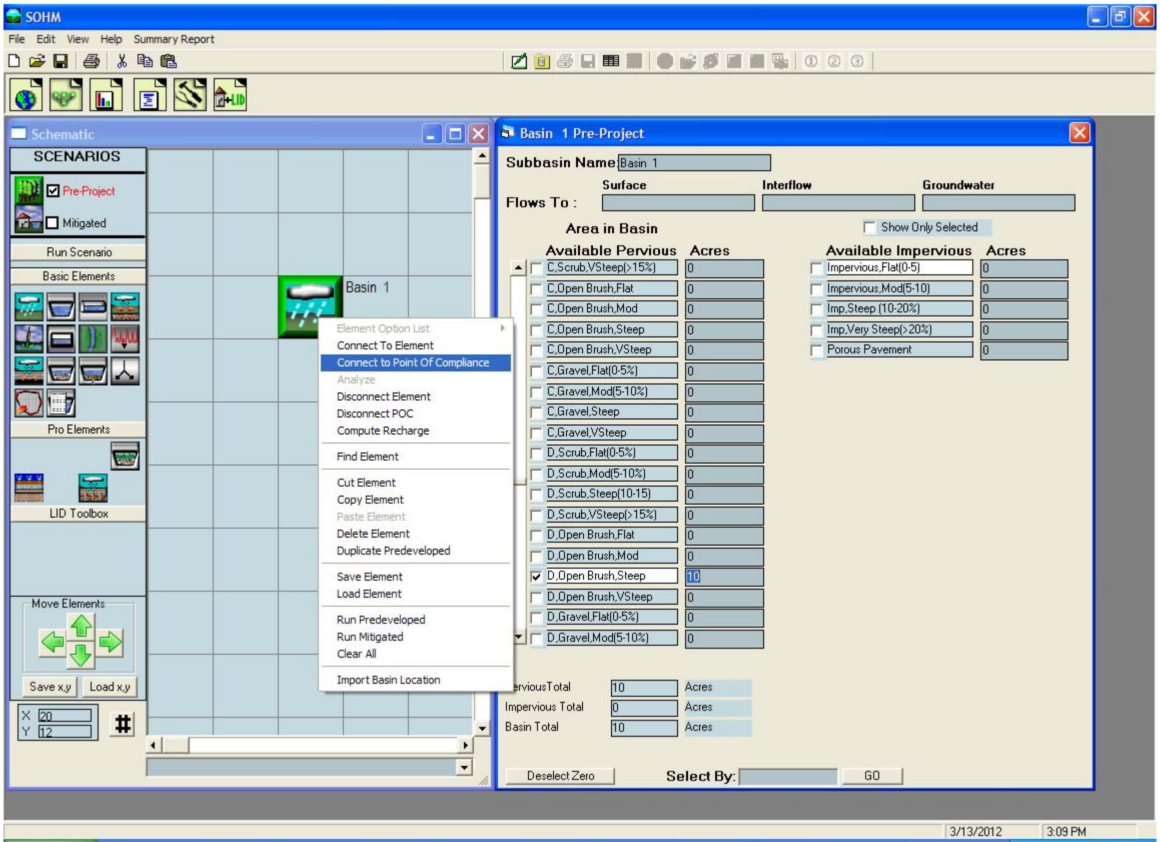
To the right of the grid is the land use information associated with the basin element. Select the appropriate soil, land cover, and land slope for the Predevelopment scenario. Soils are based on SCS general categories A, B, C, and D.

Land cover is based on the native vegetation for the Predevelopment area and the planned vegetation for the planned development (Mitigated scenario). Non-urban land cover has been divided into scrub, open brush, and gravel. In contrast, the developed landscape will consist of urban vegetation (lawns, flowers, planted shrubs and trees) and is regularly irrigated.

Land slope is divided into flat (0-5%), moderate (5-10%), steep (10-15%), and very steep (> 15%) land slopes.

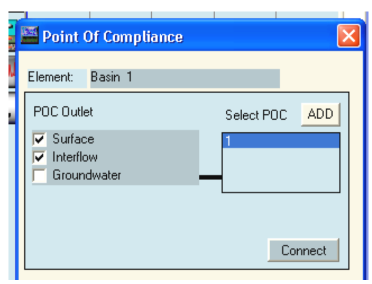
HSPF parameter values in SOHM have been adjusted for the different soil, land cover, and land slope categories.

For this example we will assume that the Predevelopment land use is 10 acres of D soil with open brush vegetation on a steep slope (10-15%). Note that the Predevelopment land use never includes man-made impervious areas and existing impervious areas must be modeled as they were prior to any land use development on the project site.

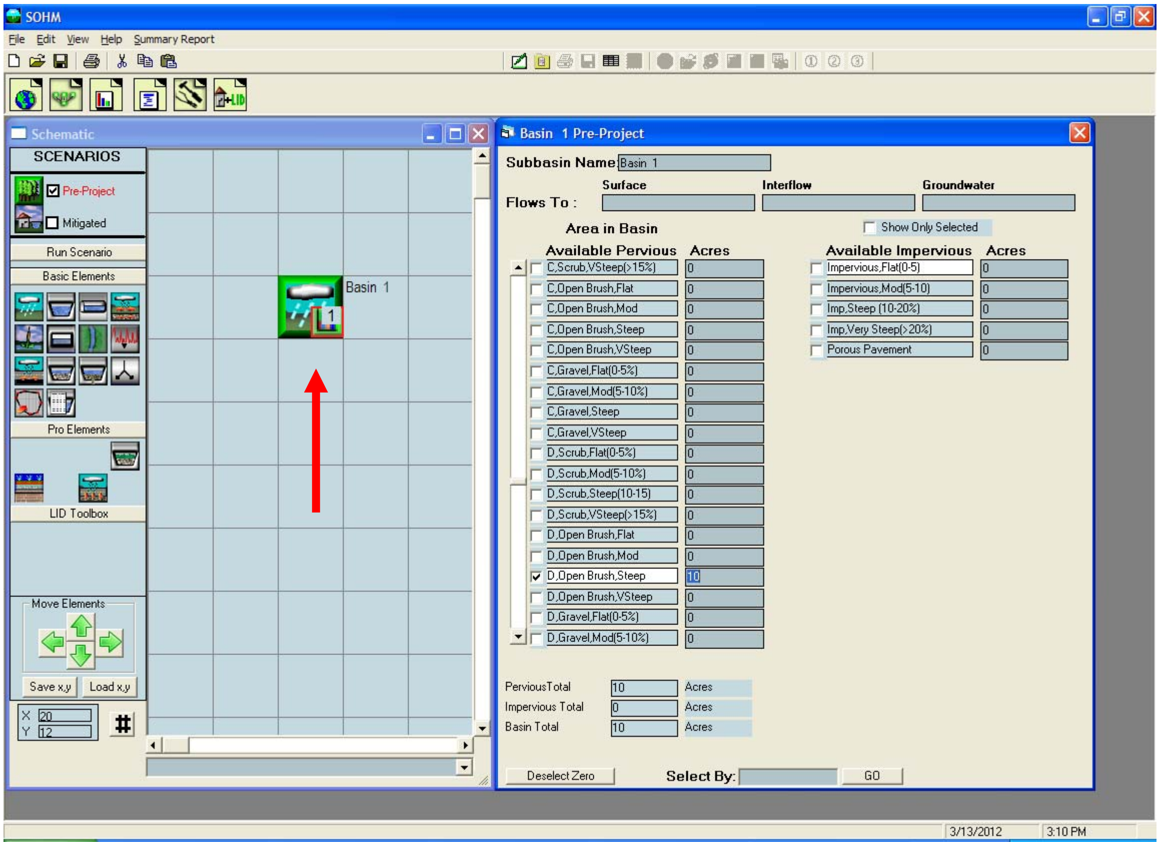


The exit from this basin will be selected as our point of compliance for the Predevelopment scenario. Right click on the basin element and highlight Connect to Point of Compliance (the point of compliance is defined as the location at which the runoff from both the Predevelopment scenario and the Mitigated scenario are compared).

The Point of Compliance screen will be shown for Predevelopment Basin 1. The POC (Point of Compliance) outlet has been checked for both surface runoff and interflow (shallow subsurface flow). These are the two flow components of stormwater runoff. Do not check the groundwater box unless there is observed and documented base flow on the project site.

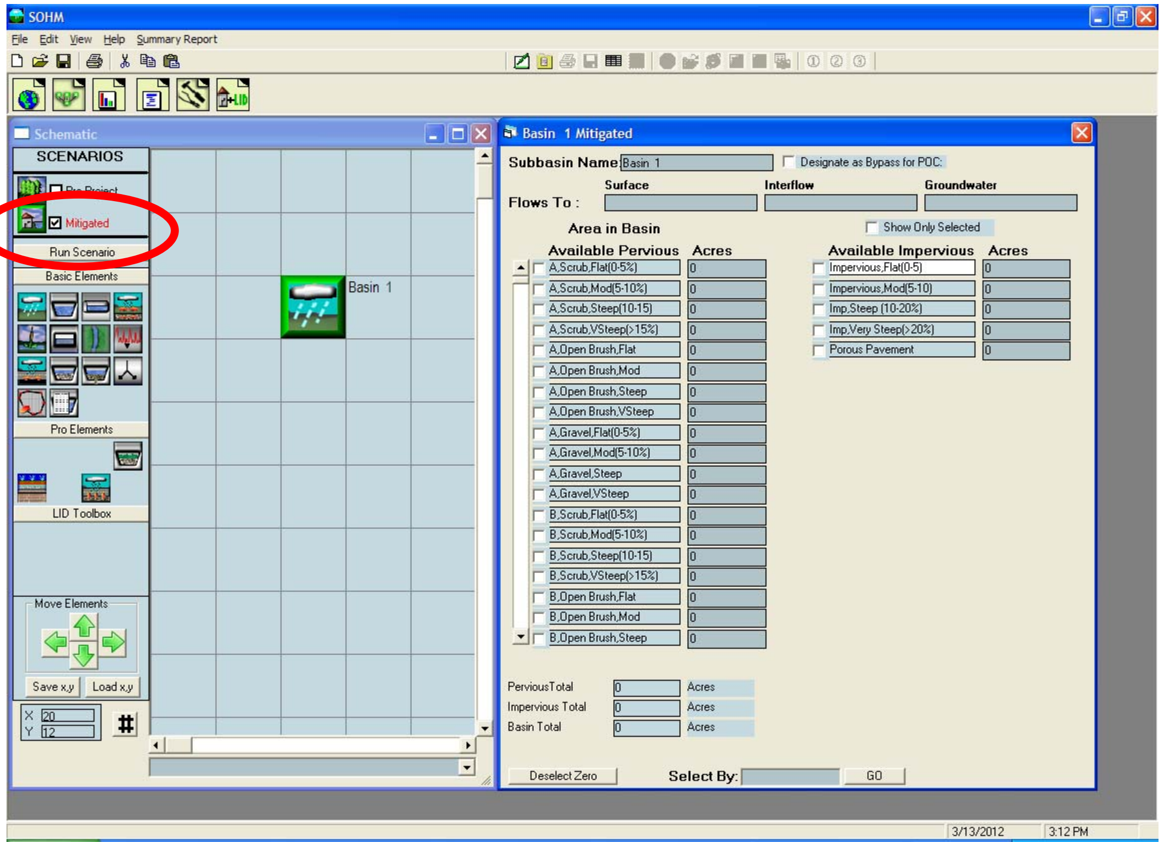


Click the Connect button in the low right corner to connect this point of compliance to the Predevelopment basin.

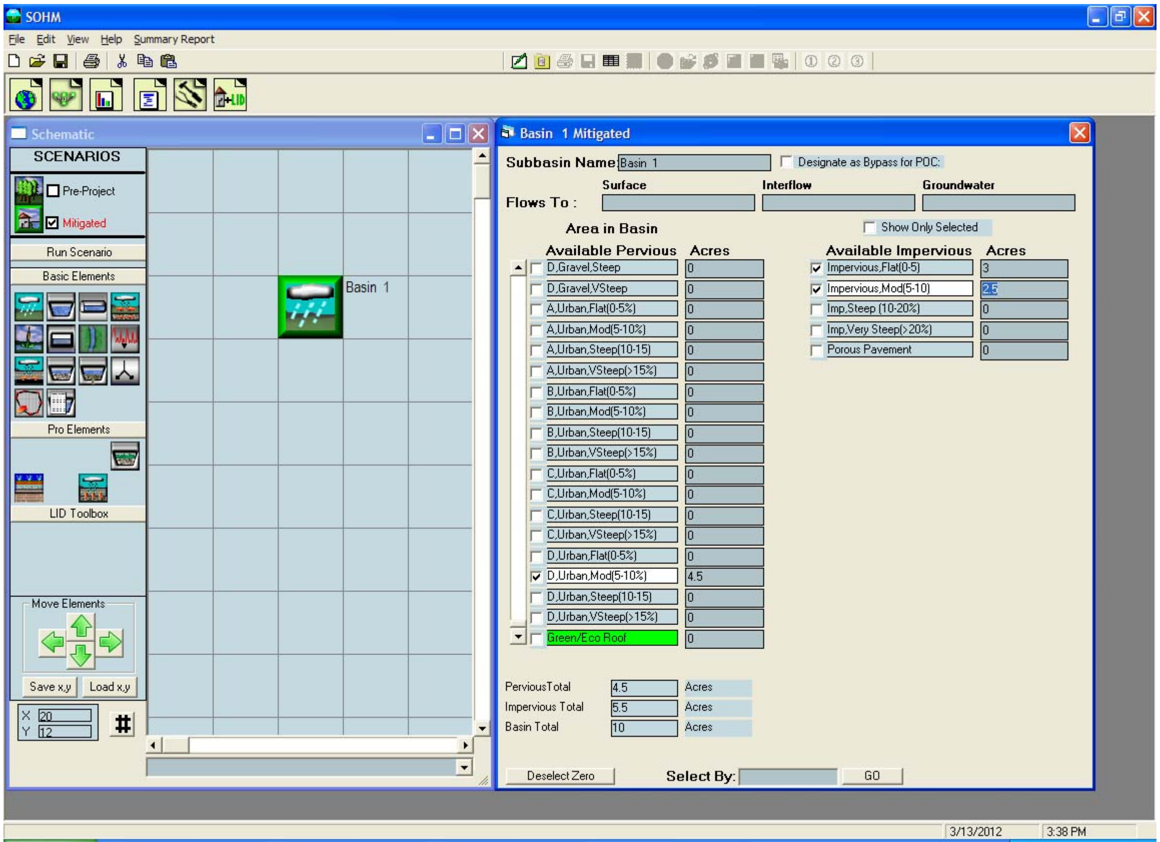


After the point of compliance has been added to the basin the basin element will change. A small box with a bar chart graphic and a number will be shown in the lower right corner of the basin element. This small POC box identifies this basin as a point of compliance. The number is the POC number (e.g., POC 1).

4. Set up the Mitigated scenario.



First, check the Mitigated scenario box and place a basin element on the grid.

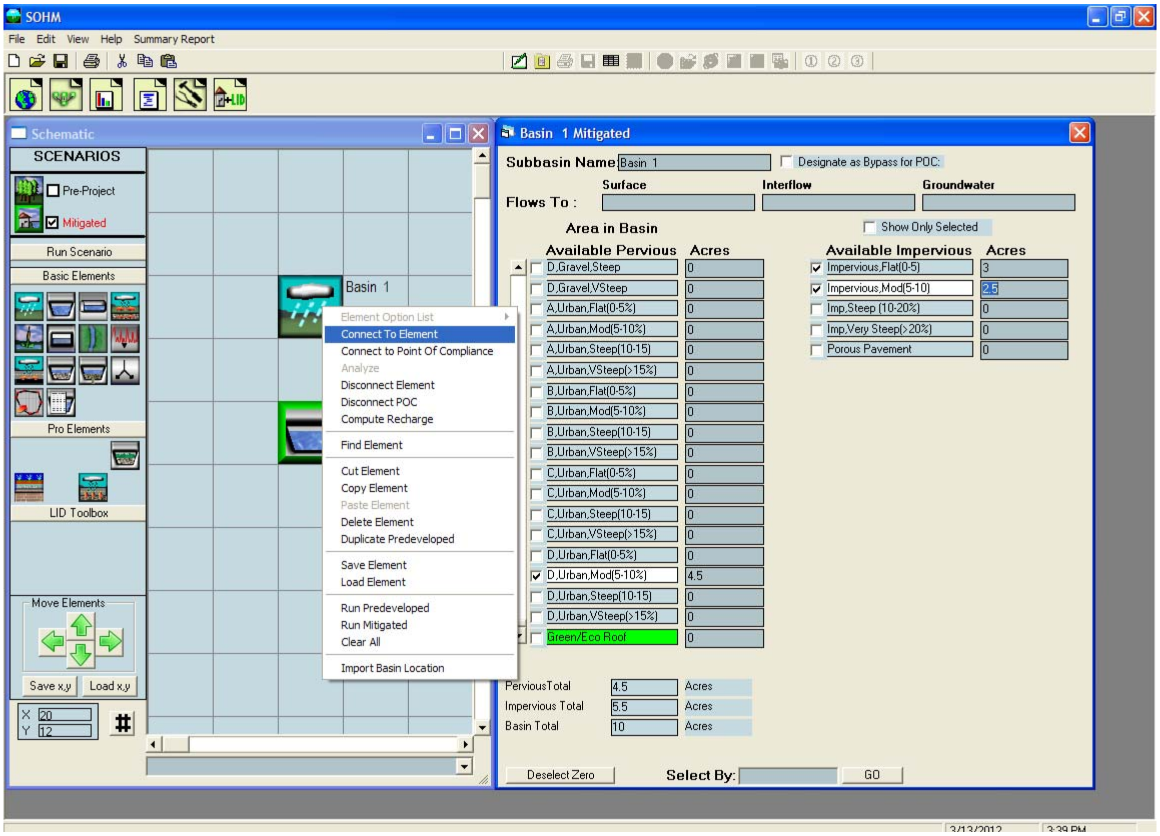


For the Mitigated land use we have:

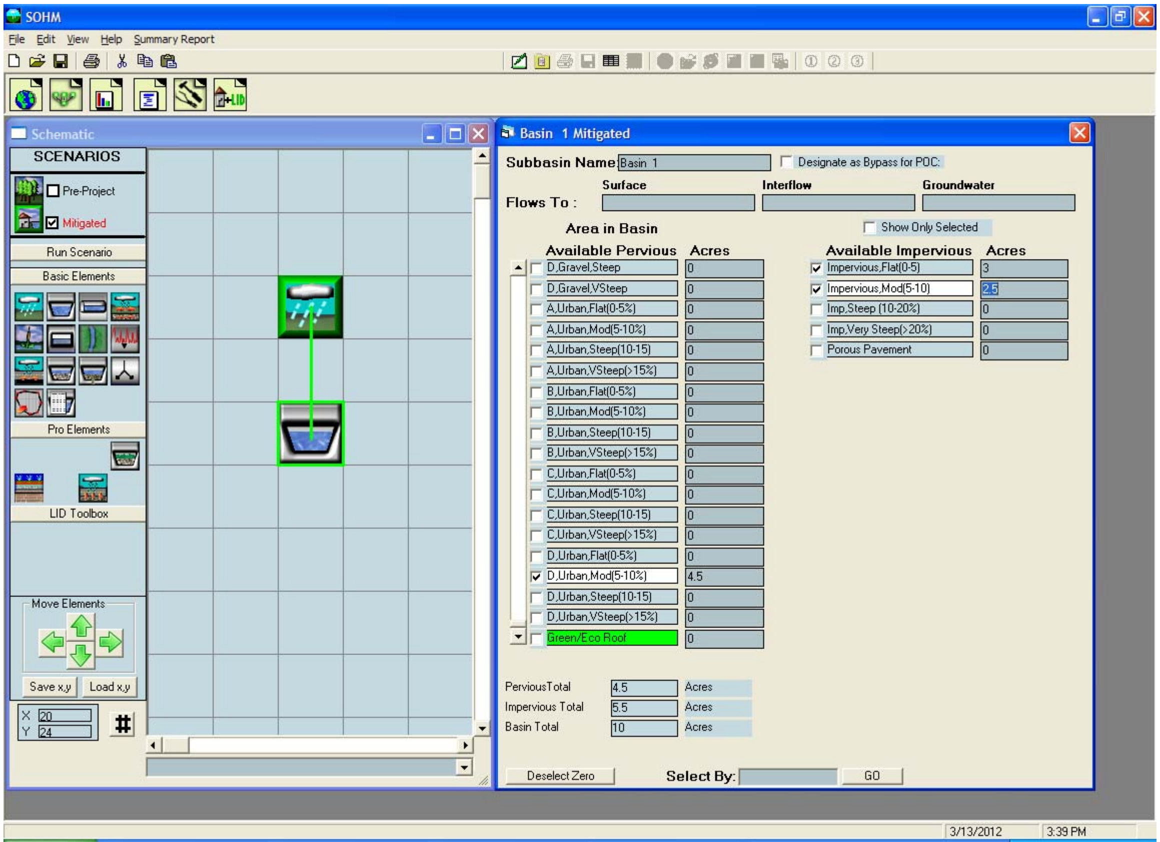
- 4.5 acres of D soil, urban vegetation, moderate slope
- 3 acres of impervious, flat slope
- 2.5 acres of impervious, moderate slope

We will add a trapezoidal pond downstream of the basin.

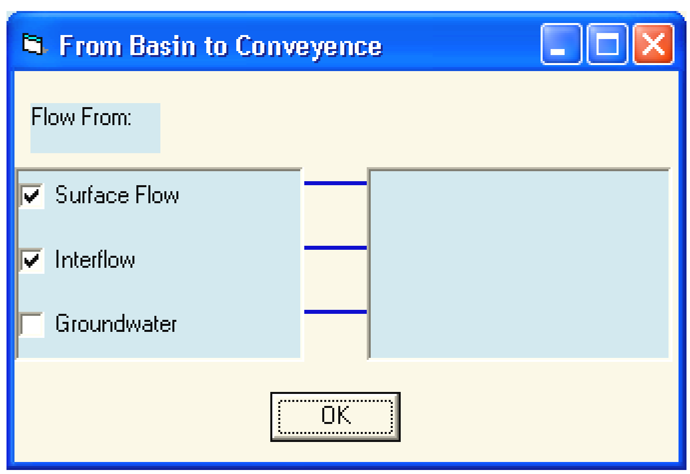
The impervious land categories include roads, roofs, sidewalks, parking, and driveways. All are modeled the same, except that steeper slopes have less surface retention storage prior to the start of surface runoff.

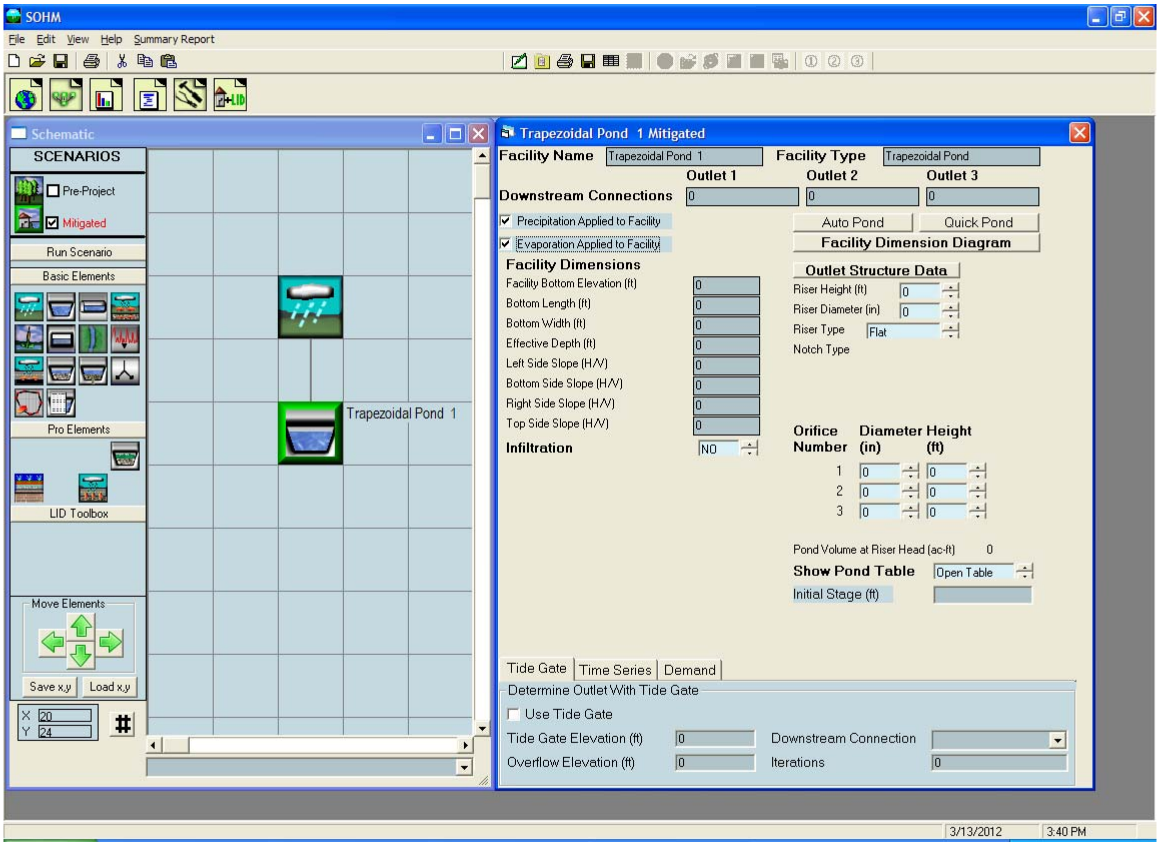


The trapezoidal pond element is placed below the basin element on the grid. Right click on the basin and select Connect To Element. A green line will appear with one end connected to the basin.

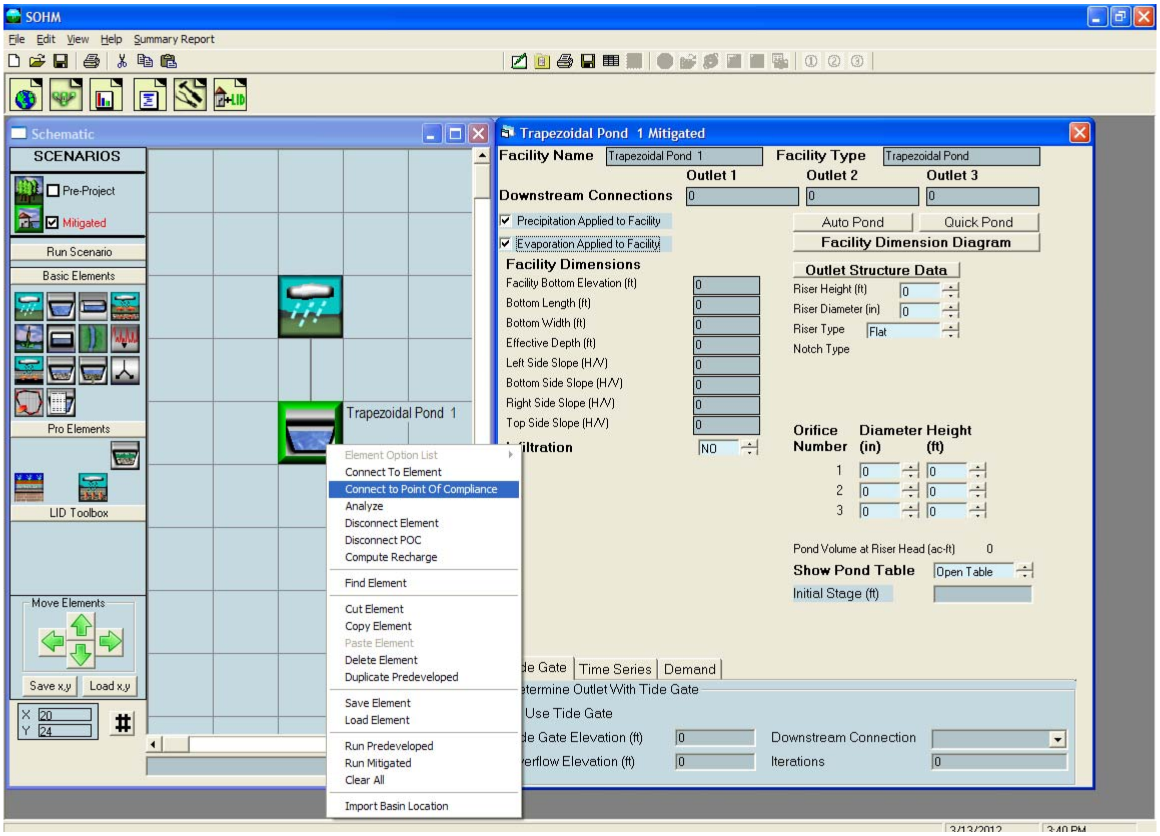


With the mouse pointer pull the other end of the line down to the trapezoidal pond and click on the pond. This will bring up the From Basin to Conveyance screen. As with the Predevelopment scenario we want to only connect the surface flow and the interflow (shallow subsurface runoff) from the basin to the pond. Click OK.

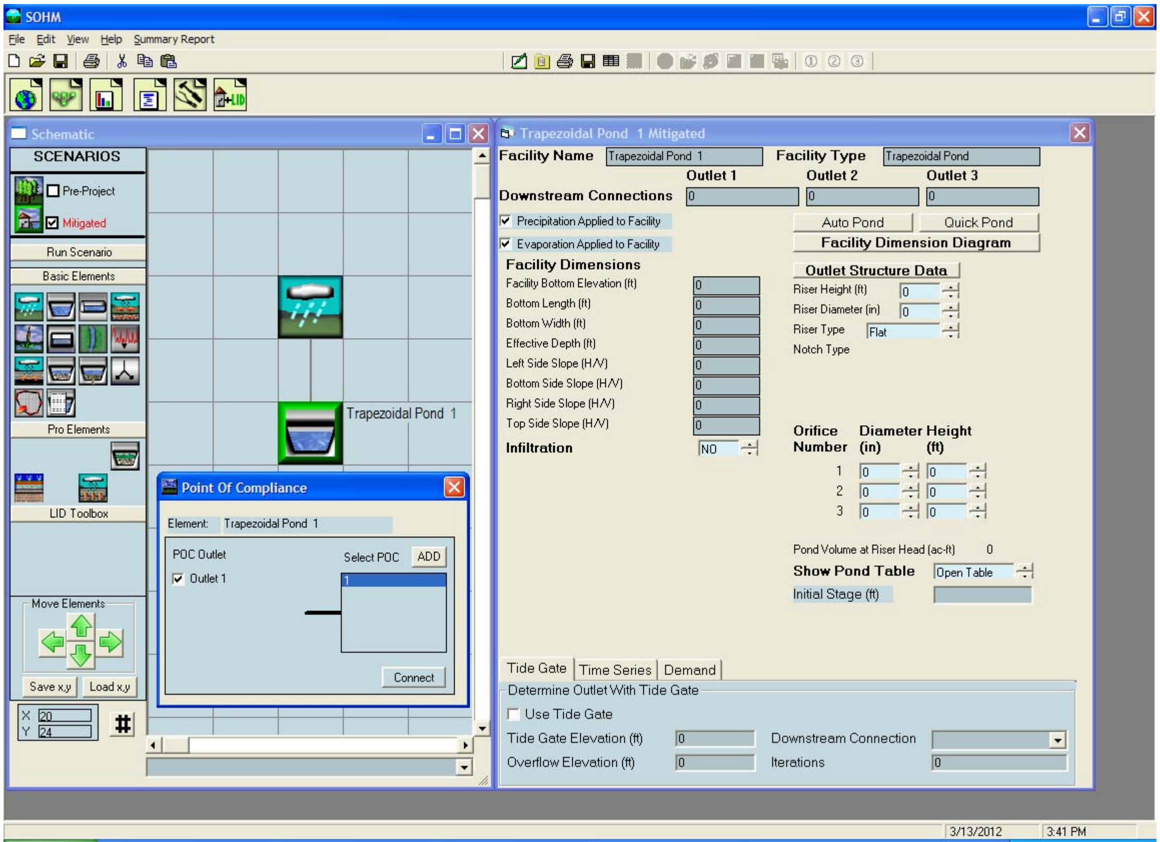




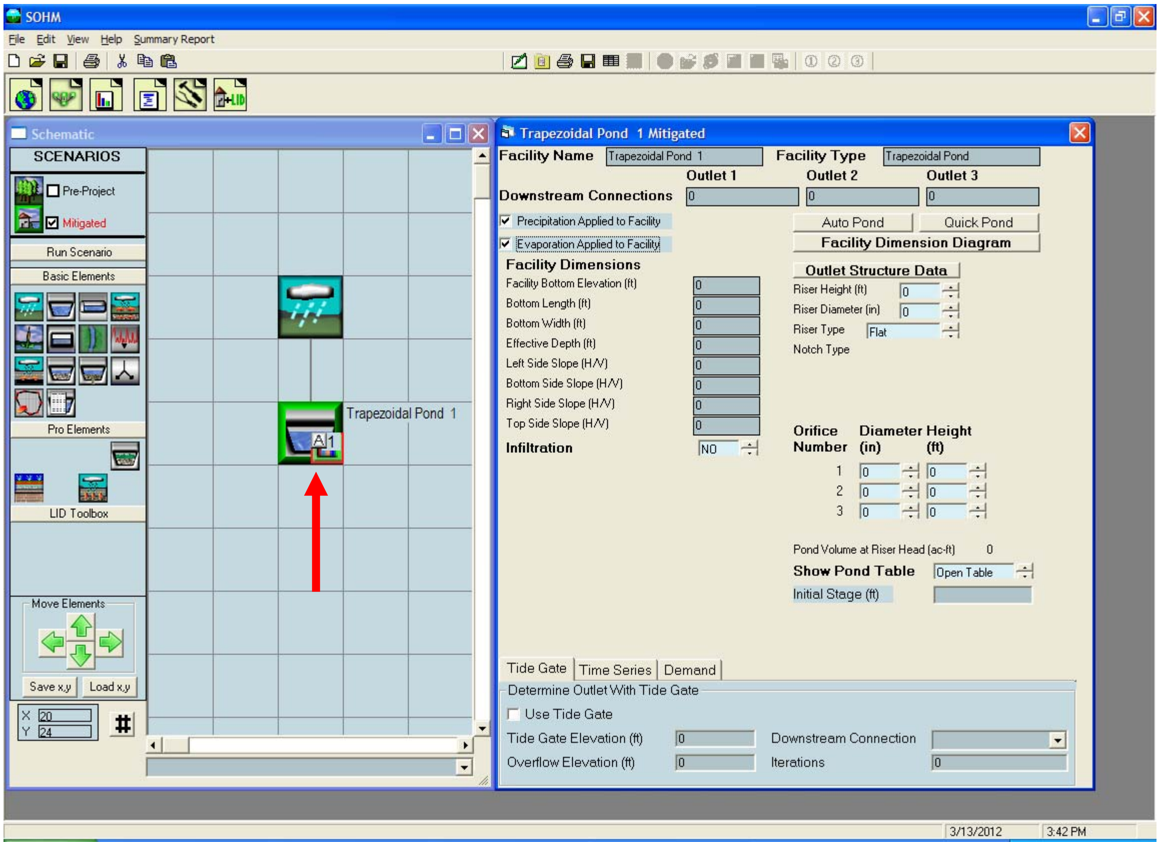
A line will connect the basin to the pond.



Right click on the trapezoidal pond element to connect the pond's outlet to the point of compliance. Highlight Connect to Point Of Compliance and click.



The Point of Compliance screen will be shown for the pond. The pond has one outlet (by default). The outflow from the pond will be compared with the Predevelopment runoff. The point of compliance is designated as POC 1 (SOHM allows for multiple points of compliance). Click on the Connect button.

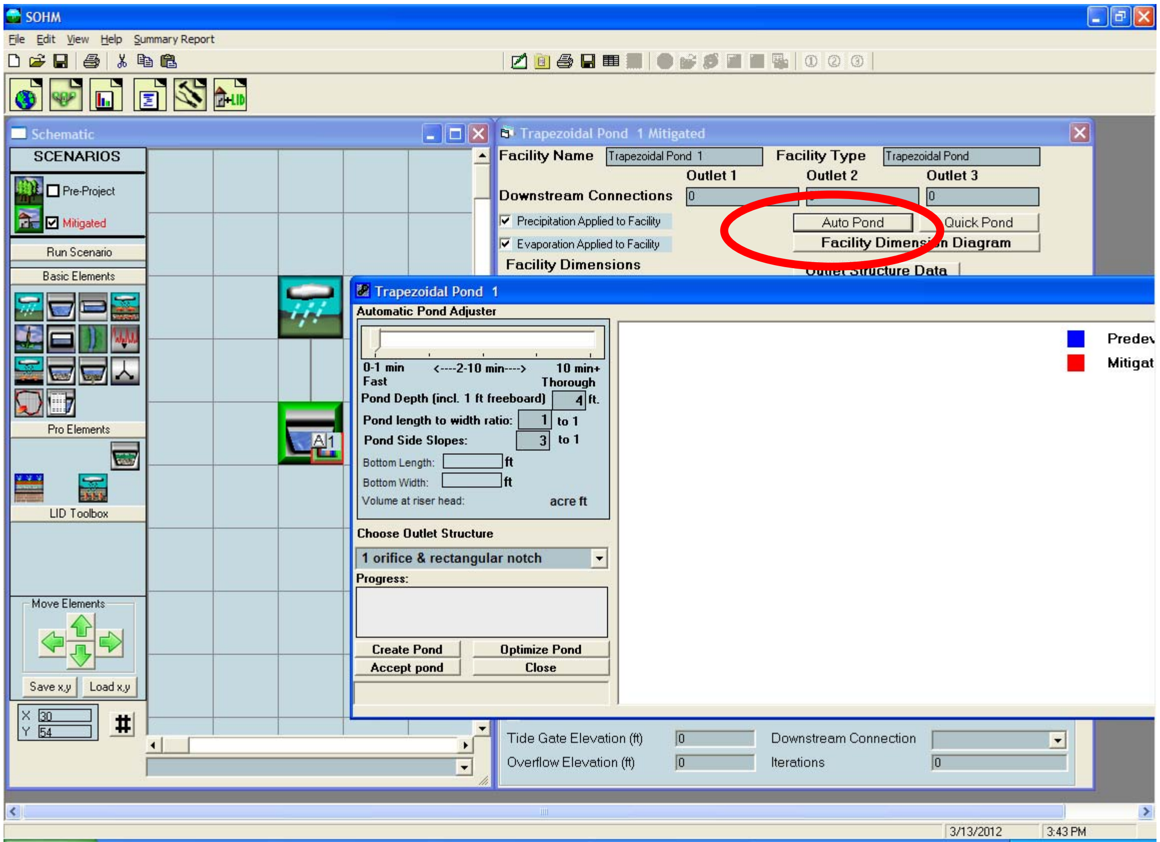


The point of compliance is shown on the pond element as a small box with the letter "A" and number 1 in the bar chart symbol in the lower right corner.

The letter "A" stands for Analysis and designates that this is an analysis location where flow and stage will be computed and the output flow and stage time series will be made available to the user. The number 1 denotes that this is POC 1.

You can have an analysis location without having a point of compliance at the same location, but you cannot have a point of compliance that is also not an analysis location.

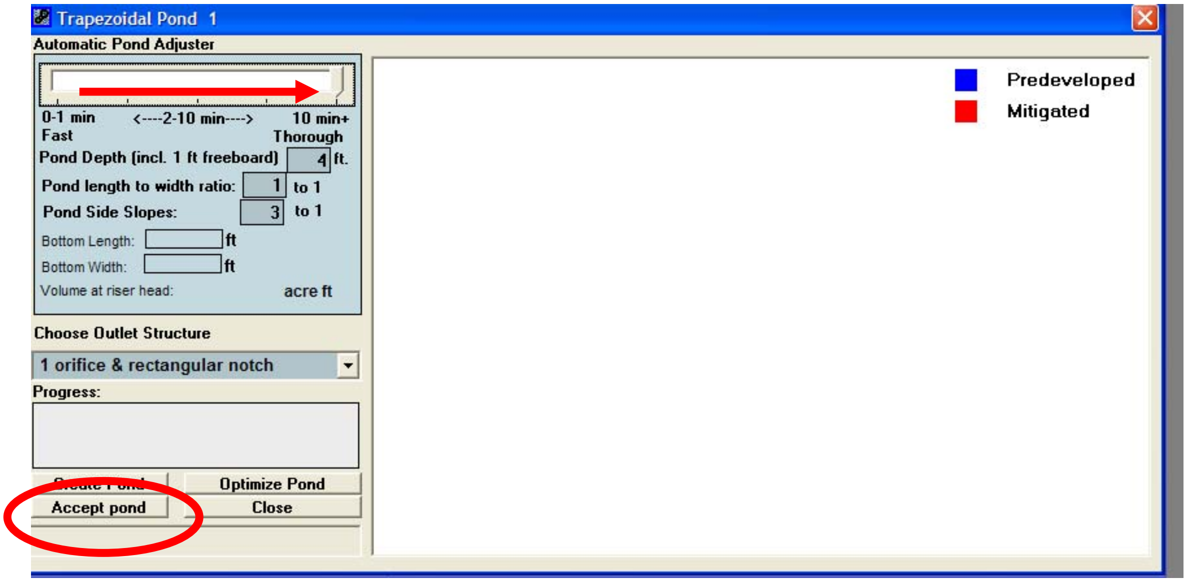
5. Sizing the pond.



A trapezoidal stormwater pond can be sized either manually or automatically (using AutoPond). For this example AutoPond will be used. (Go to page 46 to find more information about how to manually size a pond or other HMP facility.)

Click on the AutoPond button and the AutoPond screen will appear. The user can set the pond depth (default: 4 feet), pond length to width ratio (default: 1 to 1), pond side slopes (default: 3 to 1), and the outlet structure configuration (default: 1 orifice and riser with rectangular notch weir).

To optimize the pond design and create the smallest pond possible, move the Automatic Pond Adjuster pointer from the left to the right.



The pond does not yet have any dimensions. Click the Create Pond button to create initial pond dimensions, which will be the starting point for AutoPond's automated optimization process to calculate the pond size and outlet structure dimensions.

Running AutoPond automates the following SOHM processes:

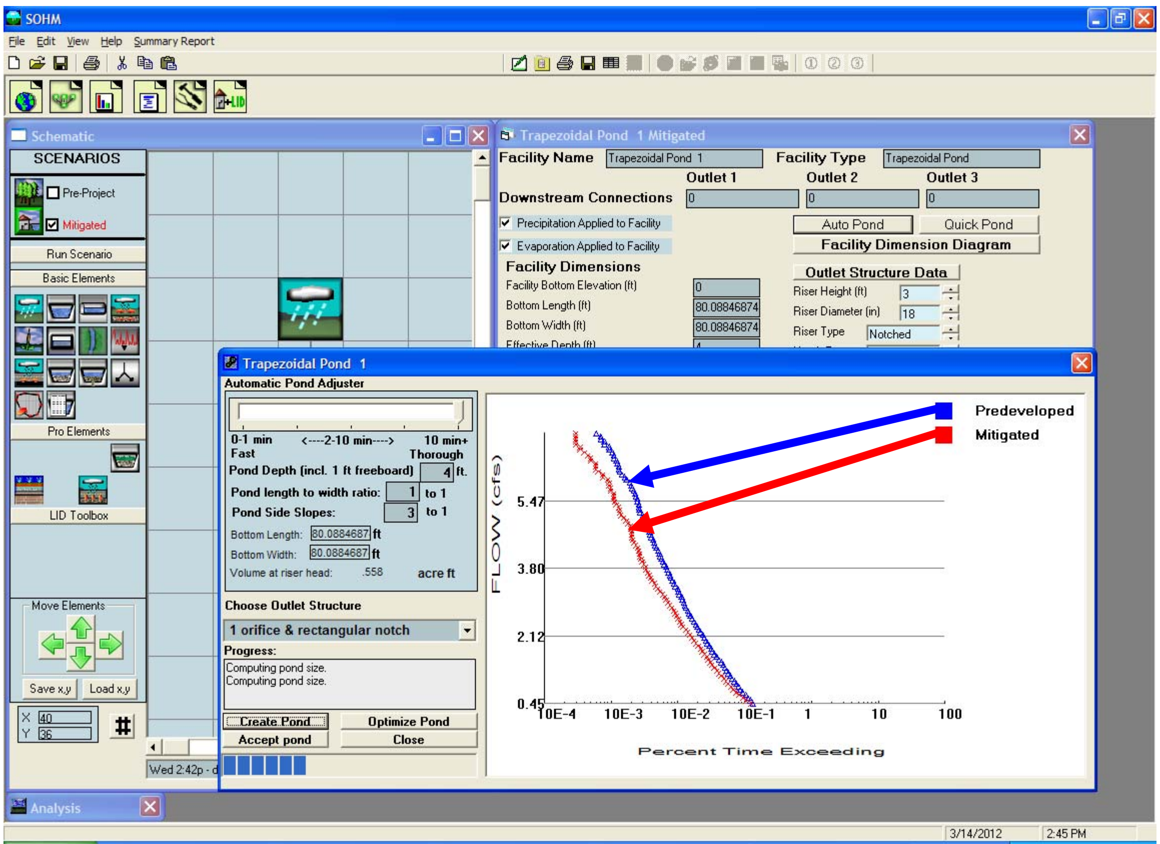
1. the 15-minute Predevelopment runoff is computed for the 40-60 years of record (it varies depending on the rain gage used),
2. the Predevelopment runoff flood frequency is calculated based on the partial duration peak flows,
3. the range of flows is selected for the flow duration (10% of the 2-year peak to the 10-year peak),
4. this flow range is divided into 100 increments, and
5. the number of 15-minute Predevelopment flow values that exceed each flow increment level (Predevelopment flow duration) are counted to create the flow duration curves and accompanying tabular results.

Next, SOHM computes the post-project runoff (in the Mitigated scenario) and routes the runoff through the pond. But before the runoff can be routed through the pond the pond must be given dimensions and an outlet configuration. AutoPond uses a set of rules based on the Predevelopment and Mitigated scenario land uses to give the pond an initial set of dimensions and an initial outlet orifice diameter and riser (the riser is given a default rectangular notch). This information allows SOHM to compute a stage-storage-discharge table for the pond.

With this initial pond stage-storage-discharge table SOHM:

1. routes the 15-minute post-project runoff through the pond for the 40-60 years of record to create to the Mitigated flow time series,
2. counts the number of 15-minute Mitigated flow values that exceed each flow increment level (this is the Mitigated flow duration), and
3. computes the ratio of Mitigated flow values to Predevelopment flow values for each flow increment level (comparing the Predevelopment and Mitigated flow duration results).

If any of the 100 individual ratio values is greater than allowed by the flow duration criteria then the pond fails to provide an appropriate amount of mitigation and needs to be resized.



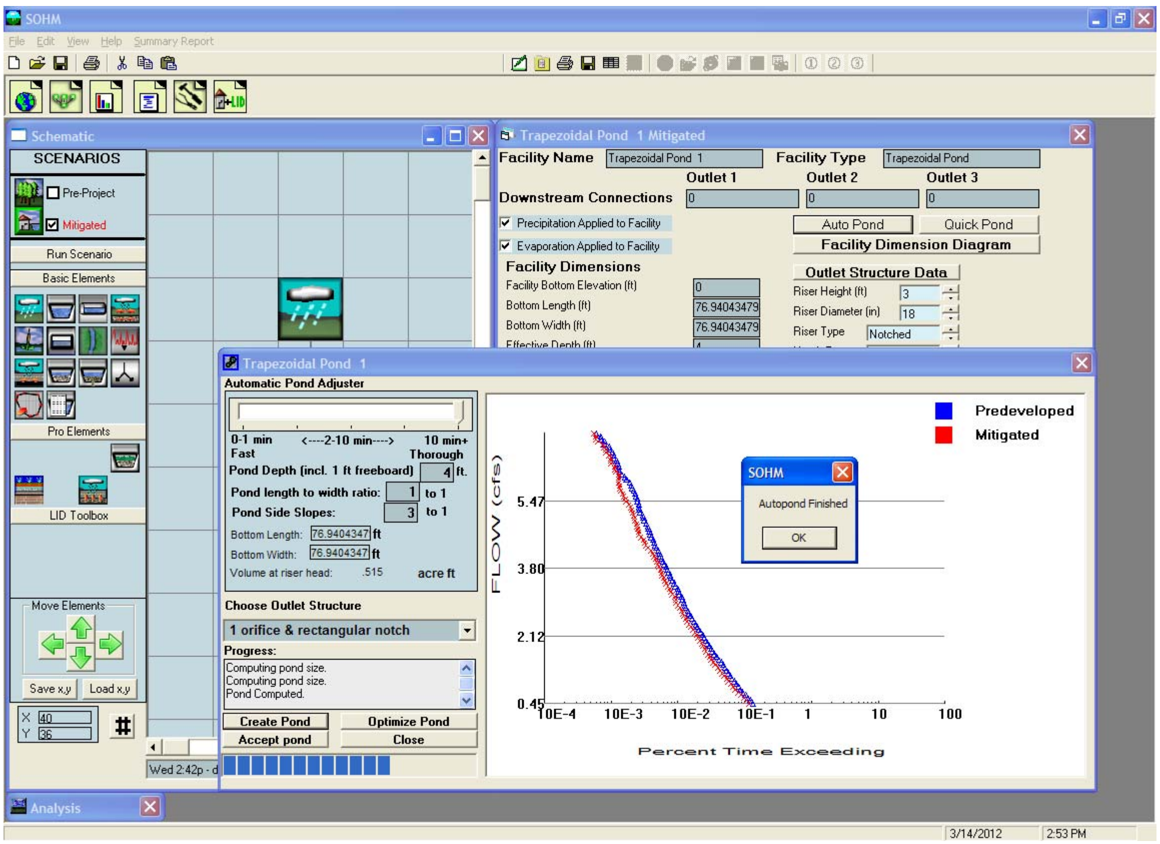
Flow duration results are shown in the plots above. The vertical axis shows the range of flows from 10% of the 2-year flow (0.45 cfs) to the 10-year flow (7.14 cfs). The horizontal axis is the percent of time that flows exceed a flow value. Plotting positions on the horizontal axis typical range from 0.001% to 1%, as explained below.

For the entire 40- to 60-year simulation period (depending on the period of record of the precipitation station used) all of the 15-minute time steps are checked to see if the flow for that time step is greater than the minimum flow duration criteria value (0.38 cfs, in this example). For a 50-year simulation period there are approximately 1,600,000 15-minute values to check. Many of them are zero flows. The 10% of the Predevelopment 2-year flow value is exceeded less than 1% of the total simulation period.

This check is done for both the Predevelopment flows (shown in blue on the screen) and the Mitigated flows (shown in red).

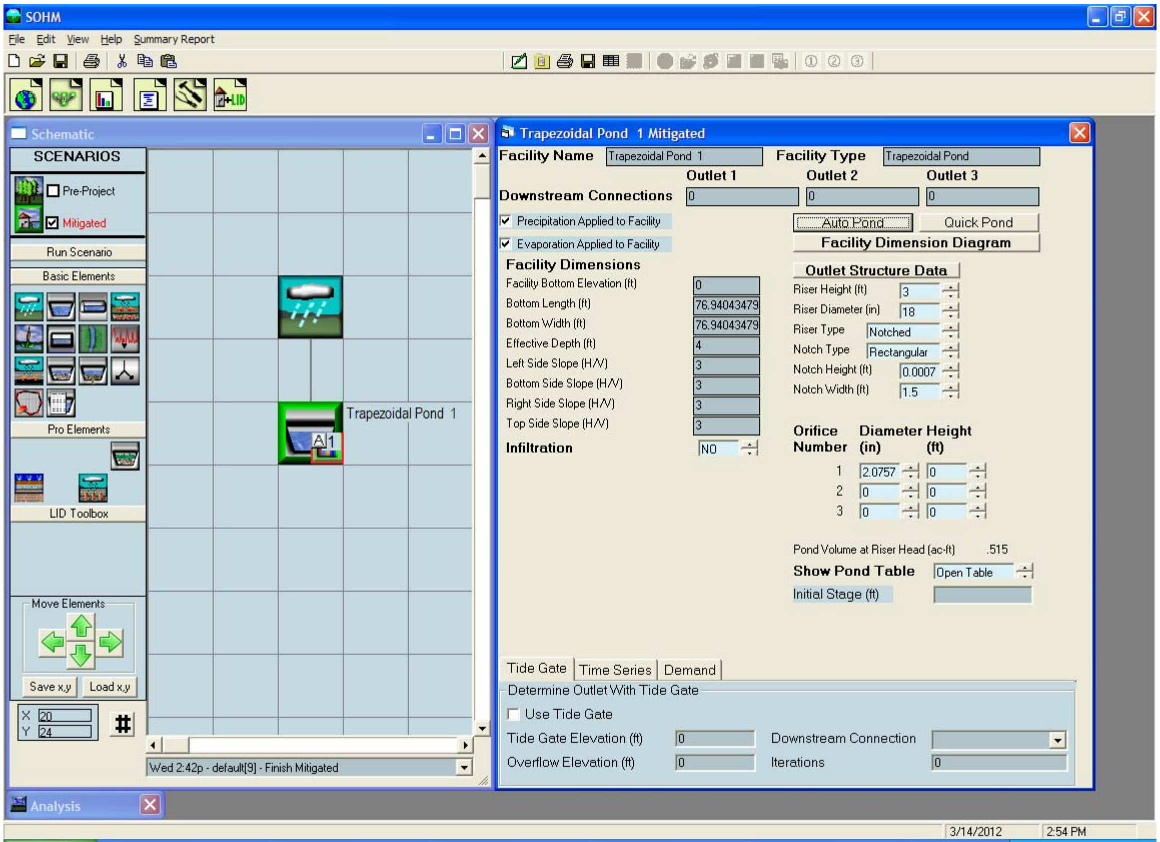
If all of the Mitigated flow duration values (in red) are to the left of the Predevelopment flow duration values (in blue) then the pond mitigates the additional erosive flows produced by the development.

If the Mitigated flow duration values (in red) are far to the left of the Predevelopment flow duration values (in blue) then the pond can be made smaller and still meet the flow duration criteria.



AutoPond goes through an iteration process by which it changes the pond dimensions and outlet configuration, then instructs SOHM to again compute the resulting Mitigated runoff, compare flow durations, and decide if it has made the results better or worse. This iteration process continues until AutoPond finally concludes that an optimum solution has been found and the Mitigated flow duration values (in red) are as close as possible to the Predevelopment flow duration values (in blue).

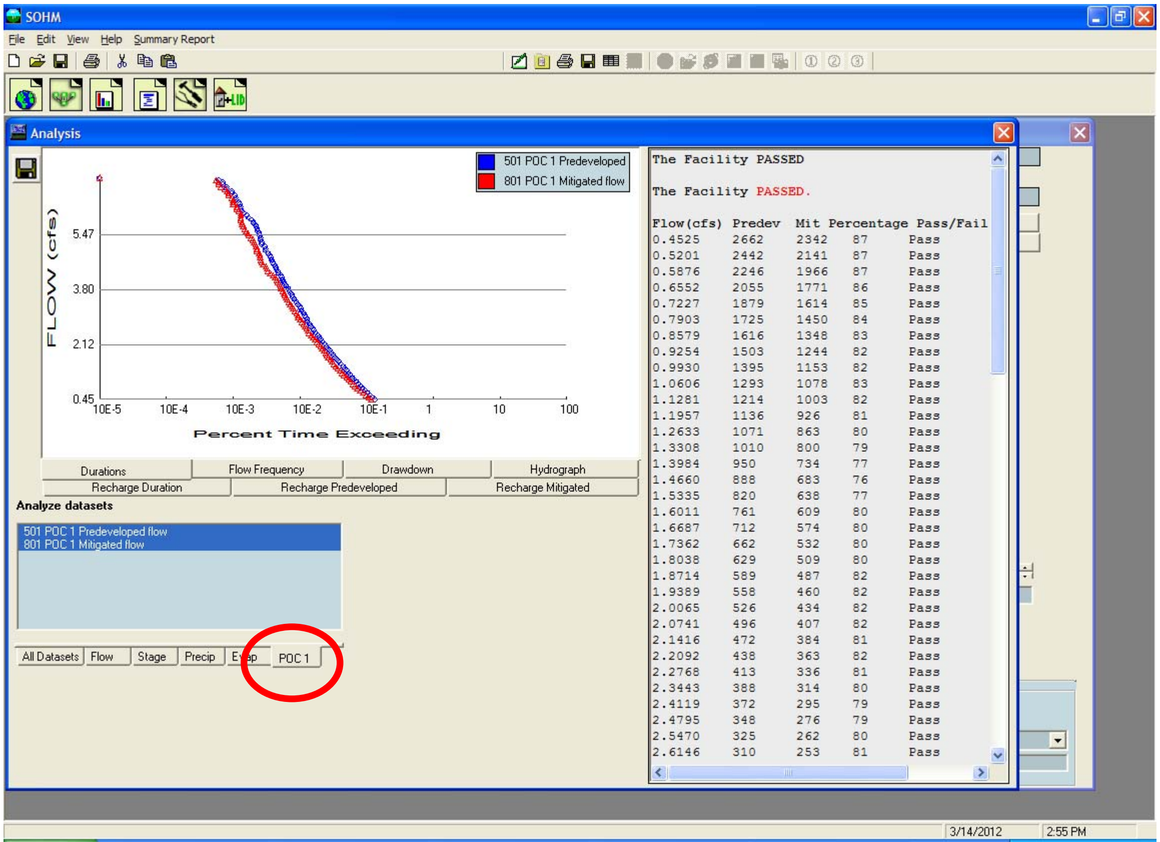
The user may continue to manually optimize the pond by manually changing pond dimensions and/or the outlet structure configuration. (Manual optimization is explained in more detail on page 46.) After making these changes the user should click on the Optimize Pond button to check the results and see if AutoPond can make further improvements.



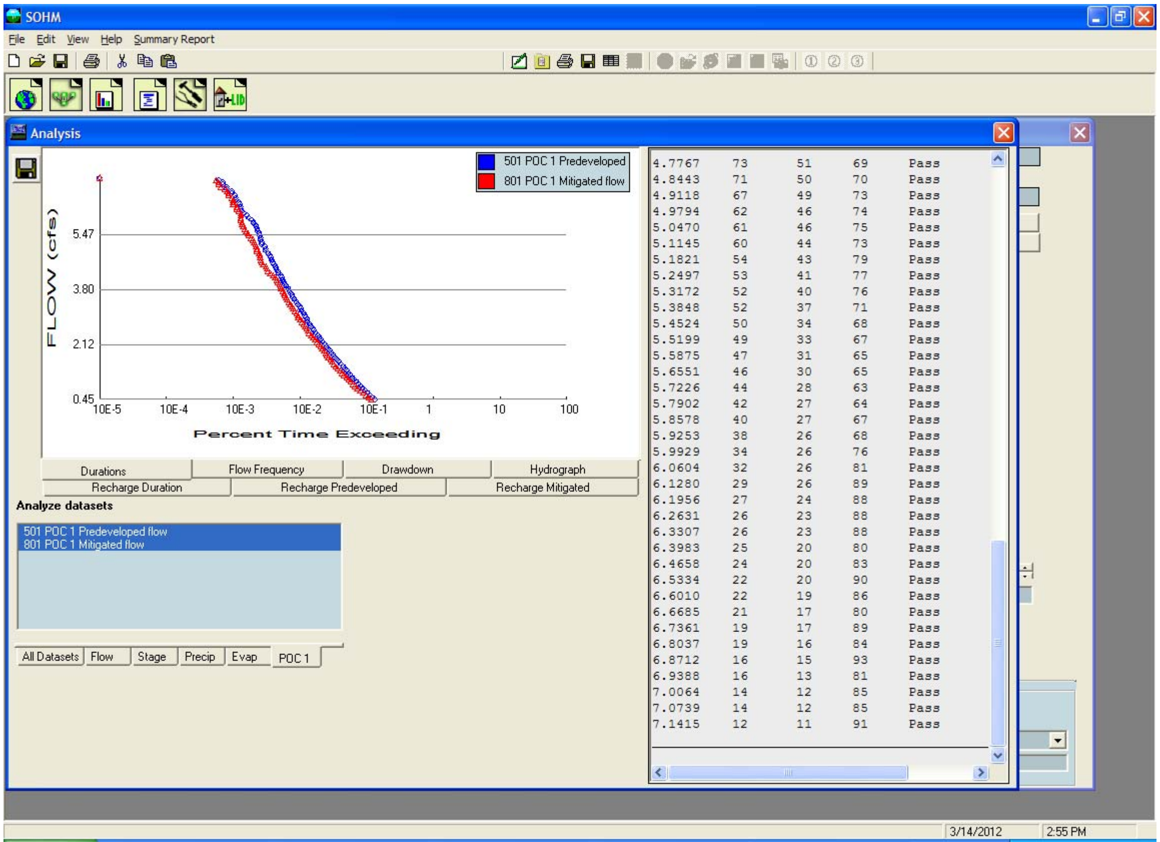
The final pond dimensions (bottom length, bottom width, effective pond depth, and side slopes) and outlet structure information (riser height, riser diameter, riser weir type, weir notch height and width, and orifice diameter and height) are shown on the trapezoidal pond screen to the right of the Schematic grid.

NOTE: If AutoPond selects a bottom orifice diameter smaller than the smallest diameter allowed by the local municipal permitting agency then the user has the option of specifying a minimum allowable bottom orifice diameter even if this size diameter is too large to meet flow duration criteria for this element. Additional mitigating BMPs may be required to meet local hydromodification control requirements. Please see ***Appendix C*** *or consult with local municipal permitting agency for more details. For manual sizing information see page 46.*

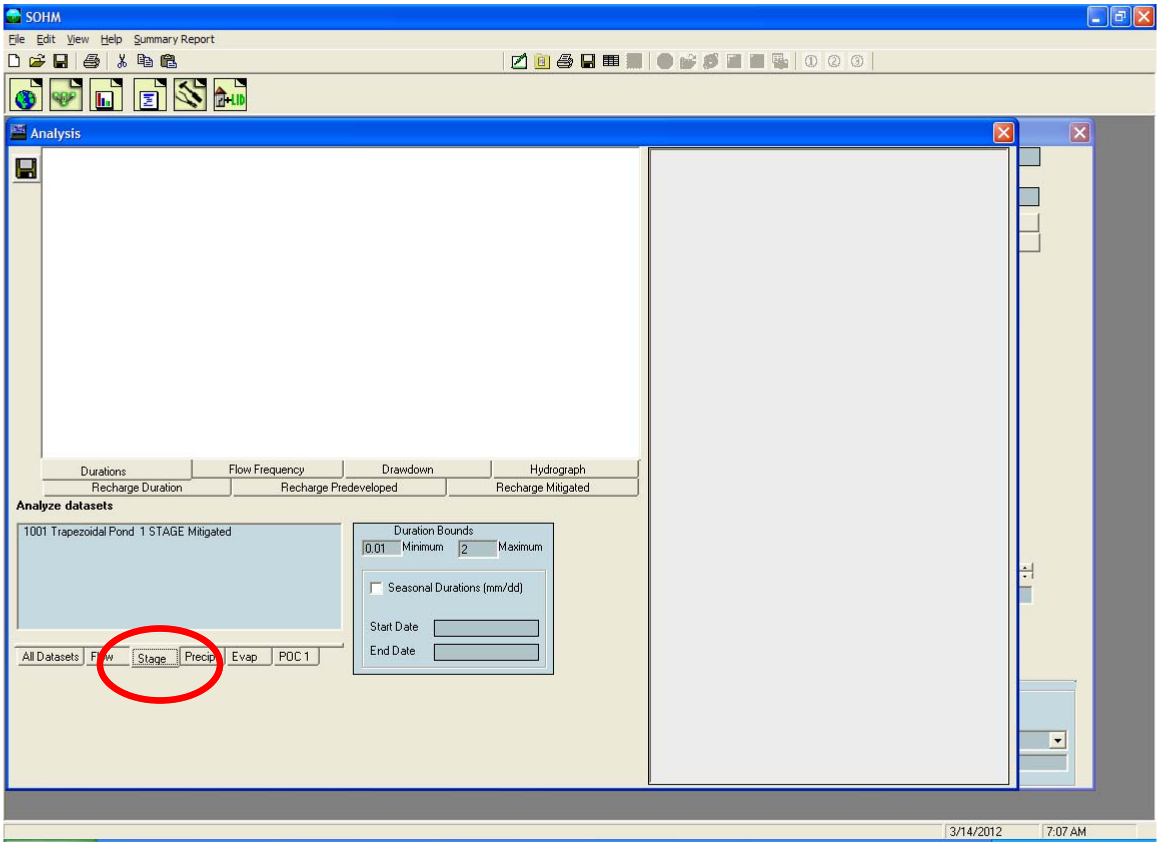
6. Review analysis.



The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results. Each time series dataset is listed in the Analyze Datasets box in the lower left corner. To review the flow duration analysis at the point of compliance select the POC 1 tab at the bottom and make sure that both the 501 POC 1 Predevelopment flow and 801 POC 1 Developed flow are highlighted.



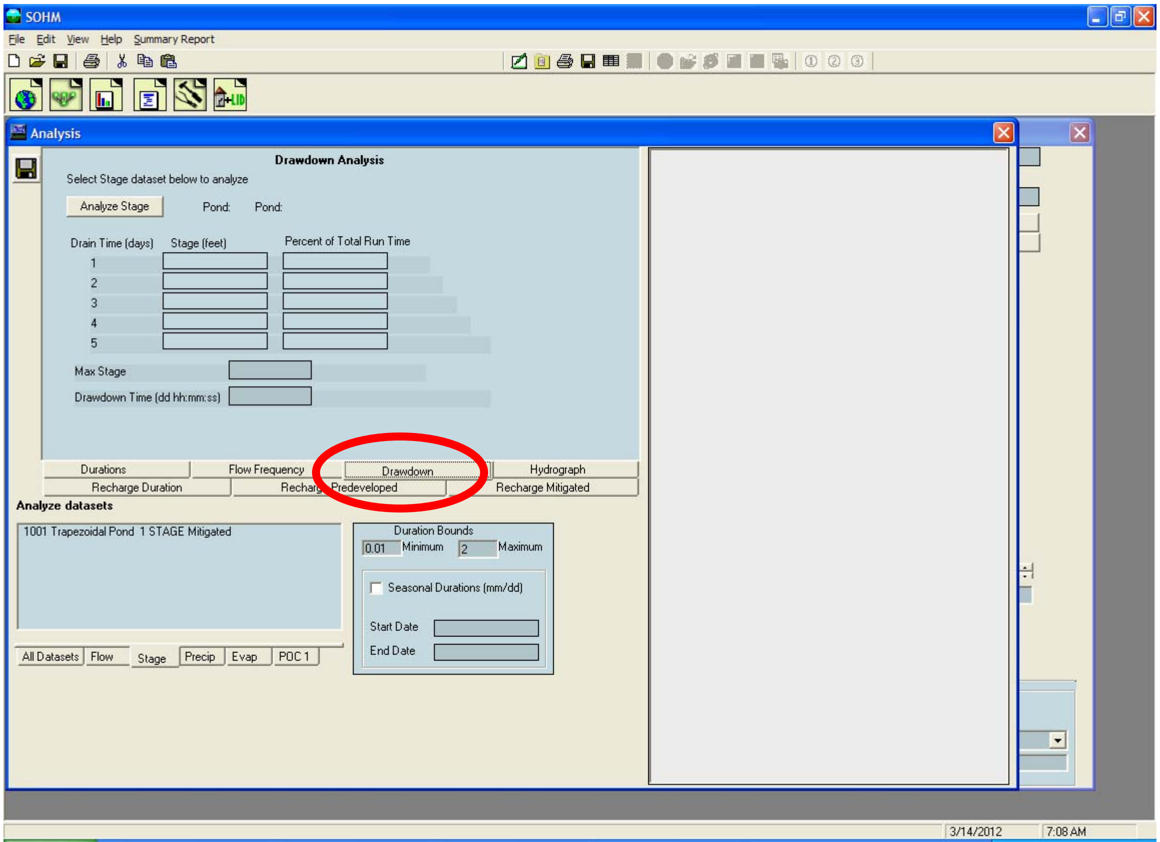
The flow duration plot for both Predevelopment and Mitigated flows will be shown along with the specific flow values and number of times Predevelopment and Mitigated flows exceeded those flow values. The Pass/Fail on the right indicates whether or not at that flow level the flow control standard criteria were met and the pond passes at that flow level (in this example from 10% of the 2-year flow to the 10-year). If not, a Fail is shown; a single Fail fails the pond design.



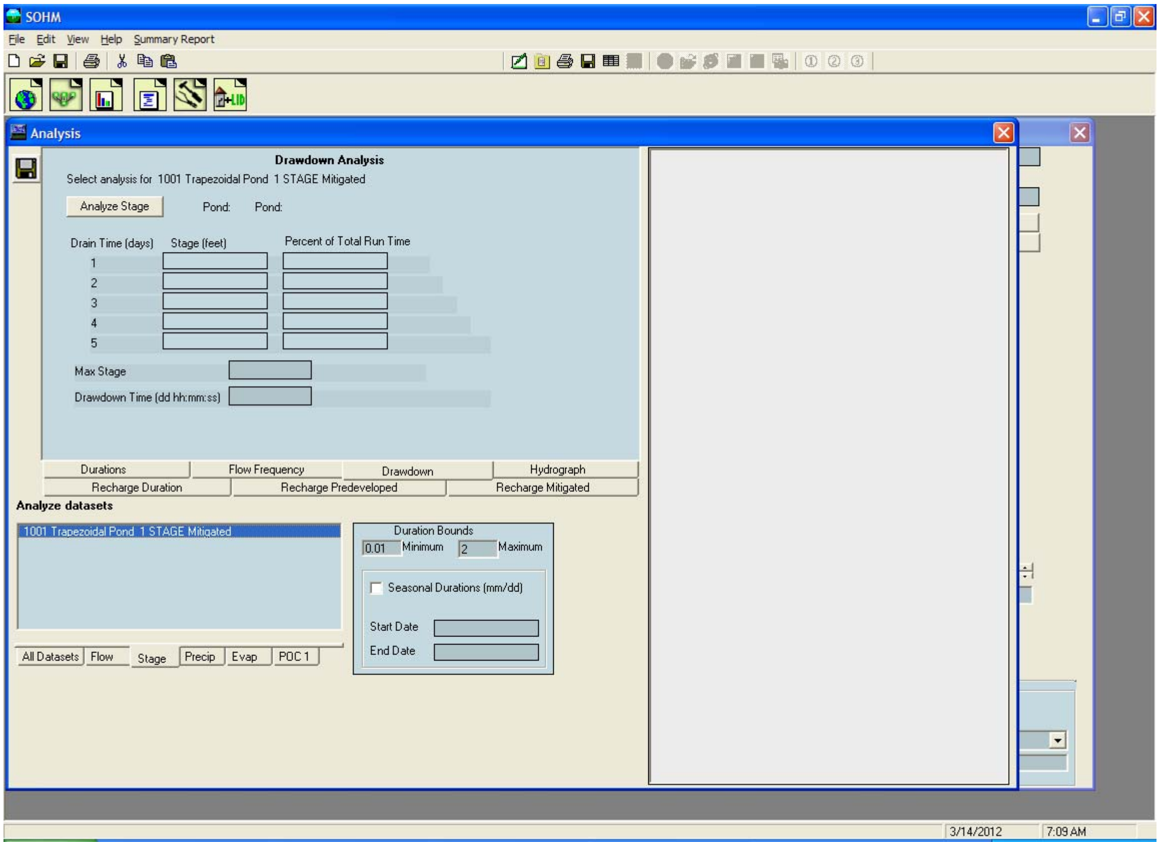
Pond drawdown/retention time is computed on the Analysis screen.

*NOTE: This information is not required for basic sizing of the flow duration facility, but can assist the user in determining the overall suitability of the mitigated design in meeting additional, related requirements for treating stormwater runoff and minimizing risk of vector (mosquito) breeding problems. See page 103 for more descriptions of this SOHM feature, and **Appendix C** for discussion and references for these requirements.*

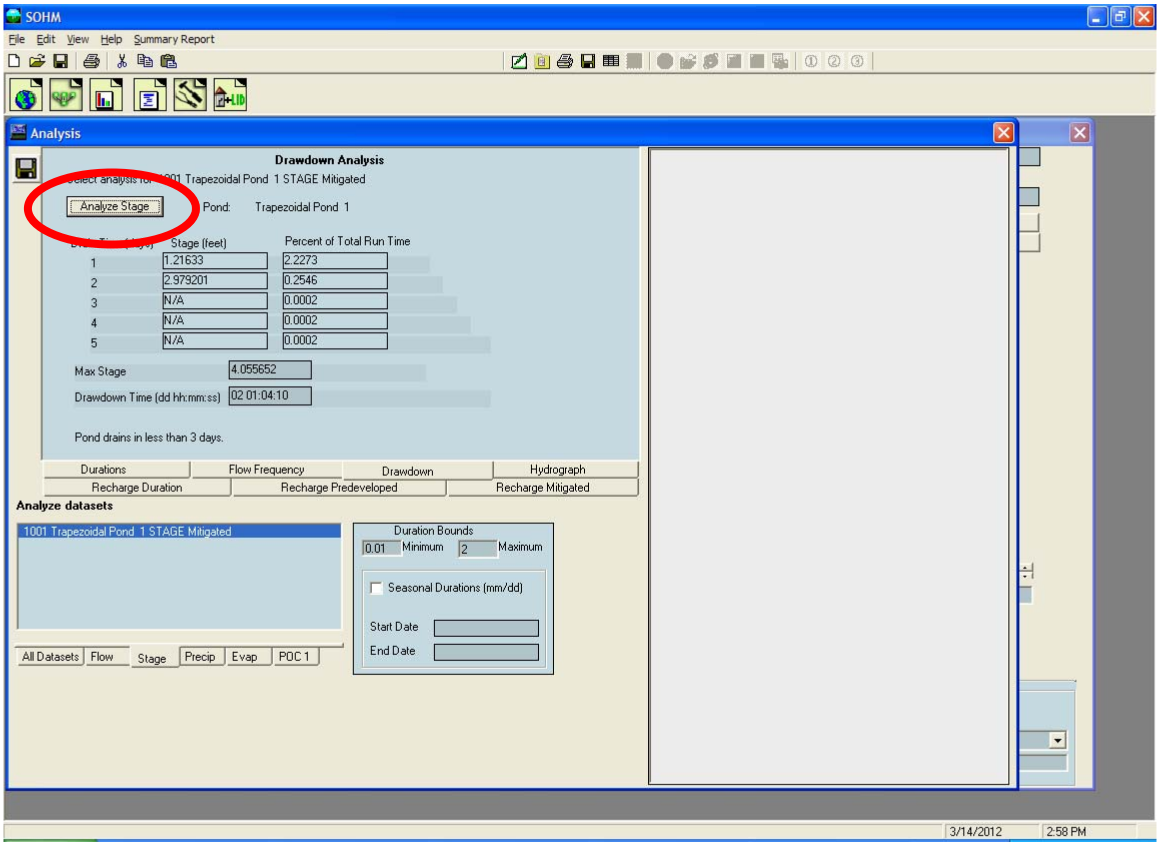
Click on the Stage tab at the bottom to get the Mitigated pond stage time series.



Click on the tab labeled Drawdown. This is where the pond drawdown/retention time results will be shown.



Select the pond you want to analyze for drawdown/retention time (in this example there is only one pond: Trapezoidal Pond 1) by clicking on the dataset and highlighting it.



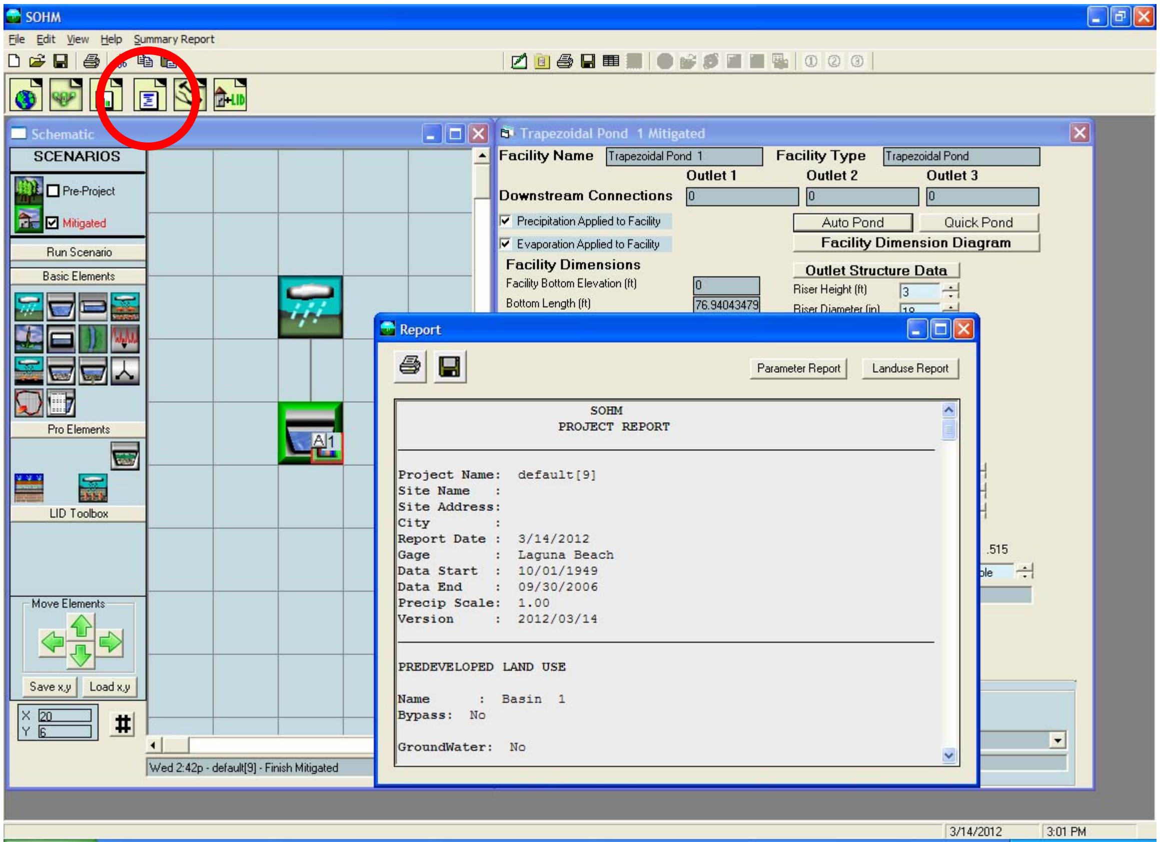
Click on the Analyze Stage button and the computed pond stages (pond water depths) are summarized and reported in terms of drain/retention time (in days).

For this example, the maximum stage computed during the entire 40-60 year simulation period is 4.05 feet. This maximum stage has a drawdown time of 2 days, 1 hour, 4 minutes, 10 seconds (approximately 49 hours).

Ponds may have drain times in excess of the allowed maximum of hours. This can occur when a pond has a small bottom orifice. If this is not acceptable then the user needs to change the pond outlet configuration, manually run the Mitigated scenario, and repeat the analyze stage computations. A situation may occur where it is not possible to have both an acceptable pond drawdown/ retention time and meet the flow duration criteria.

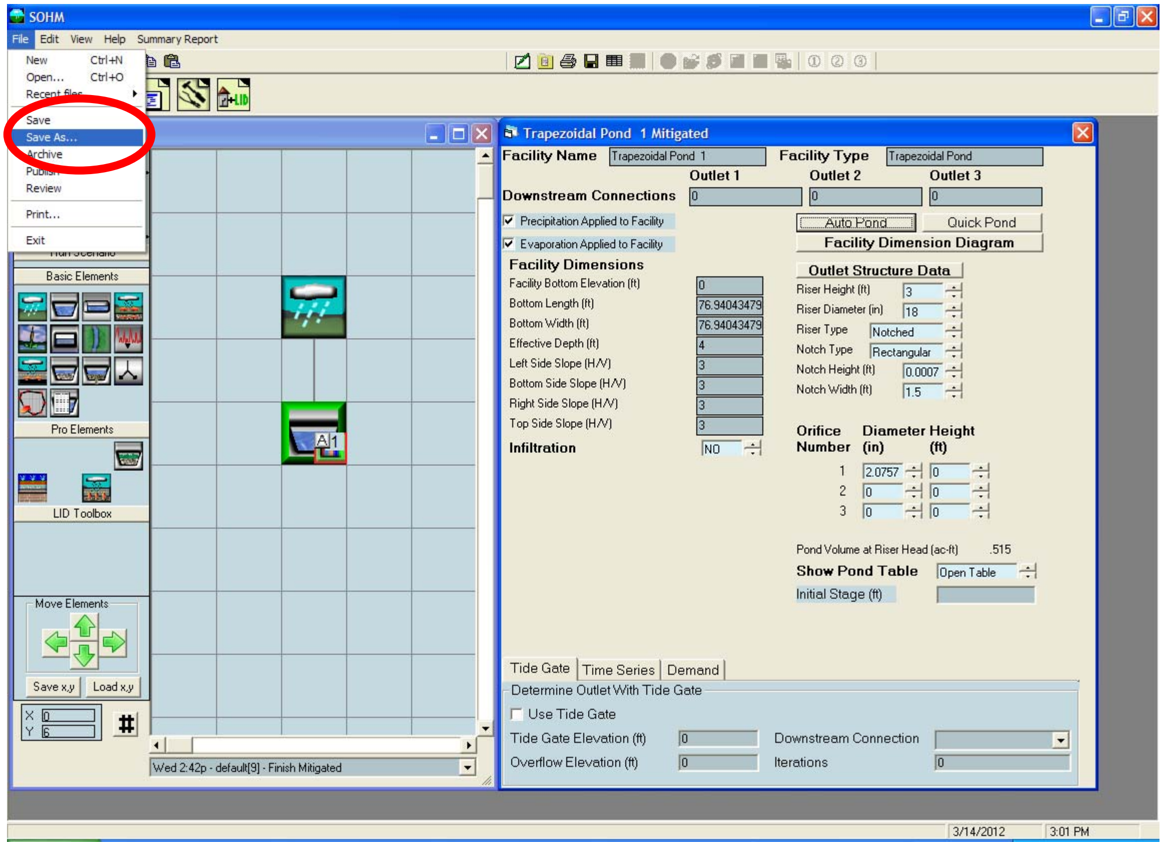
*NOTE: See **Appendix C** or the local municipal permitting agency for an overview of other requirements that may apply regarding drawdown time, and suggestions for addressing situations where it is not possible to meet all drawdown/retention time guidelines and also meet the flow duration criteria. The guidance documentation assumes that the flow duration criteria take precedence unless the user is instructed otherwise by the local municipal permitting agency.*

7. Produce report.

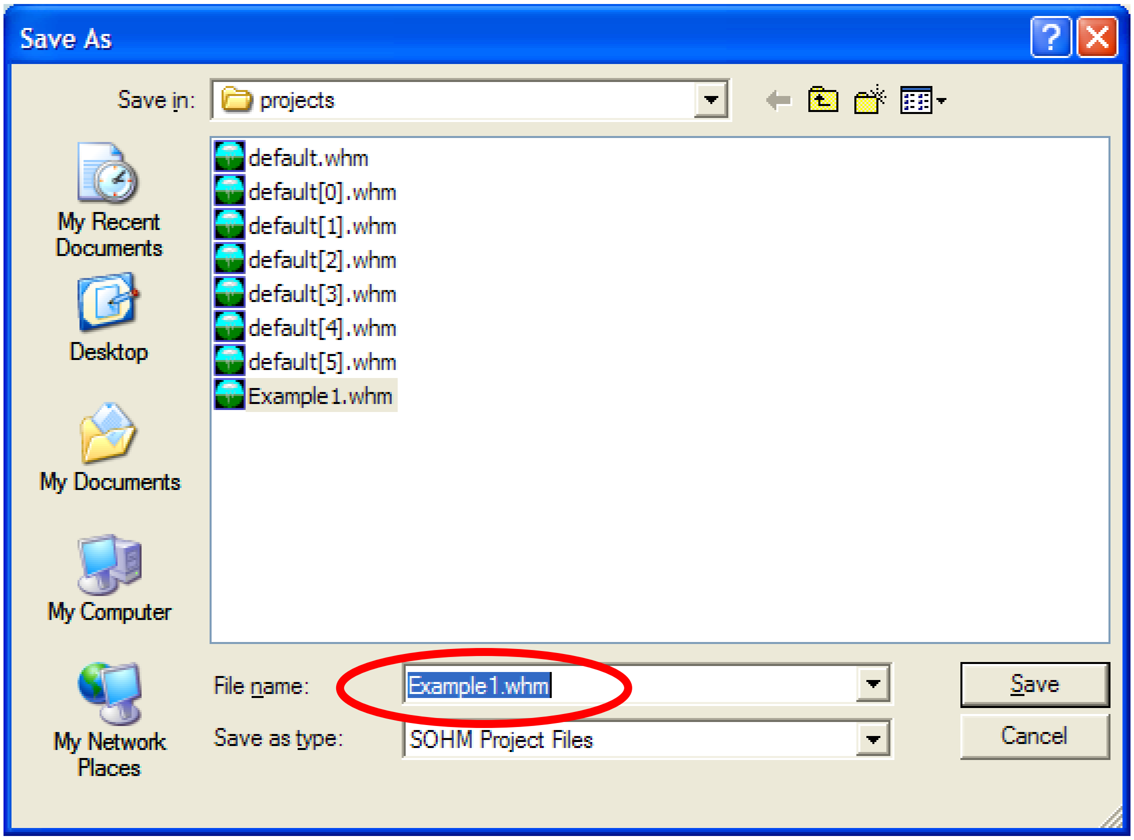


Click on the Reports tool bar button (fourth from the left) to generate a project report with all of the project information and results. Scroll down the Report screen to see all of the results.

8. Save project.

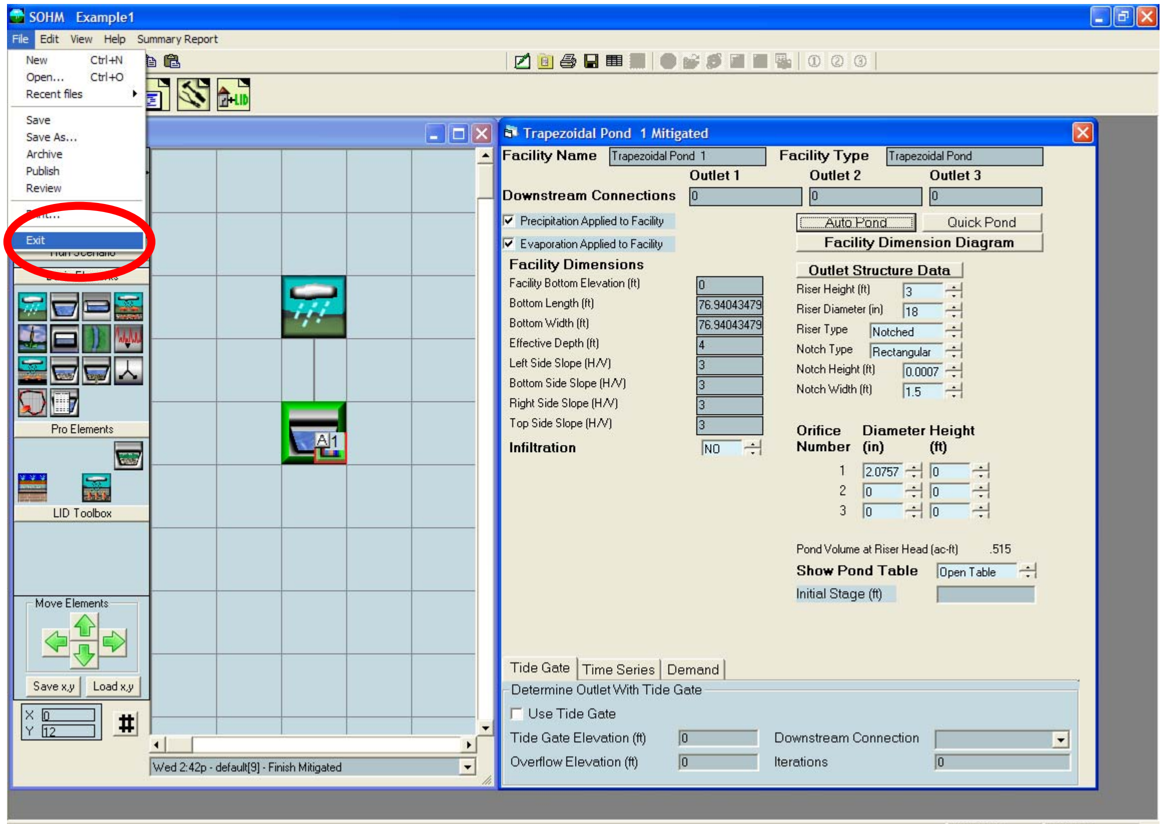


To save the project click on File in the upper left corner and select Save As.



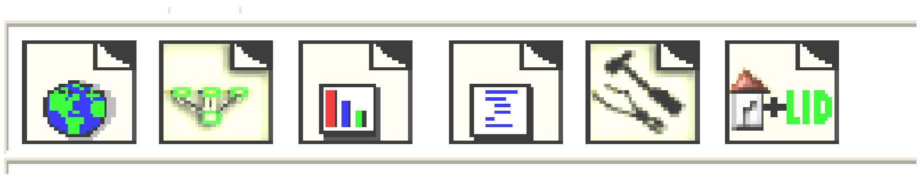
Select a file name and save the SOHM project file. The user can exit SOHM and later reload the project file with all of its information by going to File, Open.

9. Exit SOHM.



To exit SOHM click on File in the upper left corner and select Exit. Or click on the X in the red box in the upper right hand corner of the screen.

MAIN SCREENS



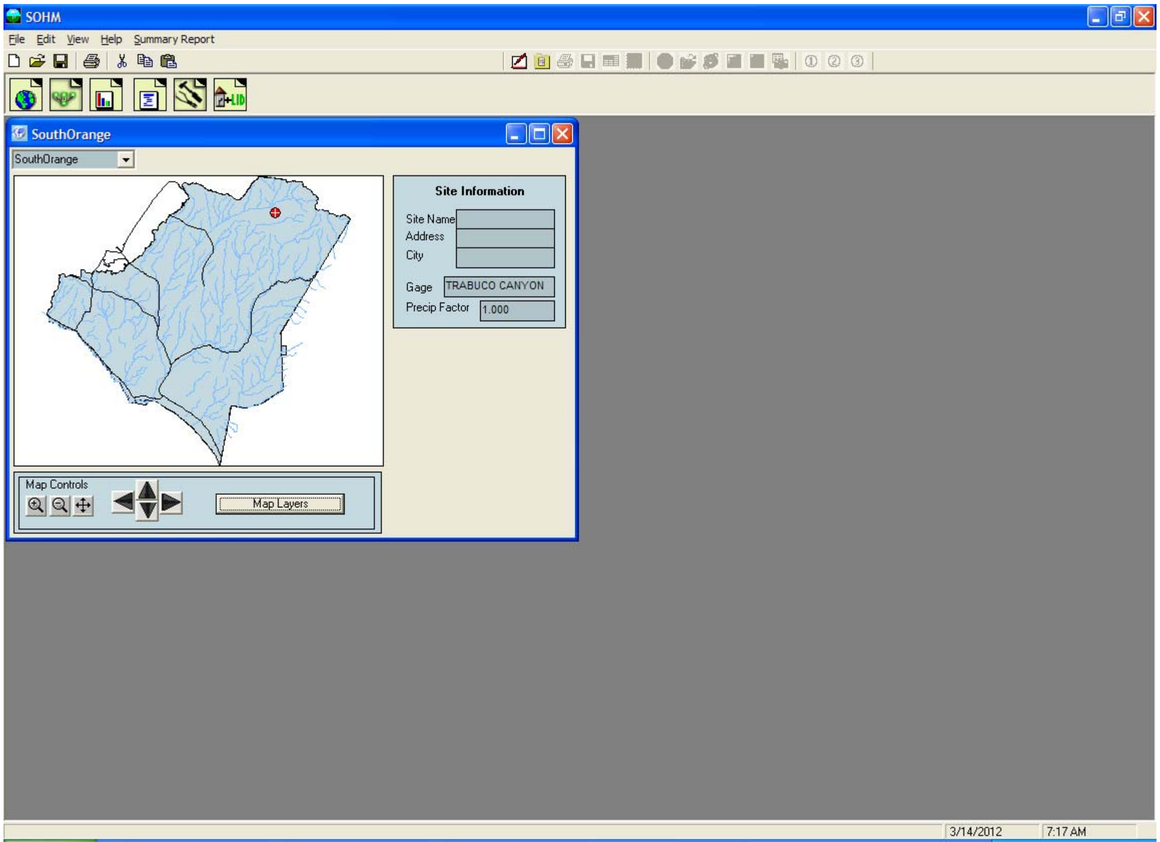
SOHM has six main screens. These main screens can be accessed through the buttons shown on the tool bar above or via the View menu.

The six main screens are:

- Map Information
- General Project Information
- Analysis
- Reports
- Tools
- LID (Low Impact Development) Analysis

Each is discussed in more detail in the following sections.

Map Information Screen



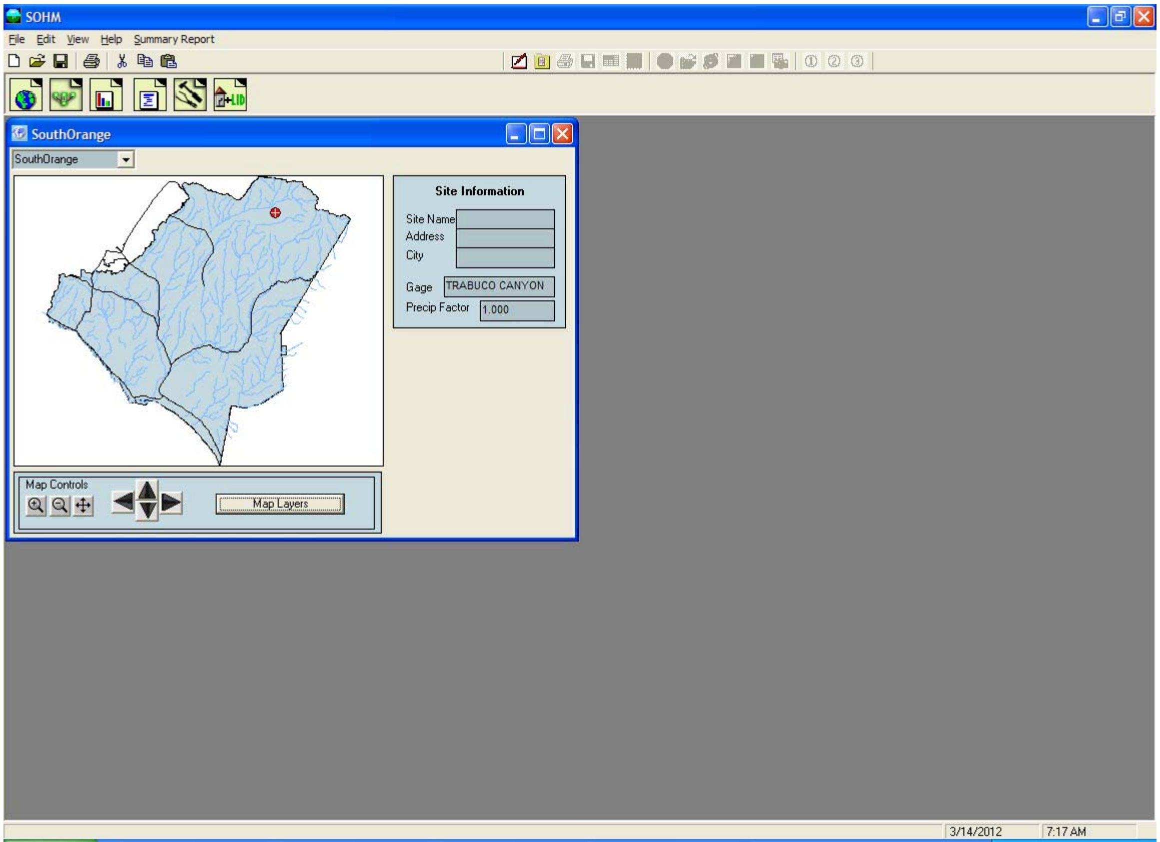
The Map Screen contains county information. The precipitation gage and precip factor are shown to the right of the map. They are based on the project site location.

The user can provide site information (optional). The site name and address will help to identify the project on the Report screen and in the printed report provided to the local municipal permitting agency.

The user locates the project site on the map screen by using the mouse and left clicking at the project site location. Right clicking on the map re-centers the view. The + and – buttons zoom in and out, respectively. The cross hair button zooms out to the full county view. The arrow keys scroll the map view.

The map layers allow the user to view different map information.

General Project Information Screen



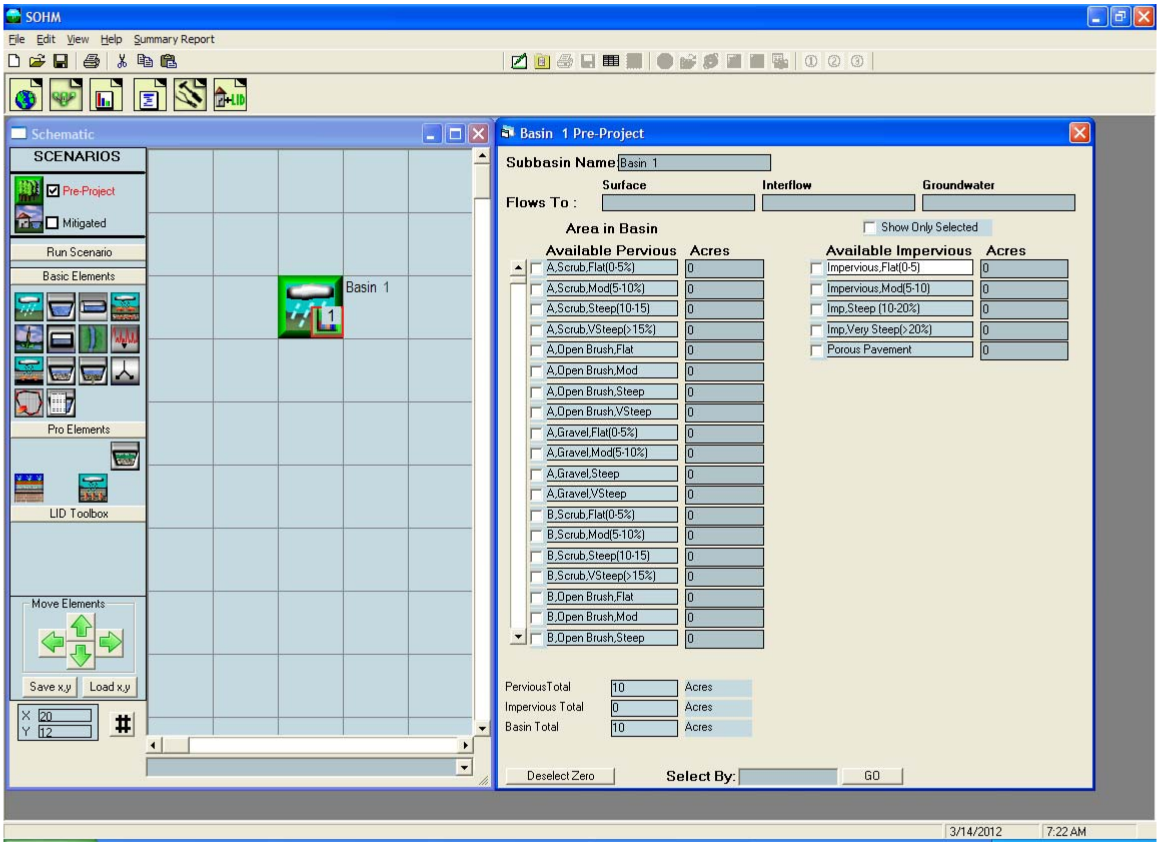
The project screen contains all of the information about the project site for the two land use scenarios: Predevelopment land use conditions and the Mitigated (developed) land use conditions. To change from one scenario to another check the box in front of the scenario name in the upper left corner of the screen.

Predevelopment is defined as the native land cover conditions prior to any land use development. Runoff from the Predevelopment scenario is used as the target for the Mitigated scenario compliance. The model will accept any land use for this scenario.

Mitigated is defined as the developed land use with mitigation measures (as selected by the user). Mitigated is used for sizing stormwater control and water quality facilities. The runoff from the Mitigated scenario is compared with the Predevelopment scenario runoff to determine compliance with flow duration criteria.

Below the scenario boxes are the Elements. Each element represents a specific feature (basin, pond, etc.) and is described in more detail in the following section.

Schematic Editor



The project screen also contains the Schematic Editor. The Schematic Editor is the grid to the right of the elements. This grid is where each element is placed and linked together. The grid, using the scroll bars on the left and bottom, expands as large as needed to contain all of the elements for the project.

All movement on the grid must be from the top of the grid down.

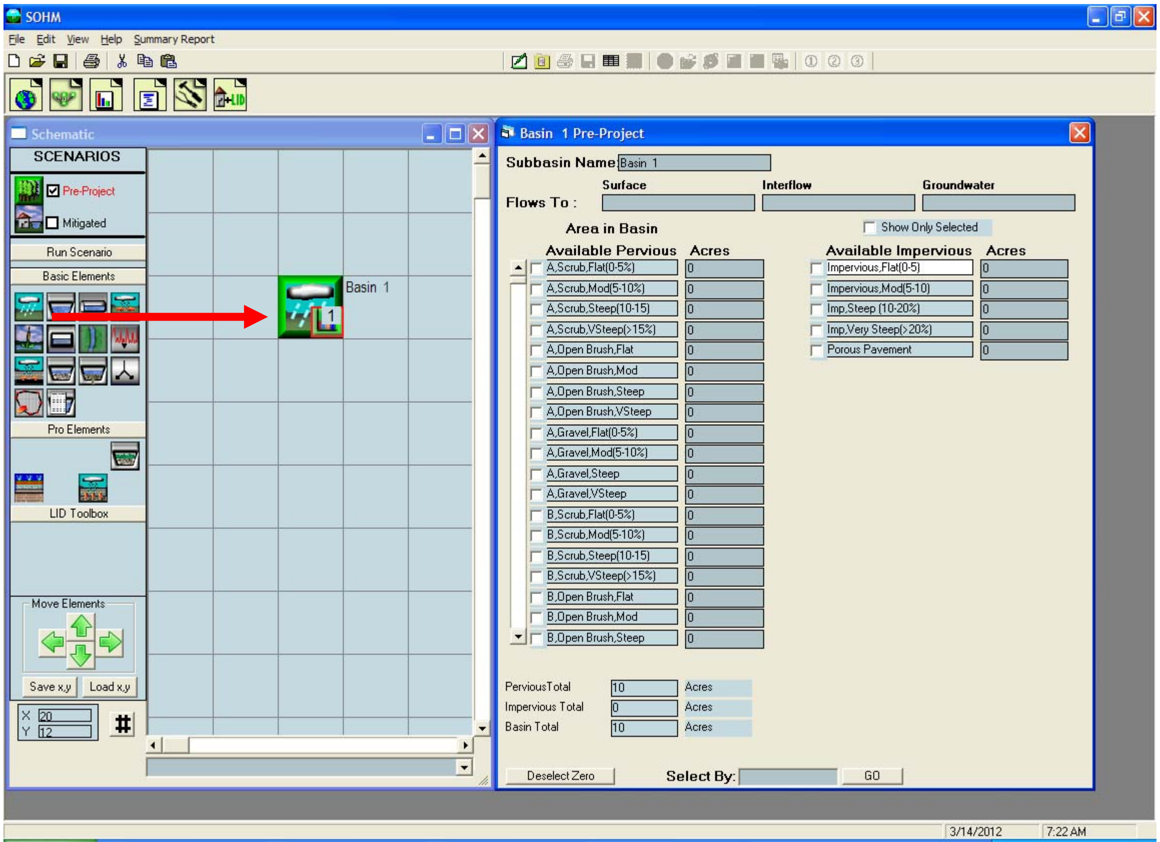
The space to the right of the grid will contain the appropriate element information.

To select and place an element on the grid, first left click on the specific element in the Elements menu and then drag the element to the selected grid square. The selected element will appear in the grid square.

The entire grid can be moved up, down, left, or right using the Move Elements arrow buttons.

The grid coordinates from one project can be saved (Save x,y) and used for new projects (Load x,y).

Basin Element



The Basin element represents a drainage area that can have any combination of soils, land cover, and land slopes. A basin produces three types of runoff: (1) surface runoff, (2) interflow, and (3) groundwater. Surface runoff is defined as the overland flow that quickly reaches a conveyance system. Surface runoff mainly comes from impervious surfaces. Interflow is shallow, subsurface flow produced by pervious land categories and varies based on soil characteristics and how these characteristics are altered by land development practices. Groundwater is the subsurface flow that typically does not enter a stormwater conveyance system, but provides base flow directly to streams and rivers.

The user can specify where each of these three types of runoff should be directed. The default setting is for the surface runoff and interflow to go to the stormwater facility; groundwater should not be connected unless there is observed base flow occurring in the drainage basin.

Table 1 shows the different pervious land types represented in the Basin element.

Table 1: SOHM Pervious Land Types

PERLND No.	Soil Type	Land Cover	Land Slope
1	A	Scrub	Flat (0-5%)
2	A	Scrub	Moderate (5-10%)
3	A	Scrub	Steep (10-15%)
4	A	Scrub	Very Steep (>15%)
5	A	Open Brush	Flat (0-5%)
6	A	Open Brush	Moderate (5-10%)
7	A	Open Brush	Steep (10-15%)
8	A	Open Brush	Very Steep (>15%)
9	A	Gravel	Flat (0-5%)
10	A	Gravel	Moderate (5-10%)
11	A	Gravel	Steep (10-15%)
12	A	Gravel	Very Steep (>15%)
13	B	Scrub	Flat (0-5%)
14	B	Scrub	Moderate (5-10%)
15	B	Scrub	Steep (10-15%)
16	B	Scrub	Very Steep (>15%)
17	B	Open Brush	Flat (0-5%)
18	B	Open Brush	Moderate (5-10%)
19	B	Open Brush	Steep (10-15%)
20	B	Open Brush	Very Steep (>15%)
21	B	Gravel	Flat (0-5%)
22	B	Gravel	Moderate (5-10%)
23	B	Gravel	Steep (10-15%)
24	B	Gravel	Very Steep (>15%)
25	C	Scrub	Flat (0-5%)
26	C	Scrub	Moderate (5-10%)
27	C	Scrub	Steep (10-15%)
28	C	Scrub	Very Steep (>15%)
29	C	Open Brush	Flat (0-5%)
30	C	Open Brush	Moderate (5-10%)
31	C	Open Brush	Steep (10-15%)
32	C	Open Brush	Very Steep (>15%)
33	C	Gravel	Flat (0-5%)
34	C	Gravel	Moderate (5-10%)
35	C	Gravel	Steep (10-15%)
36	C	Gravel	Very Steep (>15%)
37	D	Scrub	Flat (0-5%)
38	D	Scrub	Moderate (5-10%)
39	D	Scrub	Steep (10-15%)
40	D	Scrub	Very Steep (>15%)
41	D	Open Brush	Flat (0-5%)
42	D	Open Brush	Moderate (5-10%)
43	D	Open Brush	Steep (10-15%)
44	D	Open Brush	Very Steep (>15%)
45	D	Gravel	Flat (0-5%)

PERLND No.	Soil Type	Land Cover	Land Slope
46	D	Gravel	Moderate (5-10%)
47	D	Gravel	Steep (10-15%)
48	D	Gravel	Very Steep (>15%)
49	A	Urban	Flat (0-5%)
50	A	Urban	Moderate (5-10%)
51	A	Urban	Steep (10-15%)
52	A	Urban	Very Steep (>15%)
53	B	Urban	Flat (0-5%)
54	B	Urban	Moderate (5-10%)
55	B	Urban	Steep (10-15%)
56	B	Urban	Very Steep (>15%)
57	C	Urban	Flat (0-5%)
58	C	Urban	Moderate (5-10%)
59	C	Urban	Steep (10-15%)
60	C	Urban	Very Steep (>15%)
61	D	Urban	Flat (0-5%)
62	D	Urban	Moderate (5-10%)
63	D	Urban	Steep (10-15%)
64	D	Urban	Very Steep (>15%)

The user does not need to know or keep track of the HSPF PERLND number. That number is used only for internal tracking purposes.

The user inputs the number of acres of appropriate basin land use information. Pervious land use information is in the form of soil, land cover, and land slope. For example, "A, Open Brush, Flat" means SCS soil type A, open brush vegetative cover, and flat (0-5%) land slope.

There are four basic soil types: A (well infiltrating soils), B (moderate infiltrating soils), and C (poor infiltrating soils), and D (really poor infiltrating soils).

There are four basic land cover categories: scrub, open brush, gravel, and urban landscaped vegetation.

Native land cover has been divided into scrub, open brush, and gravel and refers to the natural (non-planted) vegetation. In contrast, the developed landscape will consist of urban vegetation (lawns, flowers, planted shrubs and trees). Urban vegetation is irrigated in the model.

Land slope is divided into flat (0-5%), moderate (5-10%), steep (10-15%), and very steep (>15%) land slopes.

HSPF parameter values in SOHM have been adjusted for the different soil, land cover, and land slope categories. SOHM HSPF soil parameter values take into account the hydrologic effects of land development activities that result from soil compaction when "Urban" is specified.

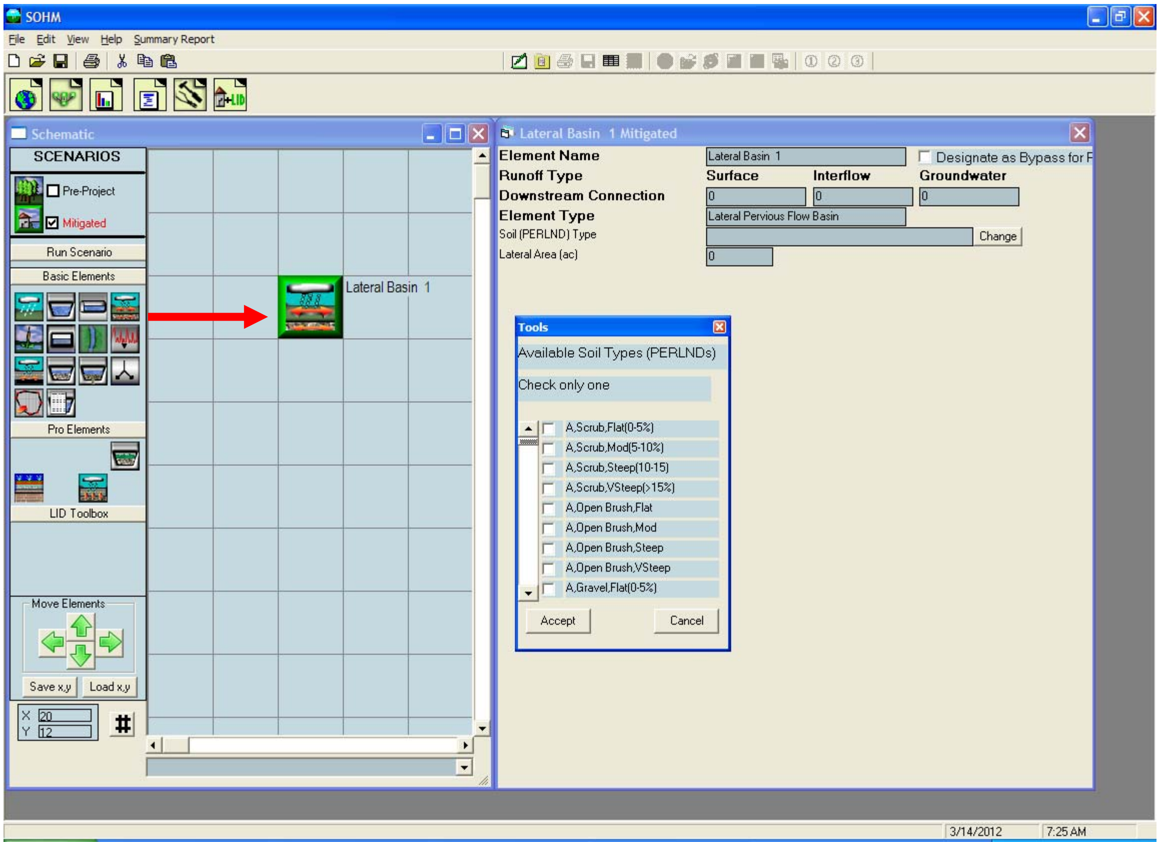
Impervious areas are divided into four different slopes (see Table 2). Impervious areas include roads, roofs, driveways, sidewalks, and parking. The slope categories are flat, moderate, steep, and very steep.

Table 2: SOHM Impervious Land Types

IMPLND No.	IMPLND Name	Land Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-10%)
3	Impervious	Steep (10-15%)
4	Impervious	Very Steep (>15%)

The user does not need to know or keep track of the HSPF IMPLND number. That number is used only for internal tracking purposes.

Lateral Basin Element (Pervious)



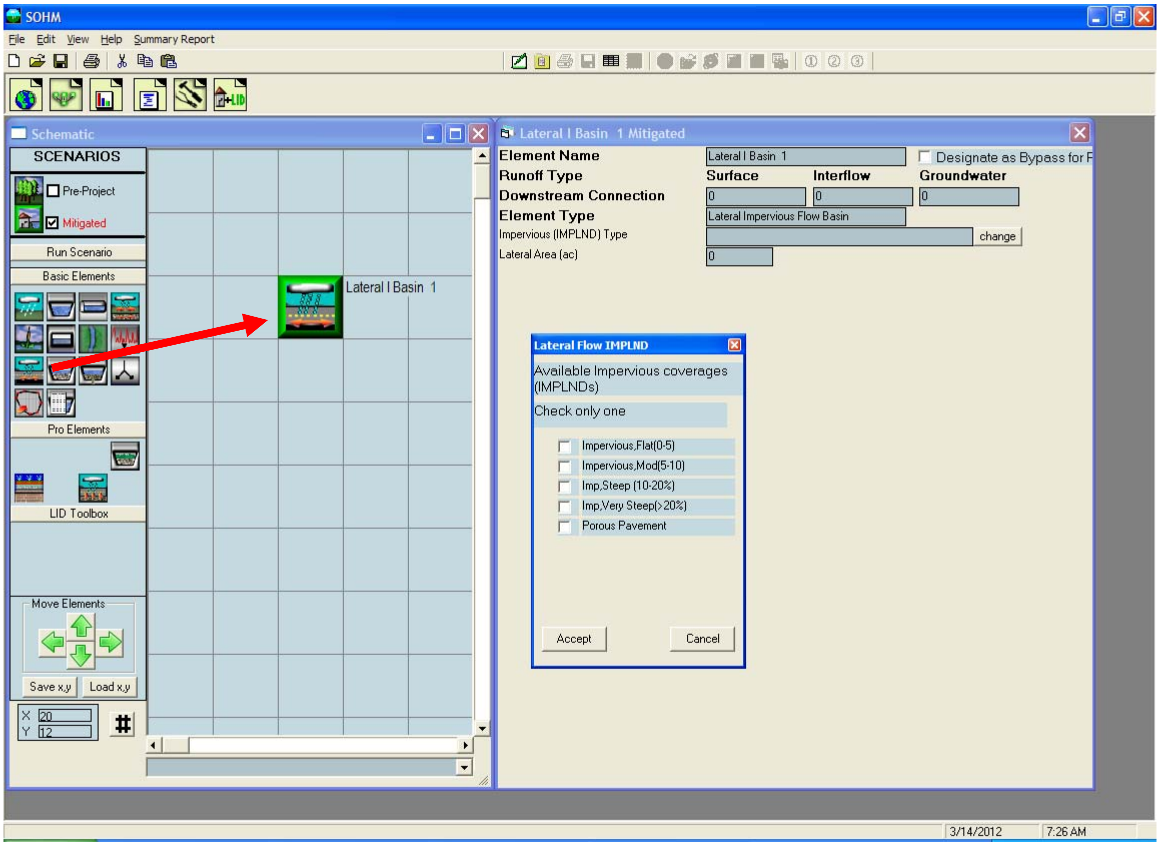
Runoff dispersion from impervious surfaces onto adjacent pervious land can be modeled using pervious and impervious lateral basins. For example, runoff from an impervious parking lot can sheet flow onto an adjacent lawn prior to draining into a stormwater conveyance system. This action slows the runoff and allows for some limited infiltration into the pervious lawn soil prior to discharging into a conveyance system.

The pervious lateral basin is similar to the standard basin except that the runoff from the lateral basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the pervious lateral basin contains only a single pervious land type. Impervious area is handled separately with the impervious lateral basin (Lateral I Basin).

The user selects the pervious lateral basin land type by checking the appropriate box on the Available Soil Types Tools screen. This information is automatically placed in the Soil (PERLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user enters the number of acres represented by the lateral basin land type.
If the lateral basin contains two or more pervious land use types then the user should create a separate lateral basin for each.

Lateral I Basin Element (Impervious)



The impervious lateral basin is similar to the standard basin except that the surface runoff from the lateral impervious basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the impervious lateral basin contains only impervious land types. Pervious area is handled separately with the pervious lateral basin (Lateral Basin).

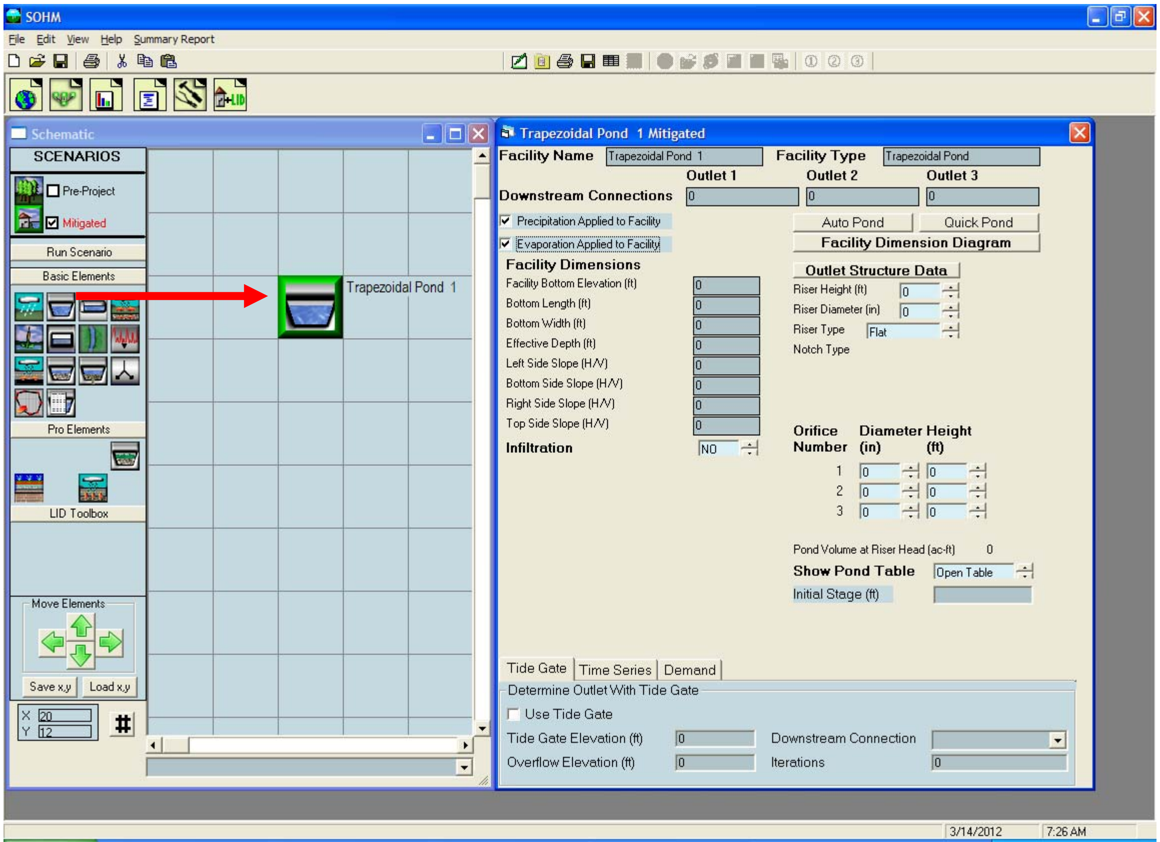
The user selects the impervious lateral basin land type by checking the appropriate box on the Available Impervious Coverages screen. This information is automatically placed in the Impervious (IMPLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user enters the number of acres represented by the lateral impervious basin land type.

If the lateral impervious basin contains two or more impervious land use types then the user should create a separate lateral I basin for each.

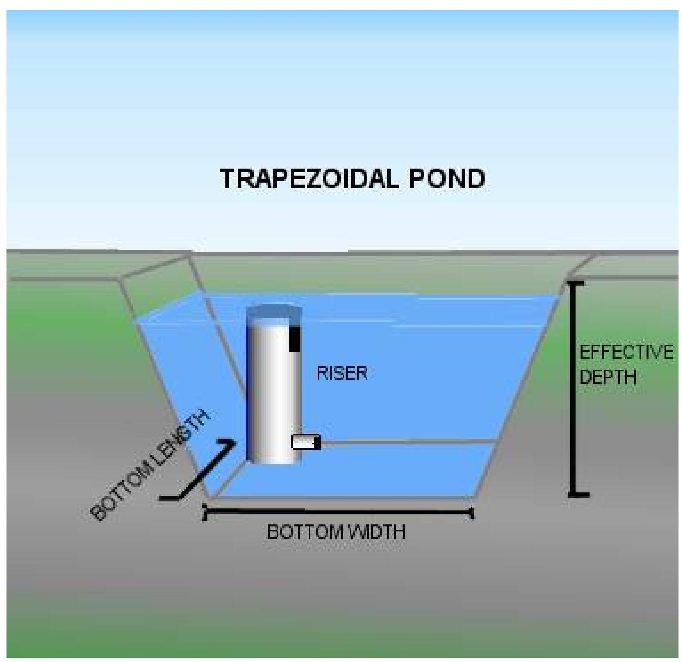
To model parking lot runoff dispersion onto adjacent lawn connect the Lateral I Basin (the parking lot) to the Lateral Basin (the lawn). In the model's calculations surface runoff from the parking lot is added to the surface of the lawn (urban vegetation). The total runoff will then directed to a stormwater conveyance system by the user.

Trapezoidal Pond Element



In SOHM there is an individual pond element for each type of pond and stormwater control facility. The pond element shown above is for a trapezoidal pond. This is the most common type of stormwater pond.

A trapezoidal pond has dimensions (bottom length and width, depth, and side slopes) and an outlet structure consisting of a riser and one or more orifices to control the release of stormwater from the pond. A trapezoidal pond includes the option to infiltrate runoff, if the soils are appropriate and there is sufficient depth to the underlying groundwater table.



The user has the option to specify that different outlets be directed to different downstream destinations, although usually all of the outlets go to a single downstream location.

AutoPond will automatically size a trapezoidal pond to meet the required flow duration criteria. AutoPond is available only in the Mitigated scenario.

QuickPond can be used to instantly add pond dimensions and an outlet configuration without checking the pond for compliancy with flow duration criteria. QuickPond is sometimes used to quickly create a scenario and check the model linkages prior to sizing the pond. Multiple clicks on the QuickPond button incrementally increase the pond size.

The user can change the default name "Trapezoidal Pond 1" to another more appropriate name, if desired.

Precipitation and evaporation must be applied to the pond unless the pond is covered.

The pond bottom elevation can be set to an elevation other than zero if the user wants to use actual elevations. All pond stage values are relative to the bottom elevation. Negative bottom elevations are not allowed.

The pond effective depth is the pond height (including freeboard) above the pond bottom. It is not the actual elevation of the top of the pond.

Pond side slopes are in terms of horizontal distance over vertical. A standard 3:1 (H/V) side slope would be given a value of 3. A vertical side slope has a value of 0.

The pond bottom is assumed to be flat.

The pond outlet structure consists of a riser and zero to three orifices. The riser has a height (typically one foot less than the effective depth) and a diameter. The riser can have either a flat top or a weir notch cut into the side of the top of the riser. The notch can be either rectangular, V-shaped, or a Sutro weir. More information on the riser weir shapes and orifices is provided later in this manual.

After the pond is given dimensions and outlet information the user can view the resulting stage-storage-discharge table by clicking on the "Open Table" arrow in the lower right corner of the pond information screen. This table hydraulically defines the pond's characteristics.

The user can use either AutoPond to size a pond or can manually size a pond. Follow the following steps for manual sizing a pond using an outlet configuration with one orifice and a riser with rectangular notch (this is usually the most efficient design):

1. Input a bottom orifice diameter that allows a discharge equal to the lower threshold (e.g., 10% of 2-year) Predevelopment flow for a stage equal to 2/3rds the

height of the riser. This discharge can be checked by reviewing the pond's stage-storage-discharge table.

2. Input a riser rectangular notch height equal to 1/3 of the height of the riser. Initially set the riser notch width to 0.1 feet.
3. Run Predevelopment and Mitigated scenarios.
4. Go to Analysis screen and check flow duration results.
5. If pond passes flow duration criteria then decrease pond dimensions.
6. If pond fails flow duration criteria then change (in order of priority) bottom orifice diameter, riser notch width, pond dimensions.
7. Iterate until there is a good match between Predevelopment and Mitigated flow duration curves or fatigue sets in.

Pond input information:
Bottom Length (ft): Pond bottom length.
Bottom Width (ft): Pond bottom width.
Effective Depth (ft): Pond height from pond bottom to top of riser plus at least 0.5 feet extra.
Left Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Bottom Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Right Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Top Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Riser Height (ft): Height of overflow pipe above pond bottom.
Riser Diameter (in): Pond overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the pond side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

A pond receives precipitation on and evaporation from the pond surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

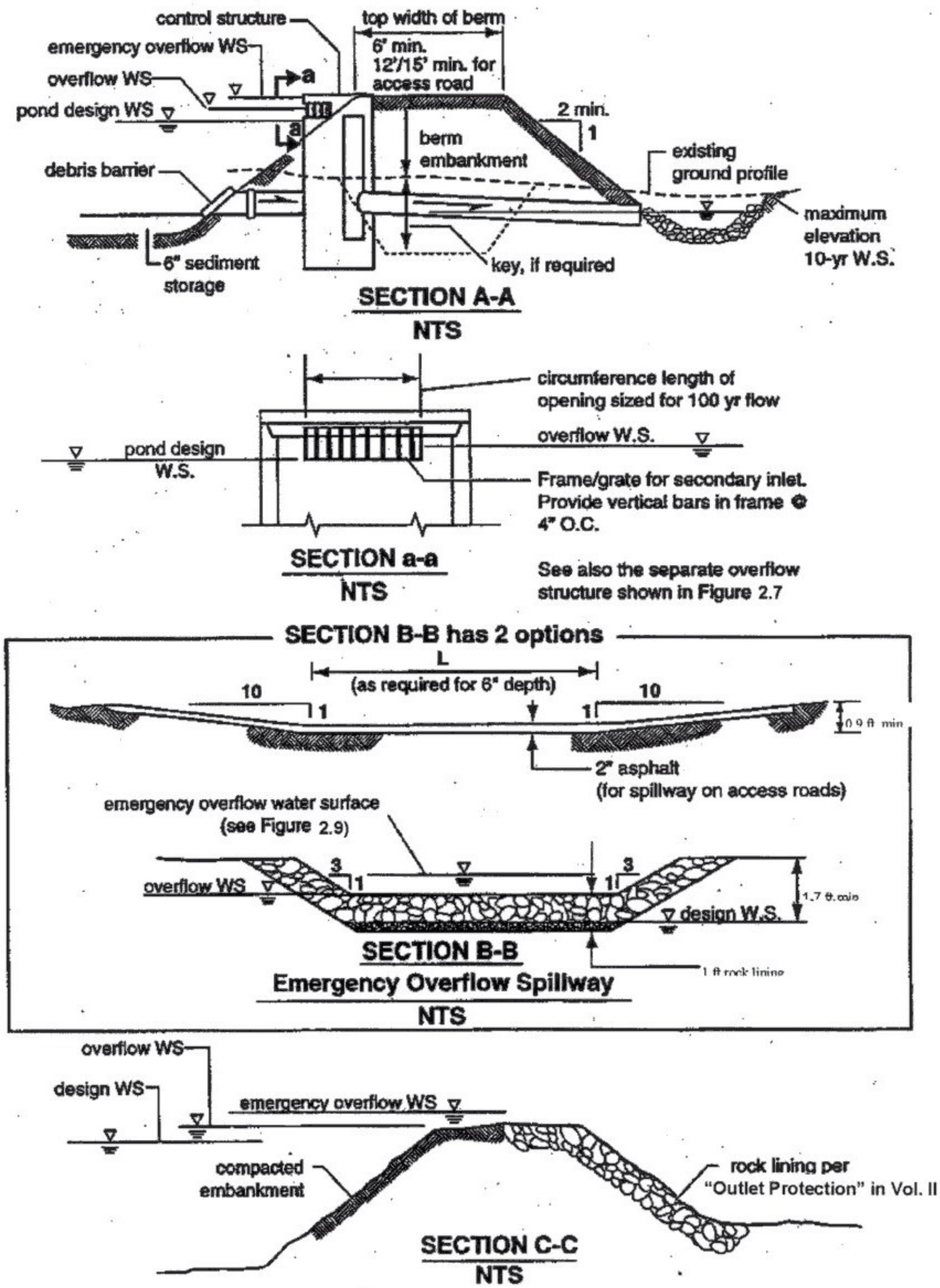
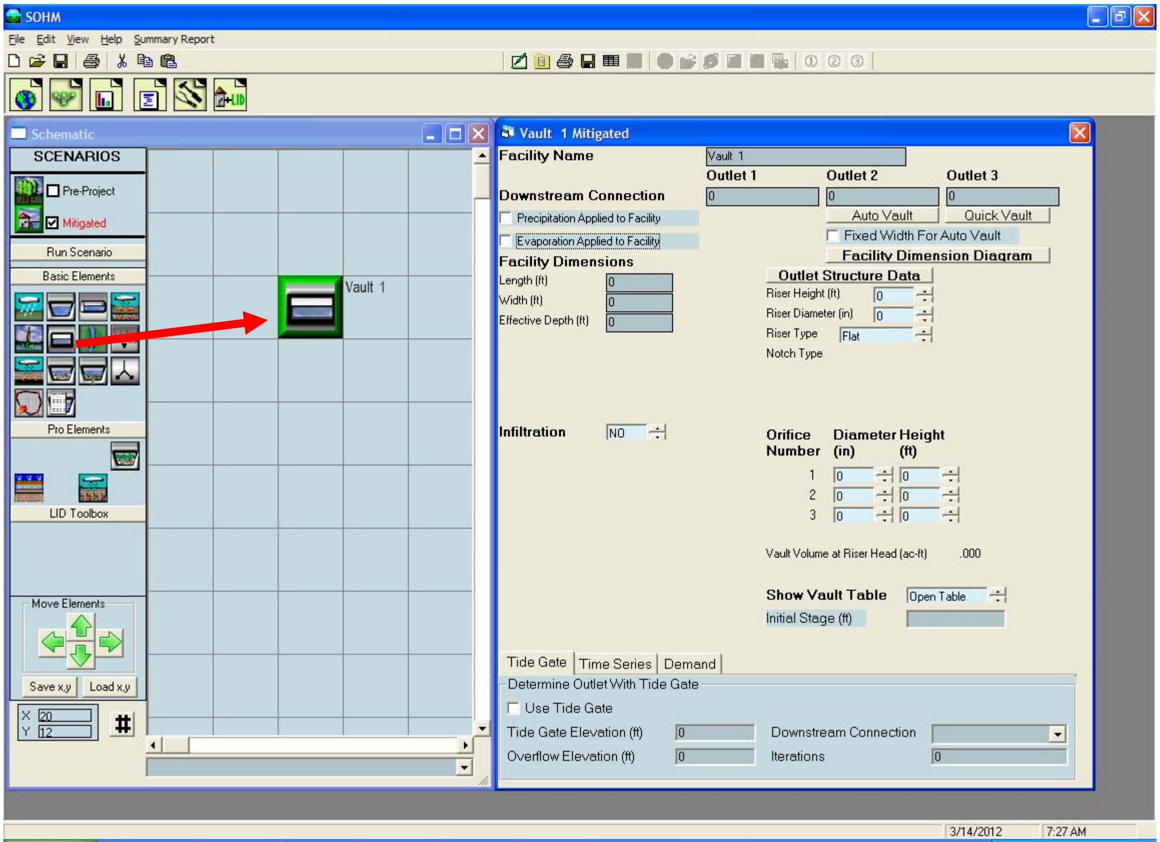


Figure 3.10 Typical Detention Pond Sections

NOTE: The detention pond section diagram shows the general configuration used in designing a pond and its outlet structure. This diagram is from the Washington State Department of Ecology's 2005 Stormwater Management Manual for Western Washington. *Consult with your local municipal permitting agency on specific design requirements for your project site.*

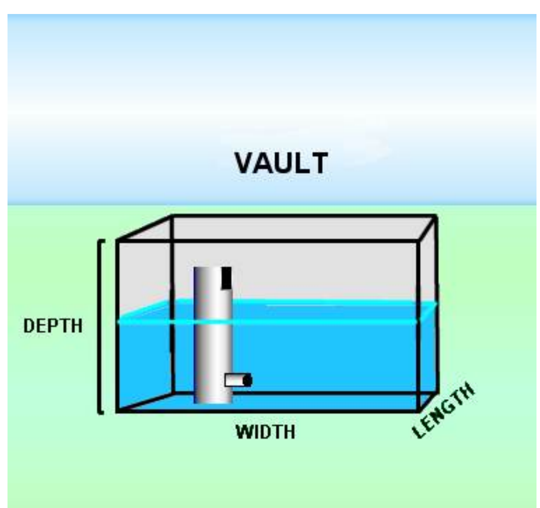
Vault Element



The storage vault has all of the same characteristics of the trapezoidal pond, except that the user does not specify the side slopes (by definition they are zero) and the vault is assumed to have a lid (no precipitation or evaporation).

AutoVault and QuickVault work the same way as AutoPond and QuickPond. Go to page 46 to find information on how to manually size a vault or other HMP facility.

Vault input information:
Bottom Length (ft): Vault bottom length.
Bottom Width (ft): Vault bottom width.
Effective Depth (ft): Vault height from vault bottom to top of riser plus at least 0.5 feet extra.
Riser Height (ft): Height of overflow pipe above vault bottom.
Riser Diameter (in): Vault overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.



For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

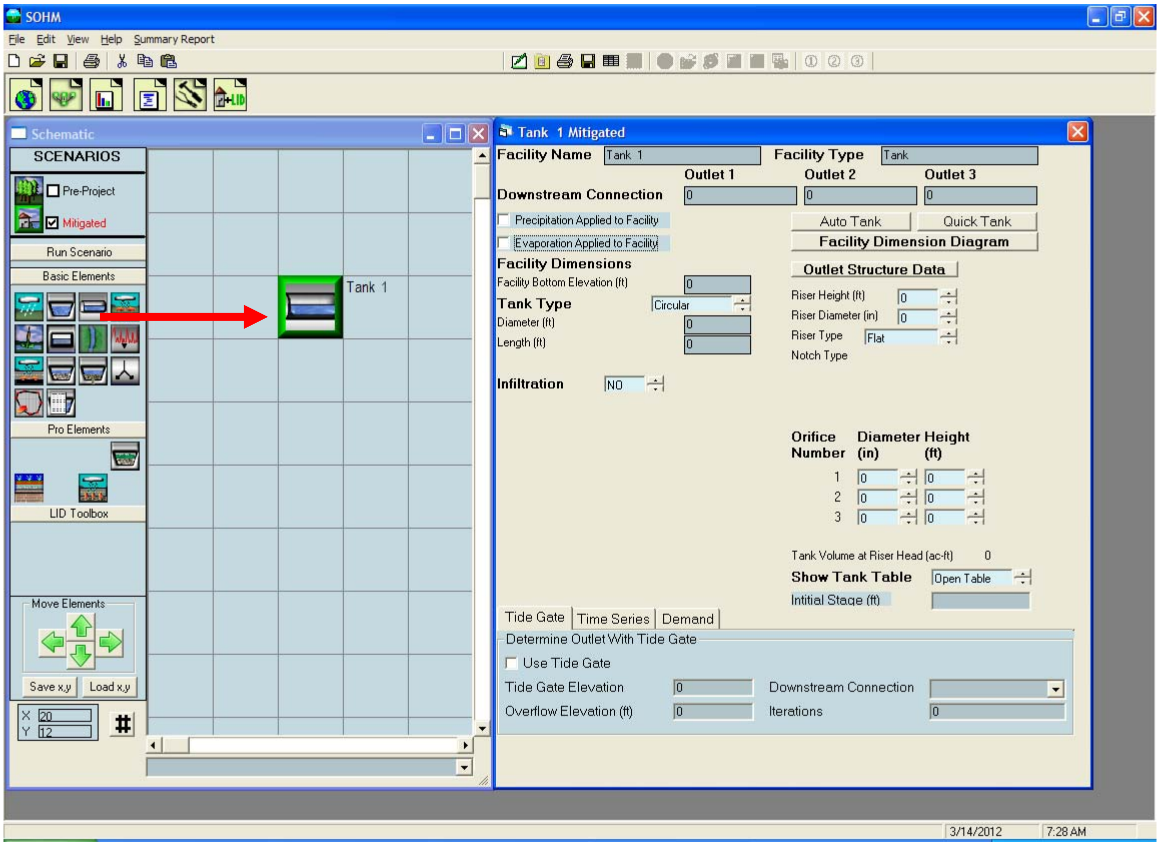
Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the vault sides is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

A vault is usually covered and does not receive precipitation on and evaporation from the vault surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should not be checked unless the vault top is open to the atmosphere.

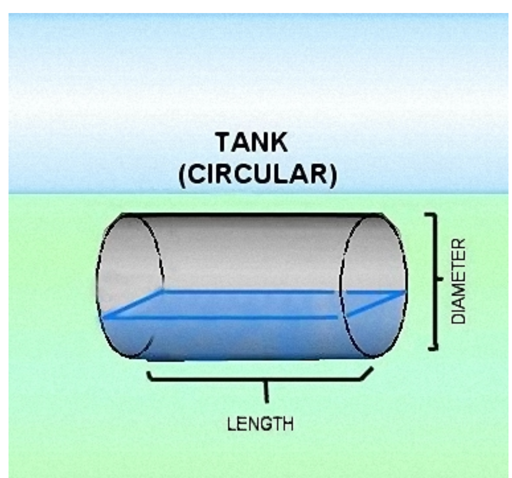
Tank Element



A storage tank is a cylinder placed on its side. The user specifies the tank's diameter and length.

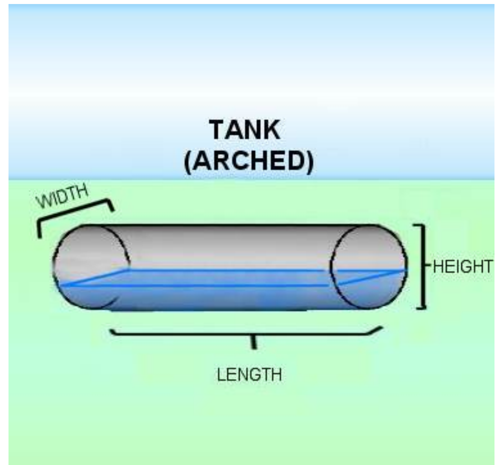
There is no AutoTank (automatic tank sizing routine). The user must manually size the tank to meet the flow duration criteria. Go to page 46 to find information on how to manually size a tank or other HMP facility.

There is a QuickTank option that creates a tank, but does not check for compliance with the flow duration criteria.



Tank input information:
Tank Type: Circular or Arched
For Circular:
Diameter (ft): Tank diameter.
Length (ft): Tank length.
For Arched:
Height (ft): Tank height.
Width (ft): Tank width (at widest point).
Length (ft): Tank length.

Riser Height (ft): Height of overflow pipe above tank bottom; must be less than tank diameter or height.
Riser Diameter (in): Tank overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.



For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

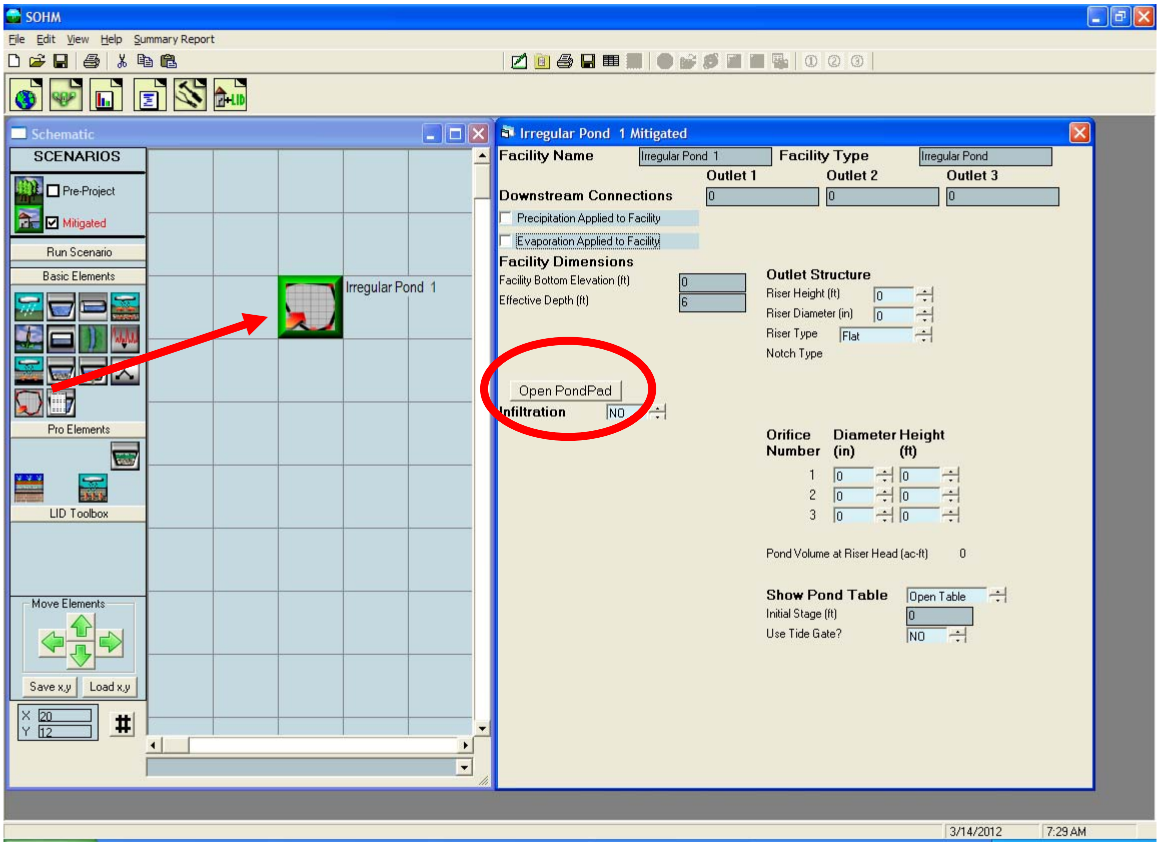
Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the tank sides is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

A tank is covered and does not receive precipitation on and evaporation from the tank surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should not be checked.

Irregular Pond Element

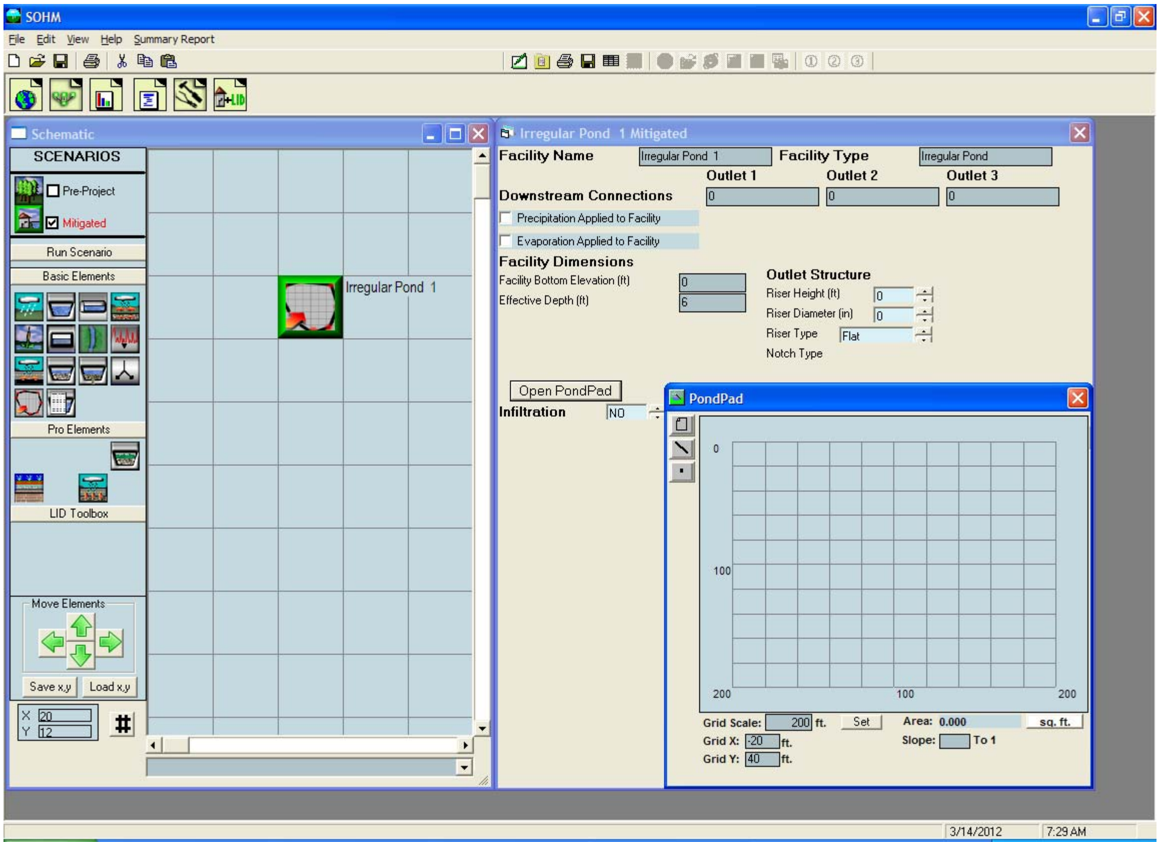


An irregular pond is any pond with a shape that differs from the rectangular top of a trapezoidal pond. An irregular pond has all of the same characteristics of a trapezoidal pond, but its shape must be defined by the user.

The AutoPond option is not available for an irregular-shaped pond. Go to page 46 to find information on how to manually size an irregular pond or other HMP facility.

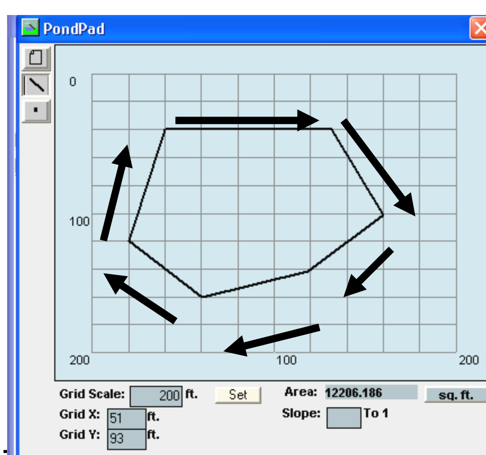
To create the shape of an irregular pond the user clicks on the "Open PondPad" button. This allows the user to access the PondPad interface (see below).

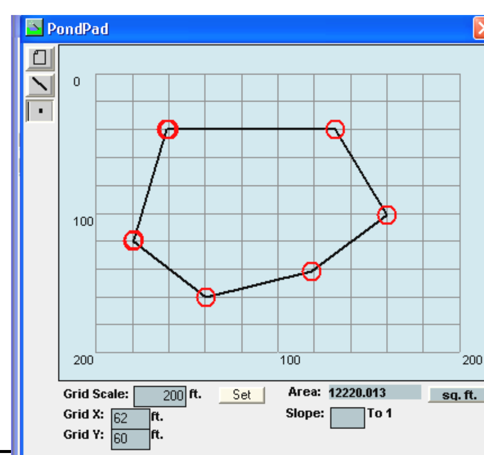
PondPad Interface



The PondPad interface is a grid on which the user can specify the outline of the top of the pond and the pond's side slopes.

The user selects the line button (second from the top on the upper left corner of the PondPad screen). Once the line button is turned on the user moves the mouse over the grid to locate the pond's corner points. The user does this in a **clockwise** direction to outline the pond's top perimeter. The user can select individual points by clicking on the point button immediately below the line button. Once selected, any individual point can be moved or repositioned.





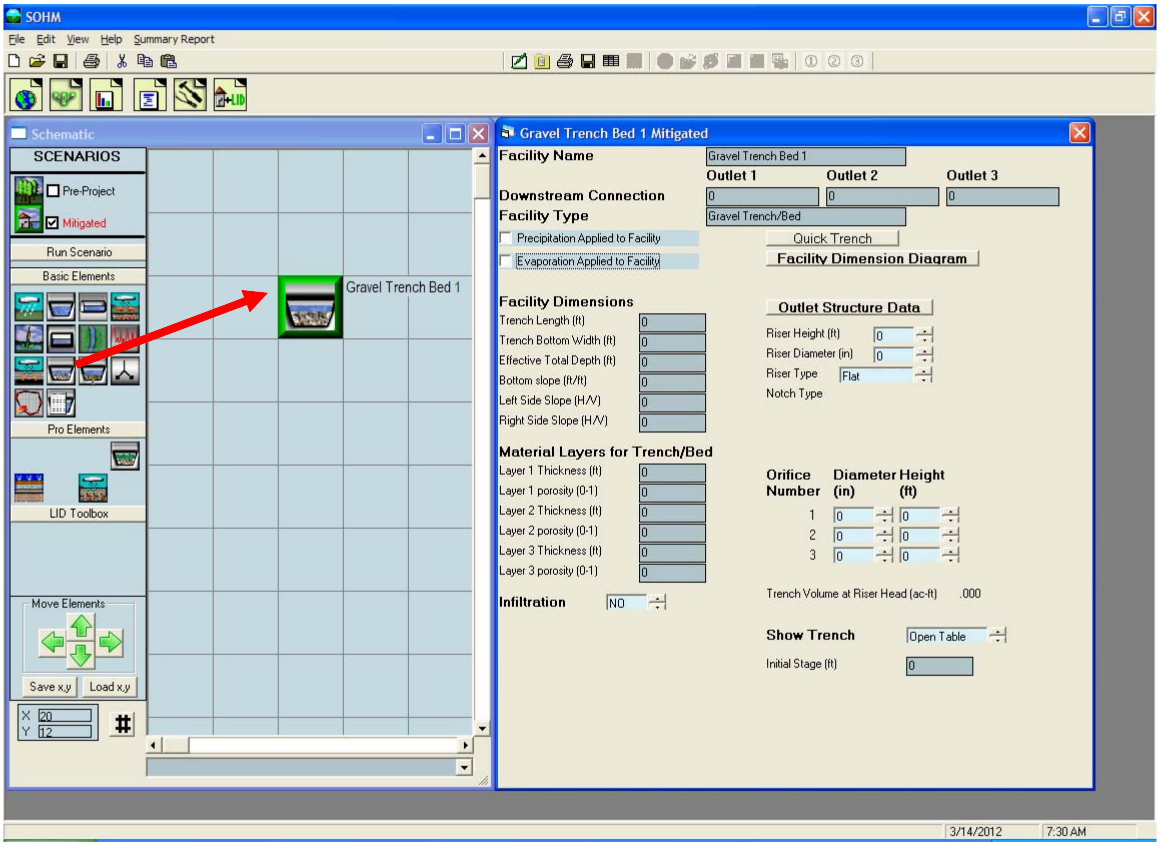
The default side slope value is 3 (3:1). The side slopes can be individually changed by right clicking on the specific side (which changes the line color from black to red) and then entering the individual side slope value in the slope text box.

The grid scale can be changed by entering a new value in the grid scale box. The default value is 200 feet.

PondPad Controls and Numbers

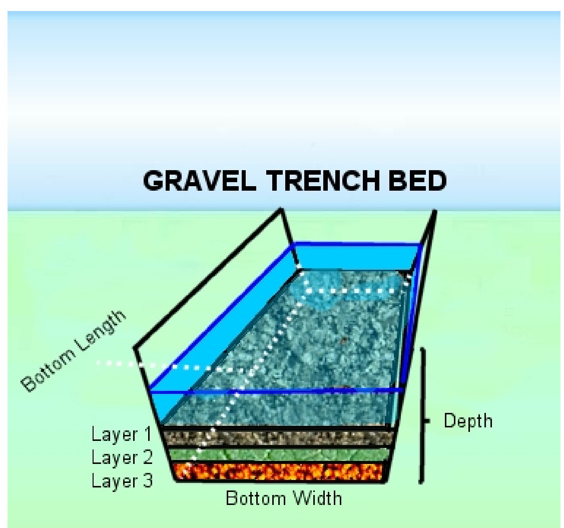
Clear:	The Clear button clears all of the lines on the grid.
Line:	The Line button allows the user to draw new lines with the mouse.
Point:	The Point button allows the user to move individual points to alter the pond shape and size.
Sq Ft:	Converts the computed pond area from square feet to acres and back.
Grid Scale:	Changes the length of a grid line. Default grid scale is 200 feet.
Grid X:	Horizontal location of the mouse pointer on the grid (0 is the upper left corner).
Grid Y:	Vertical location of the mouse pointer on the grid (0 is the upper left corner)
Area:	Top area of the pond (either in square feet or acres).
Slope:	Side slope of the selected line (side of the pond).

Gravel Trench Bed Element



The gravel trench bed is used to spread and infiltrate runoff, but also can have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.

The user specifies the trench length, bottom width, total depth, bottom slope, and left and right side slopes.



The material layers represent the gravel/rock layers and their design characteristics (thickness and porosity).

QuickTrench will instantly create a gravel trench bed with default values without checking it for compliancy with flow duration criteria.

The gravel trench bed input information:

Trench Length (ft): Trench bed length.
Trench Bottom Width (ft): Trench bed bottom width.

Effective Total Depth (ft): Height from bottom of trench bed to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical trench bed sides.

Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical trench bed sides.
Infiltration Rate (in/hr): Trench bed gravel or other media infiltration rate.
Layer 1 Thickness (ft): Trench top media layer depth.
Layer 1 Porosity: Trench top media porosity.
Layer 2 Thickness (ft): Trench middle media layer depth (Layer 2 is optional).
Layer 2 Porosity: Trench middle media porosity.
Layer 3 Thickness (ft): Trench bottom media layer depth (Layer 3 is optional).
Layer 3 Porosity: Trench bottom media porosity.
Riser Height (ft): Height of trench overflow pipe above trench surface.
Riser Diameter (in): Trench overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

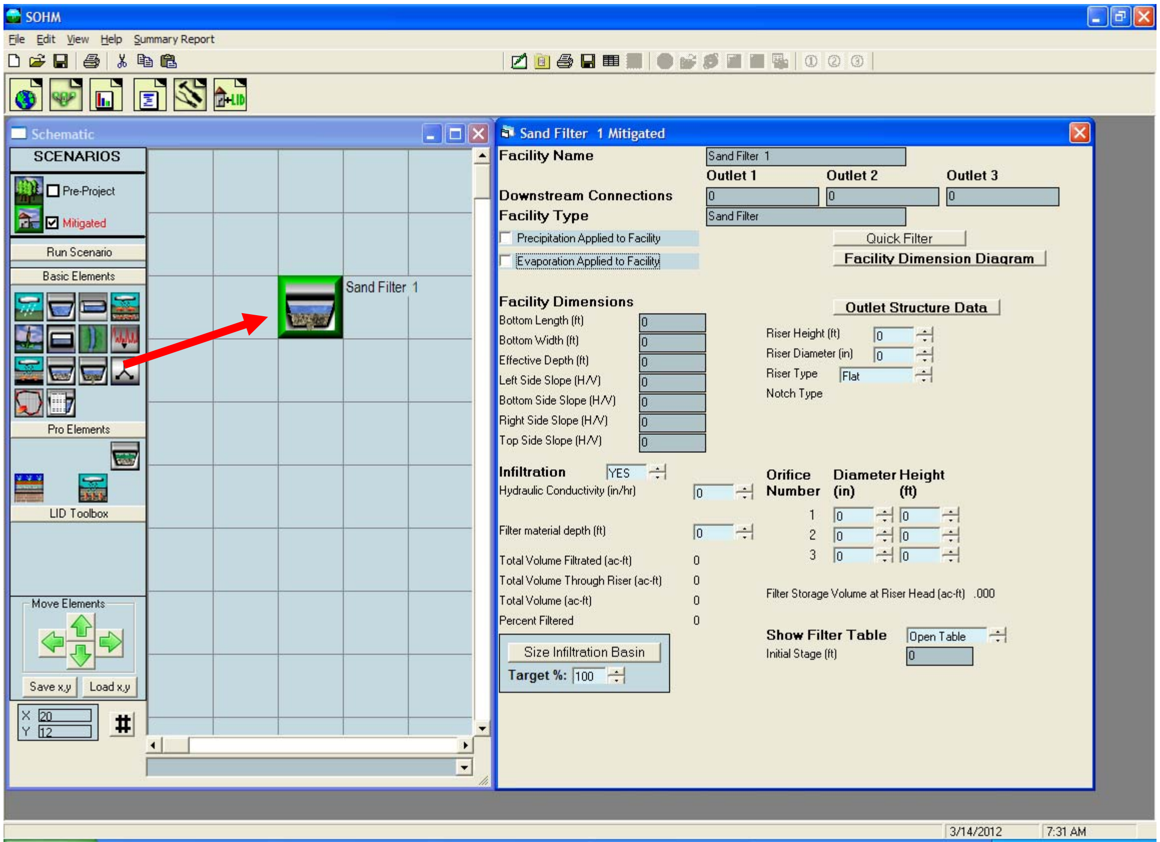
Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the trench side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

Gravel trench bed receives precipitation on and evaporation from the trench surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

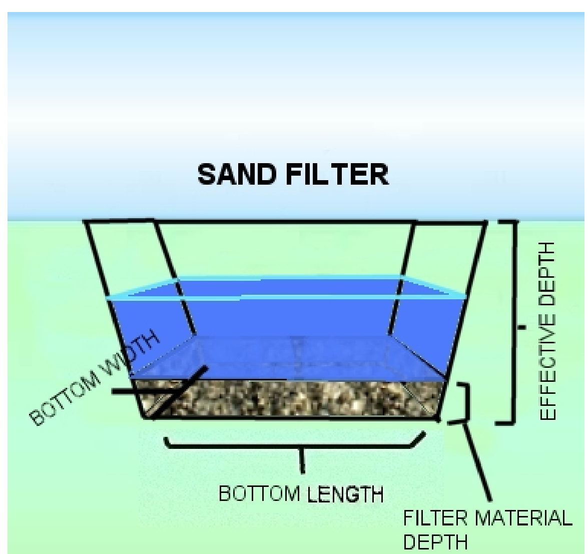
Sand Filter Element



The sand filter is a water quality facility. It does not infiltrate runoff, but is used to filter runoff through a medium and send it downstream. It can also have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.

The user must specify the facility dimensions (bottom length and width, effective depth, and side slopes. The hydraulic conductivity of the sand filter and the filter material depth are also needed to size the sand filter (default values are 1.0 inch per hour and 1.5 feet, respectively).

*NOTE: When using the sand filter element check with **Appendix C** or the local municipal permitting agency to determine the required treatment standard (percent of the total runoff volume treated by the sand filter).*



The filter discharge is calculated using the equation Q = K*I*A, where Q is the discharge in cubic feet per second (cfs). K equals the hydraulic conductivity (inches per hour). For sand filters K = 1.0 in/hr. Sand is the default medium. If another filtration material is used then the design engineer should enter the appropriate K value supported by documentation and approval by the reviewing authority.

Design of a sand filter requires input of facility dimensions and outlet structure characteristics, running the sand filter scenario, and then checking the volume calculations to see if the Percent Filtered equals or exceeds the treatment standard percentage. If the value is less than the treatment standard percentage then the user should increase the size of the sand filter dimensions and/or change the outlet structure. The sand filter input information:

Bottom Length (ft): Sand filter bottom length.
Bottom Width (ft): Sand filter bottom width.
Effective Depth (ft): Height from bottom of sand filter to top of riser plus at least 0.5 feet extra.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Bottom Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Top Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Riser Height (ft): Height of sand filter overflow pipe above sand filter surface.
Riser Diameter (in): Sand filter overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

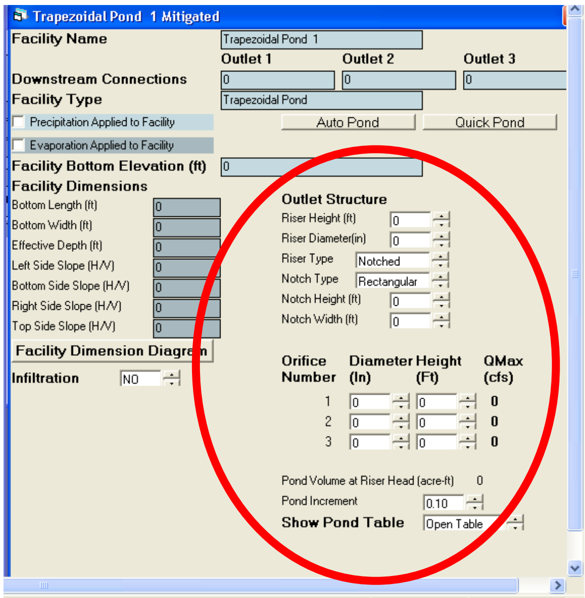
For more information on riser notch options and orifices see discussion in **Outlet Structure Configurations** section.

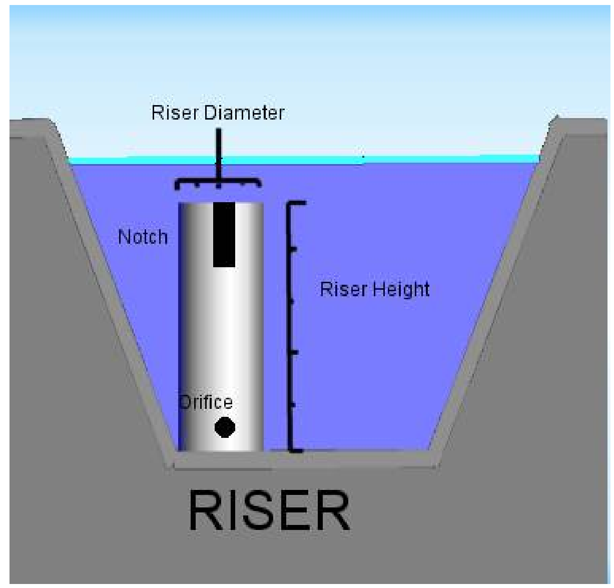
Infiltration: Yes (infiltration through the filter material)
Hydraulic Conductivity (in/hr): Filtration rate through the sand filter.
Filter material depth (ft): Depth of sand filter material (for runoff filtration).

Sand filter receives precipitation on and evaporation from the sand filter surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

Outlet Structure Configurations

The trapezoidal pond, vault, tank, irregular pond, gravel trench bed, and sand filter all use a riser for the outlet structure to control discharge from the facility.

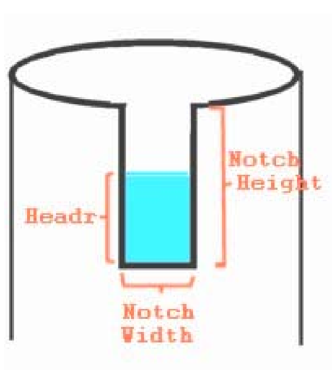




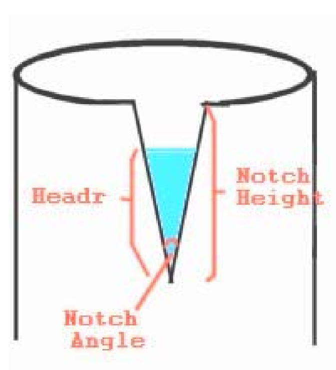
The riser is a vertical pipe with a height above pond bottom (typically one foot less than the effective depth). The user specifies the riser height and diameter.

The riser can have up to three round orifices. The bottom orifice is usually located at the bottom of the pond and/or above any dead storage in the facility. The user can set the diameter and height of each orifice. The model will automatically calculate the maximum orifice discharge value, QMax (cfs), if the pond dimensions have already been defined.

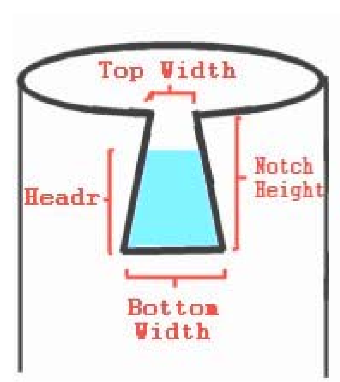
The user specifies the riser type as either flat or notched. The weir notch can be either rectangular, V-notch, or a Sutro weir. The shape of each type of weir is shown below.



Rectangular Notch



V-Notch



Sutro

By selecting the appropriate notch type the user is then given the option to enter the appropriate notch type dimensions.

Riser and orifice equations used in SOHM are provided below.

Headr = the water height over the notch/orifice bottom.
q = discharge

Riser Head Discharge:

Head = water level above riser
q = 9.739 * Riser Diameter * Head ^ 1.5

Orifice Equation:
q = 3.782 * (Orifice Diameter) ^ 2 * SQRT(Headr)

Rectangular Notch:
b = NotchWidth *- (1- 0.2 * Headr)
where b >= 0.8
q = 3.33 * b * Headr ^ 1.5

Sutro:
Wh = Top Width + {(Bottom Width- Top Width)/Notch Height }* Headr
Wd = Bottom Width - Wh (the difference between the bottom and top widths)

Q1 = (rectangular notch q where Notch Width = Wh)
Q2 = (rectangular notch q where Notch Width = Wd)

q = Q1 + Q2 / 2

V-Notch:
Notch Bottom = height from bottom of riser to bottom of notch
Theta = Notch Angle

a = 2.664261 - 0.0018641 * Theta + 0.00005761 * Theta ^2
b = -0.48875 + 0.003843 * Theta - 0.000092124 * Theta ^2
c = 0.3392 - 0.0024318 * Theta + 0.00004715 * Theta ^2

YoverH = Headr / (NotchBottom + Headr)
Coef = a + b * Headr + c * Headr ^2

q = (Coef * Tan(Theta / 2)) * (Headr ^ (5 / 2))

These equations are provided from the Washington State Department of Ecology's 2005 *Stormwater Management Manual for Western Washington.* The outlet designs are shown below. They have been reproduced from Volume III of the *Stormwater Management Manual for Western Washington* which has more information on the subject.

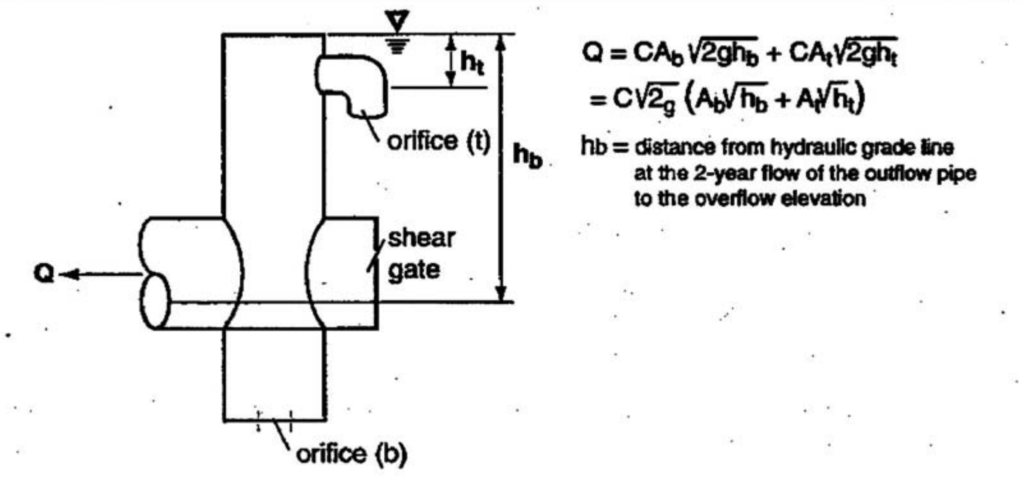


Figure 3.20 Simple Orifice

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(equation 5)}$$

where d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

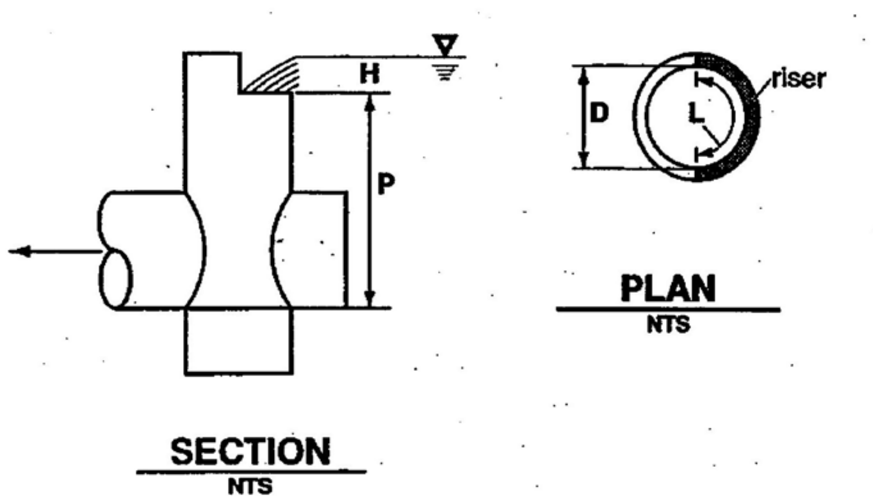


Figure 3.21 Rectangular, Sharp-Crested Weir

$Q=C\,(L - 0.2H)H^{3/2}$ (equation 6)

where Q = flow (cfs)
C = 3.27 + 0.40 H/P (ft)
H, P are as shown above
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50 percent of the circumference
D = inside riser diameter (ft)

Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

The physical configuration of the outlet structure should include protection for the riser and orifices to prevent clogging of the outlet from debris or sediment. Various outlet configurations are shown below. They have been reproduced from Volume III of the *Stormwater Management Manual for Western Washington* which has more information on the subject.

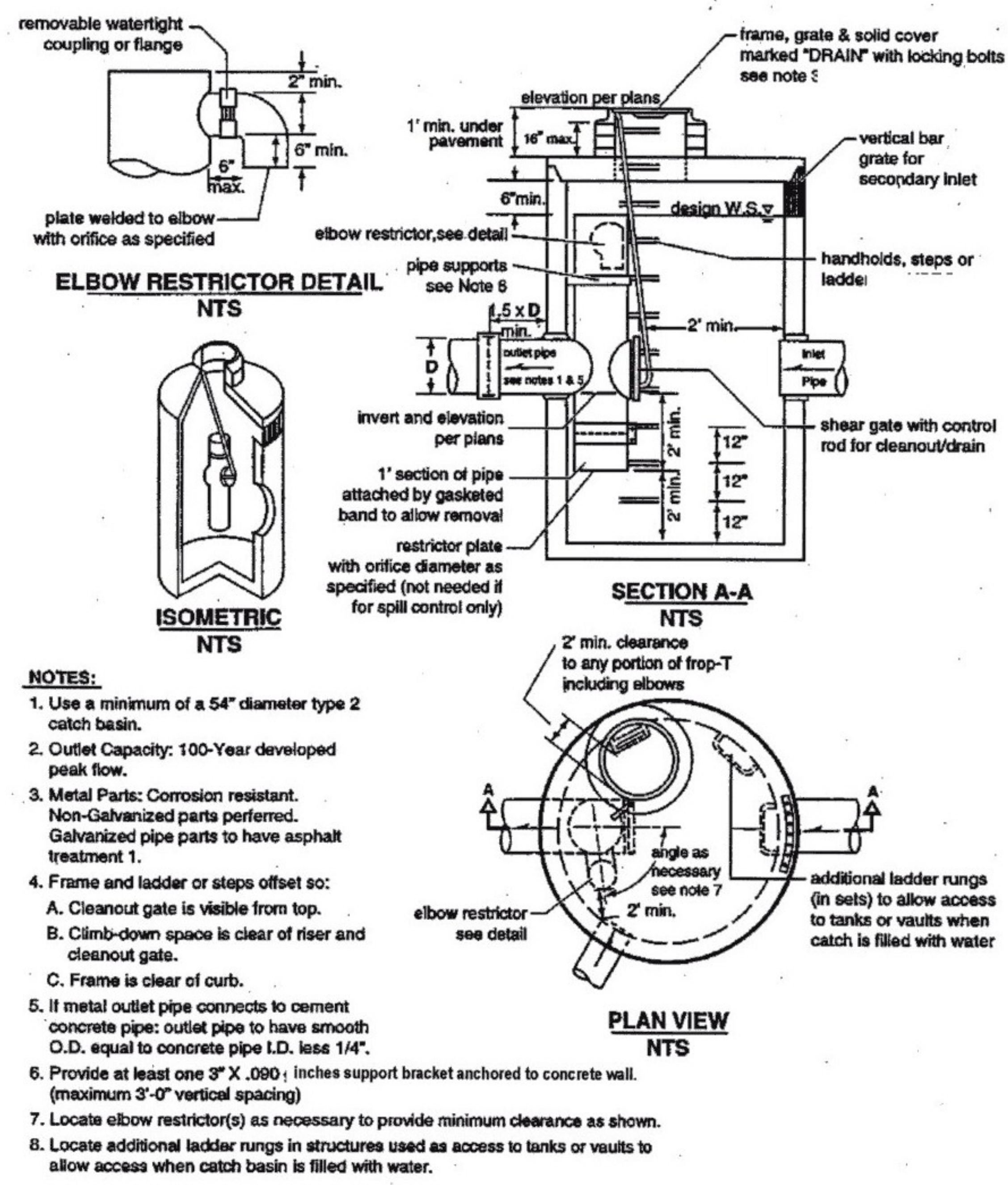


Figure 3.17 Flow Restrictor (TEE)

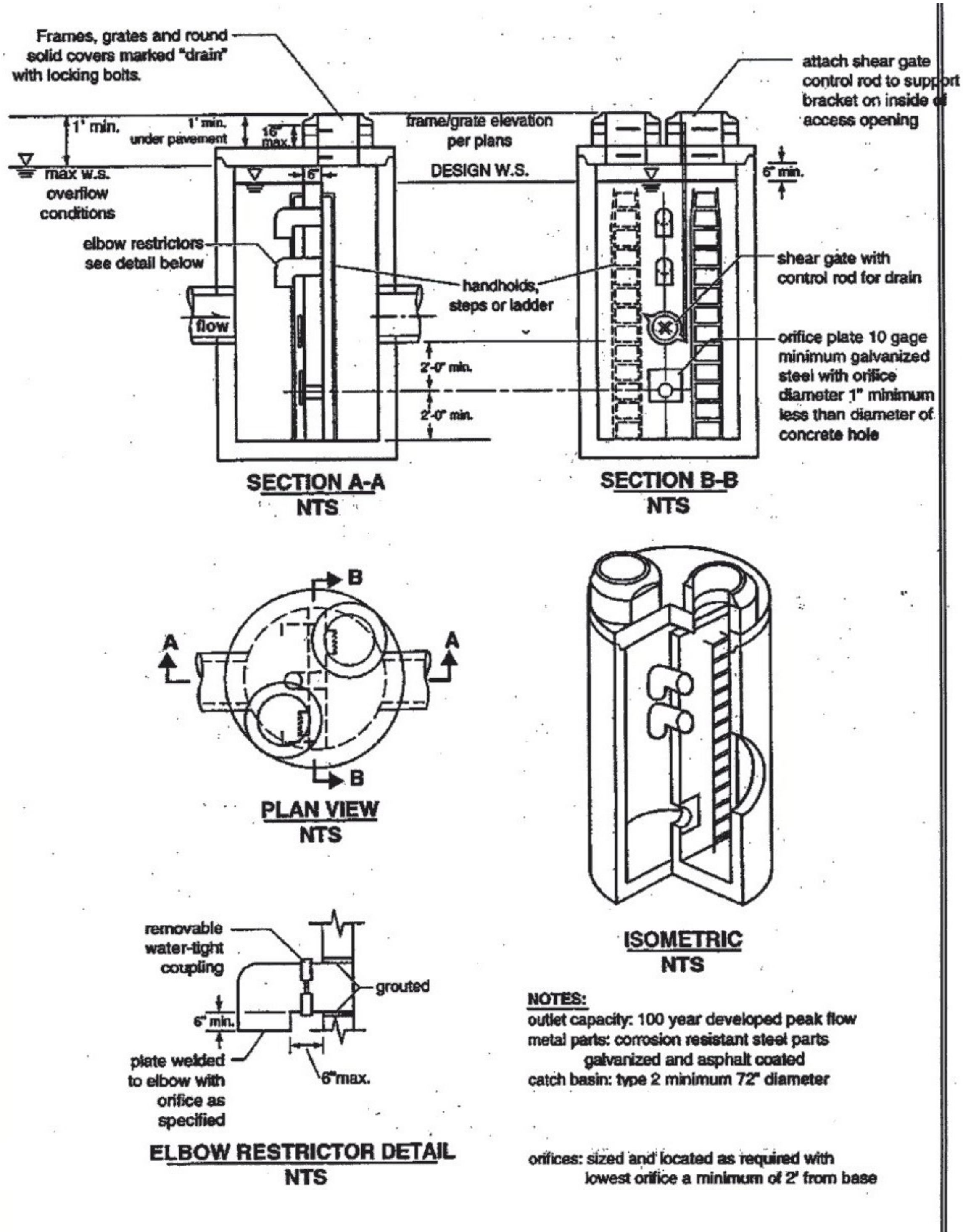


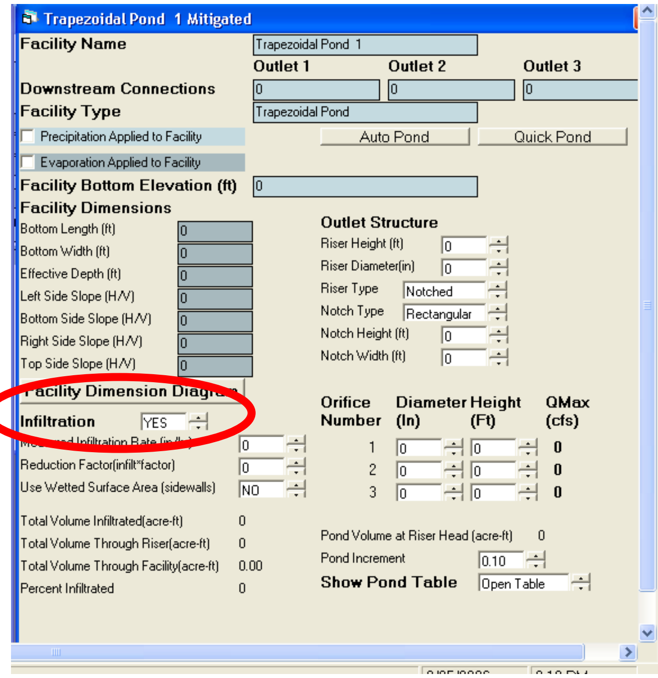
Figure 3.18 Flow Restrictor (Baffle)

Riser protection structures. Diagrams courtesy of Washington State Department of Ecology.

Infiltration

Infiltration of stormwater runoff is a recommended solution if certain conditions are met. These conditions include: a soils report, testing, groundwater protection, pre-settling, and appropriate construction techniques.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*



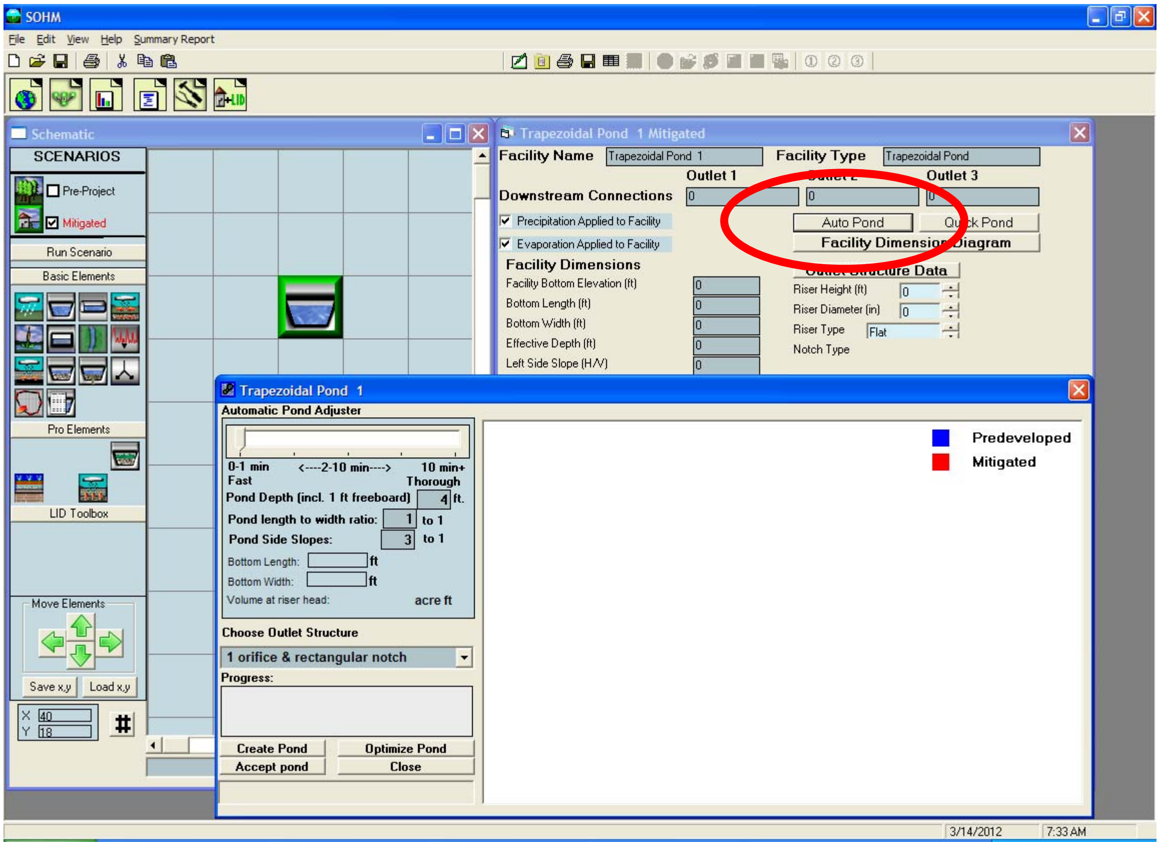
The user clicks on the Infiltration option arrow to change infiltration from NO to YES. This activates the infiltration input options: measured infiltration rate, infiltration reduction factor, and whether or not to allow infiltration through the wetted side slopes/walls.

The infiltration reduction factor is a multiplier for the measured infiltration rate and should be less than one. It is the same as the inverse of a safety factor. For example, a safety factor of 2 is equal to a reduction factor of 0.5.

Infiltration occurs only through the bottom of the facility if the wetted surface area option is turned off. Otherwise the entire wetted surface area is used for infiltration.

After the model is run and flow is routed through the infiltration facility the total volume infiltrated, total volume through the riser, total volume through the facility, and percent infiltrated are reported on the screen. If the percent infiltrated is 100% then there is no surface discharge from the facility. The percent infiltrated can be less than 100% as long as the surface discharge does not exceed the flow duration criteria.

Autopond



AutoPond automatically creates a pond size and designs the outlet structure to meet the flow duration criteria. The user can either create a pond from scratch or optimize an existing pond design.

AutoPond requires that the Predevelopment and Mitigated basins be defined prior to using AutoPond. Clicking on the AutoPond button brings up the AutoPond window and the associated AutoPond controls.

AutoPond controls:

Automatic Pond Adjuster: The slider at the top of the AutoPond window allows the user to decide how thoroughly the pond will be designed for efficiency. The lowest setting (0-1 min) at the left constructs an initial pond without checking the flow duration criteria. The second setting to the right creates and sizes a pond to pass the flow duration criteria; however, the pond is not necessarily optimized. The higher settings increase the amount of optimization. The highest setting (farthest right) will size the most efficient (smallest) pond, but will result in longer computational time.

Pond Depth: Pond depth is the total depth of the pond and should include at least one foot of freeboard (above the riser). The pond's original depth will be used when optimizing an existing pond; changing the value in the Pond Depth text box will override any previous set depth value. The default depth is 4 feet.

Pond Length to Width Ratio: This bottom length to width ratio will be maintained regardless of the pond size or orientation. The default ratio value is 1.0

Pond Side Slopes: AutoPond assumes that all of the pond's sides have the same side slope. The side slope is defined as the horizontal distance divided by the vertical. A typical side slope is 3 (3 feet horizontal to every 1 foot vertical). The default side slope value is 3.

Choose Outlet Structure: The user has the choice of either 1 orifice and rectangular notch or 3 orifices. If the user wants to select another outlet structure option then the pond must be manually sized.

Create Pond: This button creates a pond when the user does not input any pond dimensions or outlet structure information. Any previously input pond information will be deleted.

Optimize Pond: This button optimizes an existing pond. It cannot be used if the user has not already created a pond.

Accept Pond: This button will stop the AutoPond routine at the last pond size and discharge characteristics that produce a pond that passes the flow duration criteria. AutoPond will not stop immediately if the flow duration criteria have not yet been met.

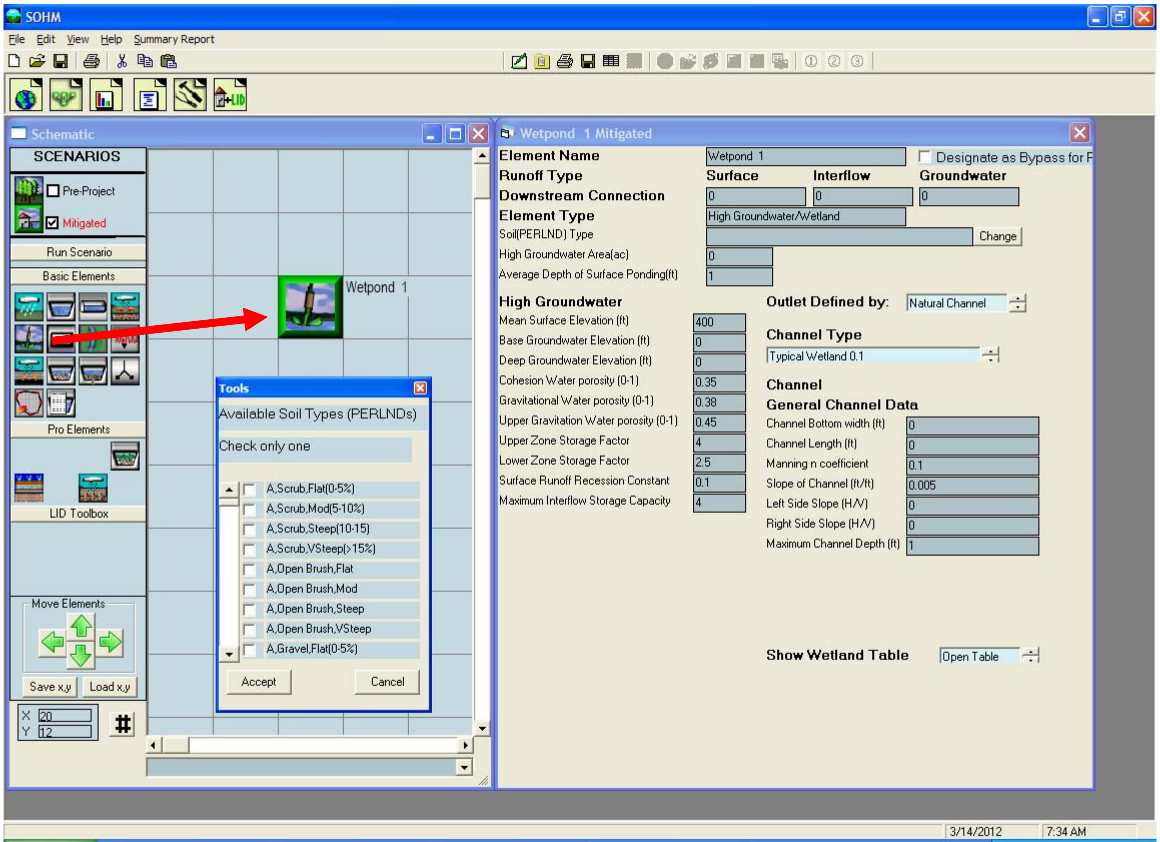
The bottom length and width and volume at riser head will be computed by AutoPond; they cannot be input by the user.

AutoVault operates the same way as AutoPond.

There are some situations where AutoPond (or AutoVault) will not work. These situations occur when complex routing conditions upstream of the pond make it difficult or impossible for AutoPond to determine which land use will be contributing runoff to the pond. For these situations the pond will have to be manually sized. Go to page 46 to find information on how to manually size a pond or other HMP facility.

*NOTE: If AutoPond selects a bottom orifice diameter smaller than the smallest diameter allowed by the local municipal permitting agency then additional mitigating BMPs may be required to meet local hydromodification control requirements. Please see **Appendix C** or consult with local municipal permitting agency for more details. For manual sizing information see page 46.*

High Groundwater/Wetland Element



The High Groundwater/Wetpond element is a complex element that should only be used in special applications by advanced SOHM users. The purpose of the high groundwater/ wetpond element is to model hydrologic conditions where high groundwater rises to the surface (or near the surface) and reduces the ability of water to infiltrate into the soil.

The element can be used to represent wetland conditions with surface ponding where the discharge from the wetland is via a surface release. The user is given the choice of using either a natural channel, berm/weir, or control structure to determine the release characteristics.

The element provides default values for some of the parameters, especially as they relate to high groundwater. The user should be fully familiar with these parameters and the appropriate values for their site prior to attempting to use this element. The high groundwater parameter definitions are shown below.

Cohension water porosity: soil pore space in micropores.

Gravitational water porosity: soil pore space in macropores in the lower and groundwater layers of the soil column.

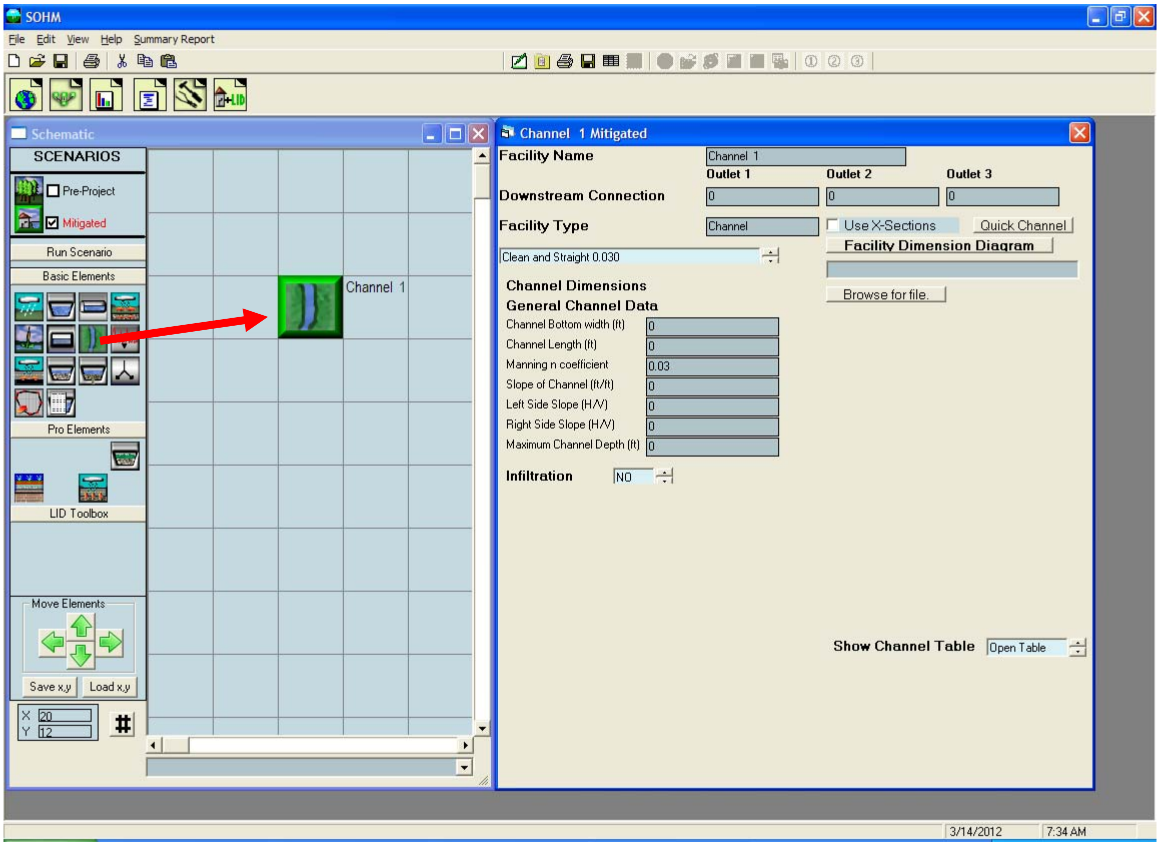
Upper gravitation water porosity: soil pore space in macropores in the upper layer of the soil column.

Upper zone storage factor: portion of the water stored in macropores in the upper soil layer which will not surface discharge, but will percolate, evaporate or transpire.

Lower zone storage factor: portion of the water stored in micropores in the lower soil layer which will not gravity drain, but will evaporate or transpire.

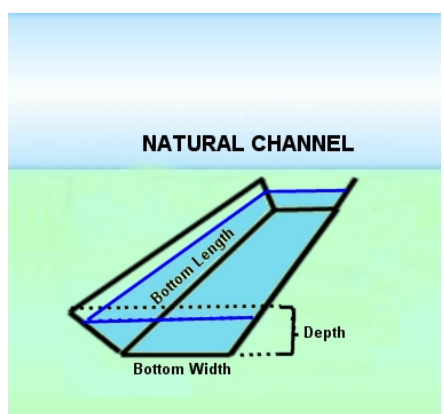
NOTE: Due to permit restrictions on infiltration for stormwater treatment measures in areas of high groundwater, consult with the local municipal permitting agency regarding any project conditions that might involve using this element.

Channel Element



The Channel element allows the user to route runoff from a basin or facility through an open channel to a downstream destination.

The channel cross section is represented by a trapezoid and is used with Manning's equation to calculate discharge from the channel. If a trapezoid does not accurately represent the cross section then the user should represent the channel with an independently calculated SSD Table element or use the Use X-Sections option.



The user inputs channel bottom width, channel length, channel bottom slope, channel left and right side slopes, maximum channel depth, and the channel's roughness coefficient (Manning's n value). The user can select channel type and associated Manning's n from a table list directly above the Channel Dimension information or directly input the channel's Manning's n value.

The channel is used to represent a natural or artificial open channel through which water is routed. It can be used to connect a basin to a pond or a pond to a pond or multiple channels can linked together.

Channel input information:

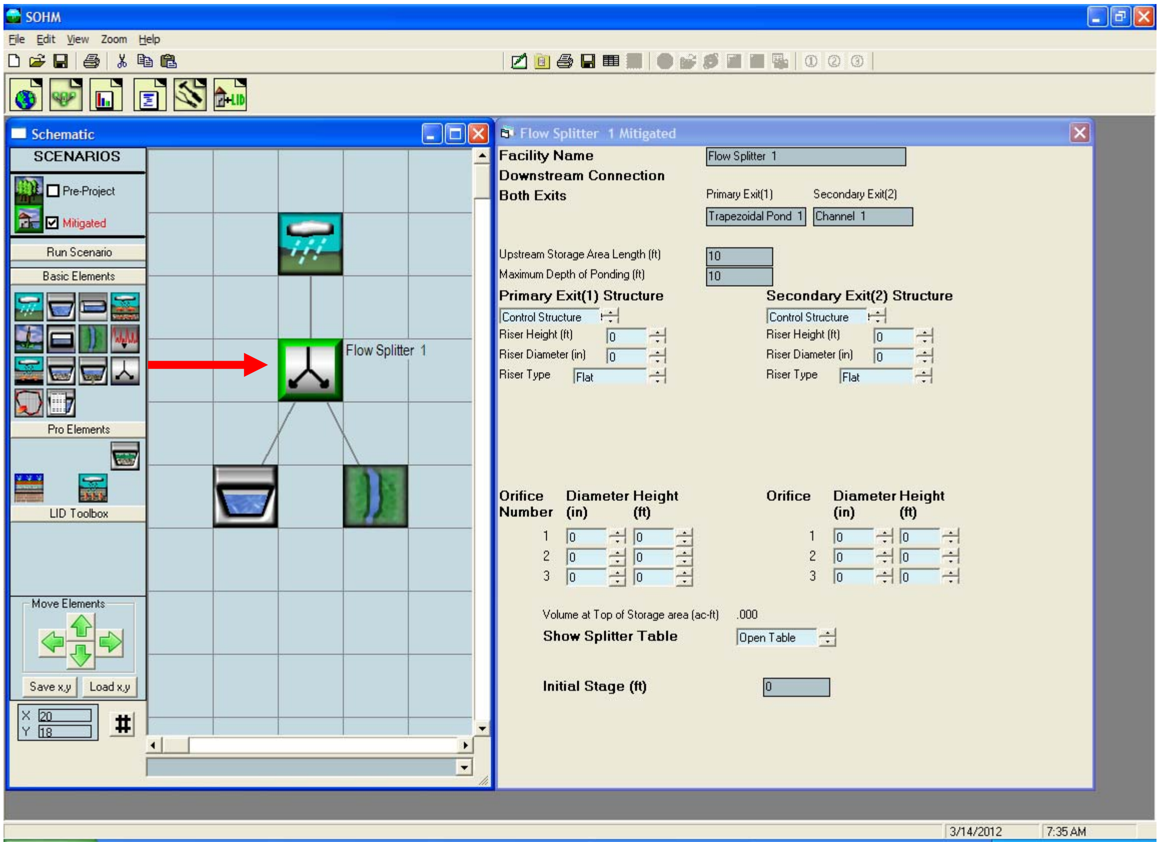
Channel Bottom Width (ft): Open channel bottom width.
Channel Length (ft): Open channel length.
Manning's n coefficient: Open channel roughness coefficient (user menu selected or input).
Slope of Channel (ft/ft): Open channel bottom slope.
Left Side Slope of Channel (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical channel sides.
Right Side Slope of Channel (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical channel sides.
Maximum Channel Depth (ft): Height from bottom of channel to top of channel bank.

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the channel side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

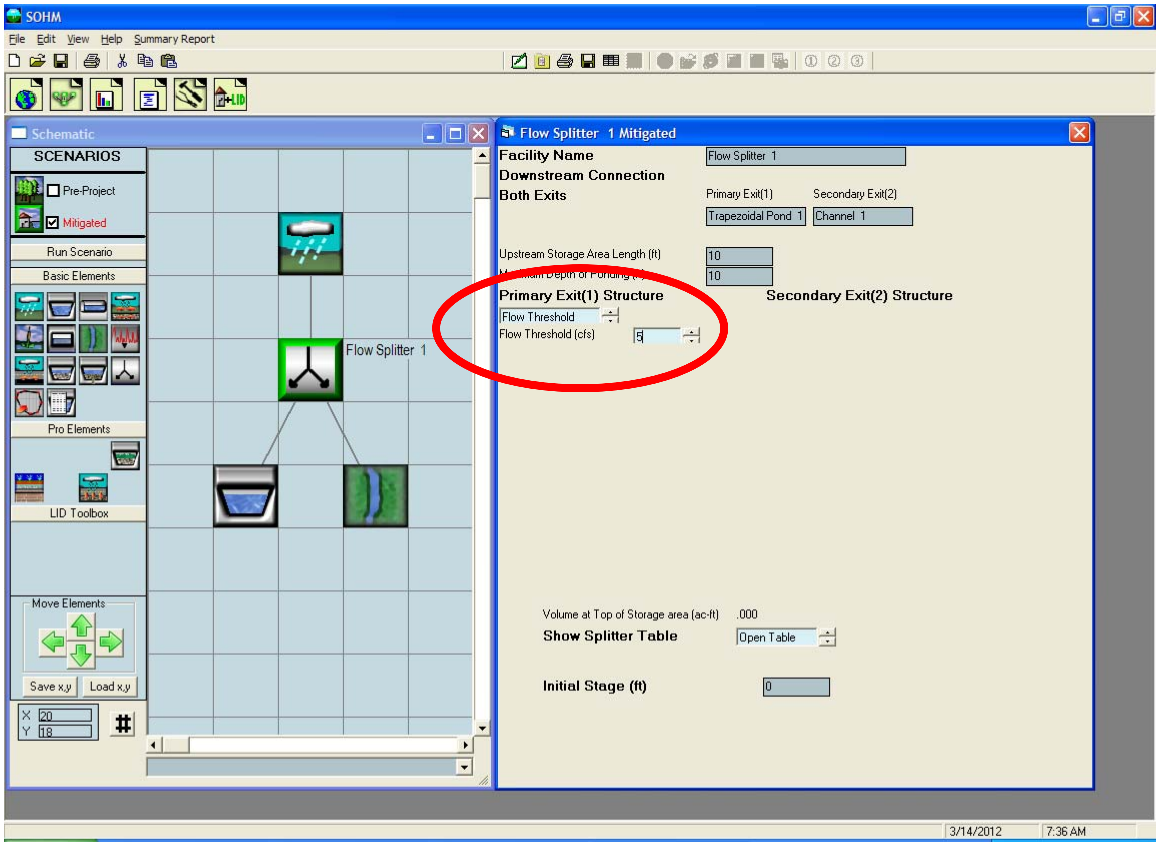
Flow Splitter Element



The flow splitter divides the runoff and sends it to two difference destinations. The splitter has a primary exit (exit 1) and a secondary exit (exit 2). The user defines how the flow is split between these two exits.

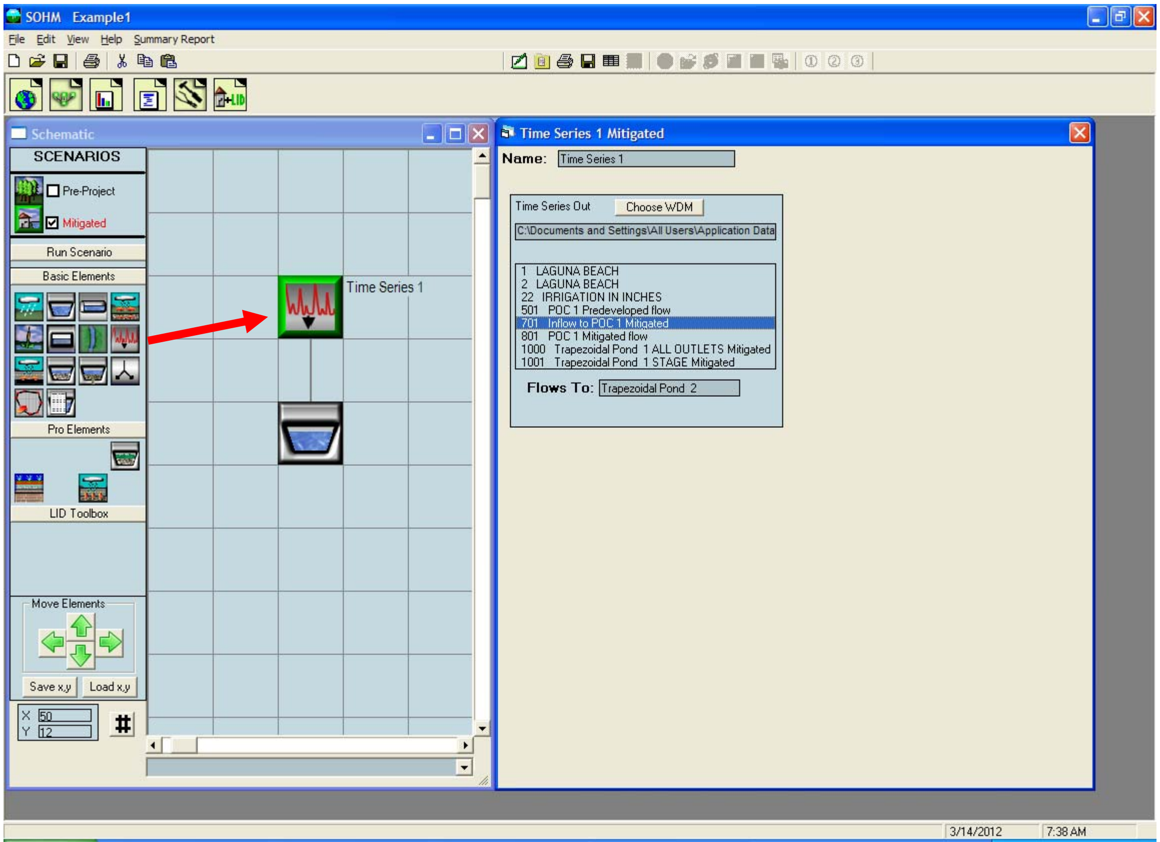
The user can define a flow control structure with a riser and one to three orifices for each exit. The flow control structure works the same way as the pond outlet structure, with the user setting the riser height and diameter, the riser weir type (flat, rectangular notch, V-notch, or Sutro), and the orifice diameter and height.

For more information on riser notch options and orifices see discussion in **Outlet Structure Configurations** section.



The second option is that the flow split can be based on a flow threshold. The user sets the flow threshold value (cfs) for exit 1 at which flows in excess of the threshold go to exit 2. For example, if the flow threshold is set to 5 cfs then all flows less than or equal to 5 cfs go to exit 1. Exit 2 gets only the excess flow above the 5 cfs threshold (total flow minus exit 1 flow).

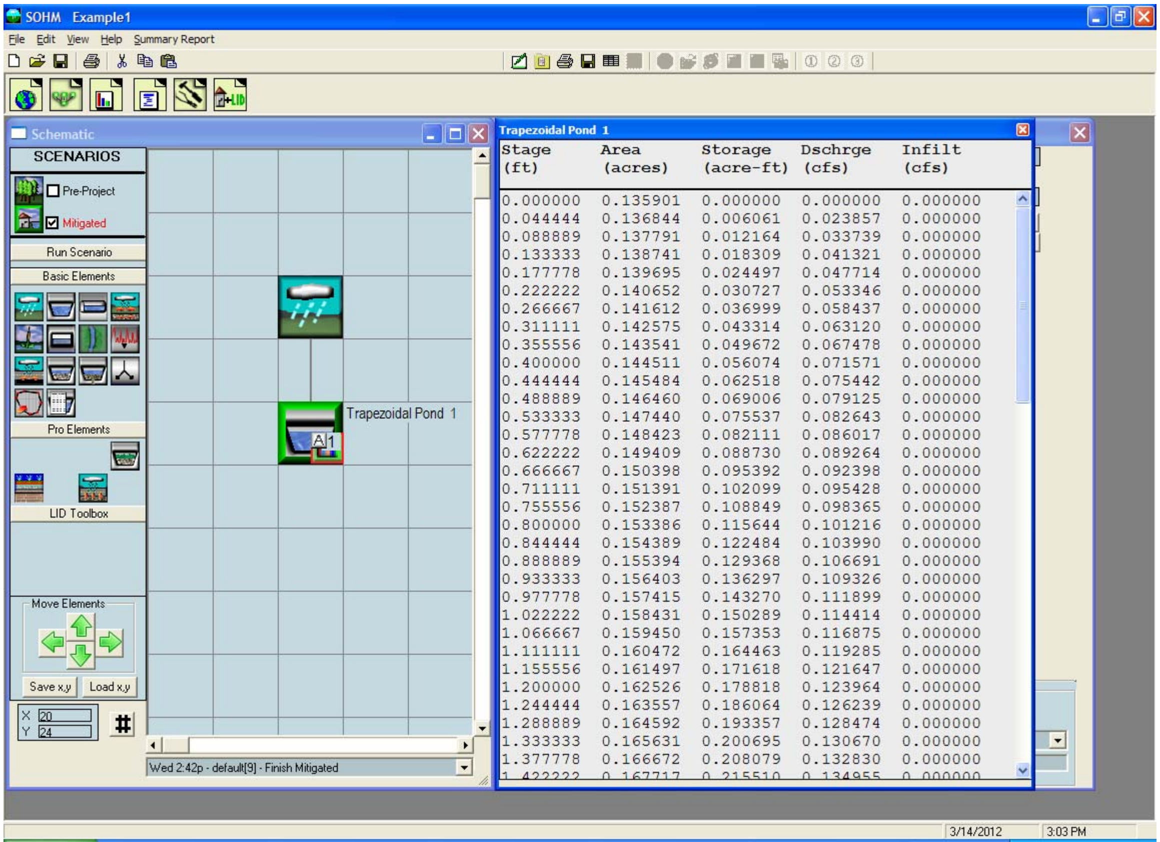
Time Series Element



SOHM uses time series of precipitation, evaporation, and runoff stored in its database (HSPF WDM file). The user has the option to create or use a time series file external from SOHM in SOHM. This may be a time series of flow values created by another HSPF model. An example is offsite runoff entering a project site. If this offsite runoff is in an existing WDM file and is the same period as SOHM data and the same simulation time step (15-minute) then it can be linked to SOHM model using the Time Series element.

To link the external time series to SOHM the user clicks on the Choose WDM button and identifies the external WDM file. The external WDM's individual time series files are shown in the Time Series Out box. The selected input dataset is the time series that will be used by SOHM.

Stage-Storage-Discharge Table

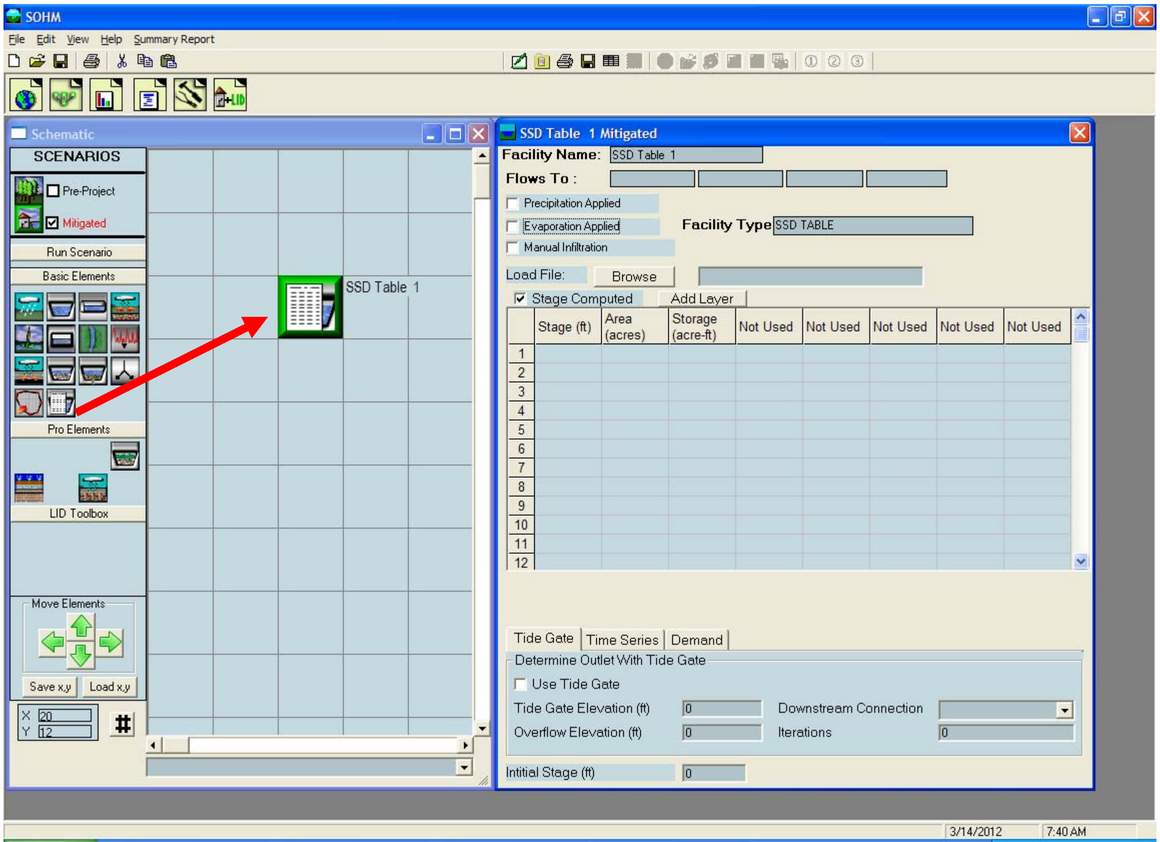


The stage-storage-discharge table hydraulically represents any facility that requires stormwater routing. The table is automatically generated by SOHM when the user inputs storage facility dimensions and outlet structure information. SOHM generates 91 lines of stage, surface area, storage, surface discharge, and infiltration values starting at a stage value of zero (facility bottom height) and increasing in equal increments to the maximum stage value (facility effective depth).

When the user or SOHM changes a facility dimension (for example, bottom length) or an orifice diameter or height the model immediately recalculates the stage-storage-discharge table.

The user can input to SOHM a stage-storage-discharge table created outside of SOHM. To use a stage-storage-discharge table created out of SOHM the SSD Table element is required. See the SSD Table element description below for more information on how to load such a table to SOHM program.

SSD Table Element



The SSD Table is a stage-storage-discharge table externally produced by the user and is identical in format to the stage-storage-discharge tables generated internally by SOHM for ponds, vaults, tanks, and channels.

The easiest way to create a SSD Table outside of SOHM is to use a spreadsheet with a separate column for stage, surface area, storage, and discharge (in that order). Save the spreadsheet file as a space or comma-delimited file. A text file can also be created, if more convenient.

The SSD Table must use the following units:
Stage: feet
Surface Area: acres
Storage: acre-feet
Discharge: cubic feet per second (cfs)

A fifth column can be used to create a second discharge (cfs). This second discharge can be infiltration or a second surface discharge.

Certain rules apply to the SSD Table whether it is created inside or outside of SOHM. These rules are:

1. Stage (feet) must start at zero and increase with each row. The incremental increase does not have to be consistent.

2. Storage (acre-feet) must start at zero and increase with each row. Storage values should be physically based on the corresponding depth and surface area, but SOHM does not check externally generated storage values.

3. Discharge (cfs) must start at zero. Discharge does not have to increase with each row. It can stay constant or even decrease. Discharge cannot be negative. Discharge should be based on the outlet structure's physical dimensions and characteristics, but SOHM does not check externally generated discharge values.

4. Surface area (acres) is only used if precipitation to and evaporation from the facility are applied.

To input an externally generated SSD Table, first create and save the table outside of SOHM. Use the Browse button to locate and load the file into SOHM.

Bioretention/Rain Garden Element

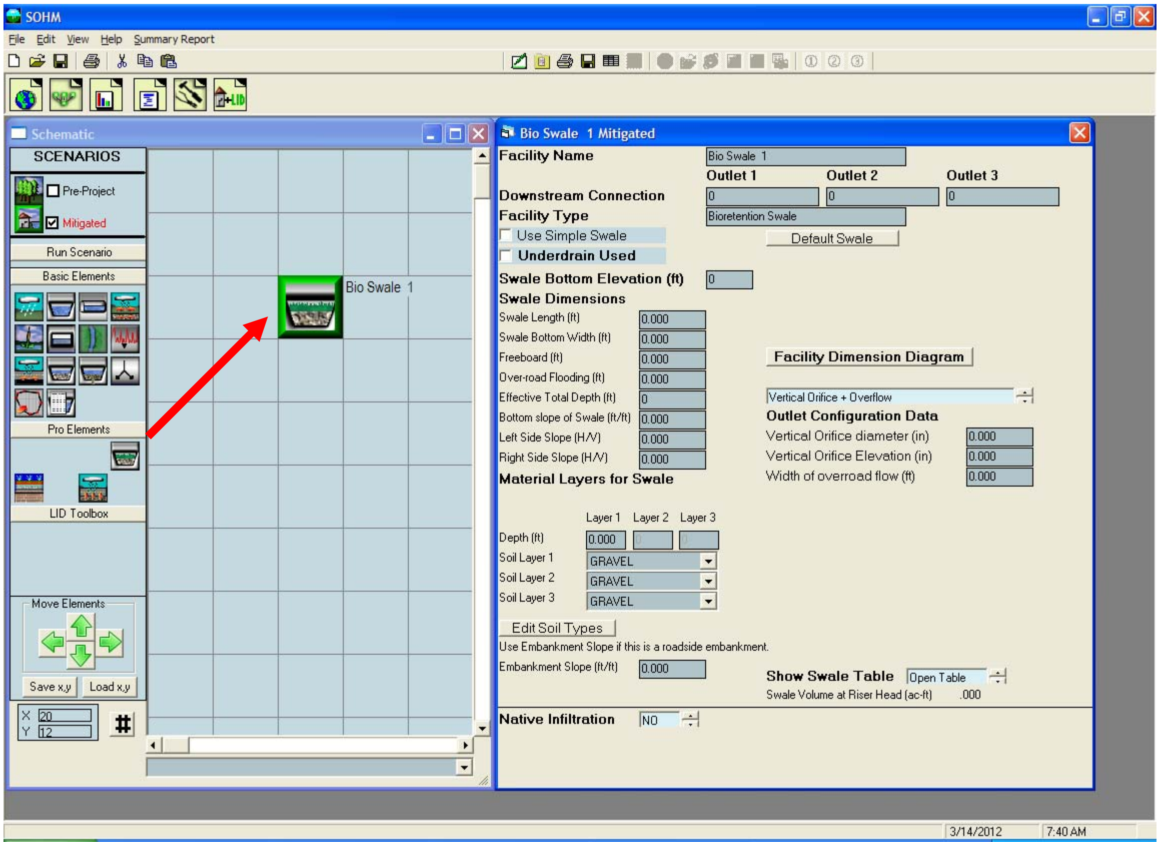
The bioretention swale element is also known as a landscape swale or rain garden. The SOHM bioretention swale element is a special conveyance feature with unique characteristics. The element uses the HSPF hydraulic algorithms to route runoff, but the HSPF routing is modified to represent the two different flow paths that runoff can take. The routing is dependent on the inflow to the swale and the swale soil capacity to absorb additional runoff. HSPF Special Actions is used to check the swale soil capacity to determine the appropriate routing option.

A bioretention swale is a swale in which the native soils have been excavated and replaced with amended soil. At the downstream end of the swale a weir controls the surface discharge from the swale and detains runoff, encouraging it to infiltrate into the amended soil. Infiltration from the amended soil to the native soil is also possible, depending on the properties of the native soil. Swales can include an underdrain pipe.

The amended soil placed in the swale is assumed to have storage capacity equal to its porosity and volume. Runoff infiltrates from the surface of the swale to the amended soil at an infiltration rate set by the user. The infiltration rate cannot exceed the available storage capacity of the amended soil. The available storage capacity is determined each time step by HSPF Special Actions. Once the amended soil is saturated then water has the opportunity to infiltrate into the underlying native soil at the native soil's infiltration rate. The native soil infiltration is input by the user and is assumed to be constant throughout the year.

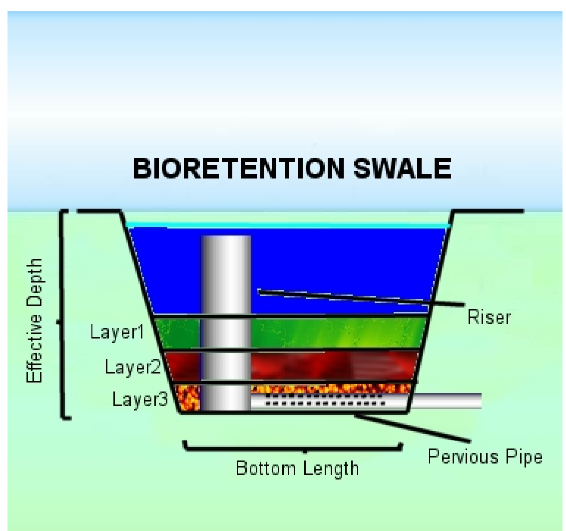
Inflow to the swale can exceed the amended soil infiltration rate. When this occurs the extra water ponds on the surface of the swale. The extra water can then infiltrate into the soil during the next time step or can flow out of the swale through its surface outlet if the ponding exceeds the surface outlet's storage.

Runoff in both the surface storage and amended soil storage is available for evapo-transpiration. Surface storage evapotranspiration is set to the potential evapo-transpiration; the amended soil evapotranspiration pan evaporation factor is set to 0.50 to reflect reduced evapotranspiration from the amended soil.



The user is required to enter the following information about the bioretention swale:

The bioretention swale dimensions are specified in terms of swale length, bottom width, freeboard, over-road flooding, effective total depth, bottom slope, and left and right side slopes.



Swale Length (ft): length dimension of swale surface bottom.
Swale Bottom Width (ft): width dimension of swale surface bottom.
Freeboard (ft): depth of surface ponding before weir/street overflow occurs.
Over-road Flooding (ft): maximum depth of flow over weir/street.
Effective Total Depth (ft): the total depth of the amended soil layer(s) plus freeboard plus over-road flooding plus vertical orifice elevation plus vertical orifice diameter; effective total depth is computed by SOHM.
Bottom Slope of Swale (ft/ft): the slope of the swale length; must be greater than zero.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical swale sides.

Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical swale sides.

In the amended soil water movement through the soil column is dependent on soil layer characteristics and saturation rates for different discharge conditions.

Consider a simple two-layered bioretention facility designed with two soil layers with different characteristics. As water enters the facility at the top, it infiltrates into the soil based on the modified Green Ampt equation (Equation 1). The water then moves through the top soil layer at the computed rate, determined by Darcy's and Van Genuchten's equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), we can determine when water will begin to infiltrate into the second layer (lower layer) of the soil column. This occurs when the matric head is less than the gravity head in the first layer (top layer).

Since the two layers have different soil characteristics, water will move through the two layers at different rates. Once both layers have achieved field capacity then the layer that first becomes saturated is determined by which layer is more restrictive. This is determined by using Darcy's equation to compute flux for each layer at the current level of saturation. The layer with the more restrictive flux is the layer that becomes saturated for that time step. The next time step the same comparison is made.

The rate and location of water discharging from the soil layer is determined by the discharge conditions selected by the user.

There are four possible combinations of discharge conditions:

1. There is no discharge from the subsurface layers (except for evapotranspiration). This means that there is no underdrain and there is no infiltration into the native soil. Which this discharge condition is unlikely, we still need to be able to model it.

2. There is an underdrain, but no native infiltration. Discharge from the underdrain is computed based on head conditions for the underdrain. The underdrain is configured to have an orifice. (It is possible for the orifice to be the same diameter as the underdrain.) With a maximum of three soil layers determining head conditions for the orifice is complicated. Each modeled layer must overcome matric head before flow through the underdrain can begin. Once matric head is overcome by gravity head for all of the layers then the underdrain begins to flow. The flow rate is determined based on the ability of the water to move through the soil layers and by the discharge from the orifice, whichever is smaller. Head conditions are determined by computing the saturation level of the lowest soil layer first. Once the lowest soil layer is saturated and flow begins then the gravity head is considered to be at the saturation level of the lowest soil layer. Once the lowest soil layer is saturated completely then the head will include the gravity head from the next soil layer above until gravity head from all soil layers is included. Gravity head from ponding on the surface is included in the orifice calculations only if all of the intervening soil layers are saturated.

3. There is native infiltration but no underdrain. Discharge (infiltration) into the native soil is computed based a user entered infiltration rate in units of inches per hour. Specific head conditions are not used in determining infiltration into the native soil. Any impact due to head on the infiltration rate is considered to be part of the determination of the native soil infiltration rate. Because it is possible to have a maximum of three soil layers, each modeled layer must overcome matric head before infiltration to the native soil can begin. Once matric head is overcome by gravity head for all modeled layers then infiltration begins at a maximum rate determined either by the ability of the water to move through the soil layers or by the ability of the water to infiltrate into the native soil, whichever is limiting.

4. There is both an underdrain and native infiltration. Underdrain flow and native infiltration are computed as discussed above. However, there is one other limitation to consider. In the case where the flow through the soil layer is less than the sum of the discharge through the underdrain and the native infiltration then the flow through the soil layer becomes the limiting flow and must be divided between the native infiltration and the underdrain. This division is done based on the relative discharge rates of each.

Note that wetted surface area can be included in the discharge calculations by adding the infiltration through the wetted surface area to the lower soil layer and the upper surface layer individually. This is done by computing the portion of the wetted surface area that is part of the upper surface layer and computing the infiltration independently from the portion of the wetted surface area that is part of the lower soil layers.

There are several equations used to determine water movement from the surface of the bioretention facility, through the soil layers, and into an underdrain or native infiltration. The water movement process can be divided into three different zones:

1) Surface ponding and infiltration into the top soil layer (soil layer 1)
2) Percolation through the subsurface layers
3) Underdrain flow and native infiltration

The modified Green Ampt equation (Equation 1) controls the infiltration rate into the top soil layer:

$$f = K\left(1 + \frac{(\phi - \theta)(d + \varphi)}{F}\right) \qquad \text{(Equation 1)}$$

f = soil surface infiltration rate (cm/hr)
ϕ=soil porosity of top soil layer
θ=soil moisture content of top soil layer
φ=suction head at the wetting front (cm)
F= soil moisture content of the top soil layer (cm)
d= surface ponding depth (cm)
K= hydraulic conductivity based on saturation of top soil layer (cm/hr)

K (relative hydraulic conductivity) can be computed using the following Van Genuchten approximation equation:

Van Genuchten approximation of relative hydraulic conductivity

$$\frac{K(\theta)}{K_{sat}} = \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/2}\left[1 - \left(1 - \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/m}\right)^m\right]^2 \qquad \text{(Equation 2)}$$

where $K(\theta)$ = relative hydraulic conductivity,
K_{sat} = saturated hydraulic conductivity,
θ = water content, θ_r = residual water content,
ϕ = porosity, α = constant, n = constant, m = constant

A few issues arise when dealing with multiple subsurface soil layers. The K value used in Equation 1 must be computed from the top soil layer. Infiltration into the upper soil layer must not exceed the lesser of the maximum percolation rates for each of the soil layers. Finally, the rate of percolation of the top layer may be reduced because the layer or layers beneath the top layer cannot accept the percolation flux because of existing saturation levels.

Water storage and movement through the three subsurface layers will be computed using Darcy's equation as shown below:

$$q = -K \frac{\partial h}{\partial z} \qquad \text{(Equation 3)}$$

Where:

q = Darcy flux (cm/hr)

K = hydraulic conductivity of the porous medium (cm/hr)

h = total hydraulic head (cm)

z = elevation (cm)

The total head, h, is the sum of the matric head, ψ, and the gravity head, z:

$$h = \psi + z \ . \qquad \text{(Equation 4)}$$

Substituting for h yields:

$$q = -K \frac{d(\psi + z)}{dz} \ . \qquad \text{(Equation 5)}$$

Hydraulic conductivity and matric head vary with soil moisture content. These values can be computed by solving the Van Genuchten's equation (Equation 6) for both values. Note that $\psi = 0$ when the soil is saturated.

Van Genuchten Equation to calculate total head

$$h = -\frac{1}{\alpha}\left[\frac{1}{SE^{1/m}} - 1\right]^{1/n} + z \qquad \text{(Equation 6)}$$

where h = total hydraulic head, α = constant, SE = effective saturation, m = constant, n = constant, and z = elevation head

Effective saturation (SE) can be computed using the following Van Genuchten equation:

Van Genuchten Equation to calculate effective saturation

$$\frac{\theta - \theta_r}{\phi - \theta_r} = \left[\frac{1}{1 + (\alpha\psi)^n}\right]^m = SE \qquad \text{(Equation 7)}$$

where θ = water content, θ_r = residual water content,
ϕ = porosity,
α = constant = $y_b - 1$,
n = constant = $\lambda + 1$,
m = constant = $1 - \frac{1}{\lambda + 1}$,
λ = pore size distribution index,
y_b = bubbling pressure
ψ = pressure head = h-z, h = total hydraulic head,
z = elevation head, and SE = effective saturation

Ignoring z (elevation head) results in h = hm (matric head).

Evapotranspiration is an important component of the bioretention facility's hydrologic processes. Evapotranspiration removes water from bioretention surface ponding and the soil column during non-storm periods. The routine will satisfy potential evapo-transpiration (PET) demands in the same sequence as implemented in HSPF:

1. Water available from vegetation interception storage
2. Water available from surface ponding
3. Water available from the bioretention soil layers (top layer first)

Water will be removed from vegetation interception storage and surface ponding and the bioretention soil layers (starting at the top layer) down to the rooting depth at the potential rate. Water is taken from the soil layers below the rooting depth based on a percentage factor to be determined. Without this factor there will be no way to remove water from below the rooting depth once it becomes completely saturated.

The user inputs:

Layer Thickness (feet): depth of amended soil.
Type of amended soil: 24 different soil types are included; the user can also create their own soil type using the Edit Soil Type button.

Note that there can be a maximum of three different amended soil layers.

Infiltration to the native soil can be turned on by setting Native Infiltration to YES. The parameters for native soil infiltration are:

Measured Infiltration Rate (inches per hour): infiltration rate of the native soil.
Infiltration Reduction Factor: between 0 and 1 (1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): YES or NO; YES allows infiltration to the native soil through the sidewalls of the swale; otherwise all infiltration is through the bottom only.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

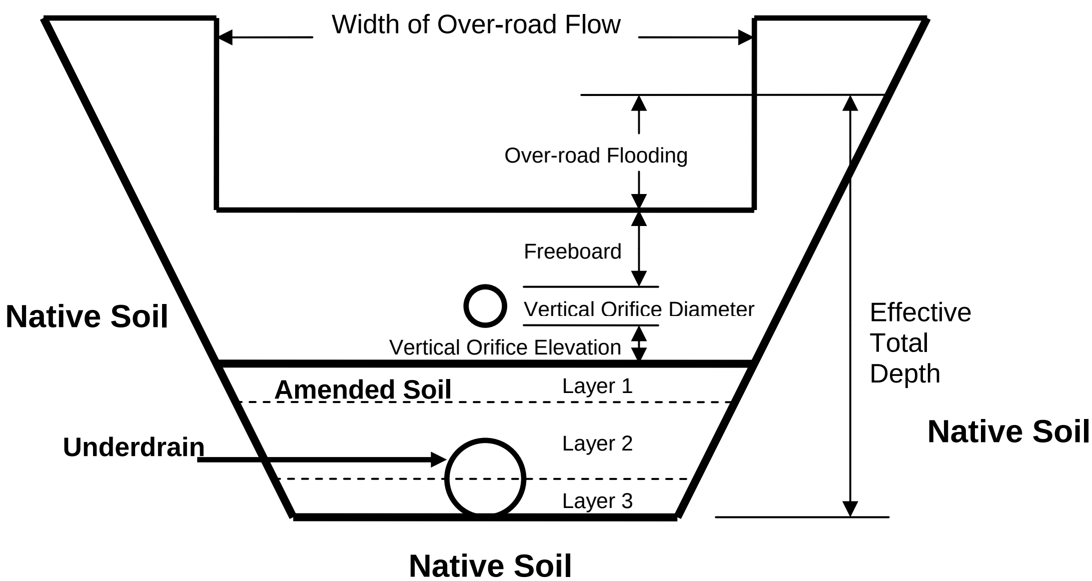
*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

The user has two swale surface outlet configuration choices: (1) vertical orifice + overflow or (2) riser outlet structure.

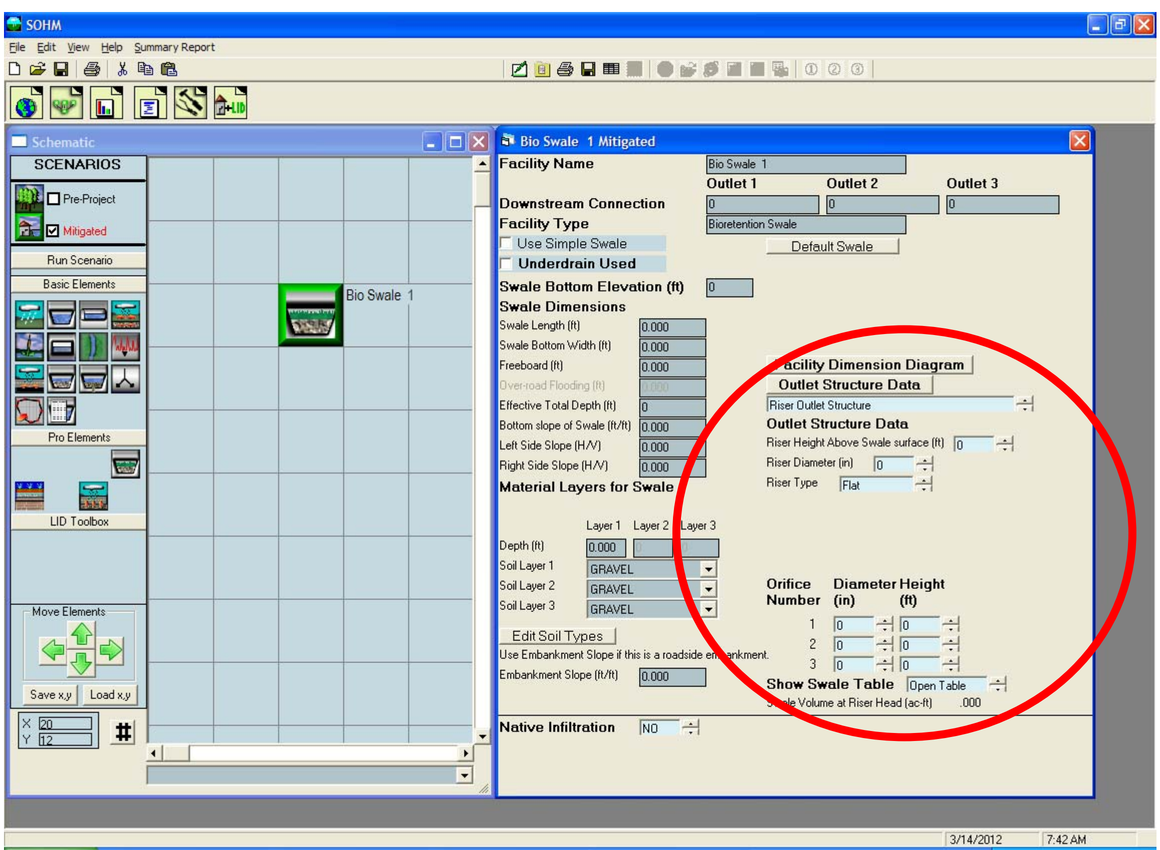
The input information required for the vertical orifice plus overflow is:

Vertical Orifice Diameter (inches): diameter of vertical opening below the weir.
Vertical Orifice Elevation (inches): vertical distance from the top of the amended soil surface to the bottom of the vertical orifice.
Width of Over-road Flow (feet): weir/street length.

Diagram of bioretention swale with vertical orifice plus overflow:



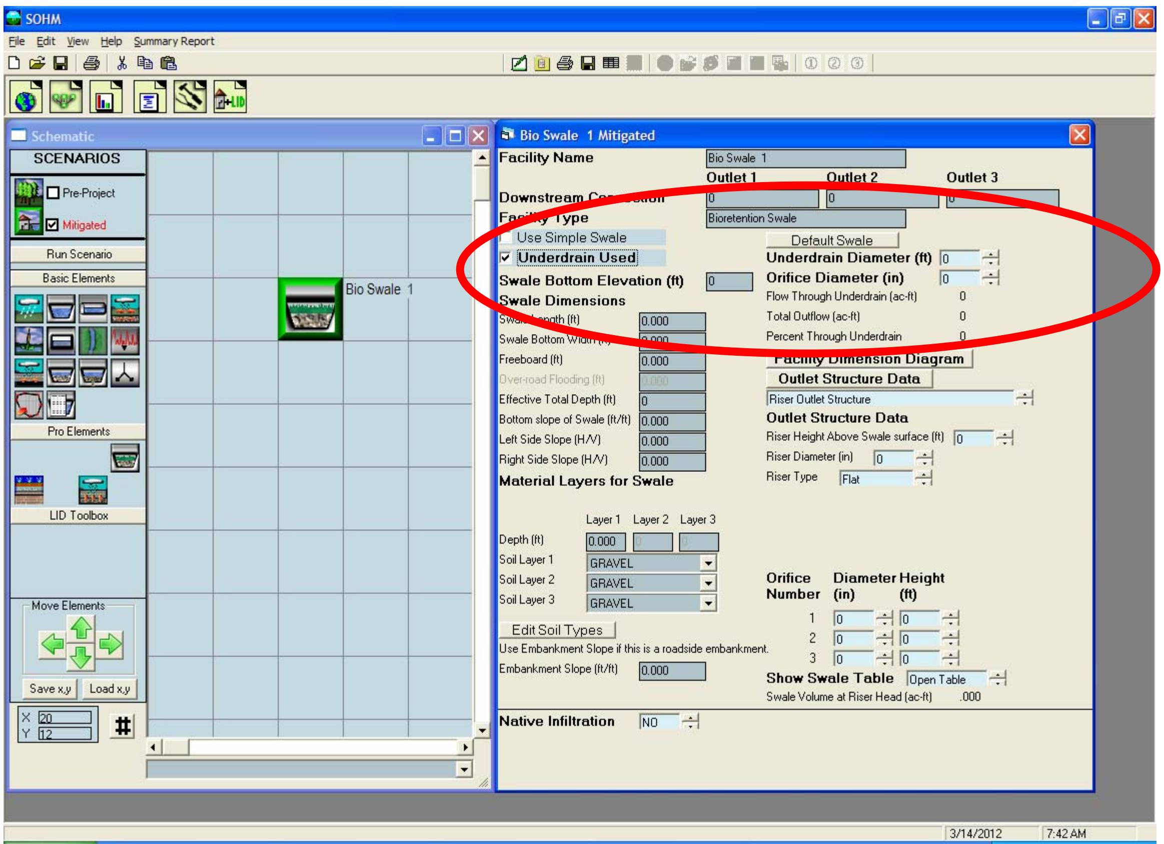
Riser outlet structure option:



The input information required for the riser outlet structure is:

Riser Height above Swale Surface (feet): depth of surface ponding before the riser is overtopped.
Riser Diameter (inches): diameter of the stand pipe.
Riser Type: Flat or Notched.
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in **Outlet Structure Configurations** section.



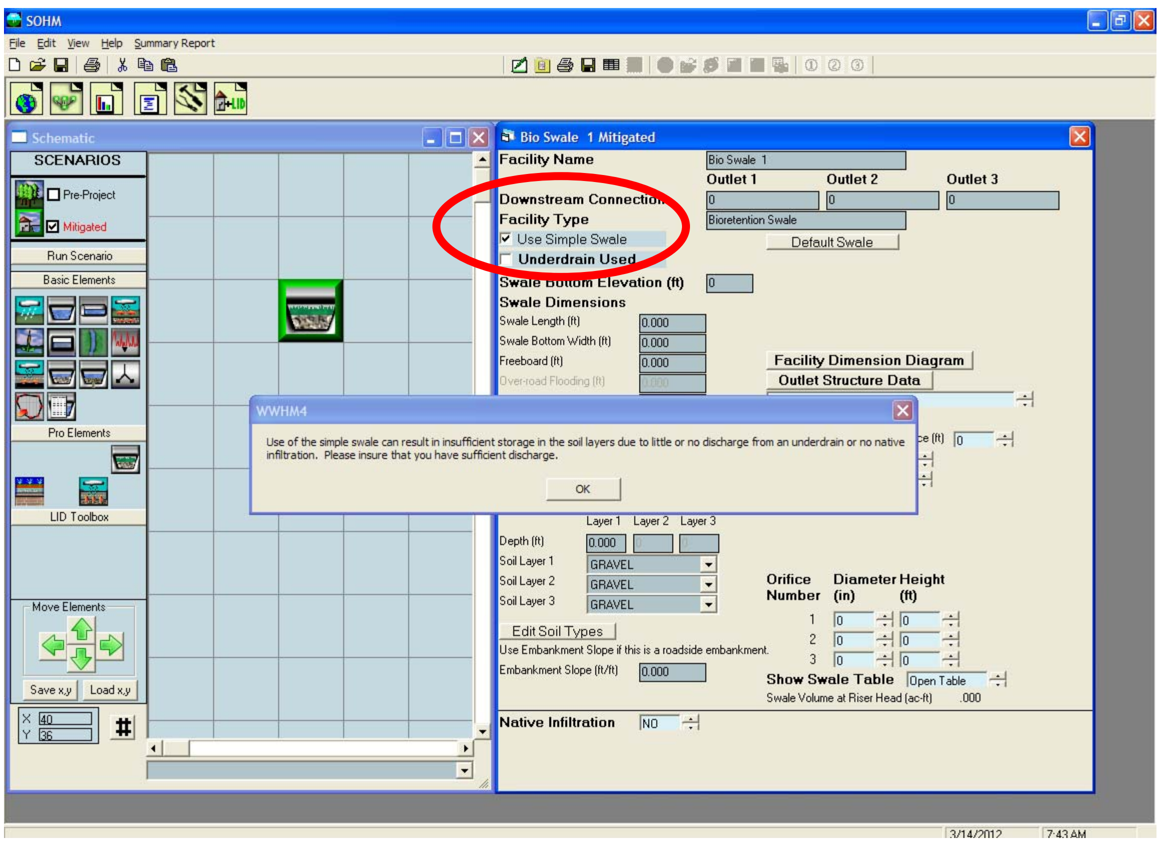
To use the underdrain click the Underdrain Used box and input an underdrain pipe diameter (feet) and underdrain outlet orifice diameter (inches). The bottom of the underdrain pipe is assumed to be at the bottom of the amended soil layer.

The amended soil layer fills with stormwater from the top on down to where it can drain to the native soil (if Native Infiltration is set to YES) and/or the underdrain pipe (if Underdrain Used box is checked).

Water enters the underdrain when the amended soil becomes saturated down to the top of the underdrain. The underdrain pipe fills and conveys water proportionally to the depth of amended soil saturation. When the amended soil is fully saturated the underdrain pipe is at full capacity. Discharge from the underdrain pipe is controlled by the underdrain orifice diameter.

If native infiltration is turned on then native infiltration will start when/if:

1. Water starts to fill the underdrain (if an underdrain is used).
2. Water enters the amended soil (if Use Wetted Surface Area (sidewalls) is set to YES).
3. Water saturates the amended soil layer(s) to 2/3rds of the total amended soil depth (if there is no underdrain and Wetted Surface Area is set to NO).



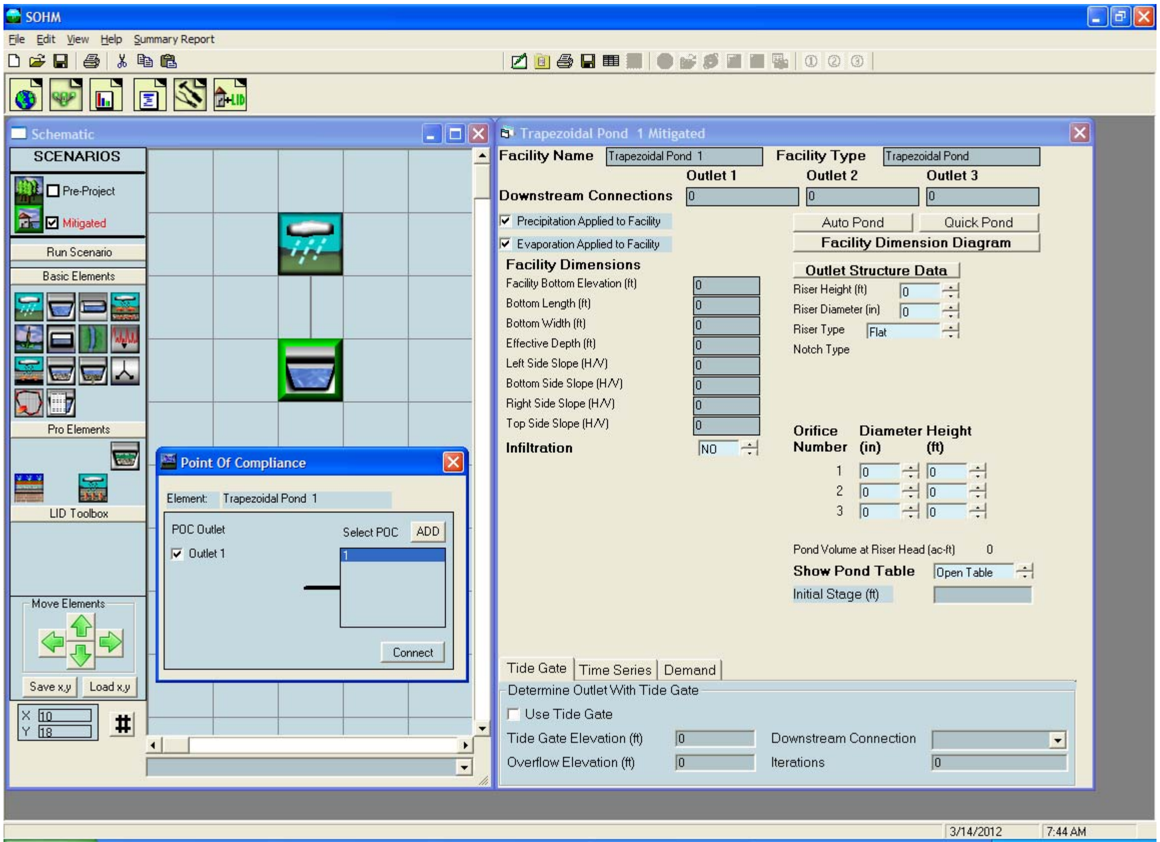
There is a simple swale option. It is computationally much faster than the standard bioretention swale. Before using the simple swale option read the note on the screen and the information below to understand the limitations of the simple swale.

The standard bioretention swale routine uses HSPF Special Actions to check the available amended soil storage and compares it with the inflow rate. Because of the check done by HSPF Special Actions simulations using bioretention swales take much longer than simulations not using bioretention swales. Simulations that normally take only seconds may take multiple minutes when one or more bioretention swales are added, depending on the computational speed of the computer used.

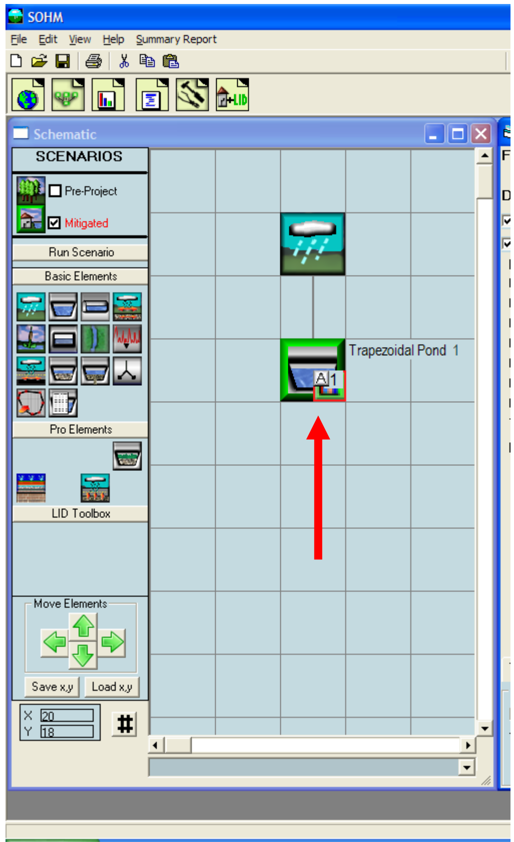
One solution to this problem is to use the simple swale option (check the Use Simple Swale box). The simple swale does not include HSPF Special Actions. It is less accurate than the standard swale. Tests have shown that the simple swale option should only be used when the swale area (and volume) is relatively small compared to the contributing basin area. If in doubt, model the bioretention swale both ways and see how close the simple swale answer is to the standard swale method. The standard swale method will always be more accurate than the simple swale.

Point Of Compliance

SOHM allows for multiple points of compliance (maximum of 59) in a single project. A point of compliance is defined as the location at which the Predevelopment and Mitigated flows will be analyzed for compliance with the flow control standard.



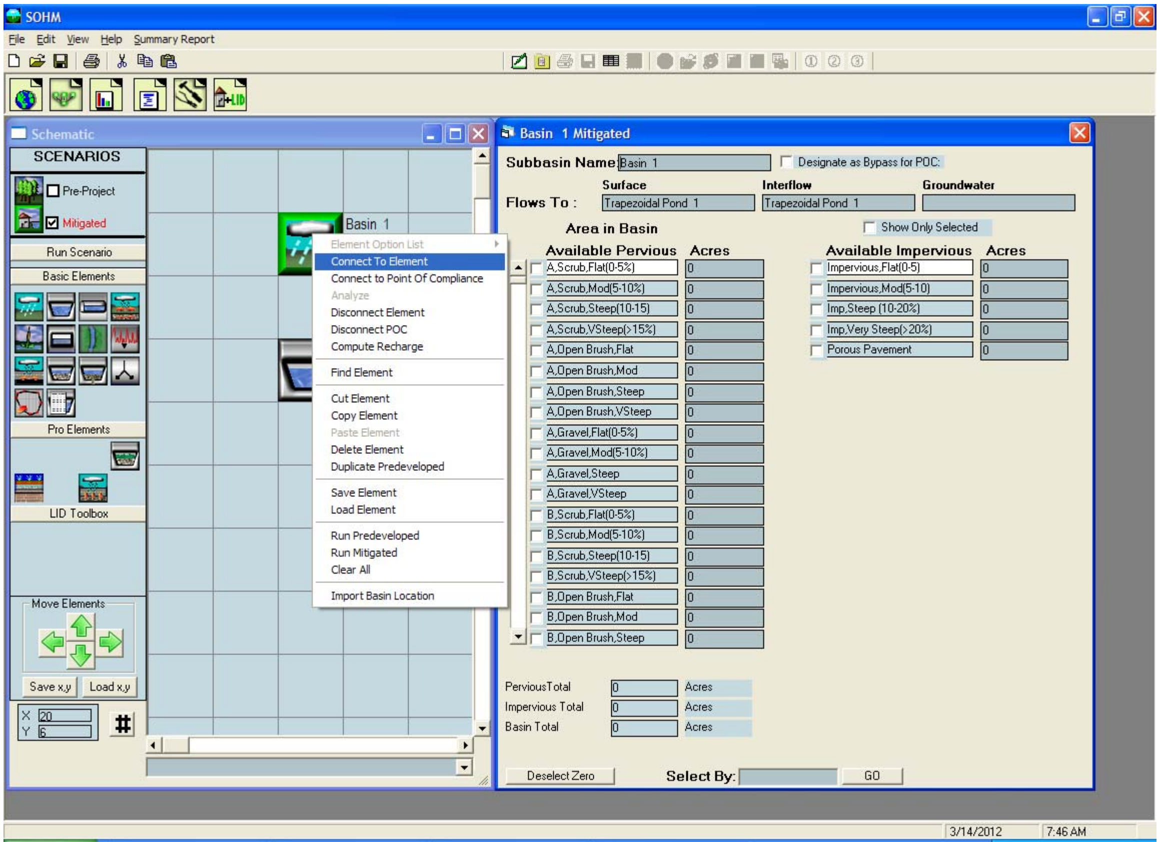
The point of compliance is selected by right clicking on the element at which the compliance analysis will be made. In the example above, the point of compliance analysis will be conducted at the outlet of the trapezoidal pond.



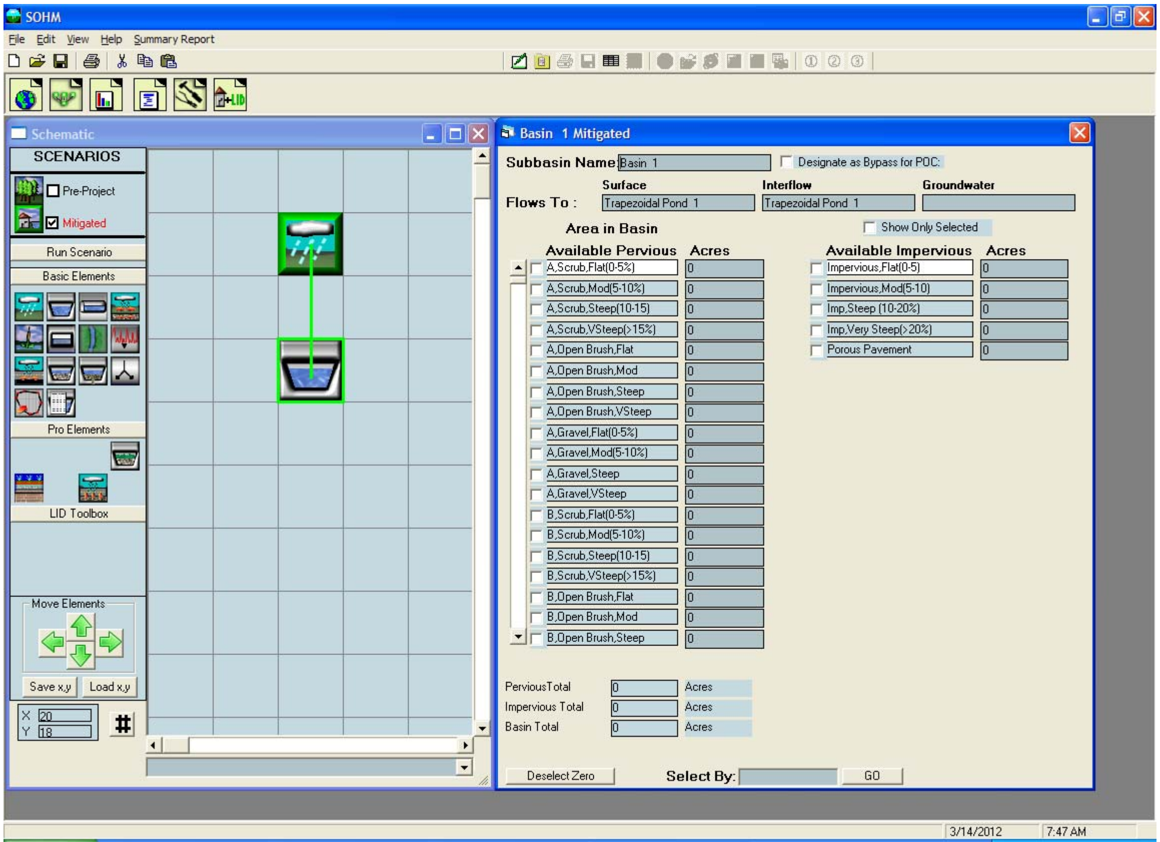
Once the point of compliance has been selected the element is modified on the Schematic screen to include a small box with the letter "A" (for Analysis) in the lower right corner. This identifies the outlet from this element as a point of compliance.

The number 1 next to the letter "A" is the number of the POC (POC 1).

Connecting Elements

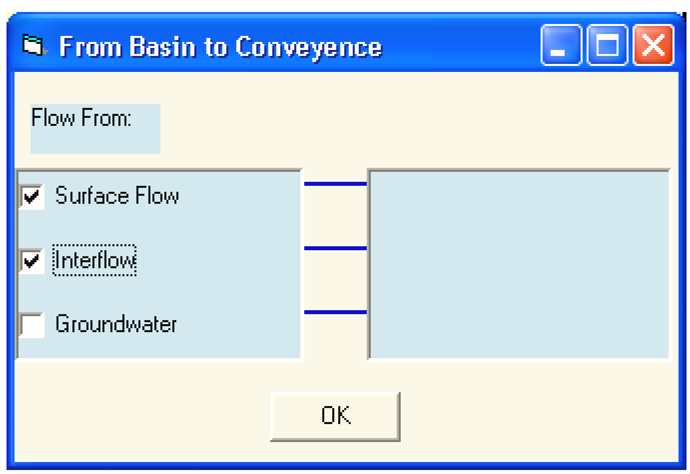


Elements are connected by right clicking on the upstream element (in this example Basin 1) and selecting and then left clicking on the Connect To Element option. By doing so SOHM extends a line from the upstream element to wherever the user wants to connect that element.

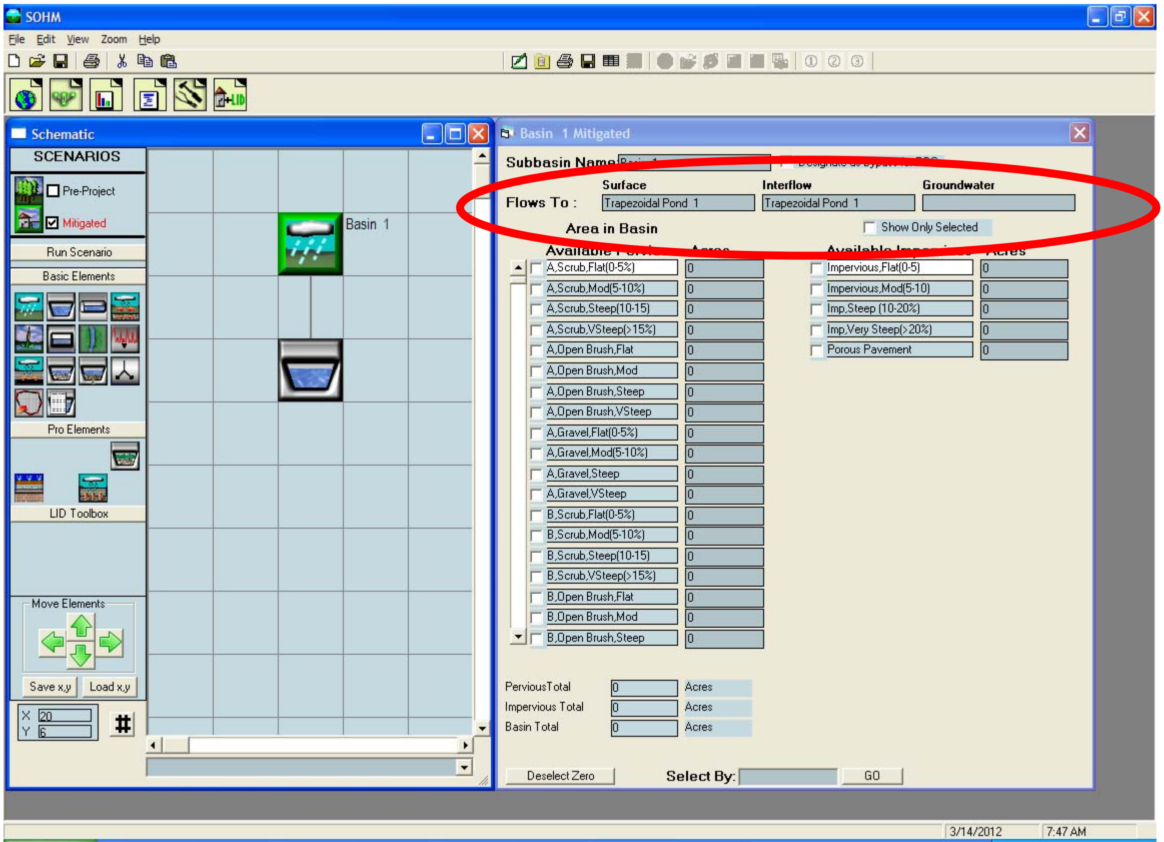


The user extends the connection line to the downstream element (in this example, a pond) and left clicks on the destination element. This action brings up the From Basin to Conveyance box that allows the user to specify which runoff components to route to the downstream element.

Stormwater runoff is defined as surface flow + interflow. Both boxes should be checked. Groundwater should not be checked for the standard land development mitigation analysis. Groundwater should only be checked when there is observed and documented base flow occurring from the upstream basin.

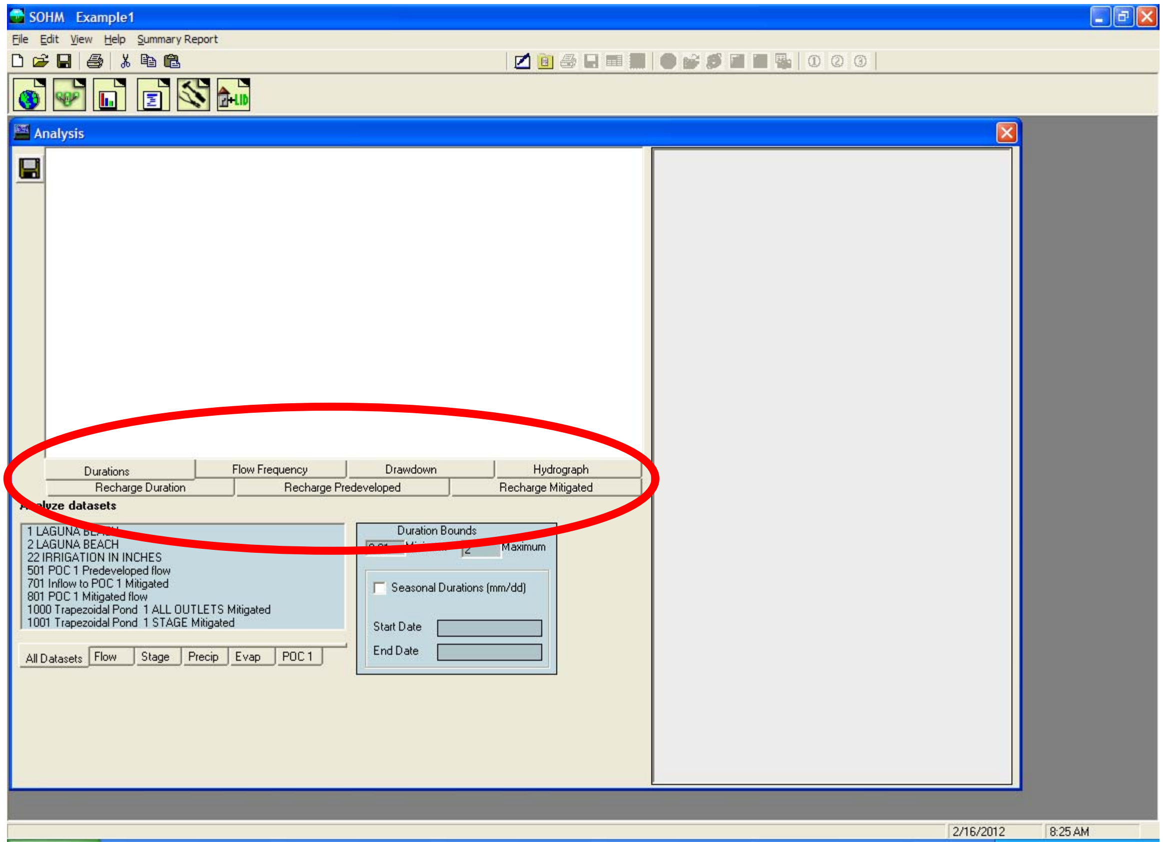


After the appropriate boxes have been checked click the OK button.



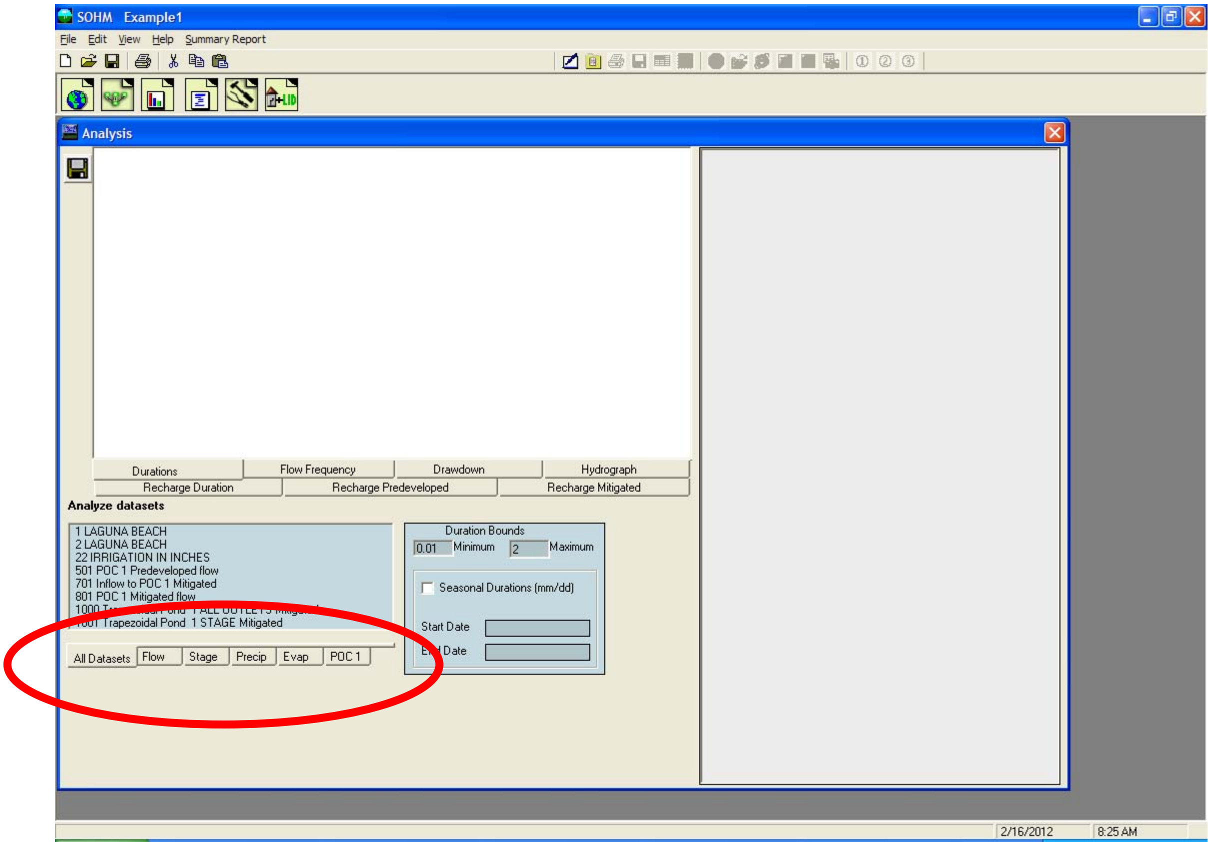
The final screen will look like the above screen. The basin information screen on the right will show that Basin 1 surface and interflow flows to Trapezoidal Pond 1 (groundwater is not connected).

ANALYSIS SCREEN



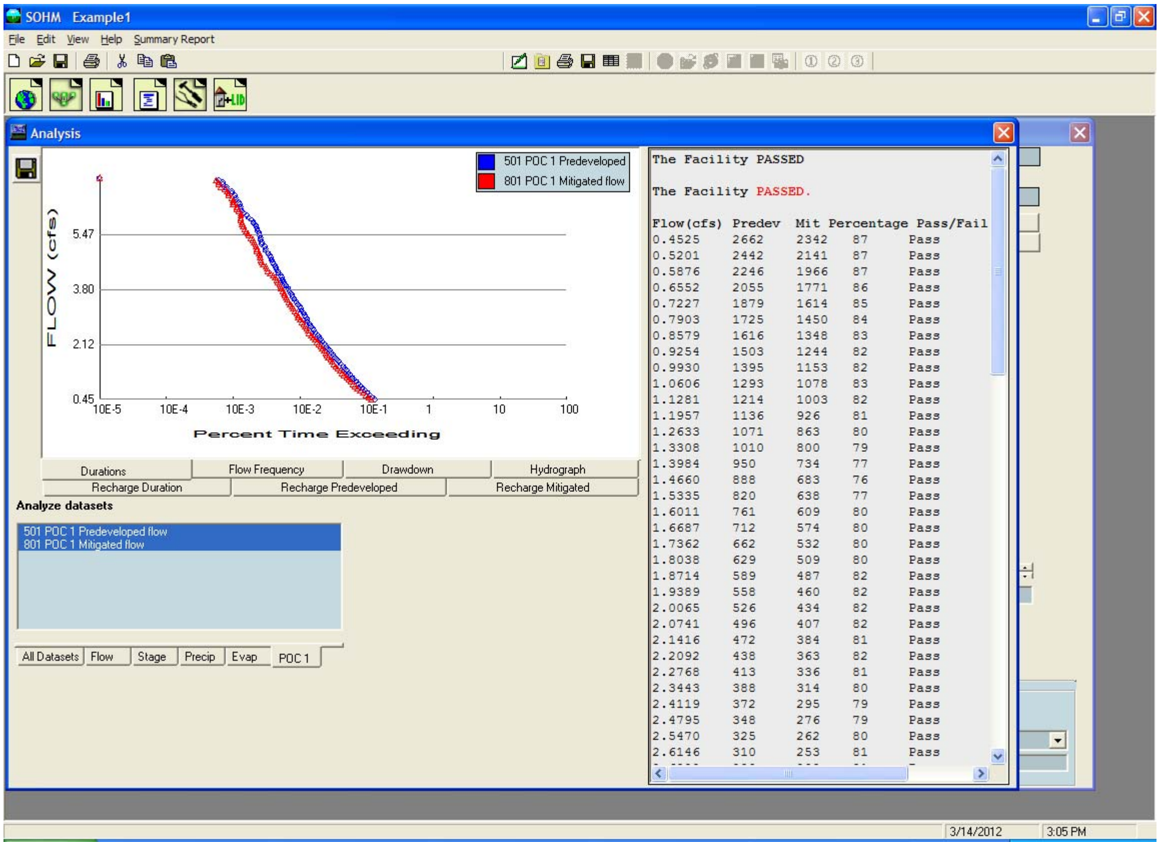
The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results of the Predevelopment and Mitigated scenarios. The Analysis screen allows the user to analyze and compare flow durations, flow frequency, drawdown times, and hydrographs.

The recharge tabs are for the optional analysis of determining Predevelopment and Mitigated recharge to the groundwater.



The user can analyze all time series datasets or just flow, stage, precipitation, evaporation, or point of compliance (POC) flows by selecting the appropriate tab below the list of the different datasets available for analysis.

Flow Duration



Flow duration at the point of compliance (POC 1) is the most common analysis. A plot of the flow duration values is shown on the left, the flow values on the right.

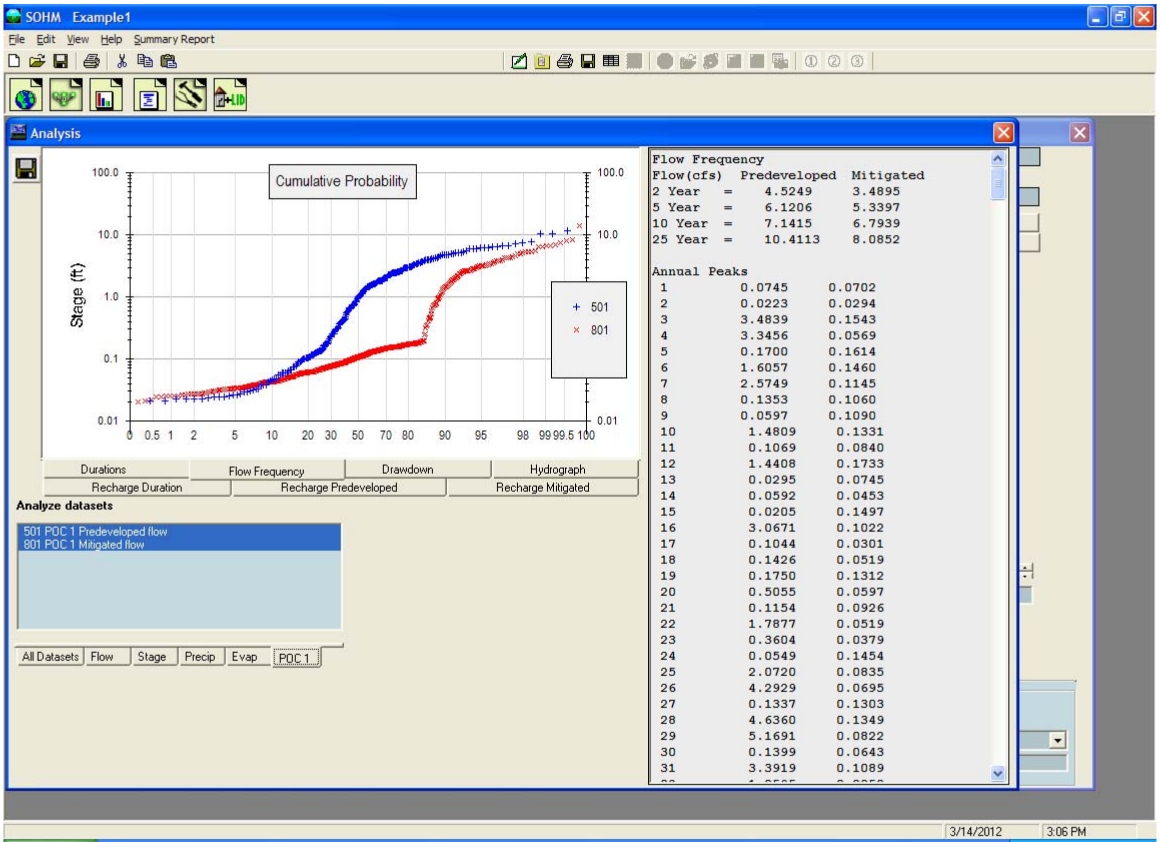
The flow duration flow range is from the lower threshold flow frequency value (10% of the 2-year value) to the upper threshold flow frequency value (10-year value). As shown in the flow duration table to the right of the flow duration curves, this flow range is divided into approximately 100 levels (flow values).

The division of the flow range into a large number of levels is important to make sure that the erosive flows do not increase between the lower threshold (10% of the 2-year flow) and the 2-year flow frequency value and between increasing flow frequency levels (3-year, 4-year, 5-year, etc.). The majority of the erosive flows occur between the 10% of the 2-year flow value and the 2-year flow frequency value. It is important to divide the flow levels in that range into multiple level steps to not miss any occasions when the mitigated flows exceed the predevelopment flows.

For each flow level/value SOHM counts the number of times that the flow at the Point of Compliance for the Predevelopment scenario (Predev) exceeds that specific flow level/value. It does the same count for the Mitigated scenario flow (Mit). The total number of counts is the number of simulated hours that the flow exceeds that specific flow level/value.

The Percentage column is the ratio of the Dev count to the Predev count. This ratio must be less than or equal to 110.0 for flow levels/values between the lower threshold value and the upper threshold value. If the percentage value does not exceed this maximum ratio (110% for the lower threshold value to the 10-year value) then the Pass/Fail column shows a Pass for that flow level. If they are exceeded then a Fail is shown. A single Fail and the facility fails the flow duration criteria. The facility overall Pass/Fail is listed at the top of the flow duration table.

Flow Frequency



Flow frequency plots are shown on the left and the 2-, 5-, 10-, and 25-year frequency values are on the right. Flow frequency calculations are based on selecting partial duration flow values and ranking them by their Cunnane Plotting Position.

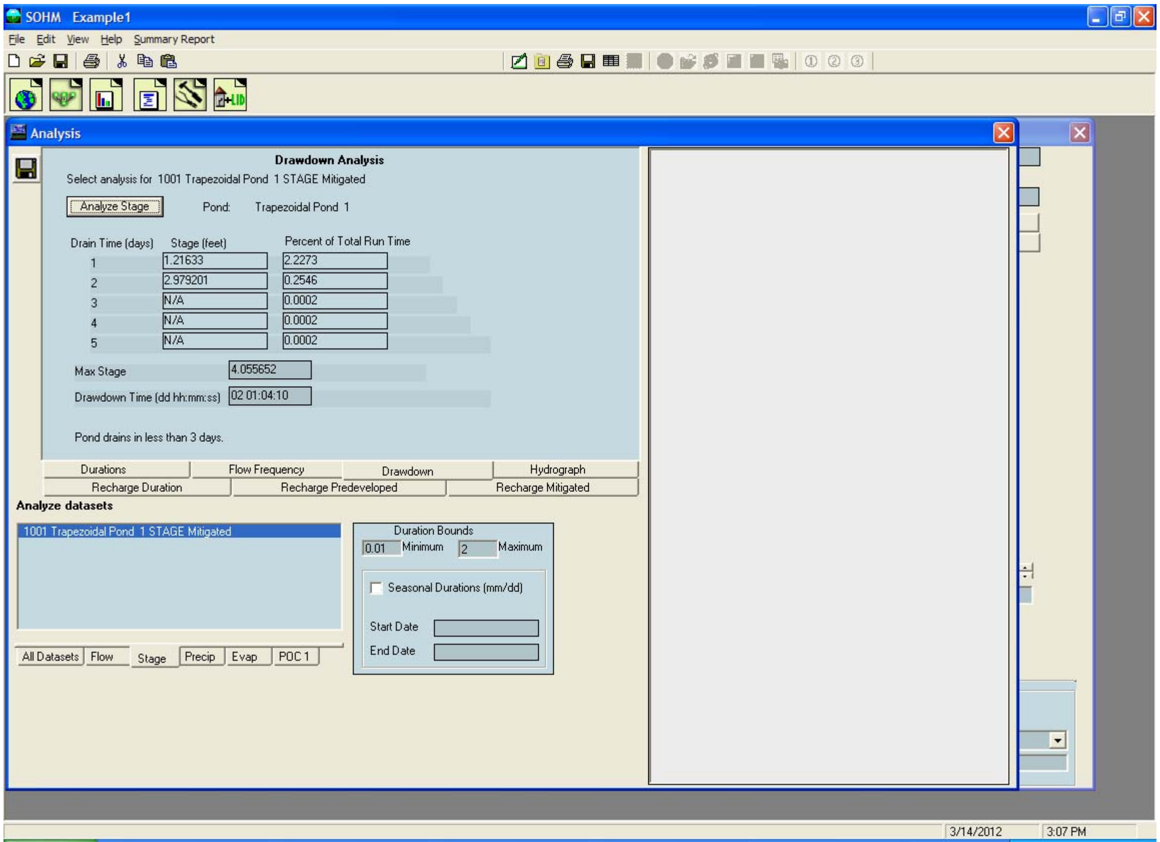
The Cunnane Plotting Position formula is:

Tr = (N+a)/(m-b) where Tr = return period (years)
m = rank (largest event, m = 1)
N = number of years
a = 0.2
b = 0.4

Probability = 1/Tr

The return period value, Tr, is used in SOHM to determine the 2-year, 5-year, 10-year, and 25-year peak flow values. If necessary, the 2-year, 5-year, 10-year, and 25-year values are interpolated from the Tr values generated by Cunnane.

Drawdown



The drawdown screen is used to compute pond stages (water depths). These stages are summarized and reported in terms of drain/retention time (in days).

For this example, the maximum stage computed during the entire 40-60 year simulation period is 4.05 feet. This maximum stage has a drawdown time of 2 days, 1 hour, 4 minutes, 10 seconds (approximately 49 hours).

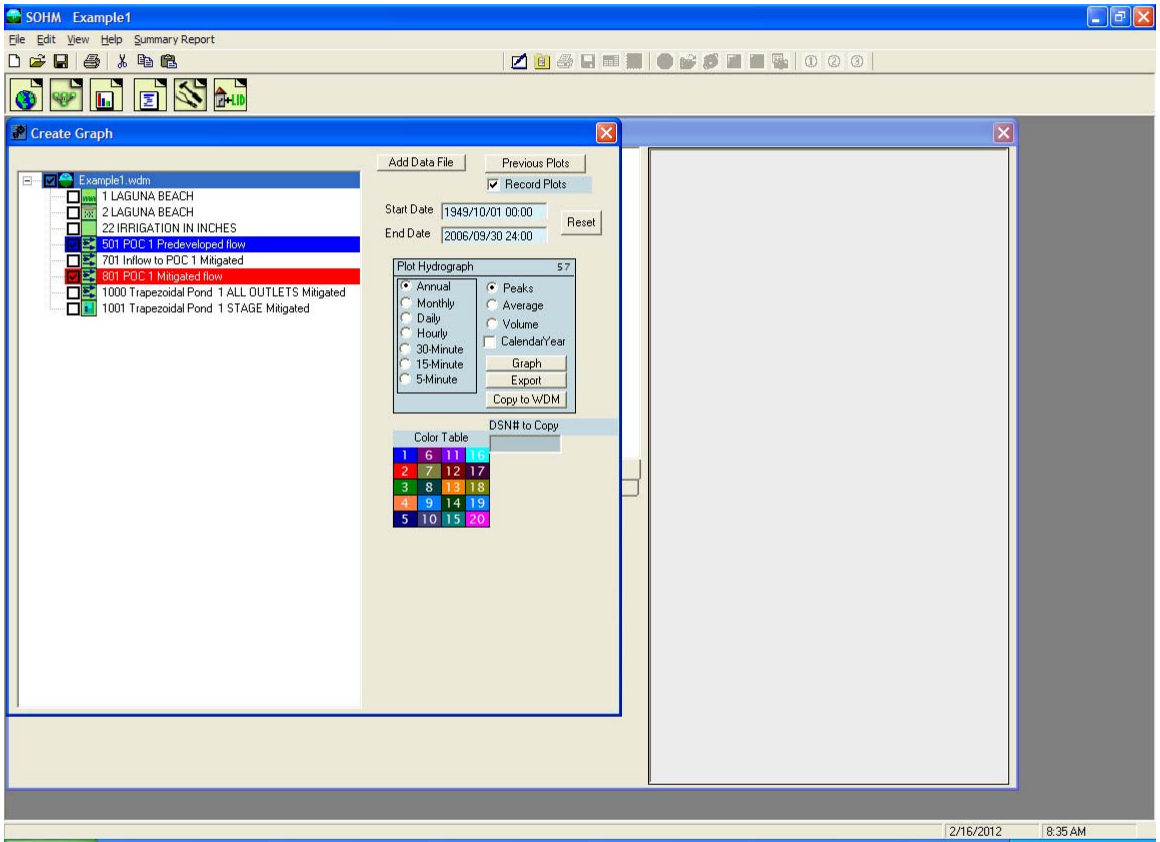
The 1-day (24-hour) drain time is needed to drain the pond when it is at a stage of 1.22 feet. This stage occurs 2.23% of the total simulation time.

The 2-day (48-hour) drain time is needed to drain the pond when it is at a stage of 2.98 feet. This stage occurs 0.25% of the total simulation time.

Ponds may have drain times in excess of the allowed maximum. This can occur when a pond has a small bottom orifice. If this is not acceptable then the user needs to change the pond outlet configuration, manually run the Mitigated scenario, and repeat the analyze stage computations. A situation may occur where it is not possible to have both an acceptable pond drawdown/ retention time and meet the flow duration criteria.

*NOTE: The flow duration criteria take precedence unless the user is instructed otherwise by **Appendix C** or the local municipal permitting agency.*

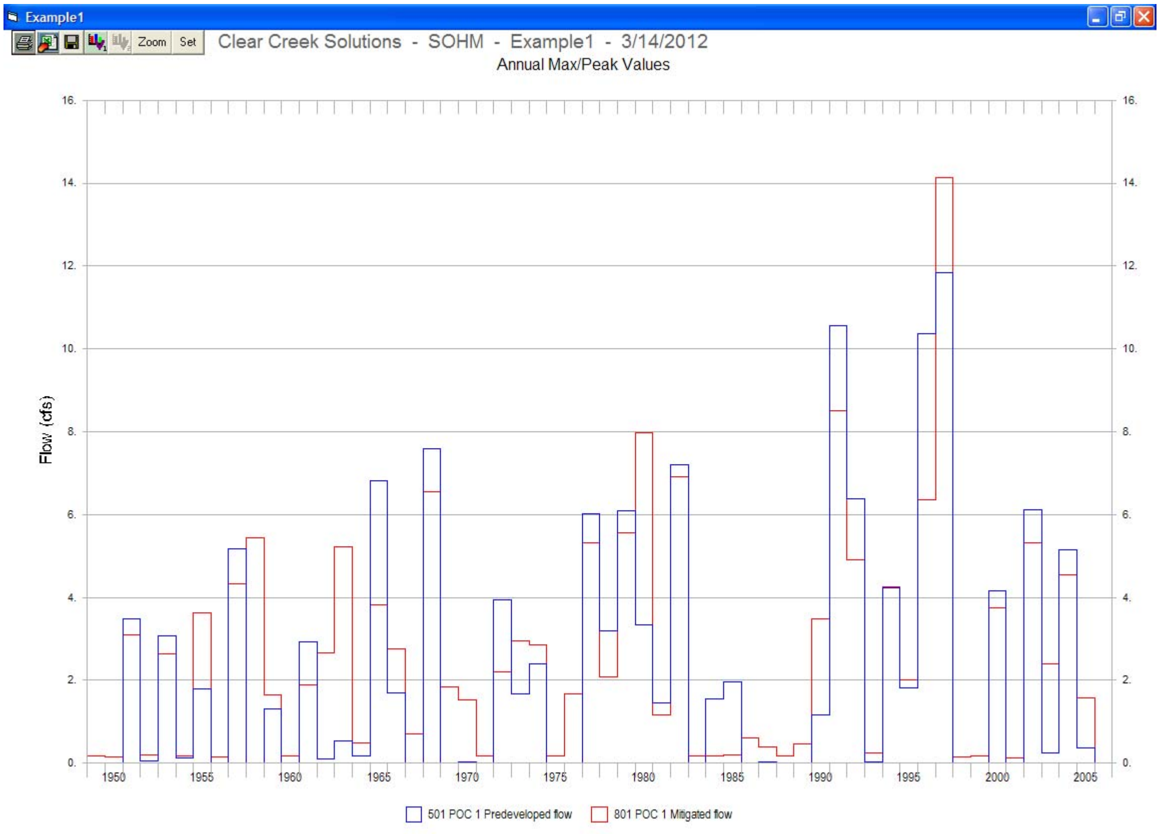
Hydrographs



The user can graph/plot any or all time series data by selecting the Hydrograph tab. The Create Graph screen is shown and the user can select the time series to plot, the time interval (yearly, monthly, daily, or 15-minute), and type of data (peaks, average, or volume).

The following numbering system is used for the flow time series:
500-599: Predevelopment flow (Predevelopment scenario)
700-799: Inflow to the POC (Mitigated runoff entering the BMP facility)
800-899: POC flow (Mitigated flow exiting the BMP facility)

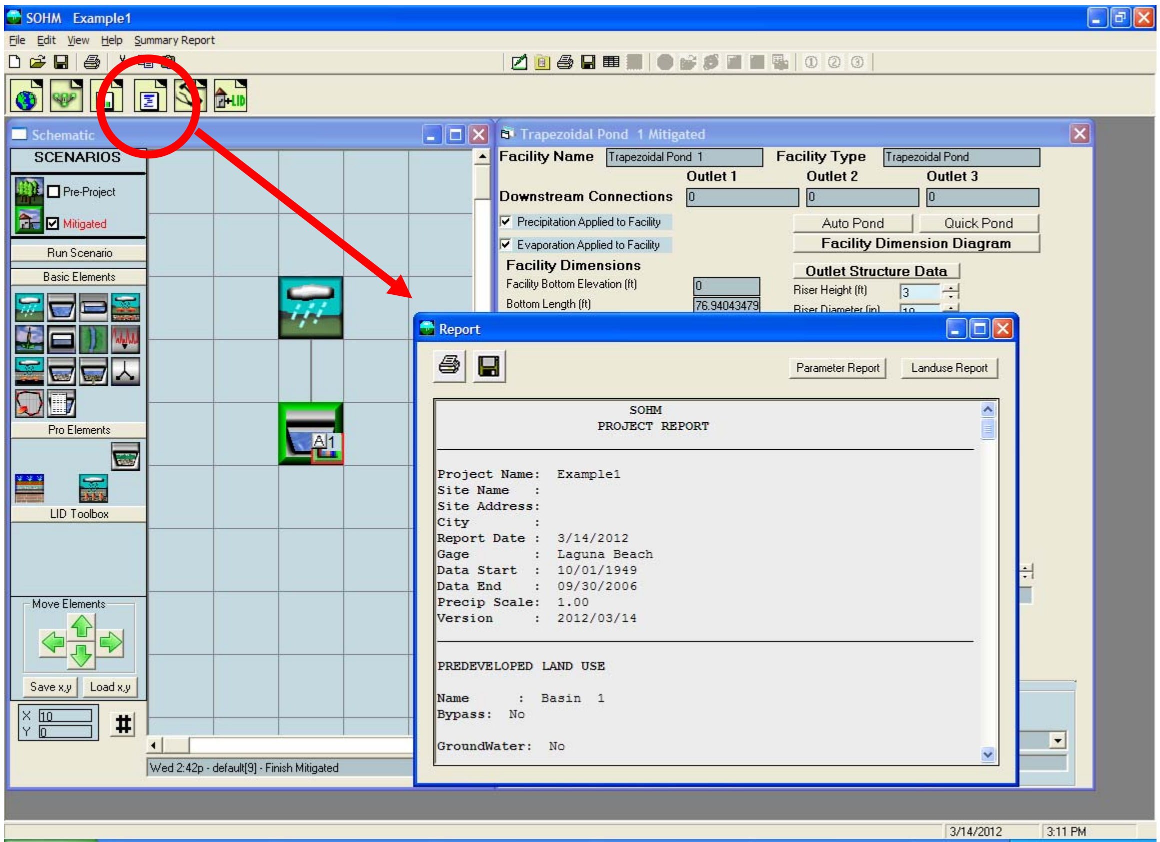
The selected time series are shown. To graph the selected time series the user clicks on the Graph button.



The hydrograph shows the yearly maximum/peak flow values for each time series for the entire simulation period (in this example, from 1949 through 2005).

The graph can be either saved or printed.

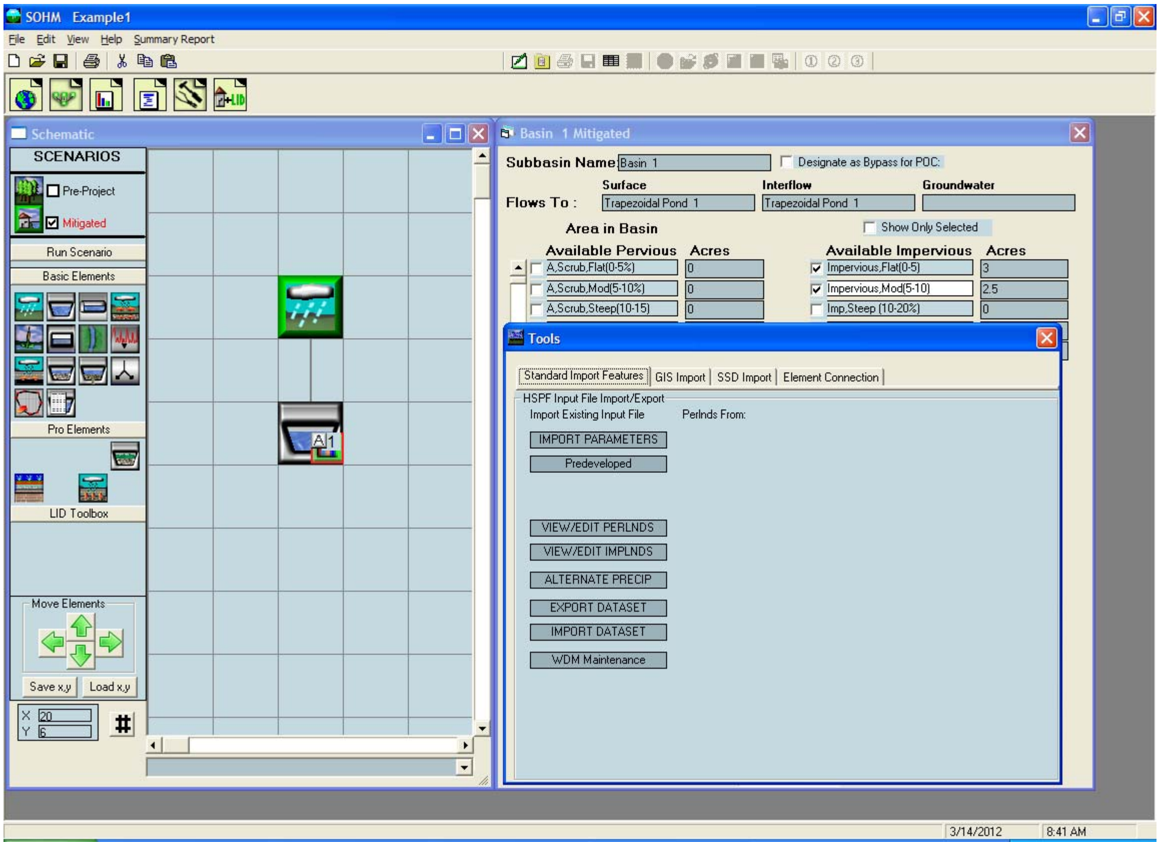
REPORTS SCREEN



The Reports tool bar button (fourth from the left) brings up the Report screen where the user can look at all of the project input and output. The project report can be saved or printed.

The project report contains the project input information provided by the user and a summary of the project output information produced by SOHM. The saved project report file can be read by Microsoft Word or any text-editing program.

TOOLS SCREEN

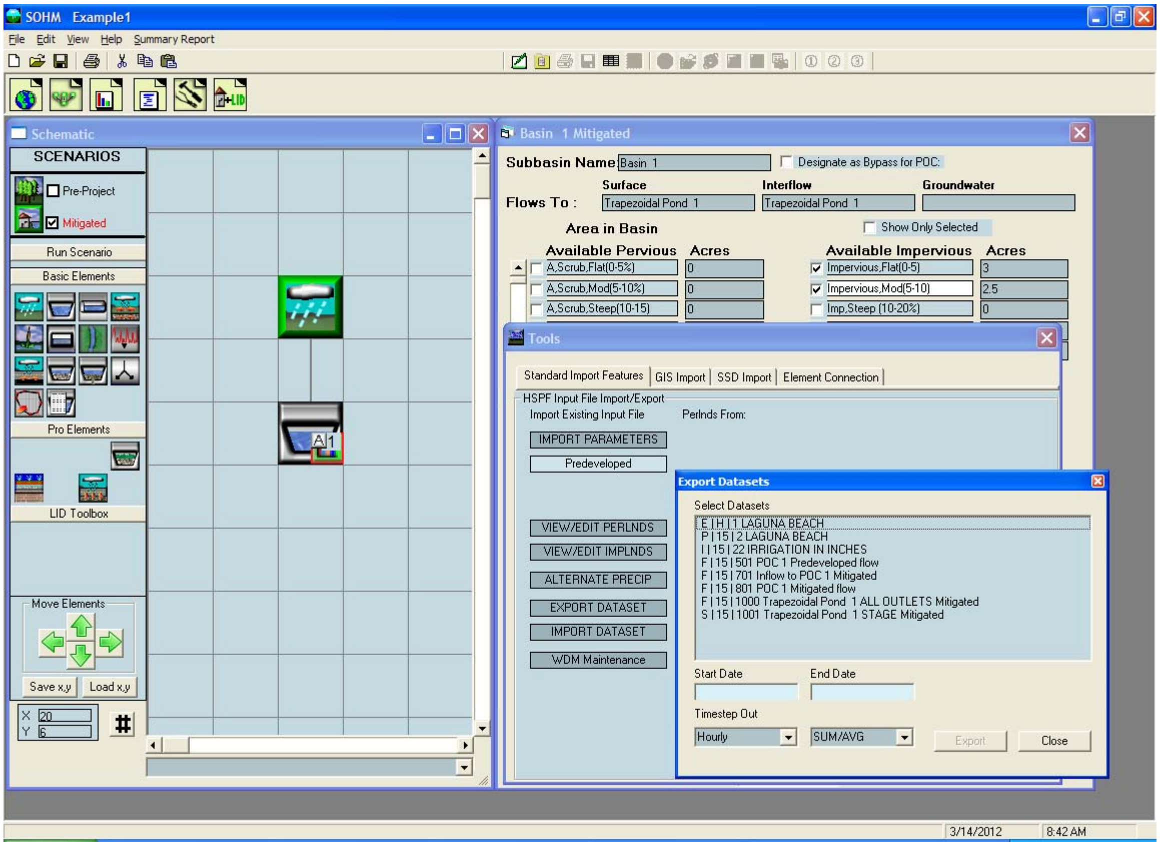


The Tools screen is accessed with the Tools tool bar (second from the right). The two purposes of the Tools screen are:

(1) To allow users to import HSPF PERLND parameter values from existing HSPF UCI files and/or view and edit SOHM PERLND parameter values.

(2) To allow users to export time series datasets.

To export a time series dataset click on the Export Dataset box.



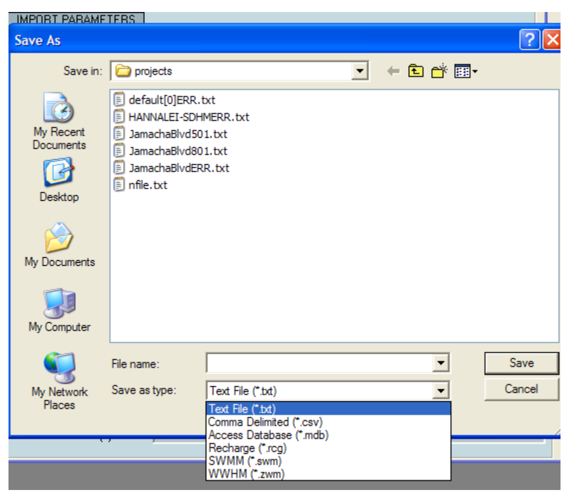
The list of available time series datasets will be shown. The user can select the start and end dates for the data they want to export.

The time step (15-minute, daily, monthly, yearly) can also be specified. If the user wants daily, monthly, or yearly data the user is given the choice of either selecting the maximum, minimum, or the sum of the 15-minute values.

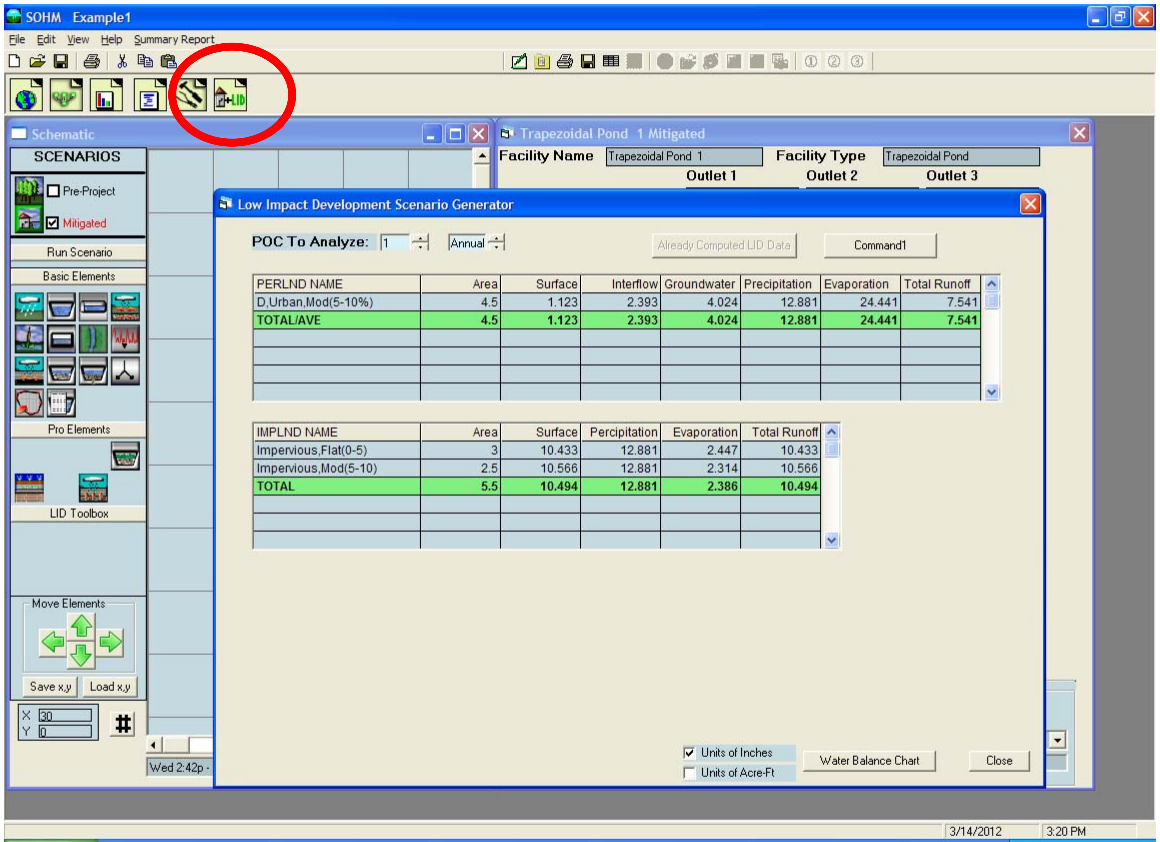
Click the Export button.

The user provides a file name and the format or type of file. The file type can be ASCII text, comma delimited, Access database, recharge, SWMM, or WWHM.

Click Save to save the exported time series file.



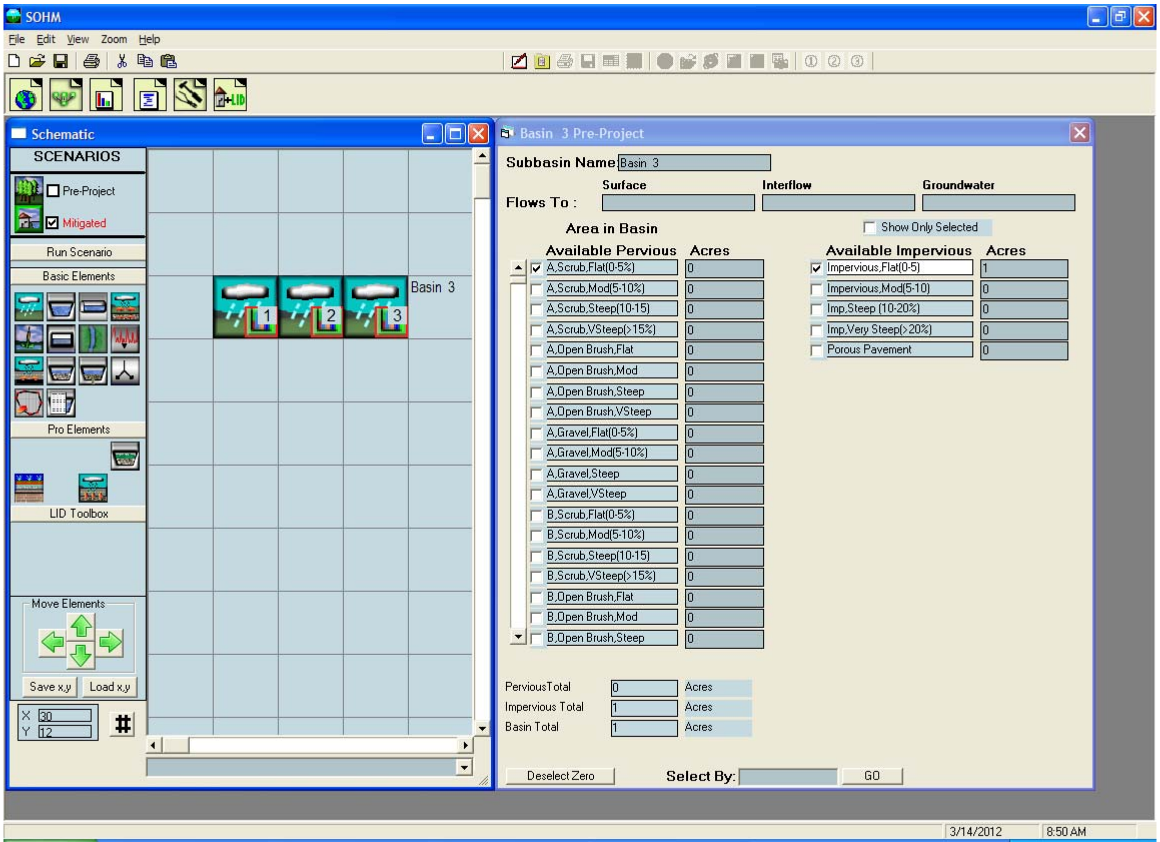
LID ANALYSIS SCREEN



The LID tool bar button (farthest on the right) brings up the Low Impact Development Scenario Generator screen.

The LID scenario generator can be used to compare the amount of runoff from different land types and combinations. The user can quickly see how changing the land use affects surface runoff, interflow, groundwater, and evapotranspiration.

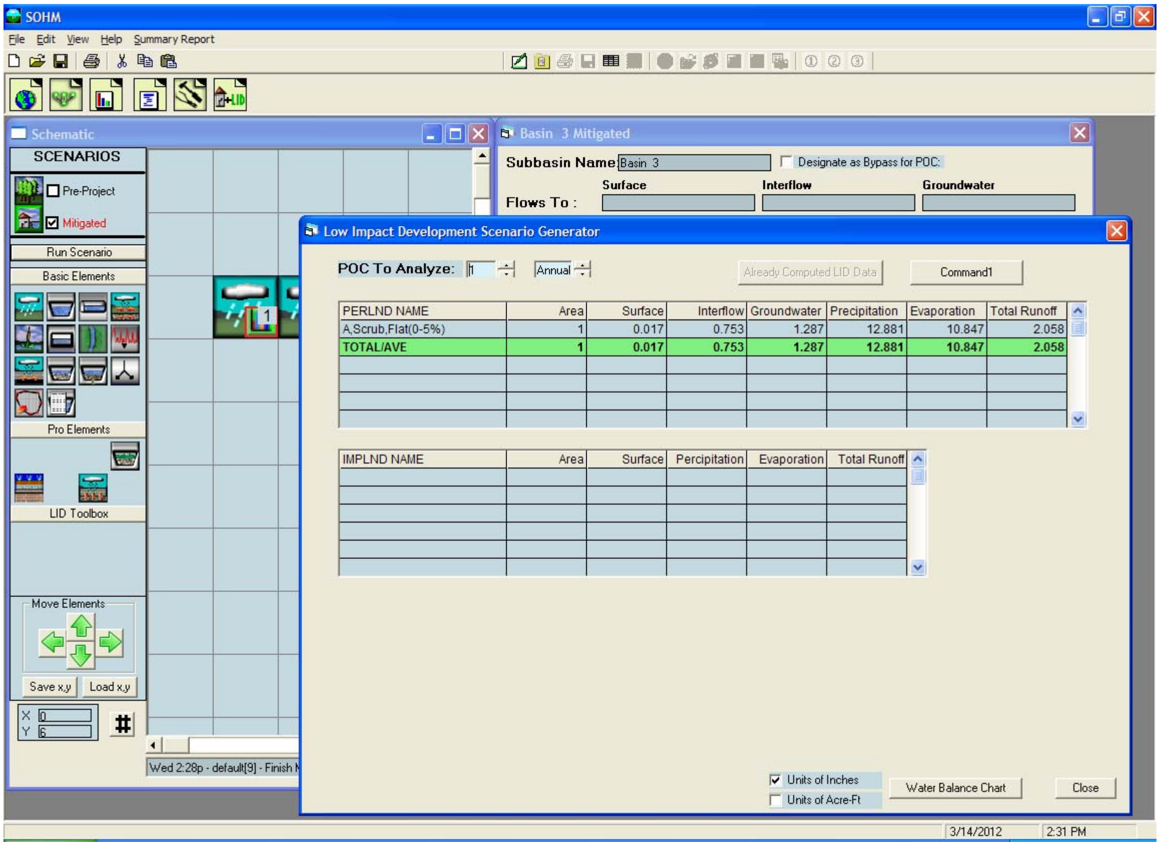
NOTE: The LID scenario generator works only in the Mitigated scenario.



The easiest way to compare different land use scenarios is to place all of them on the same Schematic Editor screen grid. Each basin can then represent a different land use scenario. Because the LID scenario generator only compares runoff volume there is no need to do any routing through a conveyance system or stormwater facility.

For this example the three basins are assigned the following land uses:
Basin 1: 1 acre A, Scrub, Flat
Basin 2: 1 acre D, Gravel, Steep
Basin 3: 1 acre Impervious, Flat

Each basin is assigned a different POC (point of compliance) for the LID analysis.



Click on the Compute LID Base Data button to generate the LID analysis data and summarize the surface runoff, interflow, groundwater, precipitation, evaporation, and total runoff for all of the basins. The results will be shown for each basin in terms of its POC.

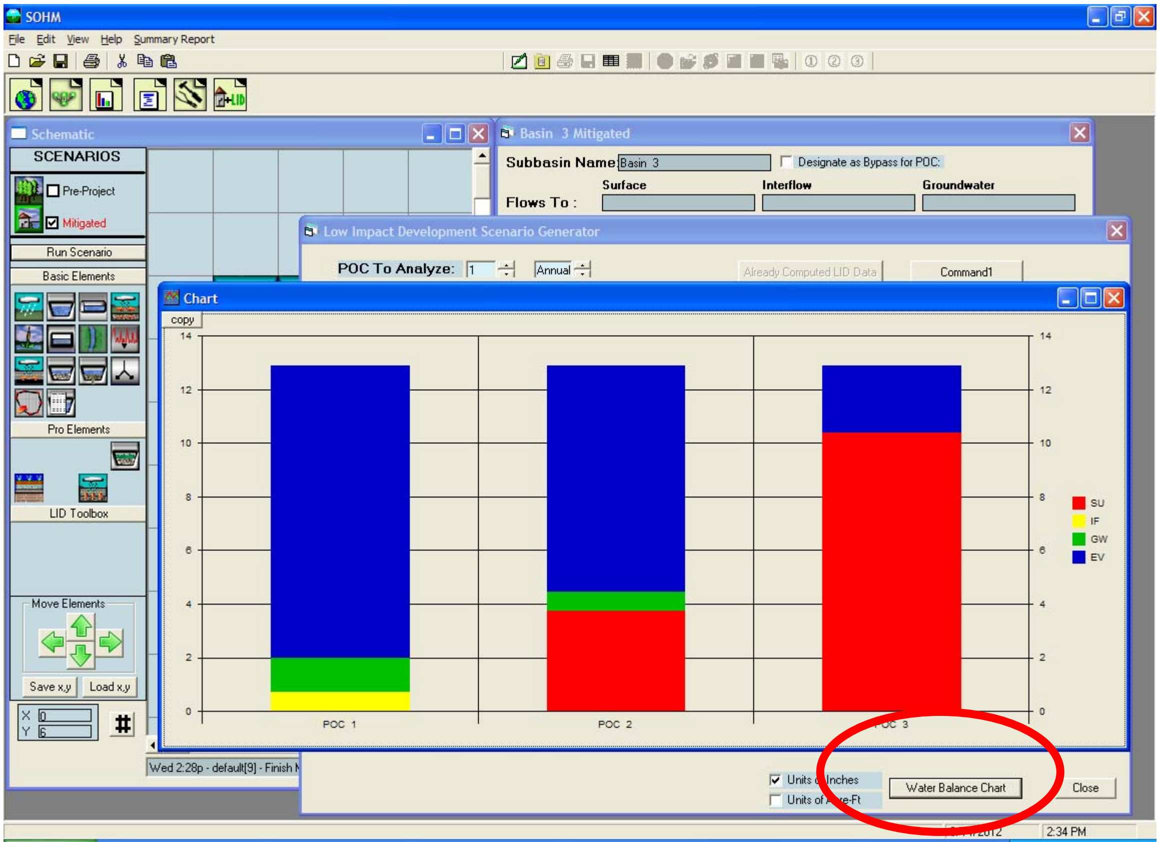
For Basin 1 (1 acre of A, Scrub, Flat) the distribution of the precipitation is:
Surface runoff = 0.017 inches per year
Interflow = 0.753 inches per year
Groundwater = 1.287 inches per year
Evaporation = 10.847 inches per year

The sum of the surface runoff + interflow + groundwater + evaporation equals 12.90 inches per year. The precipitation at this site equals 12.88 inches per year. The difference is the initial soil water storage at the start of the simulation period.

To look at the other basins click on the Select POC To arrow and select the basin of interest.

The LID analysis results can be presented in terms of either inches per year or acre-feet per year by checking the appropriate box in the lower right portion of the LID analysis screen.

To compare the different scenarios side-by-side in a graphical format click on the Display Water Balance Chart.

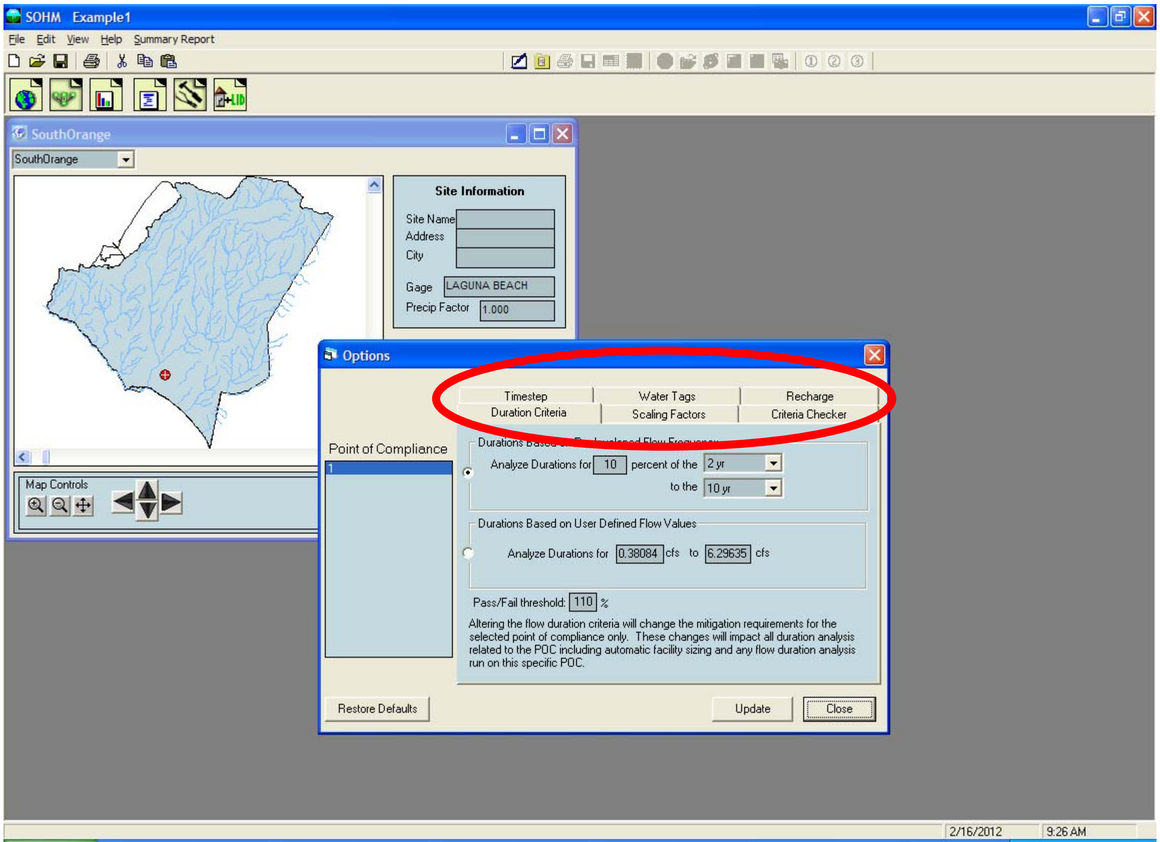


The water balance chart graphically displays the runoff distribution for all three land use scenarios side-by-side.

The bottom red is the surface runoff. Above in yellow is interflow; then green for groundwater and blue for evaporation. Basin 1 (Scenario 1) is an A soil with scrub land cover on a flat slope and produces the least amount of surface runoff and interflow (the sum of surface and interflow is the total stormwater runoff). Basin 2 is a D soil with gravel land cover on a steep slope; it produces more surface runoff and interflow than Basin 1. Basin 3 is impervious and produces the largest amount of surface runoff and interflow and the smallest amount of evaporation.

A maximum of seven scenarios can be graphed at one time.

OPTIONS



Options can be accessed by going to View, Options. This will bring up the Options screen and the ability to modify the built-in default duration criteria for flow duration matching and scaling factors for climate variables.

Duration Criteria

The flow duration criteria are:

1. If the post-development flow duration values exceed any of the predevelopment flow levels between the lower threshold (10% of the two-year) and the upper threshold (100% of the ten-year) predevelopment peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration standard has not been met.

2. If more than 10 percent of the flow duration levels exceed the 100 percent threshold then the flow duration standard has not been met.

The duration criteria in SOHM can be modified by the user if appropriate and the local municipal permitting agency allows (see NOTE below).

The user can conduct the duration analysis using either (1) durations based on Predevelopment flow frequency, or (2) durations based on user defined flow values.

If using durations based on Predevelopment flow frequency, the percent of the lower limit can be changed from the default of the 10% of the 2-year flow event to a higher or lower percent value. The lower and upper flow frequency limits (2-year and 10-year) also can be changed.

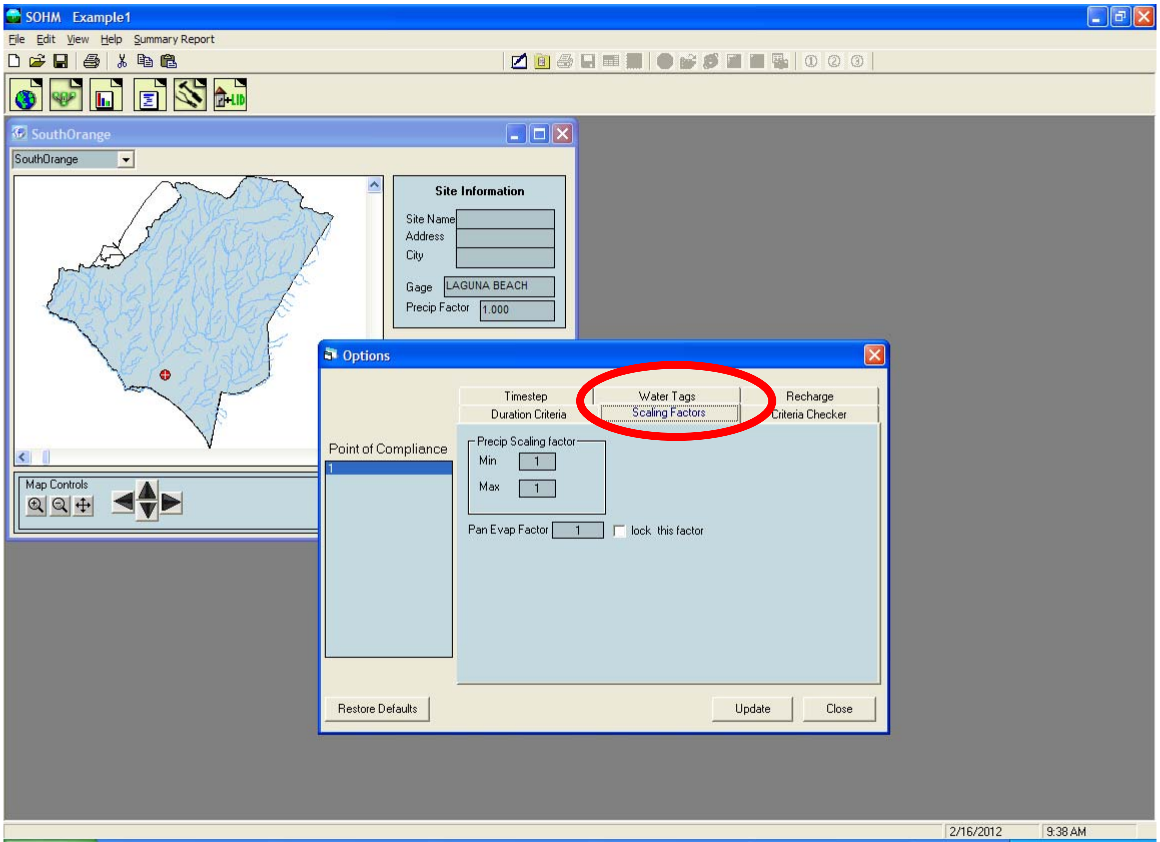
If using durations based on user defined flow values, click on that option and input the lower and upper flow values.

The default pass/fail threshold is 110%. This value can be changed by the user.

The duration criteria can be changed for a single point of compliance. Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

NOTE: Any change(s) to the default duration criteria must be approved by the appropriate local municipal permitting agency or specified in ***Appendix C****.*

Scaling Factors



The user can change the scaling factors for precipitation (minimum and maximum) and pan evaporation.

NOTE: Any change in default scaling factors requires approval by the local municipal permitting agency or ***Appendix C****.*

Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

TIPS AND TRICKS FOR LID PRACTICES AND FACILITIES

There are many different tips and tricks that can be used to tailor SOHM to solve different stormwater problems. This section presents only a fraction of the tricks that we and others have found and used, but it should give you a good idea of the options and flexibility built into SOHM.

The tips and tricks show how different LID/BMPs (Low Impact Developments/Best Management Practices) can be represented by SOHM elements.

LID/BMP practices and facilities reduce the need for and the size of stormwater control facilities. LID/BMP practices and facilities typically try to mimic the natural environment and provide source control and storage of runoff. Specific LID/BMP practices and facilities described in this section are shown in Table 1.

Table 3: LID/BMP Practices and Facilities and Equivalent SOHM Elements

BMP Category	BMP Title	SOHM Model Element
HSC-1	Localized on-lot infiltration	Bioretention swale
HSC-2	Impervious area dispersion	Lateral flow impervious area + Lateral flow soil basin
HSC-3	Street trees	Bioretention swale
HSC-4	Rain barrels	Storage vault
HSC-5	Green roof/brown roof	Green roof
HSC-6	Blue roof	Storage vault
INF-1	Infiltration basin	Trapezoidal pond or Irregular-shaped pond
INF-2	Infiltration trench	Gravel trench/bed
INF-3	Bioretention with no underdrain	Bioretention swale
INF-4	Bioinfiltration	Bioretention swale
INF-5	Dry well	Storage vault or Gravel trench/bed or Dry well
INF-6	Permeable pavement	Porous pavement
INF-7	Underground infiltration	Storage vault or Storage tank
HU-1	Above-ground cisterns	Storage vault
HU-2	Underground detention	Storage vault or Storage tank
BIO-1	Bioretention with underdrain	Bioretention swale
BIO-2	Vegetated swale	Bioretention swale or Natural channel or Vegetated swale
BIO-3	Vegetated filter strip	Bioretention swale or Lateral flow impervious area + Lateral flow soil basin
BIO-4	Wet detention basin	Trapezoidal pond or Irregular-shaped pond
BIO-5	Constructed wetland	Combination of elements
BIO-6	Dry extended detention basin	Trapezoidal pond or Irregular-shaped pond
BIO-7	Proprietary biotreatment	Bioretention swale or Planter box

BMP Category	BMP Title	SOHM Model Element
TRT-1	Sand filter	Sand filter
TRT-2	Cartridge media filter	SSD Table
PRE-1	Hydrodynamic separation device	SSD Table
PRE-2	Catch basin insert	SSD Table

NOTE: Many of these LID/BMP practices and facilities rely on infiltration into native soils. See ***Appendix C*** *or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of an infiltration reduction factor, where appropriate.*

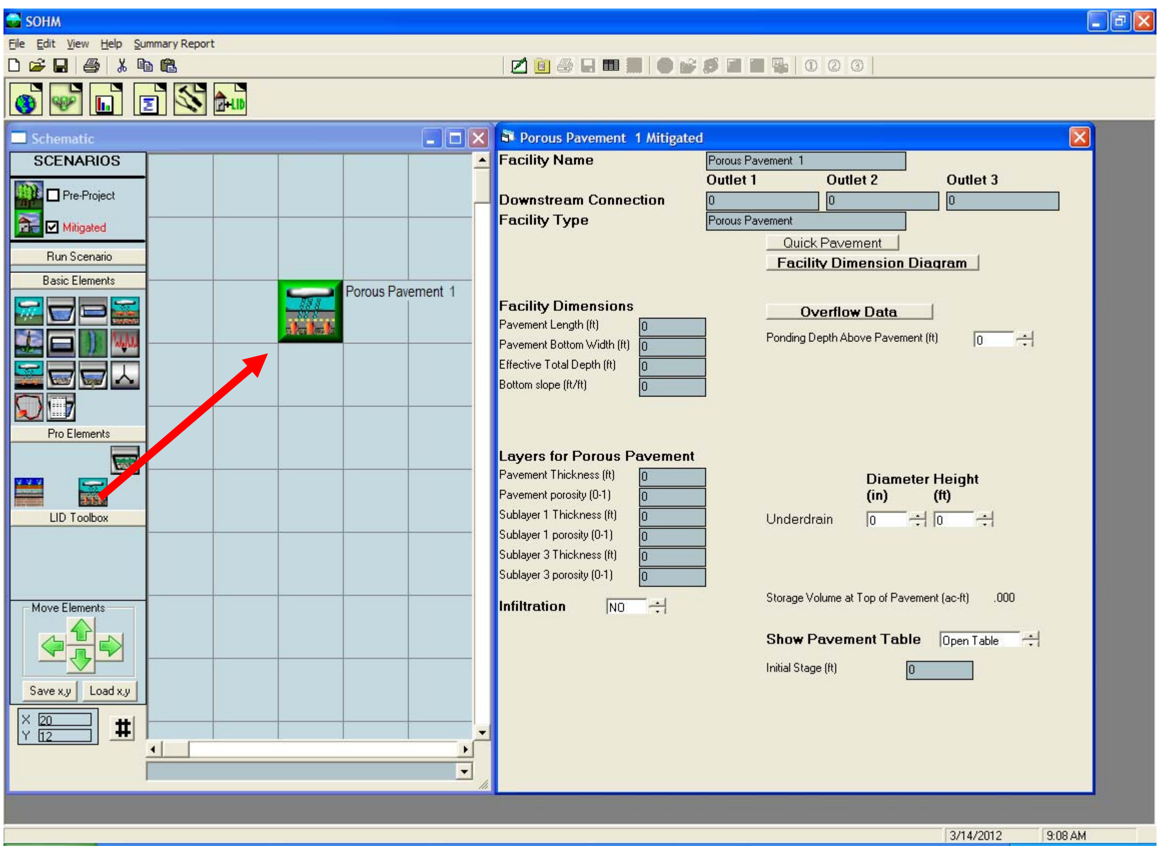
Permeable Pavement

Permeable pavement LID options include porous asphalt or concrete and grid/lattice systems (non-concrete) and paving blocks. The use of any of these LID options requires that certain minimum standards and requirements are met related to subgrade, geotextile material, separation or bottom filter layer, base material, wearing layer, drainage conveyance, acceptance testing, and surface maintenance.

NOTE: Permeable pavement can be used in place of conventional pavement for roadways, sidewalks, driveways, and parking lots. Check with ***Appendix C*** *or the local municipal permitting agency to find out under what conditions permeable pavement is allowed.*

Permeable pavement can be represented by the porous pavement element in SOHM if the following three conditions are met:

1. The infiltration rate of the permeable pavement is greater than the peak rainfall rate.
2. The infiltration rate of the permeable pavement is greater than the underlying native soil.
3. There is subgrade layer of crushed rock/gravel between the permeable pavement and the native soil.



The porous pavement dimensions and parameters are:

Pavement Length (ft): Roadway length.
Pavement Bottom Width (ft): Roadway width.
Effective Total Depth (ft): Height from bottom of permeable pavement subgrade to top of pavement plus at least 0.5 feet extra.
Bottom Slope (ft/ft): Roadway slope or grade.
Pavement Thickness (ft): Permeable pavement layer depth.
Pavement Porosity: Permeable pavement porosity.
Sublayer 1 Thickness (ft): Subgrade gravel layer depth.
Sublayer 1 Porosity: Subgrade gravel porosity.
Sublayer 3 Thickness (ft): Sand layer depth (if appropriate).
Sublayer 3 Porosity: Sand porosity.
Ponding Depth above Pavement (ft): Height at which surface runoff occurs.

*NOTE: Check with **Appendix C** or the local municipal permitting agency to find out if ponding on the surface of the pavement is allowed.*

Underdrain Diameter (inches) and Height (feet) above bottom layer-native soil interface. The underdrain is optional.

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).

If infiltration is used then the user should consult the Infiltration discussion on page 68.

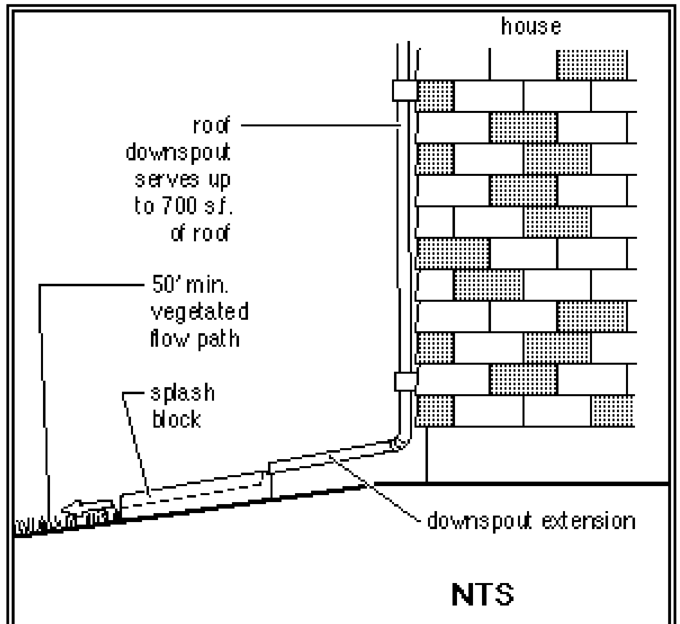
*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

Dispersion

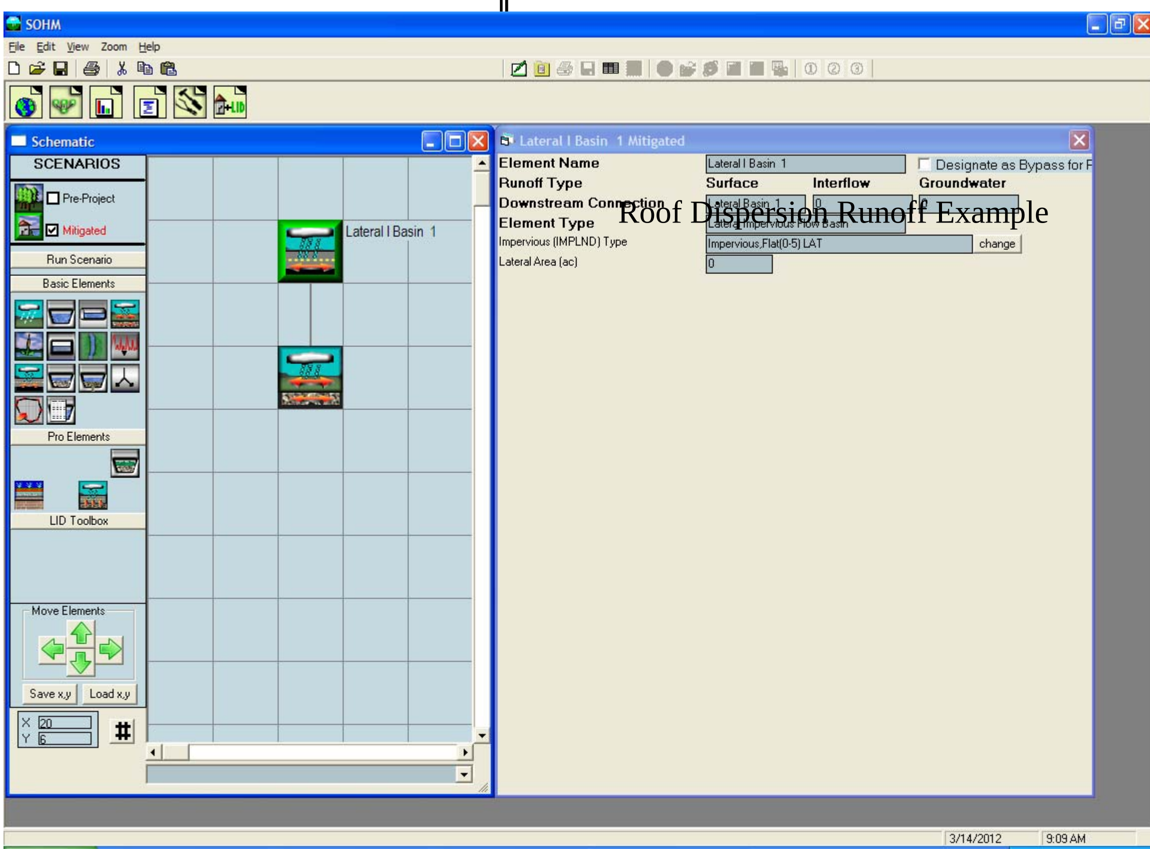
LID Dispersion practices can include roof runoff dispersion onto adjacent yard area, parking lot runoff onto adjacent lawn area, and reverse slope sidewalks draining onto adjacent vegetated areas.

NOTE: Specific minimum requirements and standards must be met to allow dispersion (see ***Appendix C*** *and the local municipal permitting agency for details).*

Dispersion is represented in SOHM with lateral flow basin elements.



Roof Dispersion Runoff Example



The impervious lateral basin (Lateral I Basin 1 in the above scenario) is connected to the pervious lateral basin (Lateral Basin 1). All of the runoff generated by impervious roof

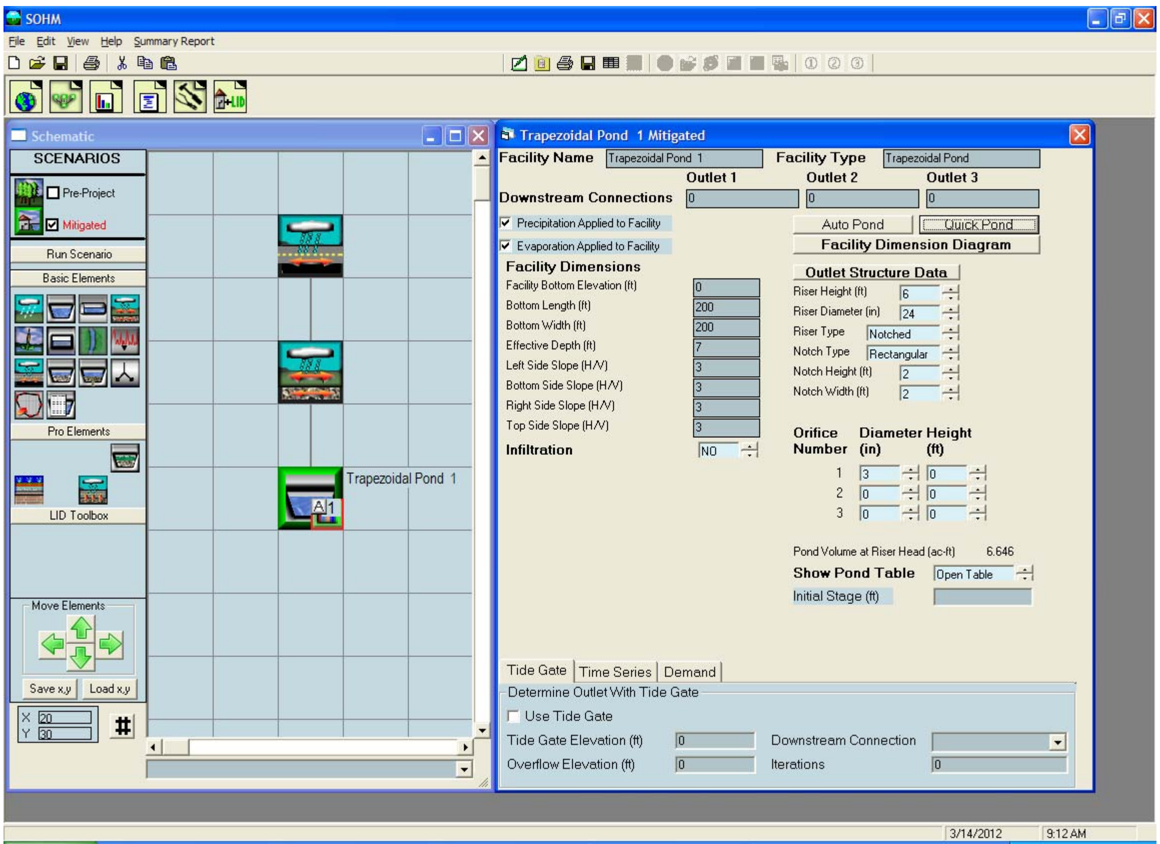
Lateral I Basin 1 is distributed onto pervious urban Lateral Basin 1 before routing to a stormwater control facility (pond, vault, etc.).

The lateral basin dimensions and parameters to adjust to represent dispersion are:

Impervious (IMPLND) type: select flat or moderate slope.

Soil (PERLND) type: select one of the 40 different pervious land types based on soil, land cover, and slope. A and B soils will provide more dispersion benefits than C or D soils because of their ability to infiltrate more runoff.

Lateral Area: size of contributing or receiving area (acres).

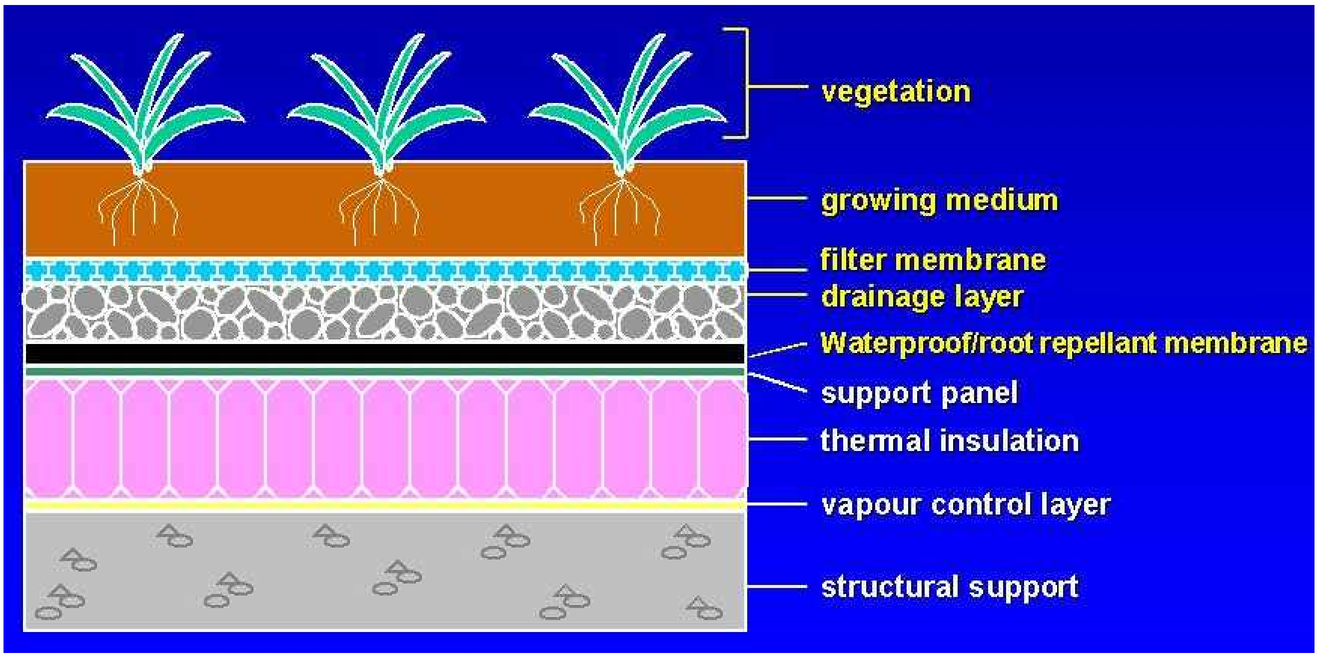


Dispersion will decrease the total runoff, but probably will not totally eliminate the need for a stormwater control facility. A pond can be connected to the discharge from the pervious lateral basin to provide the final required mitigation.

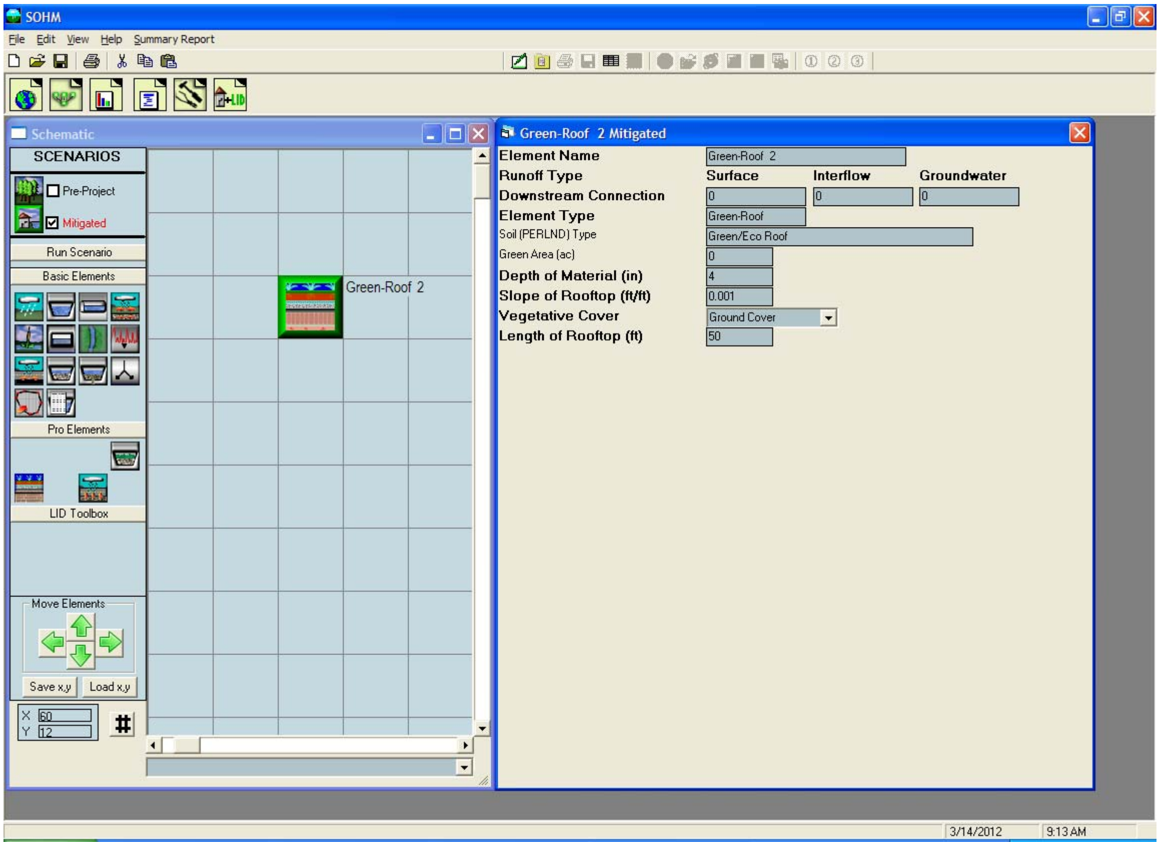
Green Roof

A green roof is roof covered with vegetation and a growing medium (typically an engineered soil mix). Green roofs are not always green and are also known as vegetated roofs or eco-roofs.

The advantage of a green roof is its ability to store some runoff on the plants' surfaces and in the growing medium. Evapotranspiration by the plants and growing medium reduces the total runoff. Runoff movement through the growing medium slows down the runoff and reduces peak discharge during storm events.



A green roof is represented by the green roof element.



The dimensions and parameters to represent a green roof are:

Green Area (ac): Green roof area.
Depth of Material (in): Depth or thickness of soil/growing medium on top of roof.
Slope of Rooftop (ft/ft): Slope of roof in the direction of surface flow.
Vegetative Cover: ground cover, shrubs, or trees.
Length of Rooftop (ft): Maximum distance runoff travels to a roof drain.

Rainwater Harvesting

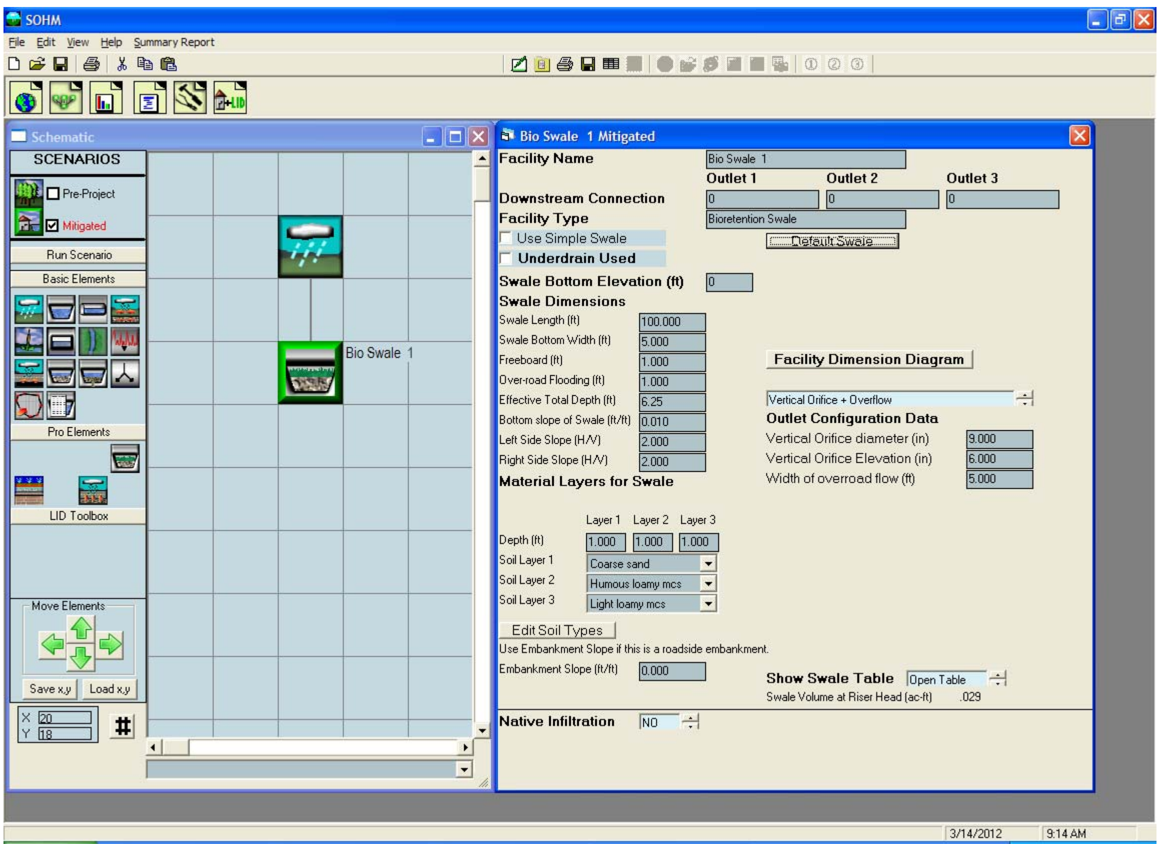
Rainwater harvesting involves water collection, storage, and reuse for residential outdoor use. The LID credit is pretty simple: the drainage area for which there is 100% capture does not have to be included in the SOHM Mitigated land use scenario.

Rain Garden

A rain garden is another name for a bioretention swale (also called a landscape swale). The rain garden is a depression partially filled with top or amended soil over the native soil. The top soil provides biofiltering and water storage.

Water is allowed to infiltrate into the native soil underlying the top soil of the bioretention area if the native soils have sufficient infiltration capacity. Stormwater enters the rain garden above ground and then infiltrate through the soil layers. An underdrain discharge pipe is optional.

In SOHM the rain garden is represented by the bioretention swale element. If the native soil is an A or B soil then no underdrain is needed; if the soil is a C or D soil then an underdrain should be included.



The bioretention swale dimensions and parameters to adjust to represent rain garden are described on page 81.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

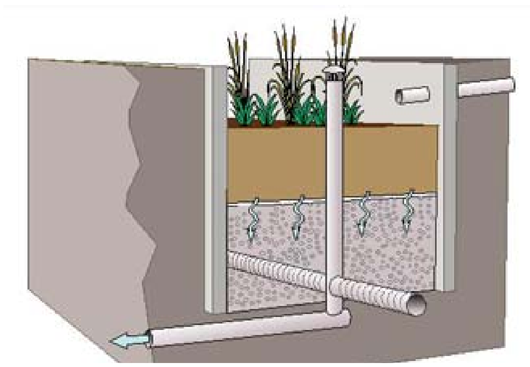
NOTE: See ***Appendix C*** *or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

No underdrain should be used for A or B soils; there is no native infiltration should be included for C or D soils.

In-Ground (Infiltration) Planter

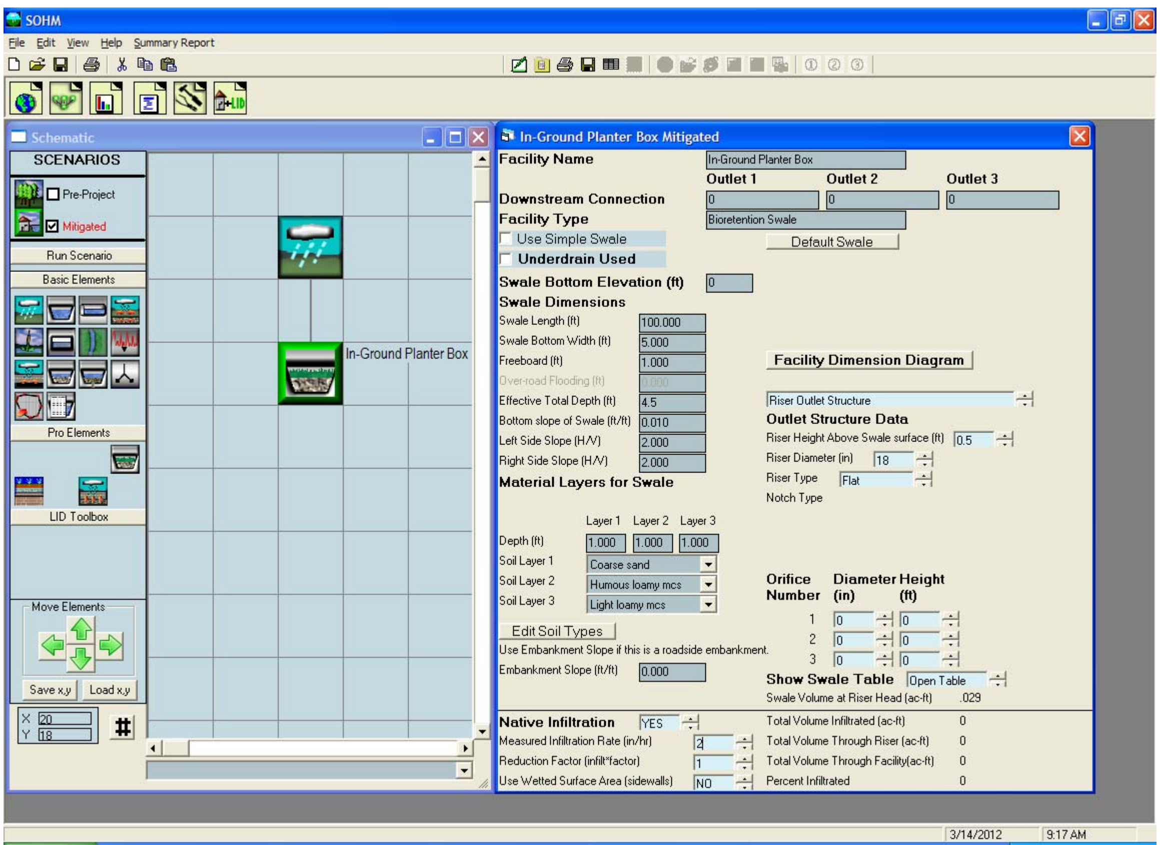
An in-ground planter allows stormwater to enter the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through a discharge pipe. Water can also infiltrate into the native soil beneath the planter.

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.



In-Ground (Infiltration) Planter

In SOHM the in-ground planter is represented by the bioretention swale element.



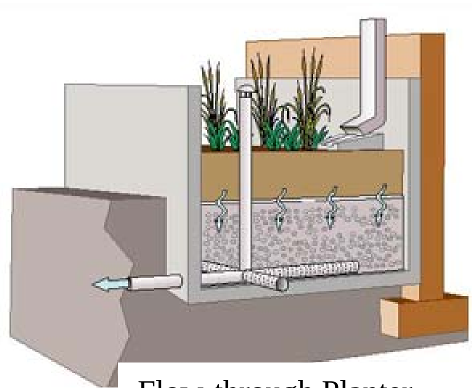
The bioretention swale dimensions and parameters to adjust to represent an in-ground (infiltration) planter are discussed on page 81.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

Flow-Through Planter

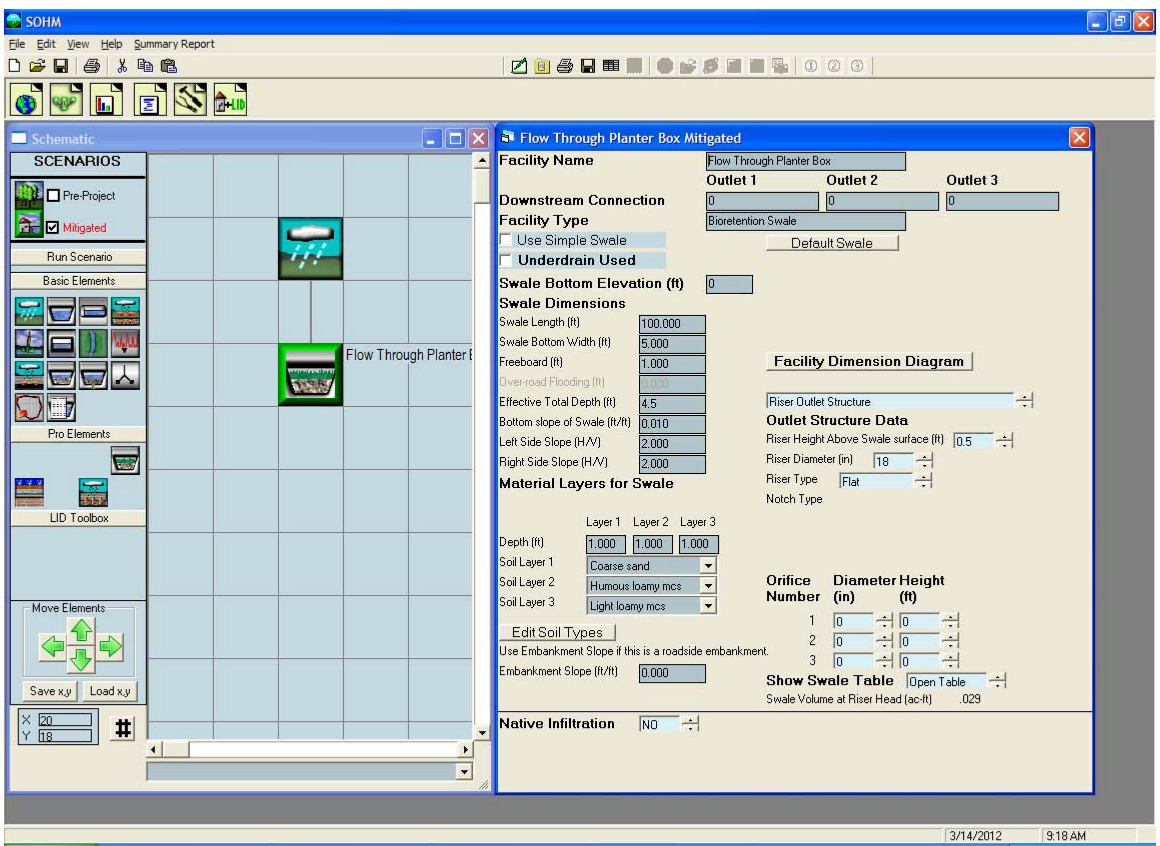
A flow-through planter is similar to the in-ground (infiltration) planter, except that water is not allowed to infiltrate into the native soil underlying the gravel layer of the planter. This is due to the native soil having poor infiltration capacity. As with the in-ground planter, stormwater enters the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through a discharge pipe.



Flow-through Planter

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.

In SOHM the flow-through planter is represented by the bioretention swale element.



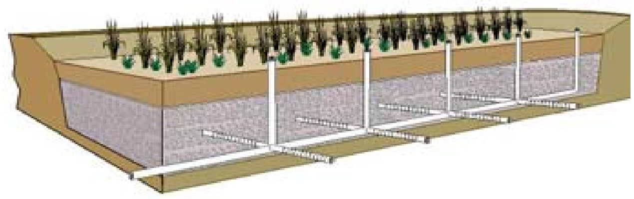
The bioretention swale dimensions and parameters to adjust to represent a flow-through planter are discussed on page 81.

Native Infiltration: No (no infiltration into the underlying native soil)

The only difference between an in-ground (infiltration) planter and a flow-through planter is whether or not native infiltration is included.

Bioretention Area

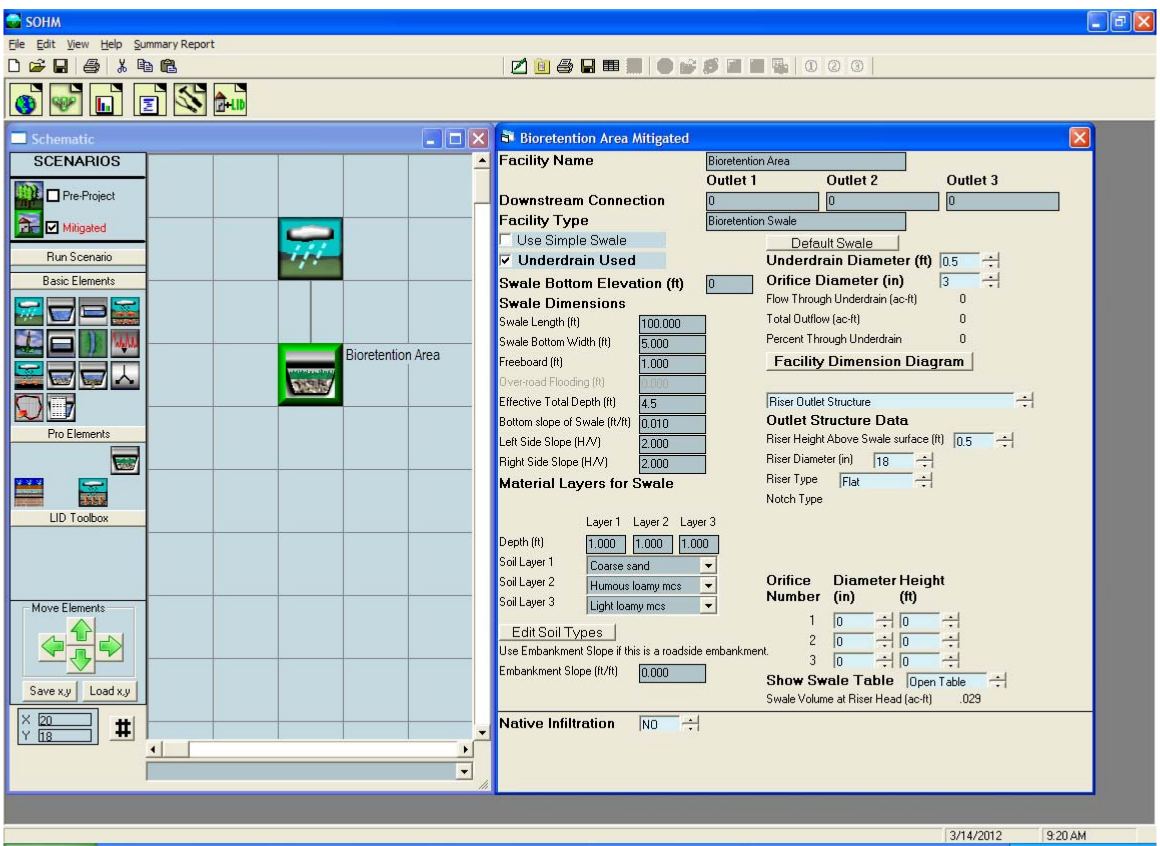
A bioretention is similar to the in-ground (infiltration) planter. Water is allowed to infiltrate into the native soil underlying the gravel layer of the bioretention area if the native soils have sufficient infiltration capacity. As with the in-ground planter, stormwater enters the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through an underdrain discharge pipe.



Bioretention Area

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.

In SOHM the bioretention area is represented by the bioretention swale element. If the native soil is an A or B soil then no underdrain is needed; if the soil is a C or D soil then an underdrain should be included.



The bioretention swale dimensions and parameters to adjust to represent bioretention area are discussed on page 81.

Native Infiltration: Yes if A or B soil (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).

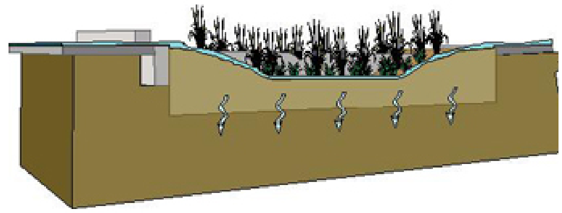
If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

There is no underdrain for A or B soils; there is no native infiltration for C or D soils.

Vegetated or Grassy (Dry) Swale

A vegetated or grassy (dry) swale is similar to the bioretention area. The major difference between a vegetated swale and a bioretention area is that when the vegetated swale overflows it produces surface runoff via weir flow out of the swale; a bioretention area discharges to an overflow pipe instead.

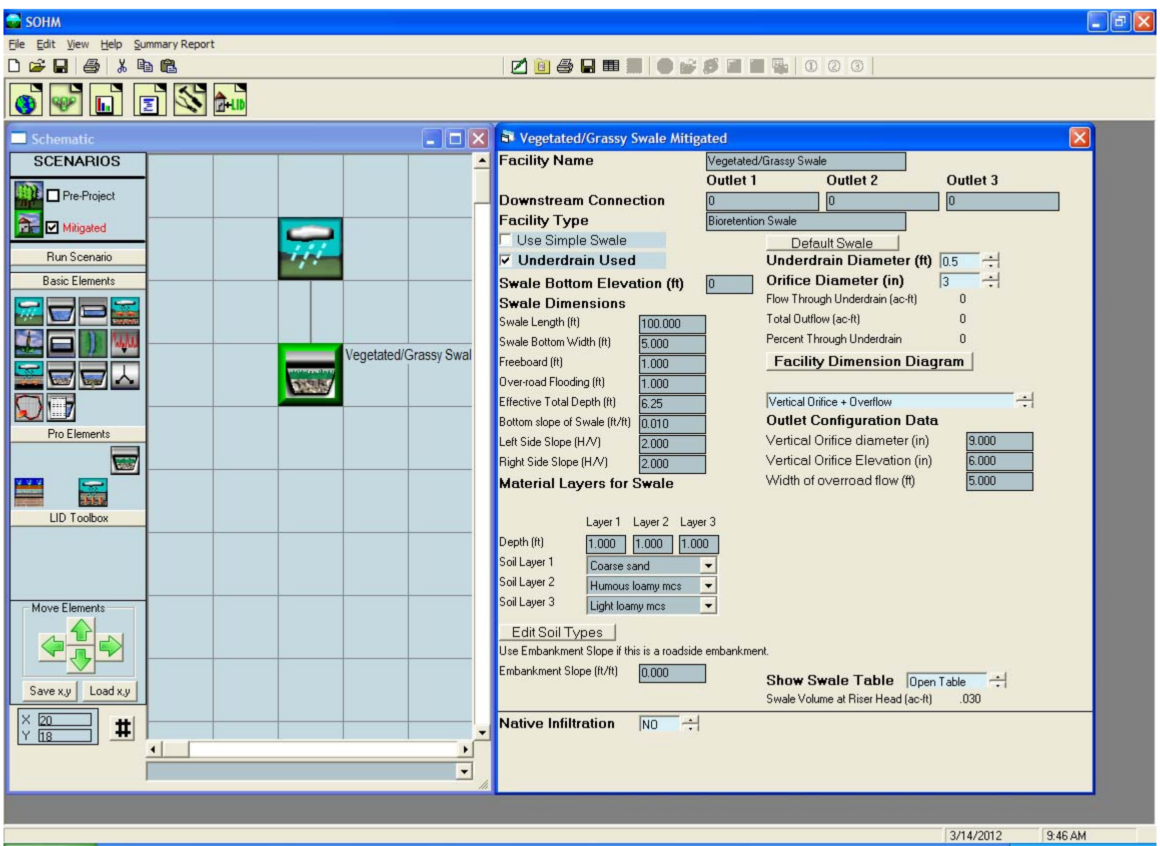


Vegetated or Grassy (Dry) Swale

If the swale is on A or B soils then there is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the vegetated swale. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.

If the swale is on C or D soils then an underdrain must be used.

In SOHM the vegetated or grassy (dry) swale can be represented by the bioretention swale element or the channel element.



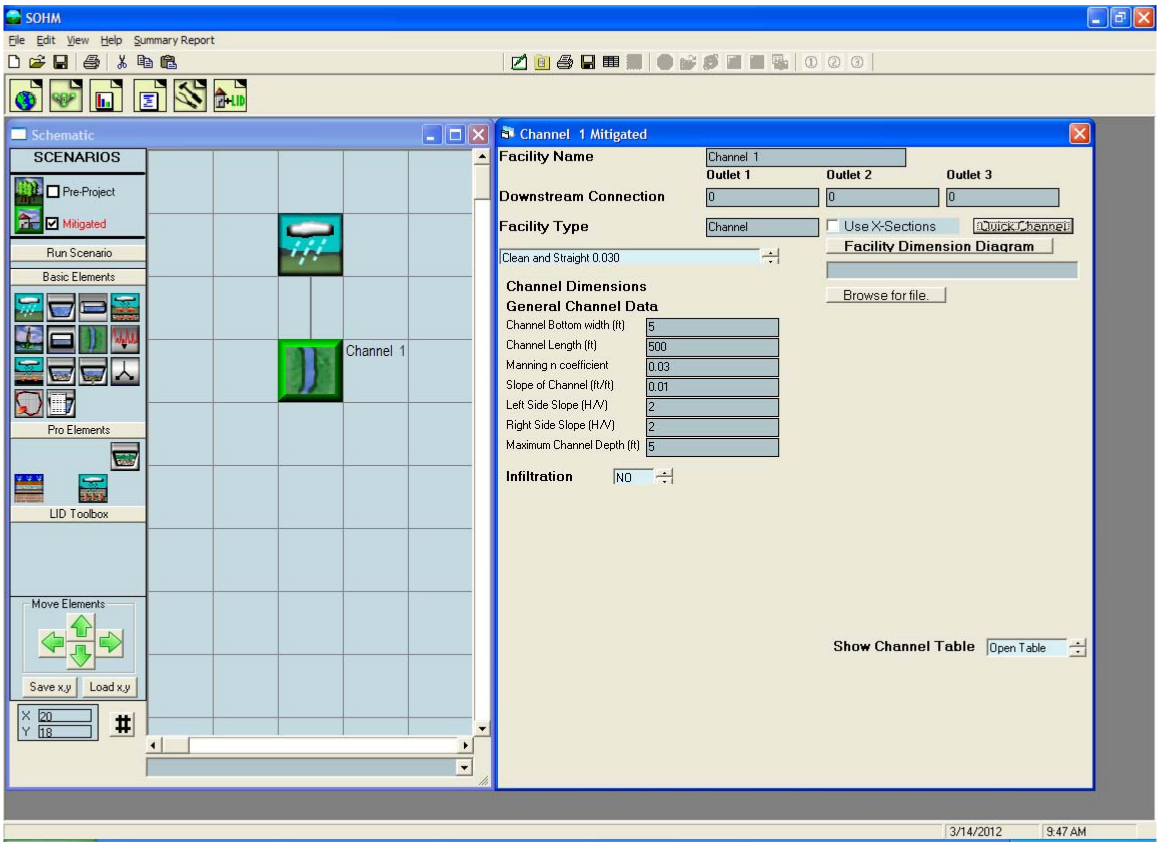
The bioretention swale dimensions and parameters to adjust to represent a vegetated/grassy swale are discussed on page 81.

Native Infiltration: Yes if A or B soil (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** Or Consult With The Local Municipal Permitting Agency For Additional Considerations Regarding Infiltration And Determination Of The Appropriate Infiltration Reduction Factor.*

There is no underdrain for A or B soils; there is no native infiltration for C or D soils.



Simple vegetated or grassy (dry) swales without an underdrain can be represented by the channel element.

The channel dimensions and parameters to adjust to represent a vegetated/grassy swale are:

Channel Bottom Width (ft): Vegetated/grassy swale width.
Channel Length (ft): Vegetated/grassy swale area length.
Manning's coefficient: Vegetated/grassy swale overland flow roughness coefficient.
Slope of Channel (ft/ft): Must be non-zero.
Left Side Slope of Channel (ft/ft): H:V Vegetated/grassy swale left side slope.

Right Side Slope (ft/ft): H:V Vegetated/grassy swale right side slope.
Maximum Channel Depth (ft): Height from bottom to top of vegetated/grassy swale side slopes.

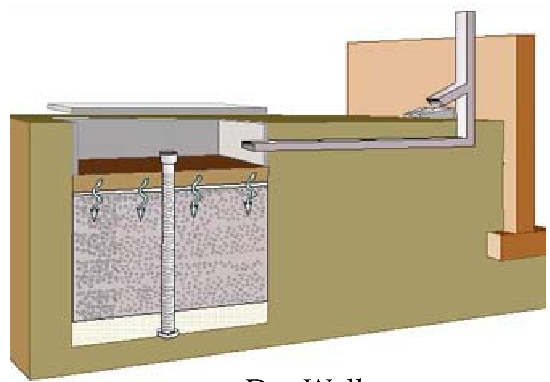
Infiltration: Yes (infiltration into the underlying soil through the swale bottom)
Infiltration Rate (in/hr): Vegetated/grassy swale channel bottom infiltration rate.
Infiltration Reduction Factor: 1/native soil infiltration rate safety factor (see page 68).

NOTE: See ***Appendix C*** *or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

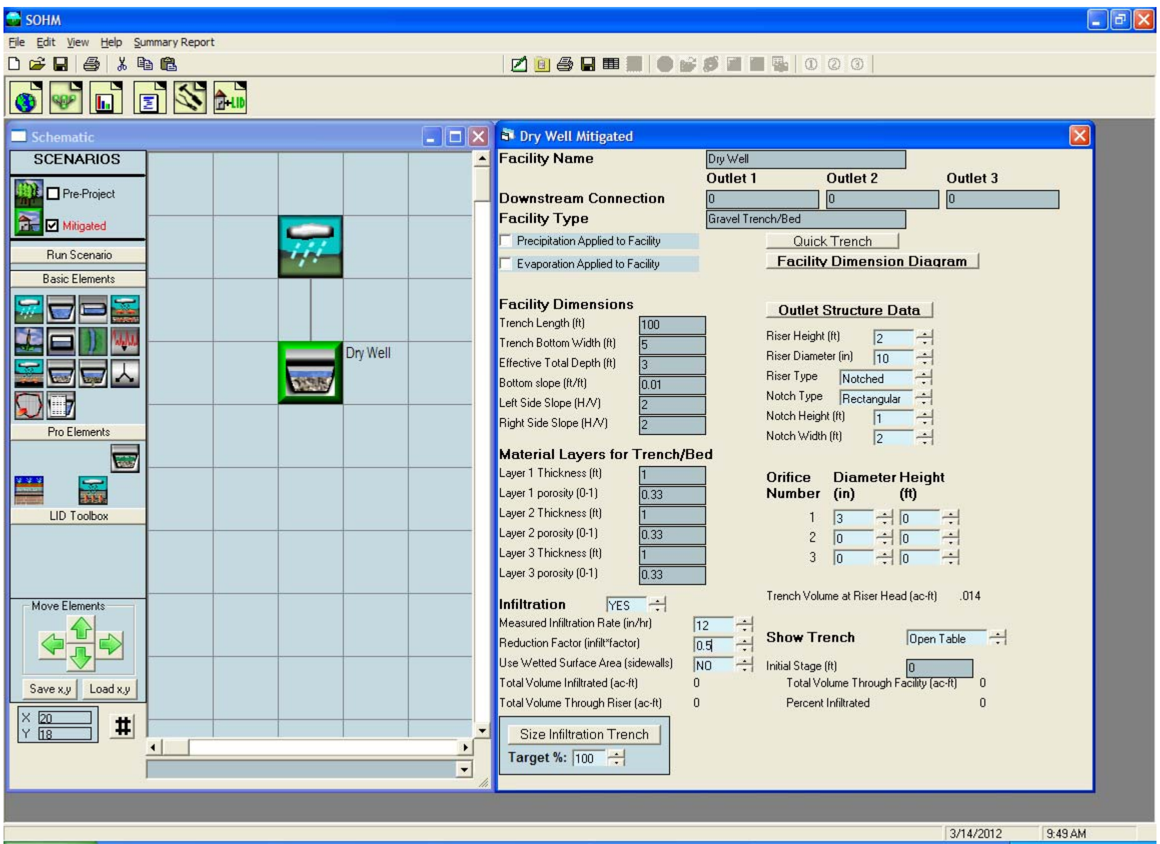
Dry Well

A dry well is similar to the in-ground (infiltration) planter, except that there is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the gravel layer of the planter. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.

In SOHM the dry well is represented by the gravel trench bed element.



Dry Well



The gravel trench bed dimensions and parameters to adjust to represent a dry well are:

Trench Length (ft): Dry well length.
Trench Bottom Width (ft): Dry well width.
Effective Total Depth (ft): Dry well height from bottom of dry well to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): 0 (zero) for vertical dry well sides.

Right Side Slope (ft/ft): 0 (zero) for vertical dry well sides.
Infiltration Rate (in/hr): Dry well soil infiltration rate.
Layer 1 Thickness (ft): Dry well soil layer depth.
Layer 1 Porosity: Dry well soil porosity.
Layer 2 Thickness (ft): Dry well gravel layer depth.
Layer 2 Porosity: Dry well gravel porosity.
Riser Height (ft): Height of dry well overflow pipe above dry well bottom.
Riser Diameter (in): Dry well overflow pipe diameter.
Riser Type: Flat

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).

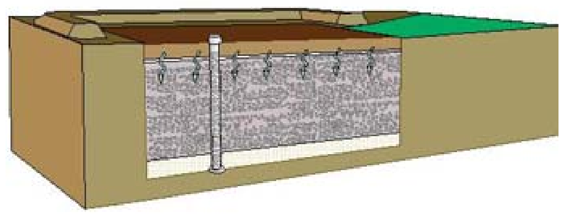
If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

Note that the dry well is covered; there is no precipitation on or evaporation from the dry well. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be left unchecked.

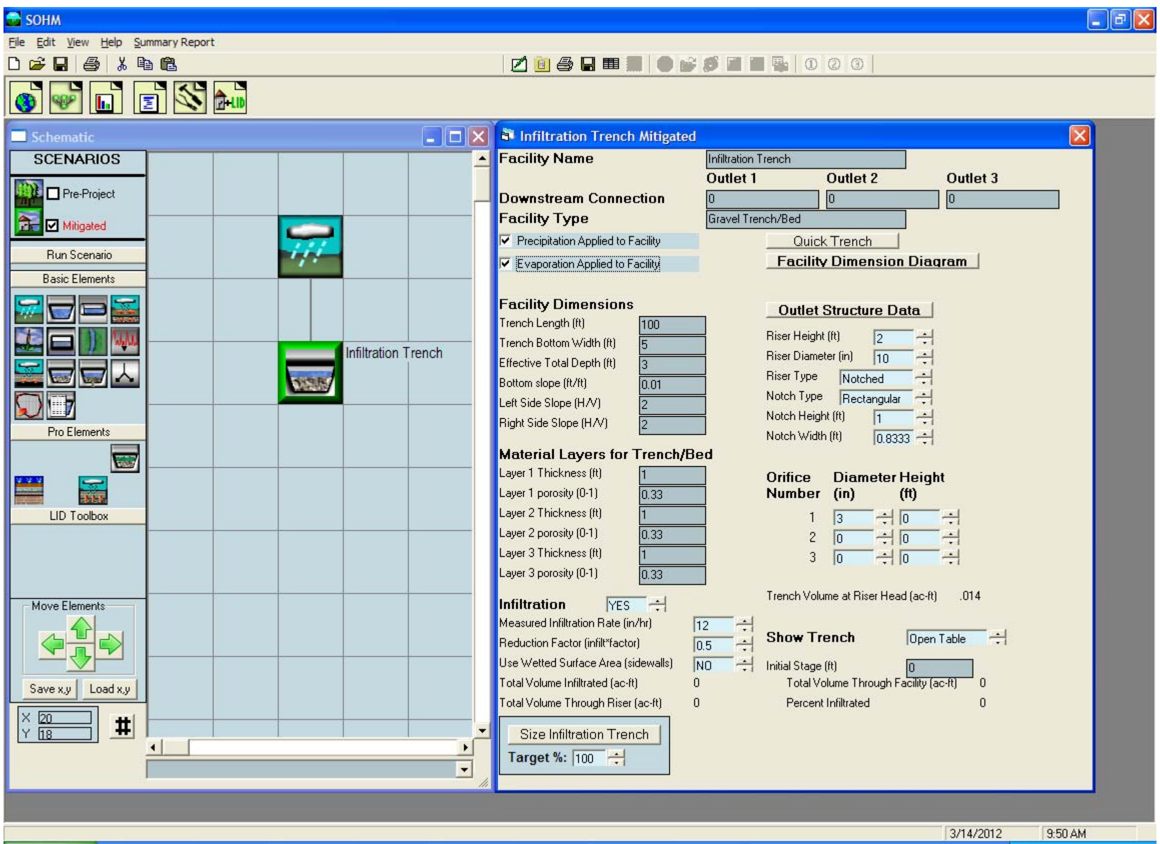
Infiltration Trench

An infiltration trench is similar to the dry well. There is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the gravel layer of the planter. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.



Infiltration Trench

In SOHM the infiltration trench is represented by the gravel trench bed element.



The gravel trench bed dimensions and parameters to adjust to represent an infiltration trench are:

Trench Length (ft): Infiltration trench length.
Trench Bottom Width (ft): Infiltration trench width.
Effective Total Depth (ft): Infiltration trench height from bottom of trench to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): 0 (zero) for vertical infiltration trench sides.

Right Side Slope (ft/ft): 0 (zero) for vertical infiltration trench sides.
Infiltration Rate (in/hr): Infiltration trench soil infiltration rate.
Layer 1 Thickness (ft): Infiltration trench soil layer depth.
Layer 1 Porosity: Infiltration trench soil porosity.
Layer 2 Thickness (ft): Infiltration trench gravel layer depth.
Layer 2 Porosity: Infiltration trench gravel porosity.
Riser Height (ft): Height of infiltration trench overflow pipe above trench bottom. If a weir is preferred instead of a riser then set the riser height to the weir height and set the riser diameter to the weir length.
Riser Diameter (in): Infiltration trench overflow pipe diameter.
Riser Type: Flat

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).

If infiltration is used then the user should consult the Infiltration discussion on page 68.

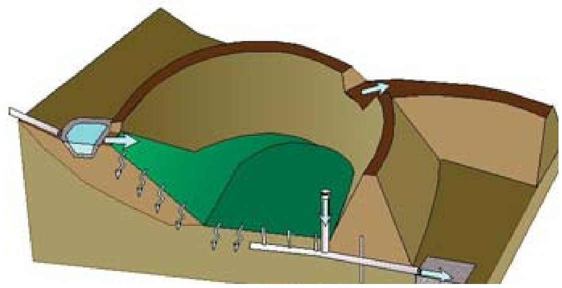
*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

Note that, unlike the dry well, the infiltration trench receives precipitation on and evaporation from the trench surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

Infiltration Basin/Pond

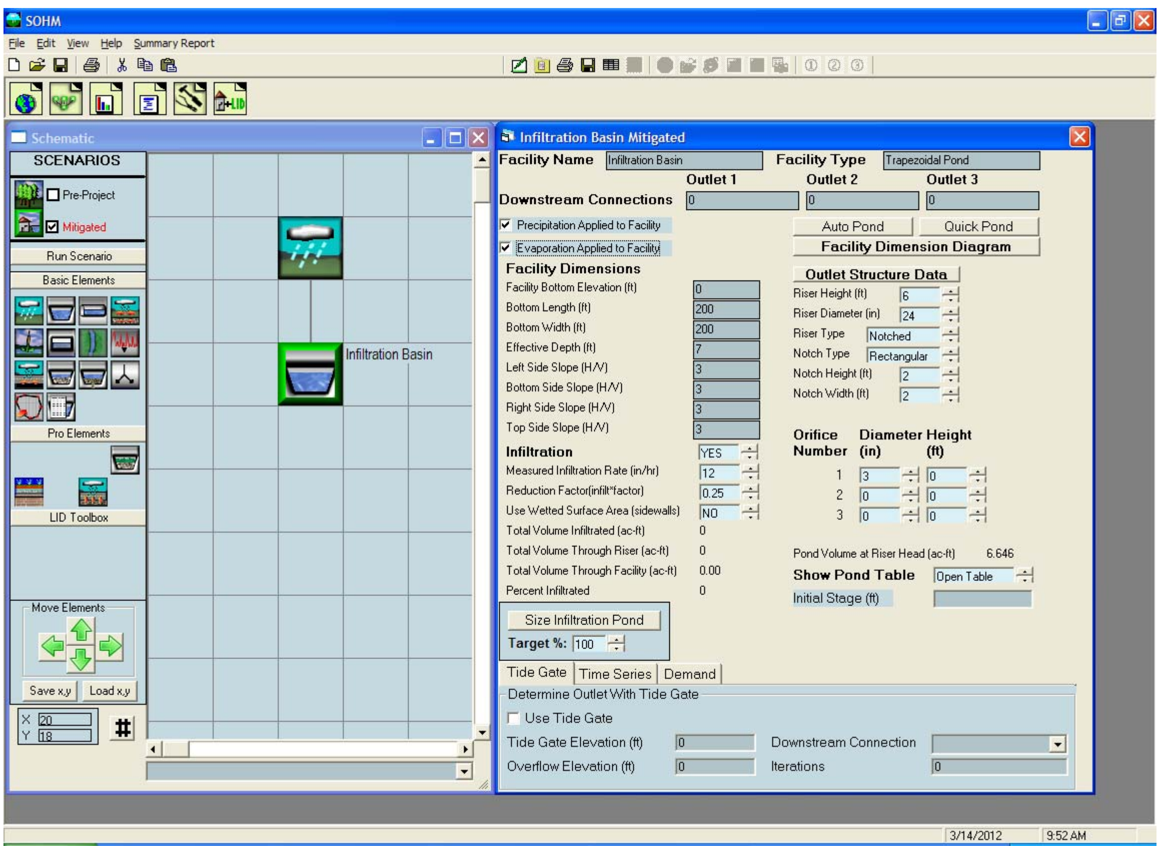
An infiltration basin/pond allows stormwater to enter the basin/pond above ground and then infiltrate through the bottom of the basin/pond before exiting through a discharge pipe. Water can also infiltrate into the native soil beneath the basin/pond.

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.



Infiltration Basin/Pond

In SOHM the infiltration basin/pond is represented by the trapezoidal or irregular-shaped pond element.



The pond dimensions and parameters to adjust to represent an infiltration basin are:

Bottom Length (ft): Infiltration basin/pond length.
Bottom Width (ft): Infiltration basin/pond width.
Effective Depth (ft): Infiltration basin height from basin/pond bottom to top of riser plus at least 0.5 feet extra.

Left Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Bottom Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Right Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Top Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Riser Height (ft): Height of infiltration basin/pond overflow pipe above basin/pond soil surface.
Riser Diameter (in): Infiltration basin/pond overflow pipe diameter.
Riser Type: Flat

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 68).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the basin/pond side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 68.

*NOTE: See **Appendix C** or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.*

An infiltration basin/pond receives precipitation on and evaporation from the basin/pond surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

APPENDIX A

DEFAULT SOHM HSPF PERVIOUS PARAMETER VALUES

The default SOHM HSPF pervious parameter values are found in SOHM file defaultpers.uci.

HSPF parameter documentation is found in the document:
Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. Hydrological Simulation Program – Fortran, User's Manual for Version 12. AQUA TERRA Consultants. Mountain View, CA.

Table 1: SOHM Pervious Land Types

PERLND No.	Soil Type	Land Cover	Land Slope
1	A	Scrub	Flat (0-5%)
2	A	Scrub	Moderate (5-10%)
3	A	Scrub	Steep (10-15%)
4	A	Scrub	Very Steep (>15%)
5	A	Open Brush	Flat (0-5%)
6	A	Open Brush	Moderate (5-10%)
7	A	Open Brush	Steep (10-15%)
8	A	Open Brush	Very Steep (>15%)
9	A	Gravel	Flat (0-5%)
10	A	Gravel	Moderate (5-10%)
11	A	Gravel	Steep (10-15%)
12	A	Gravel	Very Steep (>15%)
13	B	Scrub	Flat (0-5%)
14	B	Scrub	Moderate (5-10%)
15	B	Scrub	Steep (10-15%)
16	B	Scrub	Very Steep (>15%)
17	B	Open Brush	Flat (0-5%)
18	B	Open Brush	Moderate (5-10%)
19	B	Open Brush	Steep (10-15%)
20	B	Open Brush	Very Steep (>15%)
21	B	Gravel	Flat (0-5%)
22	B	Gravel	Moderate (5-10%)
23	B	Gravel	Steep (10-15%)
24	B	Gravel	Very Steep (>15%)
25	C	Scrub	Flat (0-5%)
26	C	Scrub	Moderate (5-10%)
27	C	Scrub	Steep (10-15%)
28	C	Scrub	Very Steep (>15%)
29	C	Open Brush	Flat (0-5%)
30	C	Open Brush	Moderate (5-10%)
31	C	Open Brush	Steep (10-15%)
32	C	Open Brush	Very Steep (>15%)
33	C	Gravel	Flat (0-5%)
34	C	Gravel	Moderate (5-10%)
35	C	Gravel	Steep (10-15%)
36	C	Gravel	Very Steep (>15%)
37	D	Scrub	Flat (0-5%)

PERLND No.	Soil Type	Land Cover	Land Slope
38	D	Scrub	Moderate (5-10%)
39	D	Scrub	Steep (10-15%)
40	D	Scrub	Very Steep (>15%)
41	D	Open Brush	Flat (0-5%)
42	D	Open Brush	Moderate (5-10%)
43	D	Open Brush	Steep (10-15%)
44	D	Open Brush	Very Steep (>15%)
45	D	Gravel	Flat (0-5%)
46	D	Gravel	Moderate (5-10%)
47	D	Gravel	Steep (10-15%)
48	D	Gravel	Very Steep (>15%)
49	A	Urban	Flat (0-5%)
50	A	Urban	Moderate (5-10%)
51	A	Urban	Steep (10-15%)
52	A	Urban	Very Steep (>15%)
53	B	Urban	Flat (0-5%)
54	B	Urban	Moderate (5-10%)
55	B	Urban	Steep (10-15%)
56	B	Urban	Very Steep (>15%)
57	C	Urban	Flat (0-5%)
58	C	Urban	Moderate (5-10%)
59	C	Urban	Steep (10-15%)
60	C	Urban	Very Steep (>15%)
61	D	Urban	Flat (0-5%)
62	D	Urban	Moderate (5-10%)
63	D	Urban	Steep (10-15%)
64	D	Urban	Very Steep (>15%)

Table 2: SOHM HSPF Pervious Parameter Values – Part I

PERLND No.	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1	5.20	0.090	400	0.05	0.80	0.955
2	4.80	0.070	350	0.10	0.80	0.955
3	4.50	0.045	300	0.15	0.80	0.955
4	4.20	0.030	250	0.20	0.80	0.955
5	5.20	0.090	400	0.05	0.80	0.955
6	4.80	0.070	350	0.10	0.80	0.955
7	4.50	0.045	300	0.15	0.80	0.955
8	4.20	0.030	250	0.20	0.80	0.955
9	2.60	0.045	400	0.05	0.80	0.955
10	2.40	0.035	350	0.10	0.80	0.955
11	2.20	0.022	300	0.15	0.80	0.955
12	2.00	0.018	250	0.20	0.80	0.955
13	5.00	0.070	400	0.05	0.80	0.955
14	4.70	0.055	350	0.10	0.80	0.955
15	4.40	0.040	300	0.15	0.80	0.955
16	4.10	0.025	250	0.20	0.80	0.955
17	5.00	0.070	400	0.05	0.80	0.955
18	4.70	0.055	350	0.10	0.80	0.955
19	4.40	0.040	300	0.15	0.80	0.955
20	4.10	0.025	250	0.20	0.80	0.955
21	2.50	0.035	400	0.05	0.80	0.955
22	2.30	0.028	350	0.10	0.80	0.955
23	2.10	0.020	300	0.15	0.80	0.955
24	1.90	0.015	250	0.20	0.80	0.955
25	4.80	0.045	400	0.05	0.80	0.955
26	4.50	0.040	350	0.10	0.80	0.955
27	4.20	0.030	300	0.15	0.80	0.955
28	3.90	0.015	250	0.20	0.80	0.955
29	4.80	0.045	400	0.05	0.80	0.955
30	4.50	0.040	350	0.10	0.80	0.955
31	4.20	0.030	300	0.15	0.80	0.955
32	4.00	0.015	250	0.20	0.80	0.955
33	2.40	0.022	400	0.05	0.80	0.955
34	2.20	0.020	350	0.10	0.80	0.955
35	2.00	0.015	300	0.15	0.80	0.955
36	1.80	0.010	250	0.20	0.80	0.955
37	4.60	0.040	400	0.05	0.80	0.955
38	4.30	0.035	350	0.10	0.80	0.955
39	4.00	0.025	300	0.15	0.80	0.955
40	3.70	0.012	250	0.20	0.80	0.955
41	4.60	0.040	400	0.05	0.80	0.955
42	4.30	0.035	350	0.10	0.80	0.955
43	4.00	0.025	300	0.15	0.80	0.955
44	3.70	0.012	250	0.20	0.80	0.955

PERLND No.	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
45	2.30	0.020	400	0.05	0.80	0.955
46	2.10	0.018	350	0.10	0.80	0.955
47	1.90	0.012	300	0.15	0.80	0.955
48	1.70	0.008	250	0.20	0.80	0.955
49	5.00	0.070	400	0.05	0.80	0.955
50	4.70	0.055	350	0.10	0.80	0.955
51	4.40	0.040	300	0.15	0.80	0.955
52	4.10	0.025	250	0.20	0.80	0.955
53	4.80	0.070	400	0.05	0.80	0.955
54	4.50	0.055	350	0.10	0.80	0.955
55	4.20	0.040	300	0.15	0.80	0.955
56	4.00	0.025	250	0.20	0.80	0.955
57	4.60	0.045	400	0.05	0.80	0.955
58	4.30	0.040	350	0.10	0.80	0.955
59	4.00	0.030	300	0.15	0.80	0.955
60	3.70	0.015	250	0.20	0.80	0.955
61	4.40	0.040	400	0.05	0.80	0.955
62	4.10	0.035	350	0.10	0.80	0.955
63	3.90	0.025	300	0.15	0.80	0.955
64	3.60	0.012	250	0.20	0.80	0.955

LZSN: Lower Zone Storage Nominal (inches)
INFILT: Infiltration (inches per hour)
LSUR: Length of surface flow path (feet)
SLSUR: Slope of surface flow path (feet/feet)
KVARY: Variable groundwater recession
AGWRC: Active Groundwater Recession Constant (per day)

Table 3: SOHM HSPF Pervious Parameter Values – Part II

PERLND No.	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
1	2.0	2.0	0.0	0.03	0.00
2	2.0	2.0	0.0	0.03	0.00
3	2.0	2.0	0.0	0.03	0.00
4	2.0	2.0	0.0	0.03	0.00
5	2.0	2.0	0.0	0.03	0.00
6	2.0	2.0	0.0	0.03	0.00
7	2.0	2.0	0.0	0.03	0.00
8	2.0	2.0	0.0	0.03	0.00
9	2.0	2.0	0.0	0.03	0.00
10	2.0	2.0	0.0	0.03	0.00
11	2.0	2.0	0.0	0.03	0.00
12	2.0	2.0	0.0	0.03	0.00
13	2.0	2.0	0.0	0.03	0.00
14	2.0	2.0	0.0	0.03	0.00
15	2.0	2.0	0.0	0.03	0.00
16	2.0	2.0	0.0	0.03	0.00
17	2.0	2.0	0.0	0.03	0.00
18	2.0	2.0	0.0	0.03	0.00
19	2.0	2.0	0.0	0.03	0.00
20	2.0	2.0	0.0	0.03	0.00
21	2.0	2.0	0.0	0.03	0.00
22	2.0	2.0	0.0	0.03	0.00
23	2.0	2.0	0.0	0.03	0.00
24	2.0	2.0	0.0	0.03	0.00
25	3.0	2.0	0.0	0.03	0.00
26	3.0	2.0	0.0	0.03	0.00
27	3.0	2.0	0.0	0.03	0.00
28	3.0	2.0	0.0	0.03	0.00
29	3.0	2.0	0.0	0.03	0.00
30	3.0	2.0	0.0	0.03	0.00
31	3.0	2.0	0.0	0.03	0.00
32	3.0	2.0	0.0	0.03	0.00
33	3.0	2.0	0.0	0.03	0.00
34	3.0	2.0	0.0	0.03	0.00
35	3.0	2.0	0.0	0.03	0.00
36	3.0	2.0	0.0	0.03	0.00
37	4.0	2.0	0.0	0.03	0.00
38	4.0	2.0	0.0	0.03	0.00
39	4.0	2.0	0.0	0.03	0.00
40	4.0	2.0	0.0	0.03	0.00
41	4.0	2.0	0.0	0.03	0.00
42	4.0	2.0	0.0	0.03	0.00
43	4.0	2.0	0.0	0.03	0.00
44	4.0	2.0	0.0	0.03	0.00
45	4.0	2.0	0.0	0.03	0.00

PERLND No.	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
46	4.0	2.0	0.0	0.03	0.00
47	4.0	2.0	0.0	0.03	0.00
48	4.0	2.0	0.0	0.03	0.00
49	2.0	2.0	0.0	0.03	0.00
50	2.0	2.0	0.0	0.03	0.00
51	2.0	2.0	0.0	0.03	0.00
52	2.0	2.0	0.0	0.03	0.00
53	2.0	2.0	0.0	0.03	0.00
54	2.0	2.0	0.0	0.03	0.00
55	2.0	2.0	0.0	0.03	0.00
56	2.0	2.0	0.0	0.03	0.00
57	3.0	2.0	0.0	0.03	0.00
58	3.0	2.0	0.0	0.03	0.00
59	3.0	2.0	0.0	0.03	0.00
60	3.0	2.0	0.0	0.03	0.00
61	4.0	2.0	0.0	0.03	0.00
62	4.0	2.0	0.0	0.03	0.00
63	4.0	2.0	0.0	0.03	0.00
64	4.0	2.0	0.0	0.03	0.00

INFEXP: Infiltration Exponent
INFILD: Infiltration ratio (maximum to mean)
DEEPFR: Fraction of groundwater to deep aquifer or inactive storage
BASETP: Base flow (from groundwater) Evapotranspiration fraction
AGWETP: Active Groundwater Evapotranspiration fraction

Table 4: SOHM HSPF Pervious Parameter Values – Part III

PERLND No.	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	see Table 8	0.90	0.30	4.00	0.70	see Table 9
2	see Table 8	0.70	0.30	3.20	0.45	see Table 9
3	see Table 8	0.50	0.30	2.60	0.40	see Table 9
4	see Table 8	0.30	0.30	1.30	0.30	see Table 9
5	see Table 8	0.80	0.25	4.00	0.70	see Table 9
6	see Table 8	0.65	0.25	3.20	0.45	see Table 9
7	see Table 8	0.45	0.25	2.60	0.40	see Table 9
8	see Table 8	0.25	0.25	1.30	0.30	see Table 9
9	see Table 8	0.60	0.20	1.50	0.70	see Table 9
10	see Table 8	0.50	0.20	1.40	0.45	see Table 9
11	see Table 8	0.40	0.20	1.20	0.40	see Table 9
12	see Table 8	0.20	0.20	1.00	0.30	see Table 9
13	see Table 8	0.90	0.30	3.00	0.70	see Table 9
14	see Table 8	0.70	0.30	2.40	0.45	see Table 9
15	see Table 8	0.50	0.30	1.60	0.40	see Table 9
16	see Table 8	0.30	0.30	1.00	0.30	see Table 9
17	see Table 8	0.80	0.25	3.00	0.70	see Table 9
18	see Table 8	0.65	0.25	2.40	0.45	see Table 9
19	see Table 8	0.45	0.25	1.60	0.40	see Table 9
20	see Table 8	0.25	0.25	1.00	0.30	see Table 9
21	see Table 8	0.60	0.20	1.40	0.70	see Table 9
22	see Table 8	0.50	0.20	1.30	0.45	see Table 9
23	see Table 8	0.40	0.20	1.10	0.40	see Table 9
24	see Table 8	0.20	0.20	0.80	0.30	see Table 9
25	see Table 8	0.90	0.30	2.00	0.70	see Table 9
26	see Table 8	0.70	0.30	1.20	0.45	see Table 9
27	see Table 8	0.50	0.30	0.80	0.40	see Table 9
28	see Table 8	0.30	0.30	0.40	0.30	see Table 9
29	see Table 8	0.80	0.25	2.00	0.70	see Table 9
30	see Table 8	0.65	0.25	1.20	0.45	see Table 9
31	see Table 8	0.45	0.25	0.80	0.40	see Table 9
32	see Table 8	0.25	0.25	0.40	0.30	see Table 9
33	see Table 8	0.60	0.20	1.30	0.70	see Table 9
34	see Table 8	0.50	0.20	0.90	0.45	see Table 9
35	see Table 8	0.40	0.20	0.60	0.40	see Table 9
36	see Table 8	0.20	0.20	0.30	0.30	see Table 9
37	see Table 8	0.90	0.30	1.00	0.70	see Table 9
38	see Table 8	0.70	0.30	0.80	0.45	see Table 9
39	see Table 8	0.50	0.30	0.60	0.40	see Table 9
40	see Table 8	0.30	0.30	0.30	0.30	see Table 9
41	see Table 8	0.80	0.25	1.00	0.70	see Table 9
42	see Table 8	0.65	0.25	0.80	0.45	see Table 9
43	see Table 8	0.45	0.25	0.60	0.40	see Table 9
44	see Table 8	0.25	0.25	0.30	0.30	see Table 9
45	see Table 8	0.60	0.20	0.65	0.70	see Table 9

PERLND No.	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
46	see Table 8	0.50	0.20	0.45	0.45	see Table 9
47	see Table 8	0.40	0.20	0.30	0.40	see Table 9
48	see Table 8	0.20	0.20	0.20	0.30	see Table 9
49	see Table 8	0.70	0.25	3.00	0.70	see Table 9
50	see Table 8	0.50	0.25	2.40	0.45	see Table 9
51	see Table 8	0.35	0.25	1.60	0.40	see Table 9
52	see Table 8	0.20	0.25	1.00	0.30	see Table 9
53	see Table 8	0.70	0.25	3.00	0.70	see Table 9
54	see Table 8	0.50	0.25	2.40	0.45	see Table 9
55	see Table 8	0.35	0.25	1.60	0.40	see Table 9
56	see Table 8	0.20	0.25	1.00	0.30	see Table 9
57	see Table 8	0.70	0.25	3.00	0.70	see Table 9
58	see Table 8	0.50	0.25	2.40	0.45	see Table 9
59	see Table 8	0.35	0.25	1.60	0.40	see Table 9
60	see Table 8	0.20	0.25	1.00	0.30	see Table 9
61	see Table 8	0.70	0.25	3.00	0.70	see Table 9
62	see Table 8	0.50	0.25	2.40	0.45	see Table 9
63	see Table 8	0.35	0.25	1.60	0.40	see Table 9
64	see Table 8	0.20	0.25	1.00	0.30	see Table 9

CEPSC: Interception storage (inches)
UZSN: Upper Zone Storage Nominal (inches)
NSUR: Surface roughness (Manning's n)
INTFW: Interflow index
IRC: Interflow Recession Constant (per day)
LZETP: Lower Zone Evapotranspiration fraction

Table 5: SOHM HSPF Pervious Parameter Values – Part IV

PERLND No.	MELEV	BELV	GWDATM	PCW	PGW	UPGW
1	400	0	0	0.35	0.38	0.45
2	400	0	0	0.35	0.38	0.45
3	400	0	0	0.35	0.38	0.45
4	400	0	0	0.35	0.38	0.45
5	400	0	0	0.33	0.35	0.42
6	400	0	0	0.33	0.35	0.42
7	400	0	0	0.33	0.35	0.42
8	400	0	0	0.33	0.35	0.42
9	400	0	0	0.31	0.33	0.40
10	400	0	0	0.31	0.33	0.40
11	400	0	0	0.31	0.33	0.40
12	400	0	0	0.31	0.33	0.40
13	400	0	0	0.30	0.32	0.40
14	400	0	0	0.30	0.32	0.40
15	400	0	0	0.30	0.32	0.40
16	400	0	0	0.30	0.32	0.40
17	400	0	0	0.28	0.26	0.37
18	400	0	0	0.28	0.26	0.37
19	400	0	0	0.28	0.26	0.37
20	400	0	0	0.28	0.26	0.37
21	400	0	0	0.26	0.28	0.35
22	400	0	0	0.26	0.28	0.35
23	400	0	0	0.26	0.28	0.35
24	400	0	0	0.26	0.28	0.35
25	400	0	0	0.20	0.23	0.28
26	400	0	0	0.20	0.23	0.28
27	400	0	0	0.20	0.23	0.28
28	400	0	0	0.20	0.23	0.28
29	400	0	0	0.18	0.20	0.25
30	400	0	0	0.18	0.20	0.25
31	400	0	0	0.18	0.20	0.25
32	400	0	0	0.18	0.20	0.25
33	400	0	0	0.15	0.18	0.20
34	400	0	0	0.15	0.18	0.20
35	400	0	0	0.15	0.18	0.20
36	400	0	0	0.15	0.18	0.20
37	400	0	0	0.20	0.23	0.28
38	400	0	0	0.20	0.23	0.28
39	400	0	0	0.20	0.23	0.28
40	400	0	0	0.20	0.23	0.28
41	400	0	0	0.18	0.20	0.25
42	400	0	0	0.18	0.20	0.25
43	400	0	0	0.18	0.20	0.25
44	400	0	0	0.18	0.20	0.25
45	400	0	0	0.15	0.18	0.20

PERLND No.	MELEV	BELV	GWDATM	PCW	PGW	UPGW
46	400	0	0	0.15	0.18	0.20
47	400	0	0	0.15	0.18	0.20
48	400	0	0	0.15	0.18	0.20
49	400	0	0	0.35	0.38	0.45
50	400	0	0	0.35	0.38	0.45
51	400	0	0	0.35	0.38	0.45
52	400	0	0	0.35	0.38	0.45
53	400	0	0	0.30	0.32	0.40
54	400	0	0	0.30	0.32	0.40
55	400	0	0	0.30	0.32	0.40
56	400	0	0	0.30	0.32	0.40
57	400	0	0	0.20	0.23	0.28
58	400	0	0	0.20	0.23	0.28
59	400	0	0	0.20	0.23	0.28
60	400	0	0	0.20	0.23	0.28
61	400	0	0	0.20	0.23	0.28
62	400	0	0	0.20	0.23	0.28
63	400	0	0	0.20	0.23	0.28
64	400	0	0	0.20	0.23	0.28

MELEV: Mean surface elevation of the land segment (feet)
BELV: Base elevation for active groundwater (feet)
GWDATM: Datum for the groundwater elevation (feet)
PCW: Cohesion Water Porosity (fraction)
PGW: Gravitational Water Porosity (fraction)
UPGW: Upper Gravitational Water porosity (fraction)

Table 6: SOHM HSPF Pervious Parameter Values – Part V

PERLND No.	STABNO	SRRC	SREXP	IFWSC	DELTA	UELFAC	LELFAC
1	1	0.1	0	4	0.2	4	2.5
2	1	0.1	0	4	0.2	4	2.5
3	1	0.1	0	4	0.2	4	2.5
4	1	0.1	0	4	0.2	4	2.5
5	1	0.1	0	4	0.2	4	2.5
6	1	0.1	0	4	0.2	4	2.5
7	1	0.1	0	4	0.2	4	2.5
8	1	0.1	0	4	0.2	4	2.5
9	1	0.1	0	4	0.2	4	2.5
10	1	0.1	0	4	0.2	4	2.5
11	1	0.1	0	4	0.2	4	2.5
12	1	0.1	0	4	0.2	4	2.5
13	1	0.1	0	4	0.2	4	2.5
14	1	0.1	0	4	0.2	4	2.5
15	1	0.1	0	4	0.2	4	2.5
16	1	0.1	0	4	0.2	4	2.5
17	1	0.1	0	4	0.2	4	2.5
18	1	0.1	0	4	0.2	4	2.5
19	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
21	1	0.1	0	4	0.2	4	2.5
22	1	0.1	0	4	0.2	4	2.5
23	1	0.1	0	4	0.2	4	2.5
24	1	0.1	0	4	0.2	4	2.5
25	1	0.1	0	4	0.2	4	2.5
26	1	0.1	0	4	0.2	4	2.5
27	1	0.1	0	4	0.2	4	2.5
28	1	0.1	0	4	0.2	4	2.5
29	1	0.1	0	4	0.2	4	2.5
30	1	0.1	0	4	0.2	4	2.5
31	1	0.1	0	4	0.2	4	2.5
32	1	0.1	0	4	0.2	4	2.5
33	1	0.1	0	4	0.2	4	2.5
34	1	0.1	0	4	0.2	4	2.5
35	1	0.1	0	4	0.2	4	2.5
36	1	0.1	0	4	0.2	4	2.5
37	1	0.1	0	4	0.2	4	2.5
38	1	0.1	0	4	0.2	4	2.5
39	1	0.1	0	4	0.2	4	2.5
40	1	0.1	0	4	0.2	4	2.5
41	1	0.1	0	4	0.2	4	2.5
42	1	0.1	0	4	0.2	4	2.5
43	1	0.1	0	4	0.2	4	2.5
44	1	0.1	0	4	0.2	4	2.5
45	1	0.1	0	4	0.2	4	2.5

PERLND No.	STABNO	SRRC	SREXP	IFWSC	DELTA	UELFAC	LELFAC
46	1	0.1	0	4	0.2	4	2.5
47	1	0.1	0	4	0.2	4	2.5
48	1	0.1	0	4	0.2	4	2.5
49	1	0.1	0	4	0.2	4	2.5
50	1	0.1	0	4	0.2	4	2.5
51	1	0.1	0	4	0.2	4	2.5
52	1	0.1	0	4	0.2	4	2.5
53	1	0.1	0	4	0.2	4	2.5
54	1	0.1	0	4	0.2	4	2.5
55	1	0.1	0	4	0.2	4	2.5
56	1	0.1	0	4	0.2	4	2.5
57	1	0.1	0	4	0.2	4	2.5
58	1	0.1	0	4	0.2	4	2.5
59	1	0.1	0	4	0.2	4	2.5
60	1	0.1	0	4	0.2	4	2.5
61	1	0.1	0	4	0.2	4	2.5
62	1	0.1	0	4	0.2	4	2.5
63	1	0.1	0	4	0.2	4	2.5
64	1	0.1	0	4	0.2	4	2.5

STABNO: User's number for the FTABLE in the FTABLES block which contains the outflow properties from the surface storage
SRRC: Surface Runoff Recession Constant (per hour)
SREXP: Surface Runoff Exponent
IFWSC: Maximum Interflow Storage Capacity when the groundwater elevation is greater than the upper influence elevation (inches)

DELTA: groundwater tolerance level used to determine transition between regions when high water table conditions are being simulated
UELFAC: multiplier on UZSN which gives the upper zone capacity
LELFAC: multiplier on LZSN which gives the lower zone capacity

The selection of the Table 5 and Table 6 default parameter values is based on limited application of these parameters in California by the staff of Clear Creek Solutions, Inc.

NOTE: The parameter values should be used with caution and only after consultation with the appropriate local municipal permitting agency or guidance in Appendix C. Different values should only be selected following detailed local soil analysis, a thorough understanding of the parameters and algorithms, and consultation with the appropriate local municipal permitting agency.

Table 7: SOHM HSPF Pervious Parameter Values – Part VI

PERLND No.	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
1	0.00	0.00	0.090	0.00	1.040	0.30	0.01
2	0.00	0.00	0.070	0.00	0.960	0.30	0.01
3	0.00	0.00	0.050	0.00	0.900	0.30	0.01
4	0.00	0.00	0.030	0.00	0.840	0.30	0.01
5	0.00	0.00	0.080	0.00	1.040	0.30	0.01
6	0.00	0.00	0.065	0.00	0.960	0.30	0.01
7	0.00	0.00	0.045	0.00	0.900	0.30	0.01
8	0.00	0.00	0.025	0.00	0.840	0.30	0.01
9	0.00	0.00	0.060	0.00	0.520	0.30	0.01
10	0.00	0.00	0.050	0.00	0.480	0.30	0.01
11	0.00	0.00	0.040	0.00	0.440	0.30	0.01
12	0.00	0.00	0.020	0.00	0.400	0.30	0.01
13	0.00	0.00	0.090	0.00	1.000	0.30	0.01
14	0.00	0.00	0.070	0.00	0.940	0.30	0.01
15	0.00	0.00	0.050	0.00	0.880	0.30	0.01
16	0.00	0.00	0.030	0.00	0.820	0.30	0.01
17	0.00	0.00	0.080	0.00	1.000	0.30	0.01
18	0.00	0.00	0.065	0.00	0.940	0.30	0.01
19	0.00	0.00	0.045	0.00	0.880	0.30	0.01
20	0.00	0.00	0.025	0.00	0.820	0.30	0.01
21	0.00	0.00	0.060	0.00	0.500	0.30	0.01
22	0.00	0.00	0.050	0.00	0.460	0.30	0.01
23	0.00	0.00	0.040	0.00	0.420	0.30	0.01
24	0.00	0.00	0.020	0.00	0.380	0.30	0.01
25	0.00	0.00	0.090	0.00	0.960	0.30	0.01
26	0.00	0.00	0.070	0.00	0.900	0.30	0.01
27	0.00	0.00	0.050	0.00	0.840	0.30	0.01
28	0.00	0.00	0.030	0.00	0.780	0.30	0.01
29	0.00	0.00	0.080	0.00	0.960	0.30	0.01
30	0.00	0.00	0.065	0.00	0.900	0.30	0.01
31	0.00	0.00	0.045	0.00	0.840	0.30	0.01
32	0.00	0.00	0.025	0.00	0.800	0.30	0.01
33	0.00	0.00	0.060	0.00	0.480	0.30	0.01
34	0.00	0.00	0.050	0.00	0.440	0.30	0.01
35	0.00	0.00	0.040	0.00	0.400	0.30	0.01
36	0.00	0.00	0.020	0.00	0.360	0.30	0.01
37	0.00	0.00	0.090	0.00	0.920	0.30	0.01
38	0.00	0.00	0.070	0.00	0.860	0.30	0.01
39	0.00	0.00	0.050	0.00	0.800	0.30	0.01
40	0.00	0.00	0.030	0.00	0.740	0.30	0.01
41	0.00	0.00	0.080	0.00	0.920	0.30	0.01
42	0.00	0.00	0.065	0.00	0.860	0.30	0.01
43	0.00	0.00	0.045	0.00	0.800	0.30	0.01
44	0.00	0.00	0.025	0.00	0.740	0.30	0.01
45	0.00	0.00	0.060	0.00	0.460	0.30	0.01

PERLND No.	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
46	0.00	0.00	0.050	0.00	0.420	0.30	0.01
47	0.00	0.00	0.040	0.00	0.380	0.30	0.01
48	0.00	0.00	0.020	0.00	0.340	0.30	0.01
49	0.00	0.00	0.070	0.00	1.000	0.30	0.01
50	0.00	0.00	0.050	0.00	0.940	0.30	0.01
51	0.00	0.00	0.035	0.00	0.880	0.30	0.01
52	0.00	0.00	0.020	0.00	0.820	0.30	0.01
53	0.00	0.00	0.070	0.00	0.960	0.30	0.01
54	0.00	0.00	0.050	0.00	0.900	0.30	0.01
55	0.00	0.00	0.035	0.00	0.840	0.30	0.01
56	0.00	0.00	0.020	0.00	0.800	0.30	0.01
57	0.00	0.00	0.070	0.00	0.920	0.30	0.01
58	0.00	0.00	0.050	0.00	0.860	0.30	0.01
59	0.00	0.00	0.035	0.00	0.800	0.30	0.01
60	0.00	0.00	0.020	0.00	0.740	0.30	0.01
61	0.00	0.00	0.070	0.00	0.880	0.30	0.01
62	0.00	0.00	0.050	0.00	0.820	0.30	0.01
63	0.00	0.00	0.035	0.00	0.780	0.30	0.01
64	0.00	0.00	0.020	0.00	0.720	0.30	0.01

CEPS: Initial interception storage (inches)
SURS: Initial surface runoff (inches)
UZS: Initial Upper Zone Storage (inches)
IFWS: Initial interflow (inches)
LZS: Initial Lower Zone Storage (inches)
AGWS: Initial Active Groundwater storage (inches)
GWVS: Initial Groundwater Vertical Slope (feet/feet)

Table 8: SOHM HSPF Pervious Parameter Values: Monthly Interception Storage (inches)

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
4	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
9	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
16	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
17	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
18	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
19	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
20	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
21	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
22	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
23	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
24	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
25	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
26	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
27	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
28	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
29	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
30	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
31	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
32	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
33	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
34	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
35	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
36	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
37	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
38	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
39	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
40	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
41	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
42	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
43	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
44	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
45	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
46	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
47	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
48	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
49	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
50	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
51	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
52	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
53	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
54	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
55	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
56	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
57	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
58	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
59	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
60	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
61	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
62	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
63	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
64	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

Table 9: SOHM HSPF Pervious Parameter Values: Monthly Lower Zone Evapotranspiration

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
2	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
3	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
4	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
5	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
6	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
7	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
8	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
9	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
11	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
14	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
15	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
16	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
17	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
18	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
19	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
20	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
21	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
22	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
23	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
24	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
25	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
26	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
27	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
28	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
29	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
30	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
31	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
32	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
33	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
34	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
36	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
37	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
38	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
39	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
40	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
41	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
42	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
43	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
44	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
46	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
47	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
48	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
49	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
50	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
51	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
52	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
53	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
54	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
55	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
56	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
57	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
58	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
59	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
60	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
61	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
62	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
63	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
64	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50

APPENDIX B

DEFAULT SOHM HSPF IMPERVIOUS PARAMETER VALUES

The default SOHM HSPF impervious parameter values are found in SOHM file defaultpers.uci.

HSPF parameter documentation is found in the document:
Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. Hydrological Simulation Program – Fortran, User's Manual for Version 12. AQUA TERRA Consultants. Mountain View, CA.

Table 1: SOHM Impervious Land Types

IMPLND No.	IMPLND Name	Land Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-10%)
3	Impervious	Steep (10-15%)
4	Impervious	Very Steep (>15%)

Table 2: SOHM HSPF Impervious Parameter Values – Part I

IMPLND No.	LSUR	SLSUR	NSUR	RETSC
1	100	0.05	0.10	0.10
2	100	0.10	0.10	0.09
3	100	0.15	0.10	0.08
4	100	0.20	0.10	0.07

LSUR: Length of surface flow path (feet) for impervious area
SLSUR: Slope of surface flow path (feet/feet) for impervious area
NSUR: Surface roughness (Manning's n) for impervious area
RETSC: Surface retention storage (inches) for impervious area

Table 3: SOHM HSPF Impervious Parameter Values – Part II

IMPLND No.	RETS	SURS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00

RETSC: Initial surface retention storage (inches) for impervious area
SURS: Initial surface runoff (inches) for impervious area

APPENDIX C

ADDITIONAL GUIDANCE FOR USING SOHM

Scope and Purpose: This appendix includes guidance and background information that are not incorporated into the SOHM software, but which the user needs to know in order to use SOHM for designing projects in the participating jurisdictions. The three main topic areas in this appendix are flagged in the main guidance documentation text by specially formatted notes under the SOHM elements or software features to which they are related:

Appendix C Topic	Relevant Sections in Guidance documentation
Infiltration Reduction Factor	Infiltration, page 68; applicable when specifying characteristics of a facility (pond, vault, tank, some LID elements) if “yes” is selected as the Infiltration option.
Flow Duration Outlet Structures (includes sizing of low-flow orifice and alternative configurations)	Outlet Structure Configurations, pages 62-67; applicable when specifying characteristics of a flow duration facility.
Drawdown (drain) time for flow duration facilities	Drawdown (Analysis screen), page 103.

This guidance was originally created by the stormwater programs of Alameda, Santa Clara, and San Mateo counties. Please consult with the local municipal permitting agency for additional considerations.

Additional guidance and references are also discussed at the end of this appendix.

Infiltration Reduction Factor

The Western Washington Hydrology Model included this factor to reflect the requirement in the *Stormwater Management Manual for Western Washington* (SMMWW), to incorporate a Correction Factor (CF) to determine long-term infiltration rates; the inverse of the CF is the Infiltration Reduction Factor in SOHM. The SMMWW gives three methods for determining CF: 1) a table providing empirical correlations between long-term infiltration rates and USDA Soil Textural Classification; 2) ASTM gradation testing at full-scale infiltration facilities; or 3) In-situ infiltration tests, preferably using a Pilot Infiltration Test specified in an appendix of the SMMWW.

Application of a CF or safety factor attempts to account for clogging and the reduction in infiltration over time, which might apply to the bottom of a flow duration pond or the top layer of a bioretention facility. However, a safety factor is also used to account for uncertainties in the available estimate of in-situ infiltration rates. The SMMWW notes that its suggested CF values, which range from 2 to 4, “represent an average degree of long-term facility maintenance, TSS reduction through pretreatment, and site variability in the subsurface conditions”, and that increases or decreases to these factors should be considered for unusual situations.

Suggested safety factors in other texts and guidance generally range from 1 to 4. South Orange County stormwater permits may require some form of tracking and verification for treatment and hydromodification facilities. In addition, designers should not be overly conservative in selecting a very high safety factor, since this might lead to over-controlled (lower) post-project flows and an increase risk of causing impacts from deposition or sedimentation in the receiving channels. In the absence of other guidance, it is suggested that the SOHM Infiltration Reduction Factor not be less than 0.25 or greater than 0.5.

Note: South Orange County stormwater programs may also restrict the use of infiltration for treatment purposes in certain conditions; since the flow duration facilities are also performing some treatment, designers should discuss treatment measure design with the applicable jurisdiction.

Flow Duration Outlet Structures – Practical Design Considerations

Low-flow Orifice Sizing

The diameter of the low-flow (bottom) orifice is an important design parameter for flow duration facilities, since flows discharged through this outlet should be at or below the project threshold for controlled flows (Qcp). However maintenance and/or other practical considerations may dictate a practical limit to how small this orifice may be, which may be larger than the optimal theoretical diameter determined by AutoPond. As an example, the SWMMWW specifies a minimum orifice diameter of 0.5 inches, for flow restrictor assemblies that are within protective enclosures that screen out large particles and also have 1-2 ft of sump below the orifice to allow for some sediment accumulation.

While the user can manually set a minimum size for the low-flow orifice, doing so before running AutoPond is not recommended as this may impair the program's ability to optimize the pond configuration. The following general approach is suggested for designing a pond when there is a small value for the low end of the flow matching range:

1. First estimate the minimum pond volume allowing AutoPond to freely determine the diameter and placement of all orifices.
2. Then manually accept all of the pond settings except low-flow orifice diameter. Set the low-flow orifice to the desired minimum size, after consulting the local municipal permitting agency.
3. Manually run the mitigated scenario as described on page 46 and review the Analysis screen to check if the revised mitigated flow still passes the flow-duration criteria for curve matching. If so, proceed with the pond design using the revised outlet.
4. If the revised design shows Fail scoring at one or more flow levels, excess flow durations may be reduced somewhat by reducing the depth of the pond which lowers the head above the orifice (SWMMWW recognizes a practical minimum of 3 feet of live storage if pond shallowing is required at the minimum orifice size. As an alternative, further mitigation can be applied to the low-flow orifice flow by adding an additional infiltration measure downstream. This can be sized either approximately by estimating an average excess flow from the orifice or with the help of SOHM by returning to the screen for the Pond characteristics and specifying a different Downstream Connection for the bottom orifice, which is then connected to an additional element. With this revision to the post project scenario, the Point of Compliance for the system would then be located at the downstream end of the additional low-flow mitigation.

Alternative Outlet Configurations

SOHM has two default types of outlet configurations (multiple orifice or orifice plus weir notch) based on a standpipe riser structure detailed in the SMMWW. The entire standpipe is usually within a cylindrical enclosure or manhole to exclude trash and larger particles that could clog the outlet. The SMMWW notes that orifices can also be placed on a tee section or a vertical baffle within the same type of enclosure. An alternative configuration is a flat headwall with orifices and or notches, protected by racks or gratings. This may be fabricated from a large steel plate, similar in construction to the extended detention outlets specified in the Denver (Colorado) manual referenced below. This alternative outlet can be simulated in the SOHM as a very large diameter standpipe, where the width of the top notch is equal to the overflow width at the top of the plate between its supports.

Drawdown time and treatment/vector considerations

Flow duration control facilities are designed to detain stormwater on-site for an extended period of time. The drawdown time is a concern to designers in relation to three areas of design besides hydromodification management:

1. Standing water for extended periods provides a potential habitat in which mosquitoes can breed. Orange stormwater programs work with their local mosquito abatement or vector control agencies to develop guidelines for stormwater facility design; these generally recommend that design detention times not exceed 96 hours. Provisions for access and inspection by vector control personnel are also required. Contact the local permitting agency for details of local vector control provisions, which apply to both treatment measures and flow duration facilities.

2. Stormwater that is detained also undergoes water quality treatment through settling and/or infiltration of pollutants. The focus of water quality management is reducing mean annual loads and typical concentrations of pollutants in receiving waters, so treatment design focuses on typical storms which contain the bulk of annual runoff volume. Stormwater permits and guidance documents describe the local design criteria for volume based treatment measures, which apply to a wider range of projects than the hydromodification management requirements. Recommended drawdown times for detention structures are typically at least 48 hours, but not to exceed 96 hours.

3. Flood control design is intended to control peak flows for large sized storms (with expected recurrence intervals such as 25, 50 or 100 years). Flood control facilities typically require capture and detention of a specified volume of stormwater, which then is discharged out at flows that can be safely conveyed by downstream channels without undue risk of flooding. Flood control facilities usually are required to drain within 24 hours after the end of the design storm in order to be empty for the next storm event. This concern that flood control storage remain available for large events has led flood control agencies to require that any storage

volume for water quality not be credited for flood control, a feature that is sometimes referred to as "dead storage".

Although many factors affect the drawdown time, the suggestions below may help SOHM users in evaluating these other requirements. If flow duration control is required for a project site, it is recommended that the design process start with by using SOHM to obtain a preliminary design for the flow duration pond, vault, or tank. Then check the performance of the facility for vector control concerns, and against treatment and/or flood control design criteria as appropriate. The latter are both based on the concept of a single empirical "design storm" which does not directly correspond to the flow duration approach using frequency analysis in a long-term simulation. Stormwater treatment design requires the use of volume-based runoff coefficients, which although similar in concept to runoff coefficients used for flood control, are determined differently. Runoff coefficients used for flood control were derived for large storms with some conservatism built-in to estimates of peak flow rates and water surface elevations. Runoff coefficients for stormwater treatment have been adjusted to reflect runoff from small storms where a greater percentage of the rainfall is held within the catchment.

Vector Management

If the maximum allowed drawdown is seldom or never exceeded over the simulation period, then likelihood of mosquito breeding in the facility is very low and the design for the pond, vault or tank does not need to be modified. If a maximum allowed drawdown time is exceeded then the system may need to be redesigned to reduce the drawdown time. The designer should consider additional reductions in impervious area and/or LID elements to help reduce the facility size.

To evaluate the frequency and distribution of larger events in more detail, use the Hydrograph tool (page 104) to plot monthly peaks for several years at a time of the mitigated (post-project) scenario to get an idea of how often the discharge that corresponds to the maximum allowed drain time would be exceeded during warmer months, when mosquito development times are shortest.

Treatment Credit

Use the applicable design criteria to determine the minimum treatment volume for the post-project scenario. Look at the pond volume representing a 2-day drawdown in the SOHM's flow duration drawdown table. If this is larger than the calculated treatment volume, no further treatment design is needed. If the pond volume is less than the treatment volume, or always drains in less than 2 days, most or all of the water quality criteria may still be met if the combination of infiltration loss and detainment captures 80% of the runoff from the site. Infiltration loss for each pond stage is shown in the Stage-Storage-Discharge table, accessed by selecting the "Open Table" option at the bottom of the main Pond screen.

Flood Control Detention

Local flood control design criteria must be obtained from the appropriate agency, as well as any other policies or restrictions that may apply to drainage design. A single design storm event can be imported as a time series (page 78) and applied to the post-project scenario instead of the simulated precipitation record. If additional live storage is needed, it may be added to upper levels of the same facility or provided elsewhere on the site.

Guidance by Other Agencies

Some agencies in other parts of the United States have developed extensive guidance for design of stormwater management measures. Two manuals are discussed below that provide detailed discussions or examples that may be helpful to users of SOHM, although the suitability of these recommendations for Orange conditions has not been verified. These documents can help provide context and ideas for users for SOHM, but adapting these ideas requires the exercise of professional engineering judgment. **Mention of the procedures and details in these documents does not imply any endorsement or guarantee that they will be appropriate for addressing the Hydromodification Management Standards in South Orange County jurisdictions.**

Stormwater Management Manual for Western Washington (SMMWW) was prepared by the Washington Department of Ecology for implementation in 19 counties of Western Washington. The latest (2005) edition in 5 volumes is on the Web at: http://www.udfcd.org/downloads/down_critmanual.htm

Design recommendations from this manual were the basis for many features of the WWHM that have been carried over into SOHM. Portions of Volume 3 (Hydrology) that may be of interest to project designers include:

- Pages 3-2 through 3-18 illustrate several types of roof downspout controls, simple pre-engineered designs for infiltrating and/or dispersing runoff from roof areas in order to reduce runoff volume and/or increase potential groundwater recharge.
- Pages 3-50 to 3-63 discuss outlet control structures, their maintenance and source equations modeled into WWHM and SOHM
- Pages 3-75 to 3-93 regarding Infiltration Reduction Factor

Urban Storm Drain Criteria Manual by the Denver Urban Drainage and Flood Control District is on the Web at:
http://www.udfcd.org/downloads/down_critmanual.htm

Volume 3 covers design of stormwater treatment measures, including extended detention basins on pages S-66 through S-77 and structural details shown on pages SD-1 to SD-16. Although these designs are not presented for hydromodification management control, the perforated plate design concept allows fine-tuning of drawdown times and is adaptable for use in flow duration facilities.

APPENDIX D

SOHM REVIEWER CHECKLIST

SOHM Reviewer Checklist:	**Yes**	**No**
1. Received SOHM project (WHM and WH2) files?		
2. Received SOHM WDM (WDM) file?		
3. Received SOHM report (DOC) file?		
4. Project (WHM) file loads okay?		
5. Project location matches location on SOHM screen?		
6. Predevelopment scenario runs okay?		
7. Mitigated scenario runs okay?		
8. Compare SOHM Report screen with report file:		
a. Project location descriptions match?		
b. Precipitation gages match?		
c. Precipitation scales match?		
d. Flow frequency results match?		
e. All flow duration values PASS?		
f. Any pervious (PERLND) land use changes?		
g. Any impervious (IMPLND) land use changes?		
h. Any scaling factor changes?		
i. Any duration criteria changes?		
j. pond dimensions match?		
k. pond outlet structure info matches?		
9. SOHM pond dimensions match drawings?		
10. Infiltration set to YES for infiltration pond?		
11. Total SOHM drainage area matches drainage maps/drawings?		
12. Mitigated drainage area(s) match Predevelopment?		
13. Predevelopment vegetation correct?		
14. Mitigated land use areas correct?		
15. Routing correct?		
16. Check facility drawdown (if included):		
a. Used POC Mitigated stage?		
b. Drawdown times okay?		
17. Options set to default values?		
18. Other issues?		
SOHM submittal APPROVED?		