San Diego Hydrology Model 3.1

User Manual

Clear Creek Solutions, Inc.
www.clearcreeksolutions.com

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and the electronic version of this user's manual,
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SDHM 3.1 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 San Diego, 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.

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FOREWORD

The San Diego Hydrology Model 3.1 (SDHM 3.1) 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 User Manual 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 SDHM 3.1.

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. Phase 1 municipal stormwater permits in San Diego County contain requirements to develop and implement hydromodification management plans (HMPs) and to implement associated management measures.

Development of the San Diego 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 San Diego Hydrology Model 3.1 (SDHM 3.1) is adapted from WWHM Version 4, but has been modified to represent San Diego 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.

SDHM 3.1 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 the local municipal permitting agency's stormwater manual appendices C and D for additional information and suggestions for using SDHM 3.1.

Acknowledgements

The following individuals are acknowledged for their contributions to the development of SDHM 3.1 and User Manual:

- Doug Beyerlein, Joe Brascher, and Gary Maxfield of Clear Creek Solutions, Inc., for development of SDHM 3.1 and preparation of the SDHM 3.1 User Manual.
- The staff at Environmental Science Associates (ESA) for overall SDHM 3.1 project management, as part of Task Order No. 10.
- HMP Monitoring Subworkgroup members Stuart Kuhn (County of San Diego), Eric Mosolgo (City of San Diego), and Rene Vidales (County of San Diego) for general guidance and direction in the construction and implementation of SDHM 3.1.
- Laura Henry of Rick Engineering Company for review, QA/QC, and preparation of LID example projects that are included in Appendix A of this user manual.

[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.

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TABLE OF CONTENTS

INTRODUCTION TO SDHM 3.1

SDHM 3.1 is the San Diego Hydrology Model. SDHM 3.1 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 SDHM 3.1 and the SDHM 3.1 User Manual.

This user manual is organized so as to provide the user an example of a standard application using SDHM 3.1 (described in *Quick Start*) followed by descriptions of the different components and options available in SDHM 3.1. The *LID Elements* section presents some ideas of how to incorporate LID (Low Impact Development) facilities and practices into the SDHM 3.1 analysis. Appendices A and B provide a full list of the HSPF parameter values used in SDHM 3.1.

Throughout the user manual 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 SDHM 3.1 software, provided by the local municipal permitting agency's stormwater manual appendices C and D.

Purpose

The purpose of SDHM 3.1 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.

SDHM 3.1 provides:

- A uniform methodology for the San Diego County area.
- A more accurate methodology than single-event design storms.
- An easy-to-use software package.

SDHM 3.1 is based on:

- Continuous simulation hydrology (HSPF).
- Actual long-term recorded precipitation data.
- Potential evapotranspiration data.
- Existing vegetation (for Predeveloped conditions).
- Regional HSPF parameters.

Changes from SDHM 3.0 Interim Version to SDHM 3.1

- New SDHM 3.1 HSPF parameter values.
- New vertical orifice outlet control option.
- Updated drawdown calculation.

Note: Because of the above listed changes, projects that have been created in SDHM 3.0 will not work in SDHM 3.1. To convert older projects to SDHM 3.1 the user needs to manually re-input the project information into a new SDHM 3.1 project file. The project results will change and the hydromod mitigation facility may need to be re-sized.

SDHM 3.1 Computer Requirements

- Windows 2000/XP/Vista/7/8/10 with 300 MB uncompressed hard drive space
- Internet access (only required for downloading SDHM 3.1, not required for executing SDHM 3.1)
- Pentium 3 or faster processor (desirable)
- Color monitor (desirable)

Before Starting SDHM 3.1

- Knowledge of the project 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 planned distribution of the proposed development (buildings, streets, sidewalks, parking, lawn areas) overlying the soil categories.
- An existing DMA (Drainage Management Area) map including information on the Predevelopment site conditions related to topography, vegetative cover (dirt, rock, or native vegetation), NRCS soil categories, drainage infrastructure, and land slope (flat 0-5%, moderate 5-15%, and steep >15%).
- A proposed DMA map with information on the proposed development site conditions related to topography, drainage patterns and grading, pervious and impervious land cover, permeable pavement, amended soils, and landscape design.
- Consultation with the appropriate local permitting agency for guidance and development of existing and proposed DMA maps and establishment of points of compliance (POCs).

SDHM 3.1 OVERVIEW

The SDHM 3.1 software architecture and methodology is the same as that developed for BAHM (Bay Area Hydrology Model) and WWHM and uses HSPF as its computational engine[2]. Like BAHM and WWHM, SDHM 3.1 is a tool that generates flow duration curves for the predevelopment and development condition and then sizes a flow duration control facility and outlet structure to match the Predevelopment curve. The software package consists of a user-friendly graphical interface with screens for input of Predeveloped and development (Mitigated) 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 SDHM 3.1 are based on regional values. SDHM 3.1 uses the San Diego County long-term hourly precipitation data records selected by the County of San Diego.

SDHM 3.1 computes stormwater runoff for a site selected by the user. SDHM 3.1 runs HSPF in the background to generate a hourly runoff time series from the available rain gage data over a number of years. Stormwater runoff is computed for both Predeveloped and development (Mitigated) land use conditions. Then SDHM 3.1 routes the development stormwater runoff through a stormwater control facility of the user's choice.

SDHM uses the Predevelopment peak flood values from a partial duration series of individual peak events to compute the Predevelopment 2-year through 10-year flood frequency values[3] or the user can externally calculate the Predevelopment 2-year and 10-year flow values using USGS regional regression equations (see page 20 for more details). The development (Mitigated) runoff 2-year through 10-year flood frequency values are computed at the outlet of the proposed stormwater facility. The model routes the development (Mitigated) runoff through the stormwater facility. As with the Predevelopment peak flow values, partial duration development (Mitigated) flow values are selected by the model to compute the developed 2-year through 10-year flood frequency.

The Predevelopment 2-year peak flow is multiplied by a percentage (10, 30, or 50 percent) to set the lower limit of the erosive flows, in accordance with the current HMP performance criteria[4]. The Predevelopment 10-year peak flow is the upper limit. A comparison of the Predevelopment and development (Mitigated) flow duration curves is conducted for 100 flow levels between the lower limit and the upper limit. The model

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[2] SDHM 3.1 is based on WWHM Version 4.

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

[4] In SDHM 3.1, this low flow limit is a user-defined variable, to allow flexibility based on whether the site is located in an area with a lower, medium, or high susceptibility to erosive flows.

counts the number of hourly simulation intervals that Predevelopment flows exceed each of the flow levels during the entire simulation period. The model does the same analysis for the development (Mitigated) flows.

Low impact development (LID) practices 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, biofiltration, porous pavement, green roofs, rain gardens, and vegetated swales. All of these approaches reduce stormwater runoff. SDHM 3.1 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.

QUICK START

Quick Start very briefly describes the steps to quickly size a stormwater HMP storage facility using SDHM 3.1 (a more complex SDHM 3.1 example project is included in Appendix E). New users should read the descriptions of the SDHM 3.1 screens, elements, and analysis tools before going through the steps described below.

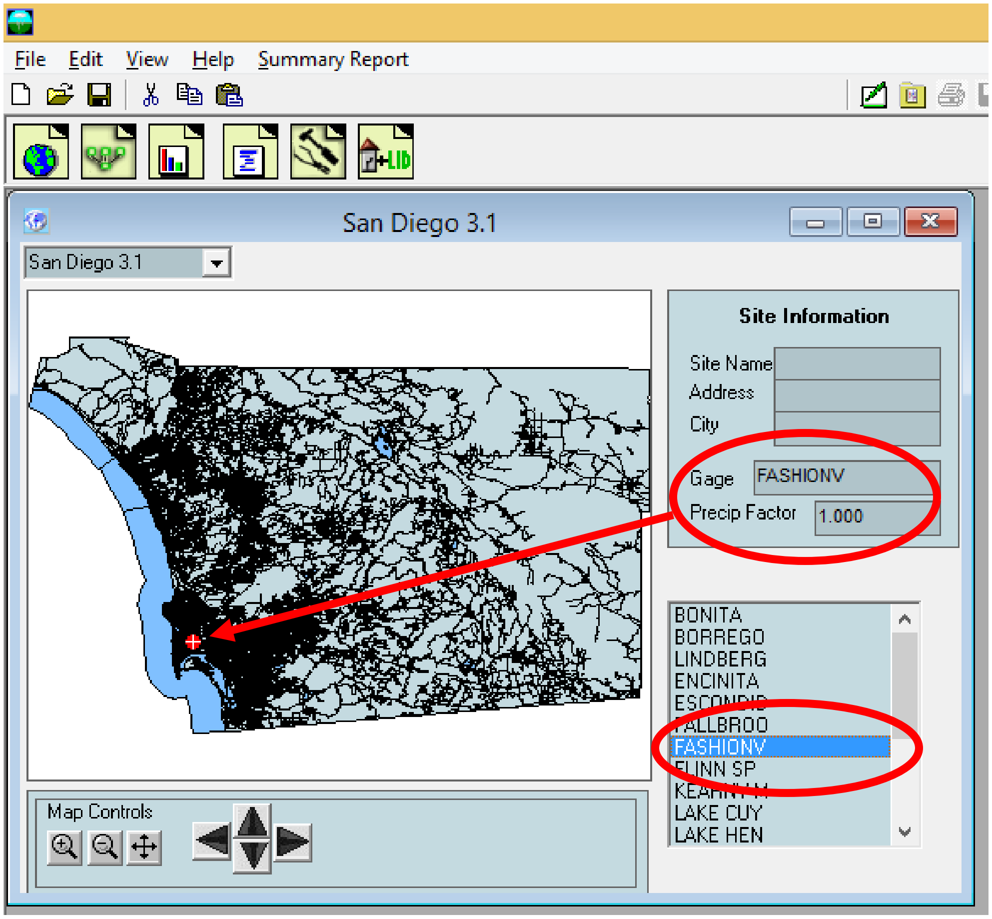
There are 12 steps involved from start to finish. These 12 steps are:

1. Select project location
2. Set up Predevelopment land use scenario
3. Set up Mitigated (developed) land use scenario
4. Calculate lower and upper HMP thresholds based on Predevelopment runoff
5. Calculate lower and upper HMP thresholds based on USGS regional equations (optional)
6. Compare sets of threshold values (optional)
7. Change thresholds (optional)
8. Size Mitigated scenario HMP facility
9. Review analysis
10. Produce report
11. Save project
12. Exit SDHM

Steps 5, 6, and 7 are optional, but are recommended.

Step 1. Select project location.

Locate the project site on the SDHM 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 dot will be placed on the map identifying the project site.

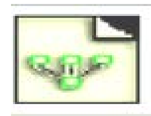


Select the appropriate rainfall station from the list on the right and SDHM 3.1 will automatically load the appropriate precipitation data

For this example we will use the Fashion Valley rain gage. The rain gage data will be multiplied by the precipitation factor (in this example: 1.000).

The site name, address, and city information is optional. It is not used by SDHM 3.1, but will be included in the project report summary.

Step 2. Set up Predevelopment land use scenario.



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

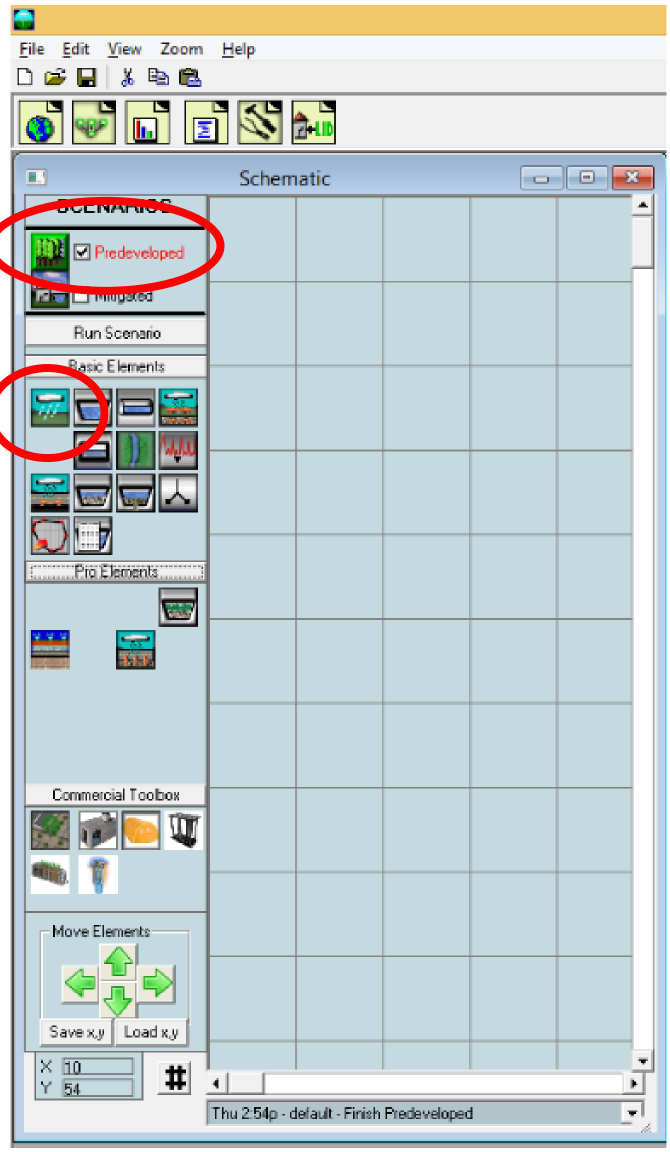
The General Project Information button will bring up the Schematic Editor.

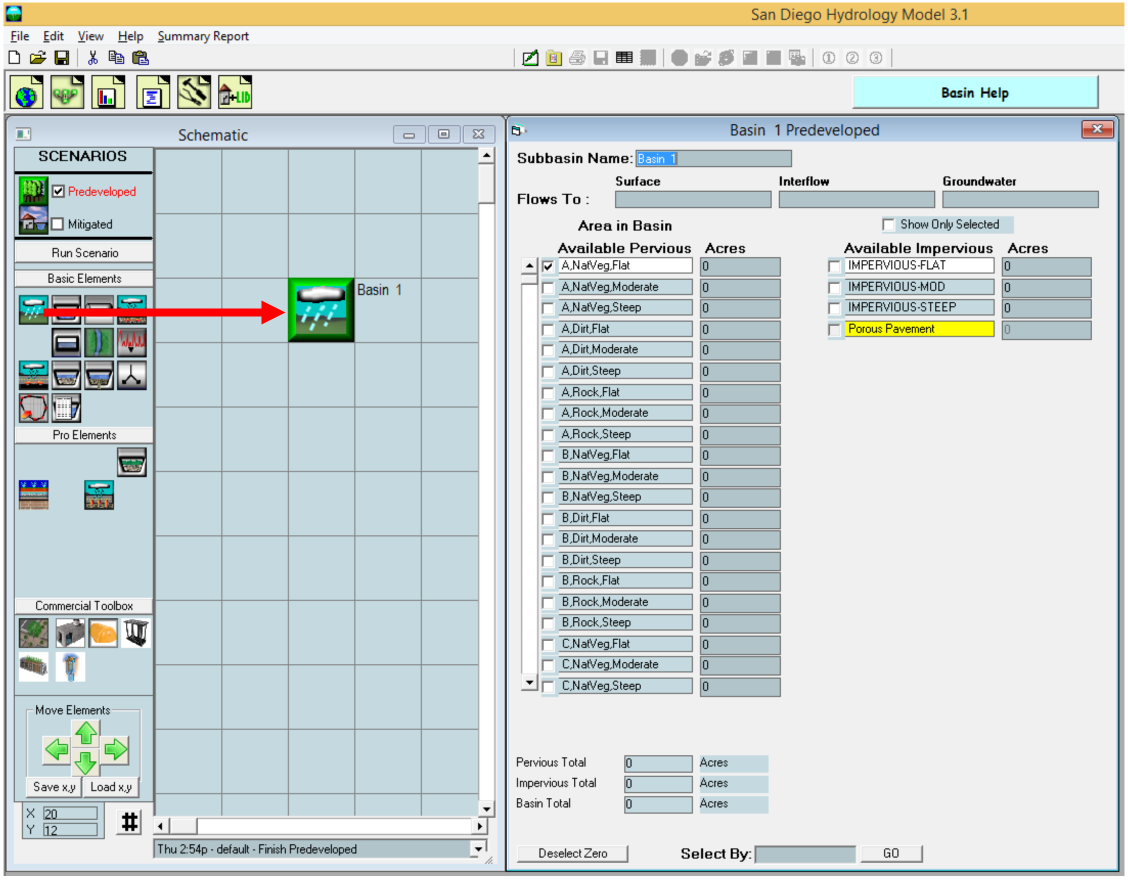
The schematic editor screen contains two scenarios: Predeveloped and Mitigated.

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

Check the Predeveloped scenario box.

Left click on the Landuse Basin element under the Basic Elements heading. The Landuse Basin element represents the project Drainage Management Area (DMA). It is the upper left element.





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

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

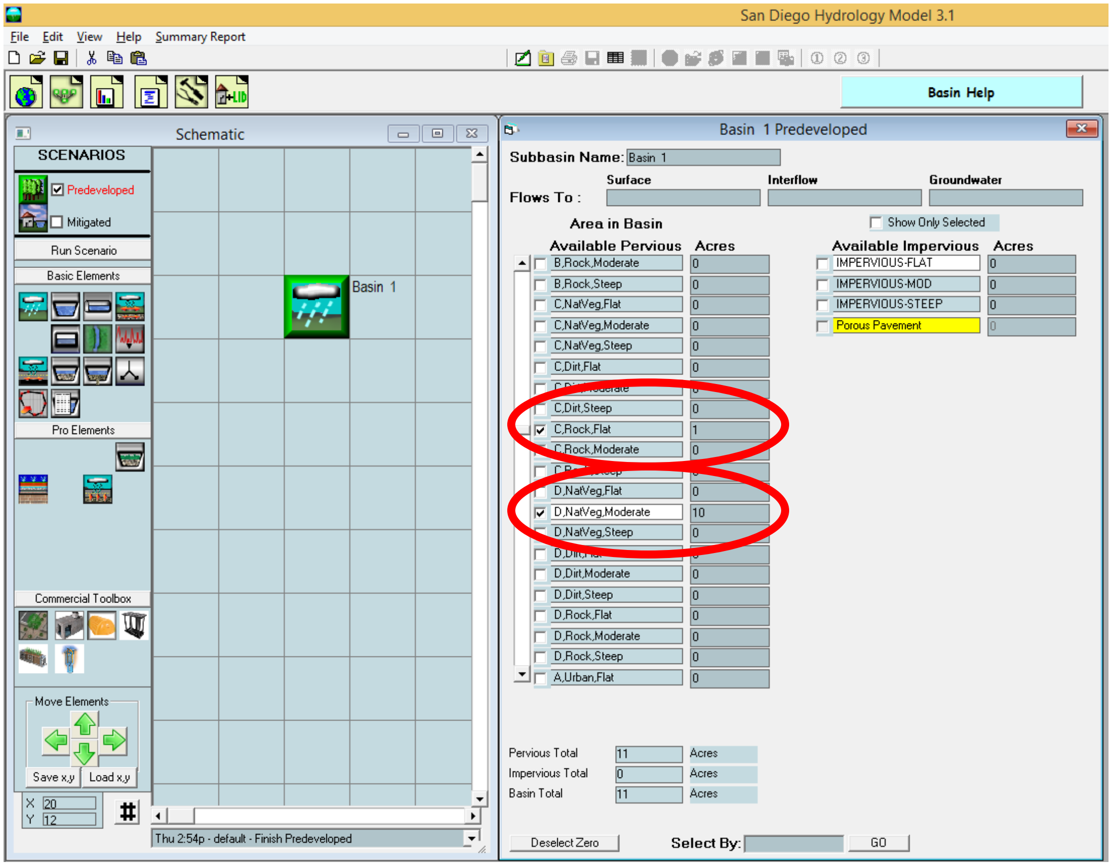
Land cover is based on the native or existing vegetation or lack of for the Predevelopment area and the planned vegetation for the planned development (Mitigated scenario). Non-urban land cover has been divided into native vegetation (NatVeg), dirt, and rock. Dirt and rock includes landscapes that are vegetated, but the majority of the surface cover is non-vegetation.

The Mitigated scenario developed landscape will consist of urban vegetation (lawns, flowers, planted shrubs and trees). It may be irrigated (Urban) or non-irrigated (UrbNoIrr).

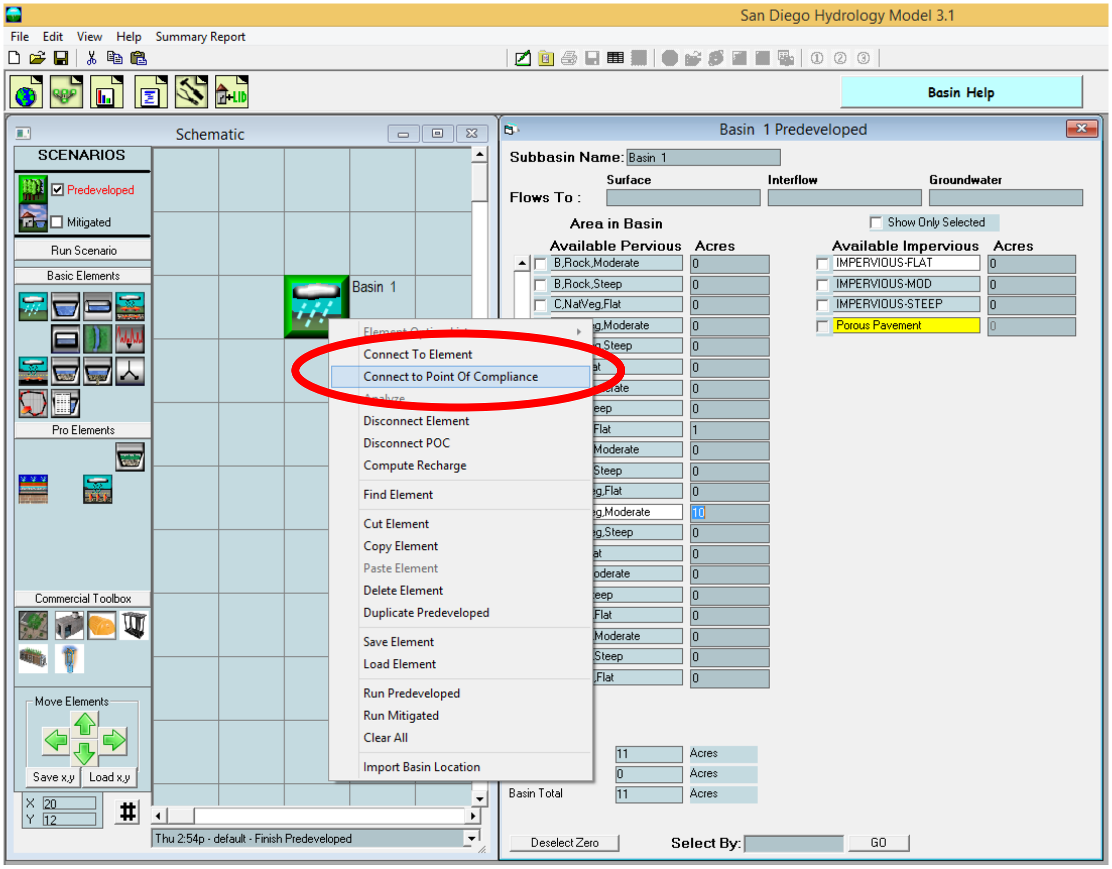
Land slope is divided into flat (0-5%), moderate (5-15%), and steep (>15%) land slopes.

HSPF parameter values in SDHM 3.1 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 native vegetation (NatVeg) on a moderate slope (5-15%) and 1 acre of C soil with rock on a flat (0-5%) slope.

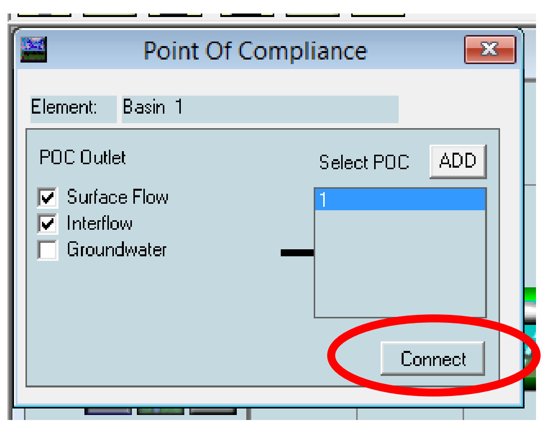


The total DMA (Drainage Management Area) is 11 acres for this Landuse Basin element (default name “Basin 1”).

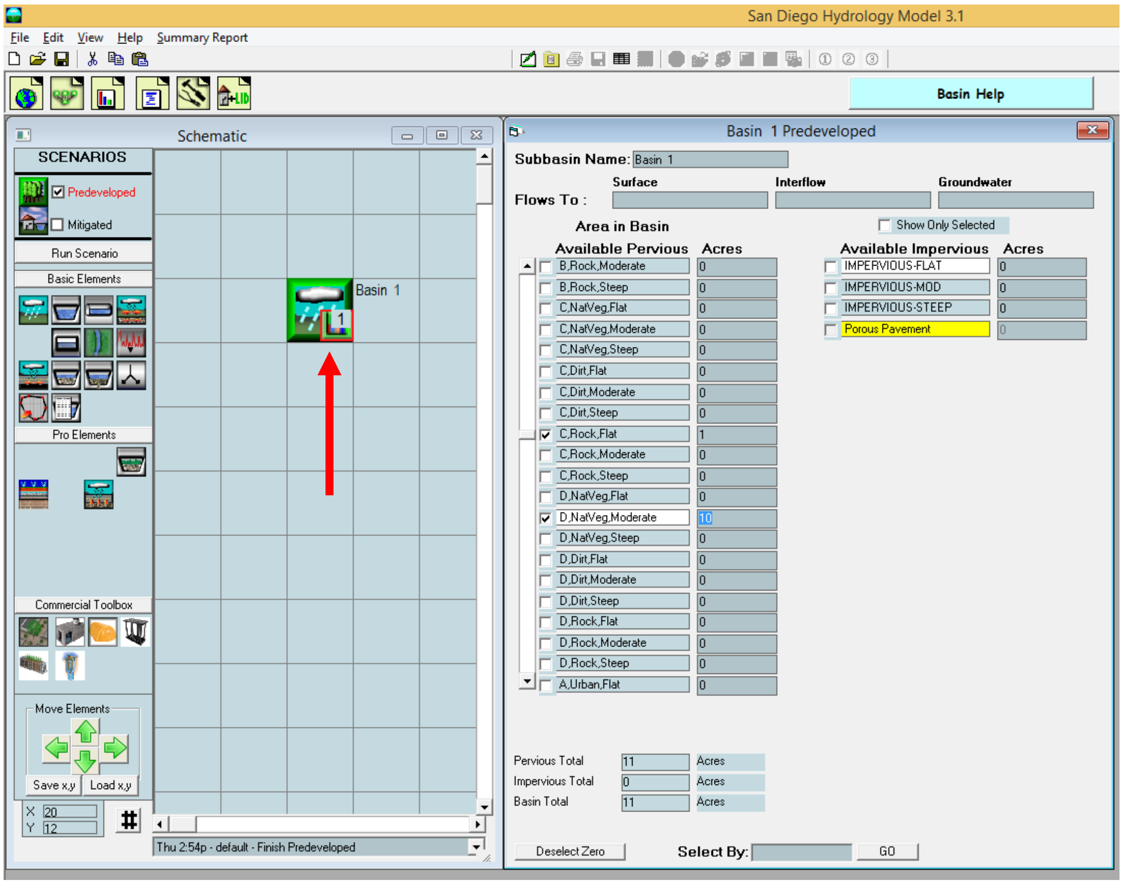


The exit from this Landuse Basin element will be selected as our point of compliance for the Predeveloped scenario. Right click on the Landuse Basin element and highlight Connect to Point of Compliance (the point of compliance is defined as the location at which the runoff from both the Predeveloped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

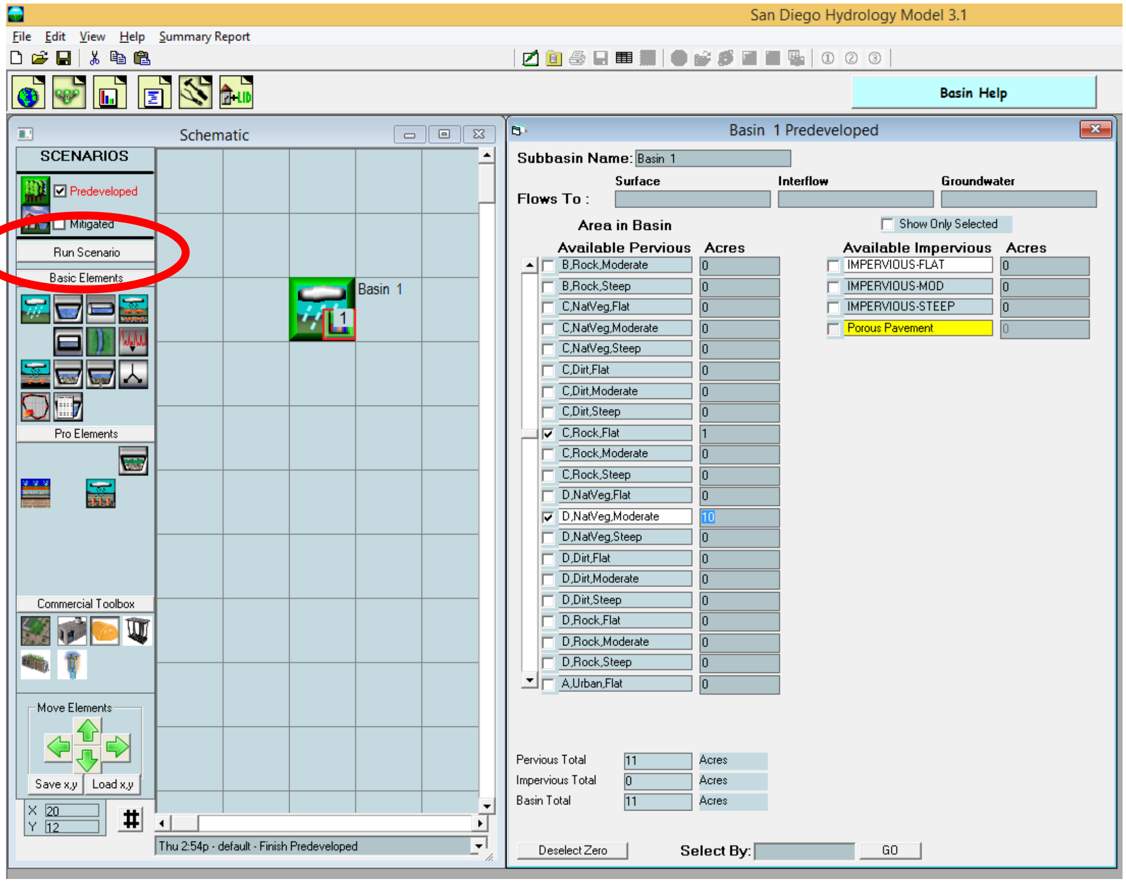
The Point of Compliance screen will be shown for Predeveloped Basin 1. The POC (Point of Compliance) outlet has been checked for both surface runoff and interflow (shallow subsurface flow). These are the two flow components of stormwater runoff. Do not check the groundwater box unless there is observed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



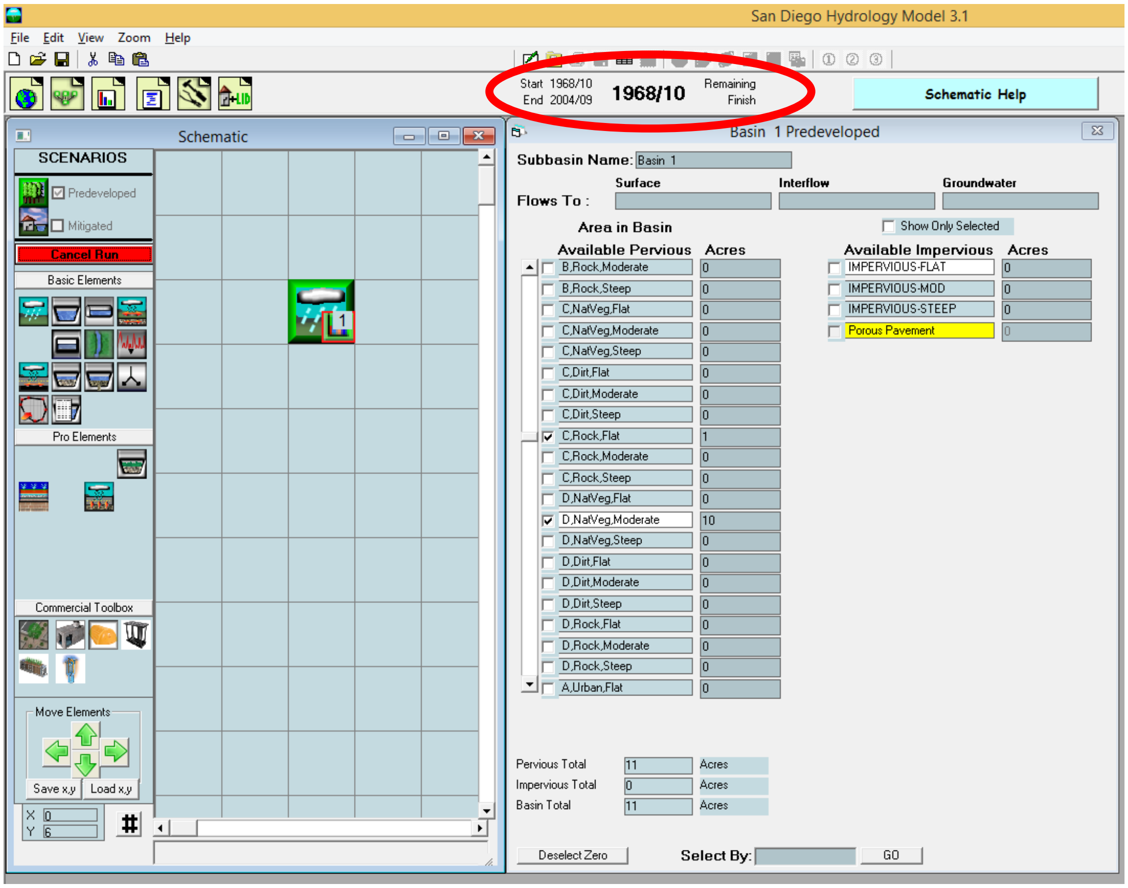
Click the Connect button in the low right corner to connect this point of compliance to the Predeveloped Landuse Basin element.



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



Click on the Run Scenario button to run the Predeveloped scenario and generate the Predeveloped runoff.



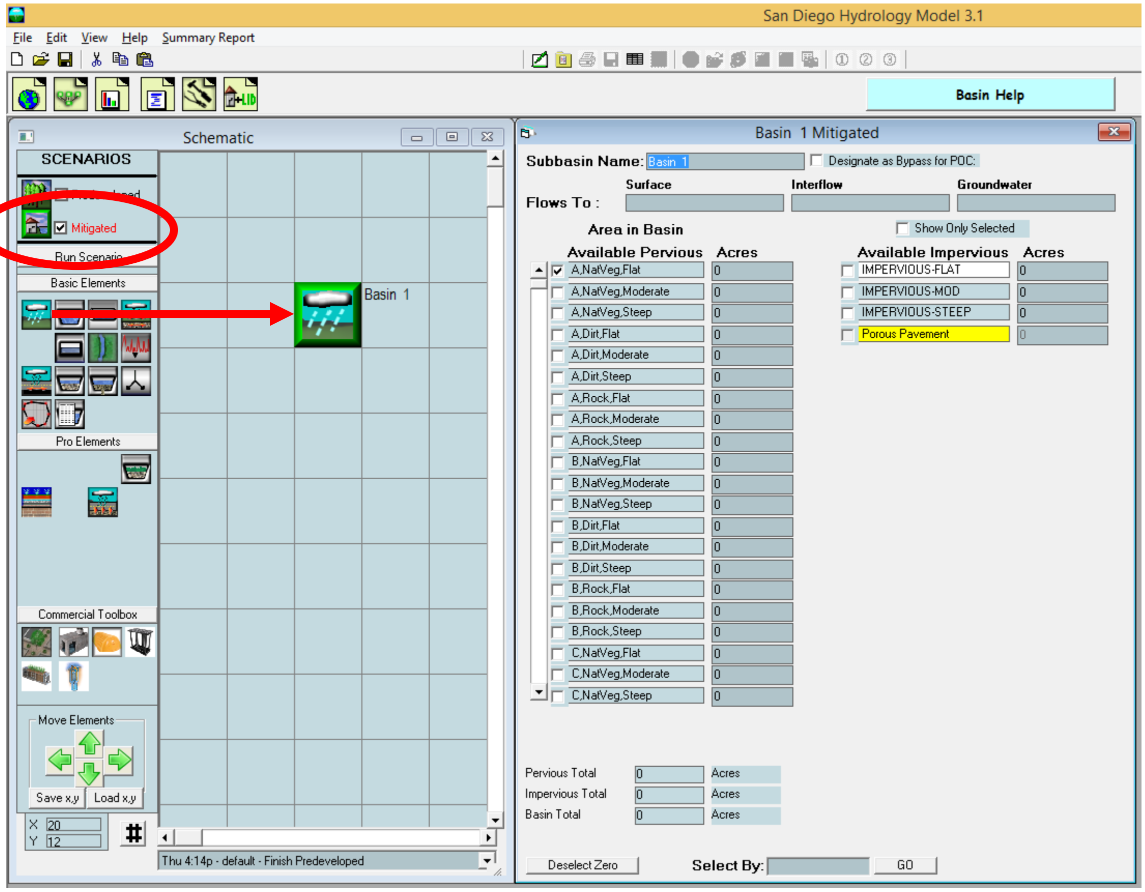
After the Run Scenario button has been clicked SDHM creates an HSPF UCI (User Control Input) file, runs HSPF for the entire simulation period, generates the resulting runoff, and stores the runoff time series data in the database (HSPF WDM file).

When HSPF is running the information of the simulation start and end date and current simulation date status are posted at the top of the screen. This information disappears when the HSPF computations are finished.

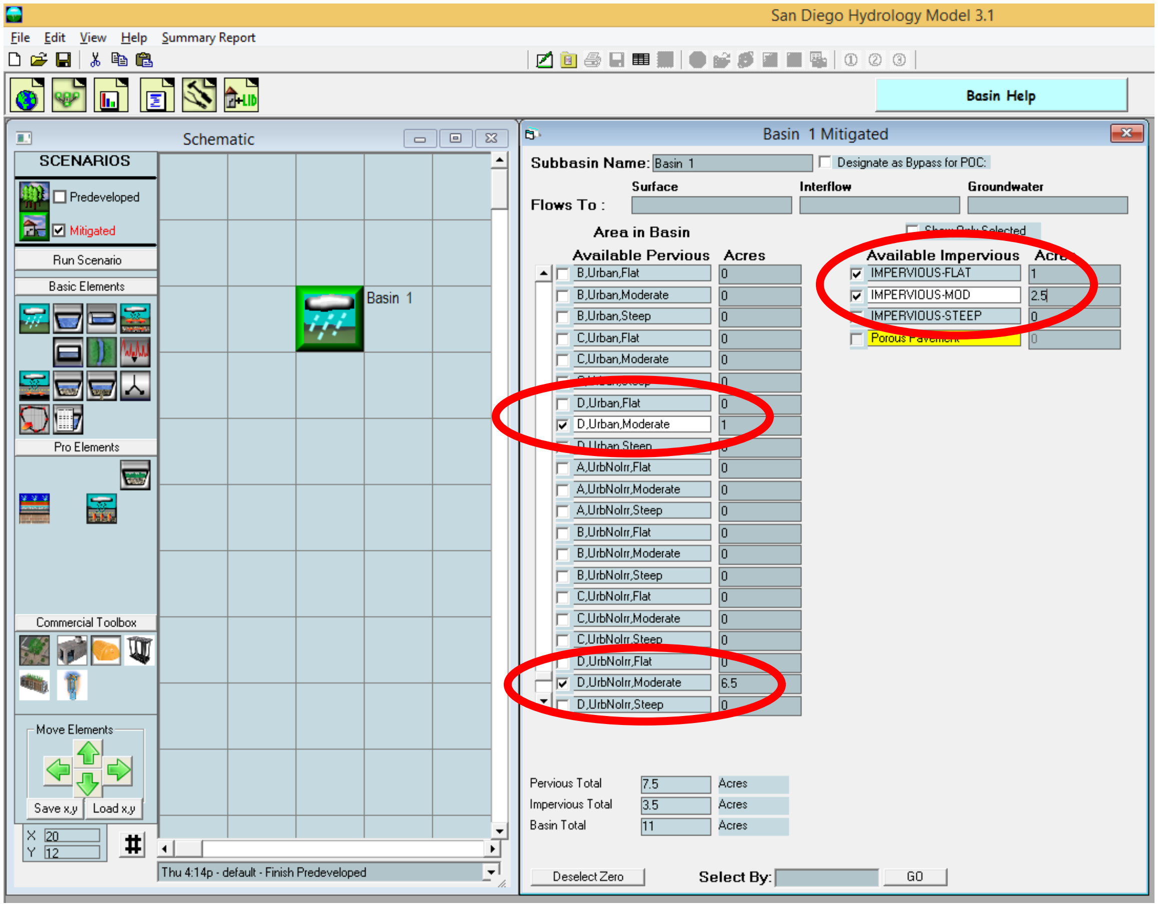
With the runoff computations finished and the Predevelopment runoff stored in the database, we will later calculate the Predevelopment 2-year (Q2) flow and 10-year (Q10) flow values (in Step 4) and compare them with the USGS regional regression Q2 and Q10 values (Step 6) to determine the lower and upper flow duration thresholds sizing the Mitigated scenario stormwater facility for HMP.

Step 3. Set up Mitigated (developed) land use scenario.

This step is very similar to Step 2.



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



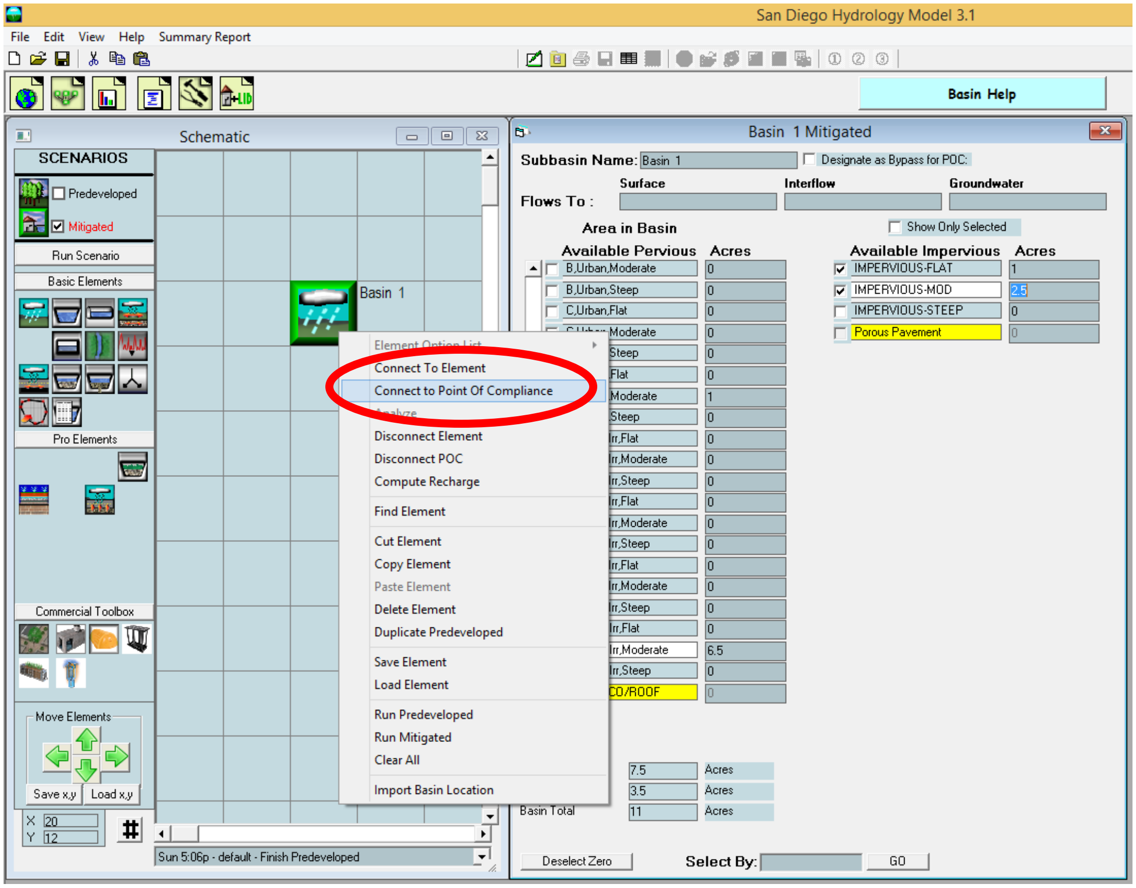
For the Mitigated land use we have:

- 6.5 acres of D soil, urban no irrigation vegetation, moderate slope
- 1.0 acre of D soil, urban (with irrigation) vegetation, moderate slope
- 1.0 acre of impervious, flat slope
- 2.5 acres of impervious, moderate slope

The total Mitigated area is 11 acres.

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 and therefore generate runoff more quickly.

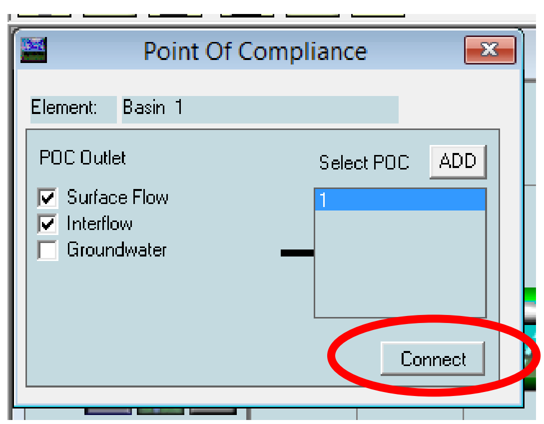
If including permeable or porous pavement do not include this area in the Landuse Basin element. This area should be placed in the separate Porous Pavement element (this is true regardless of scenario).



ONLY FOR THE PURPOSE OF CALCULATING THE Q2 AND Q10 FLOW FREQUENCY VALUES FOR COMPARISON WITH THE USGS REGIONAL VALUES we will select the exit from this Landuse Basin element as the Point of Compliance for the Mitigated scenario. We will change the location of the Mitigated POC when we size our HMP facility in Step 8.

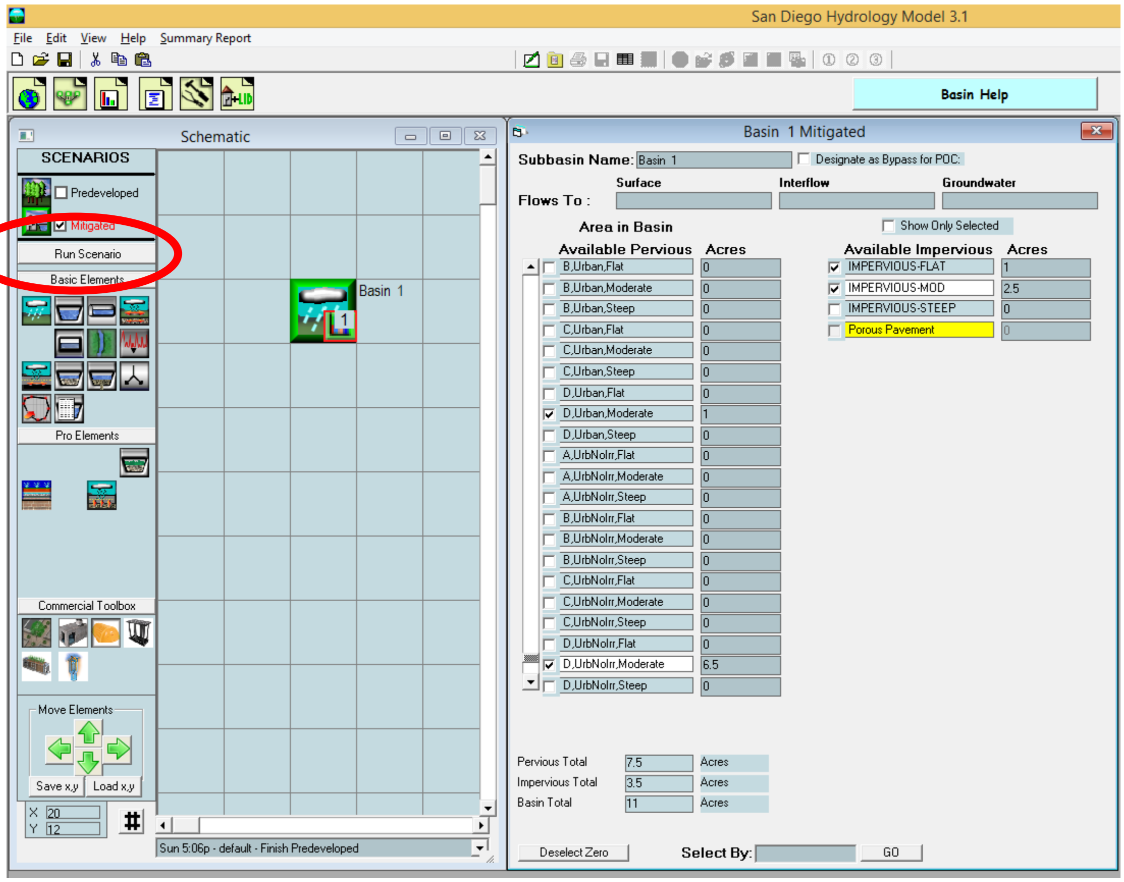
Right click on the Landuse Basin element and highlight Connect to Point of Compliance.

The Point of Compliance screen will be shown for Mitigated 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 Mitigated Landuse Basin element.

As in Step 2, after the point of compliance has been added to the Landuse Basin element the look of the element will change. A small box with a bar chart graphic and a number will be shown in the lower right corner of the Landuse Basin element. This small POC box identifies the exit from this Landuse Basin element as a point of compliance. The number is the POC number (e.g., POC 1).



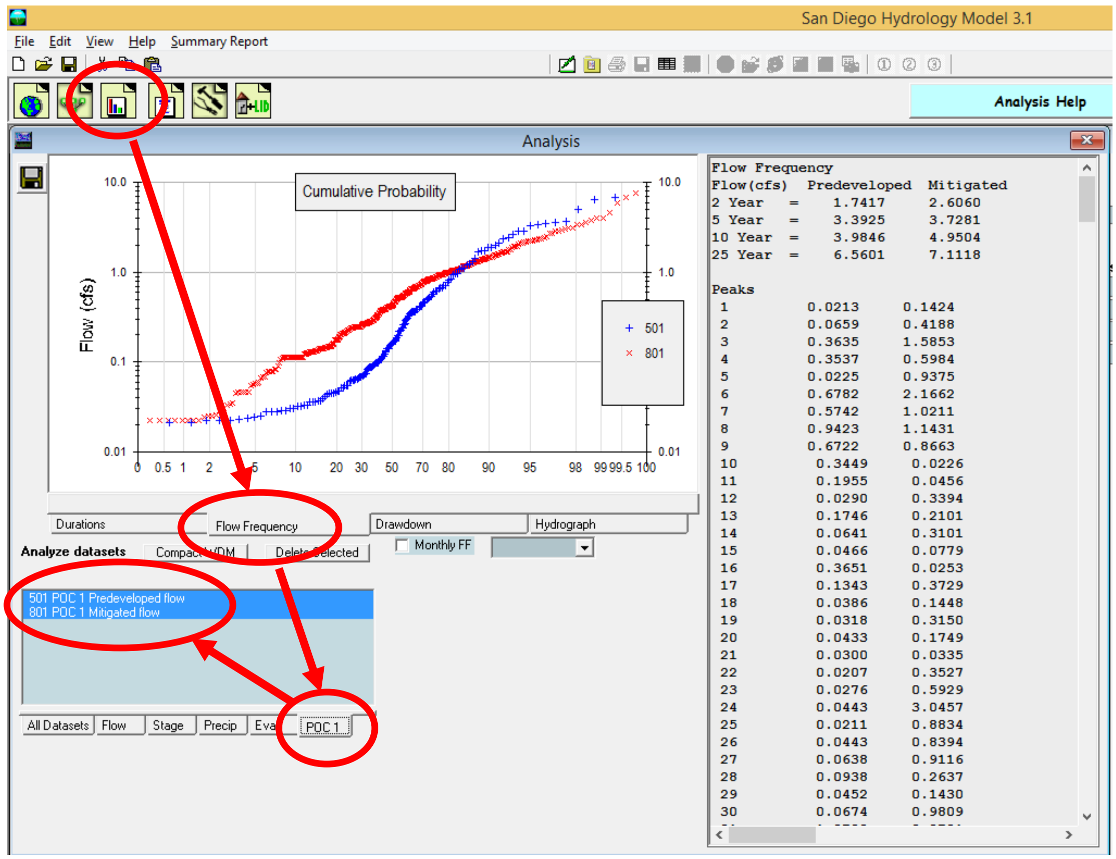
Click on the Run Scenario button to run the Mitigated scenario and generate the Mitigated runoff from the Mitigated scenario Landuse Basin element.

As with the Predeveloped scenario, after the Run Scenario button has been clicked SDHM creates an HSPF UCI (User Control Input) file, runs HSPF for the entire simulation period, generates the resulting runoff, and stores the runoff time series data in the database (HSPF WDM file).

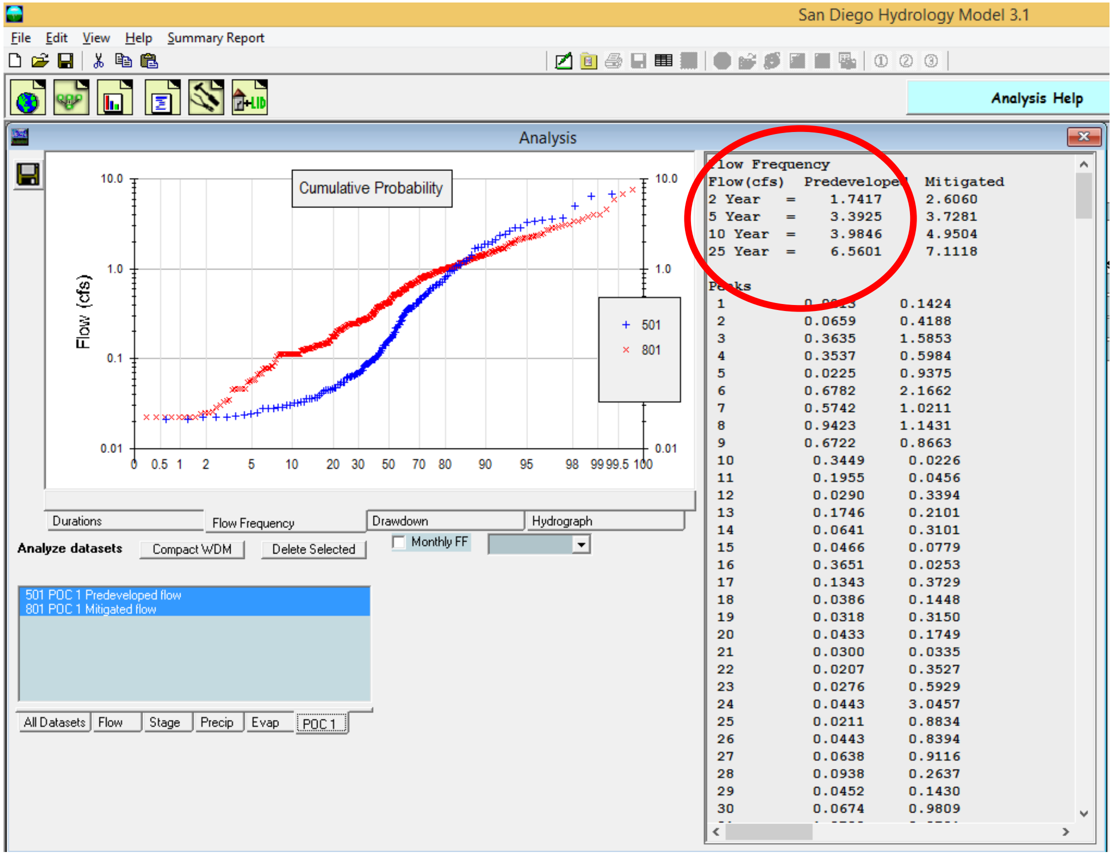
With the runoff computations finished and the Mitigated runoff stored in the database, we are now able to calculate the Predevelopment 2-year (Q2) flow and 10-year (Q10) flow values (in Step 4) and compare them with the USGS regional regression Q2 and Q10 values (Step 6) to determine the lower and upper flow duration thresholds sizing the Mitigated scenario stormwater facility for HMP.

Step 4. Calculate lower and upper HMP thresholds based on Predevelopment runoff.

The calculation of the lower and upper HMP thresholds is based on the Predevelopment runoff unless the USGS regional regression equations are used instead (see Step 5). The calculation of the lower and upper HMP thresholds is based on the 2-year peak flow (Q2) and the 10-year peak flow (Q10), respectively. Q2 and Q10 are calculated in the Flow Frequency section of the Analysis window.



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 calculate the Q2 and Q10 values first select the Flow Frequency tab and, then, select the POC 1 tab at the bottom and make sure that both the 501 POC 1 Predeveloped flow and 801 POC 1 Mitigated flow are highlighted.



The Predeveloped Q2 and Q10 values are shown in the table in the upper left section of the Analysis window.

The Predeveloped Q2 value is 1.7417 cfs; the Q10 value is 3.9846 cfs.

Remember these values. We will compare these values with the values computed using the USGS regional equations (Step 5) and select the higher of the two sets of values for the sizing of our stormwater HMP facility (Step 8).

Note that we are not using the Mitigated flow frequency values. These Mitigated values will change after the flows are routed through the stormwater HMP facility. However, because of the way that frequency is calculated in SDHM, we still needed to run this initial Mitigated scenario (Step 3) prior to calculating the Predeveloped Q2 and Q10 values.

Step 5. Calculate lower and upper HMP thresholds based on USGS regional equations (optional).

This step is done outside of SDHM.

The user has the option of changing the lower and upper thresholds based on the following USGS regional regression equations:

Q2 = 3.60*(A^0.672)*(P^0.753)
Q10 = 6.56*(A^0.783)*(P^1.07)

Where A = drainage area (sq. miles)
P = mean annual precipitation (inches)

Note: These external calculations should be included with the SDHM 3.1 information submitted to the reviewer.

Mean annual precipitation values for the standard 18 San Diego County rain gages are shown in the table below.

Rain Gage	Mean Annual Rainfall (in)
Bonita	8.9
Borrego	3.2
CCDA Lindbergh	9.9
Encinitas	10.3
Escondido	13.9
Fallbrook	15.3
Fashion Valley	10.4
Flinn Springs	13.2
Kearny Mesa	11.1
Lake Cuyamaca	30.9
Lake Henshaw	22.4
Lake Wohlford	17.0
Lower Otay	10.5
Oceanside	11.8
Poway	12.2
Ramona	14.4
San Onofre	11.6
San Vicente	12.7
Santee	13.1

For this example using the Fashion Valley rainfall and a project DMA of 11 acres:

A = 11 ac = 0.0171875 square miles
P = 10.4 inches

USGS Q2 = 1.368 cfs
USGS Q10 = 3.337 cfs

We are now ready to compare these values with the Predeveloped Q2 and Q10 values calculated in Step 4.

Step 6. Compare sets of threshold values (optional).

The Predeveloped Q2 and Q10 values from Step 4 are:

Pre Q2 = 1.7417 cfs
Pre Q10 = 3.9846 cfs

The USGS Q2 and Q10 values from Step 5 are:

USGS Q2 = 1.368 cfs
USGS Q10 = 3.337 cfs

We want to use the set of Q2 and Q10 values that produces the smallest sized stormwater facility. The larger Q2 value will produce the smaller facility because with the larger Q2 we can discharge more stormwater before reaching the lower threshold value. This means less water needs to be stored prior to discharge at the POC.

The lower threshold for the flow duration analysis is based on critical shear stress in the downstream channel. Check with the reviewing agency to determine the appropriate lower threshold for the project site. Typically the lower threshold is 10% of Q2.

The default lower threshold value is Pre 0.10Q2. If appropriate, this lower threshold can be changed by the user to a percent higher than 10% or to a completely different lower threshold value based on the USGS Q2 value. The procedure to change the threshold values is shown in Step 7.

Based on the above Pre and USGS Q2 values, for this example project we will use the default lower and upper thresholds. These values are:

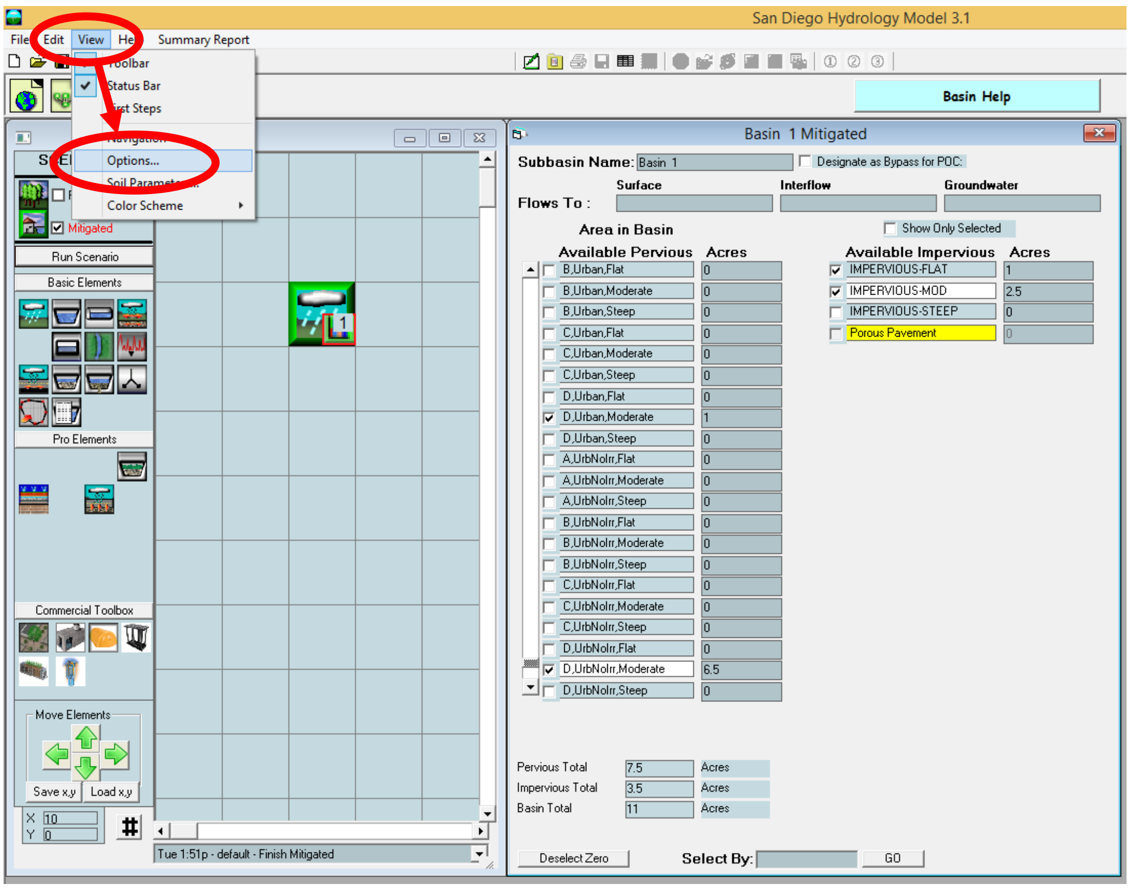
Lower threshold: 0.17417 cfs (10% of Pre Q2)
Upper threshold: 3.9846 cfs (Pre Q10)

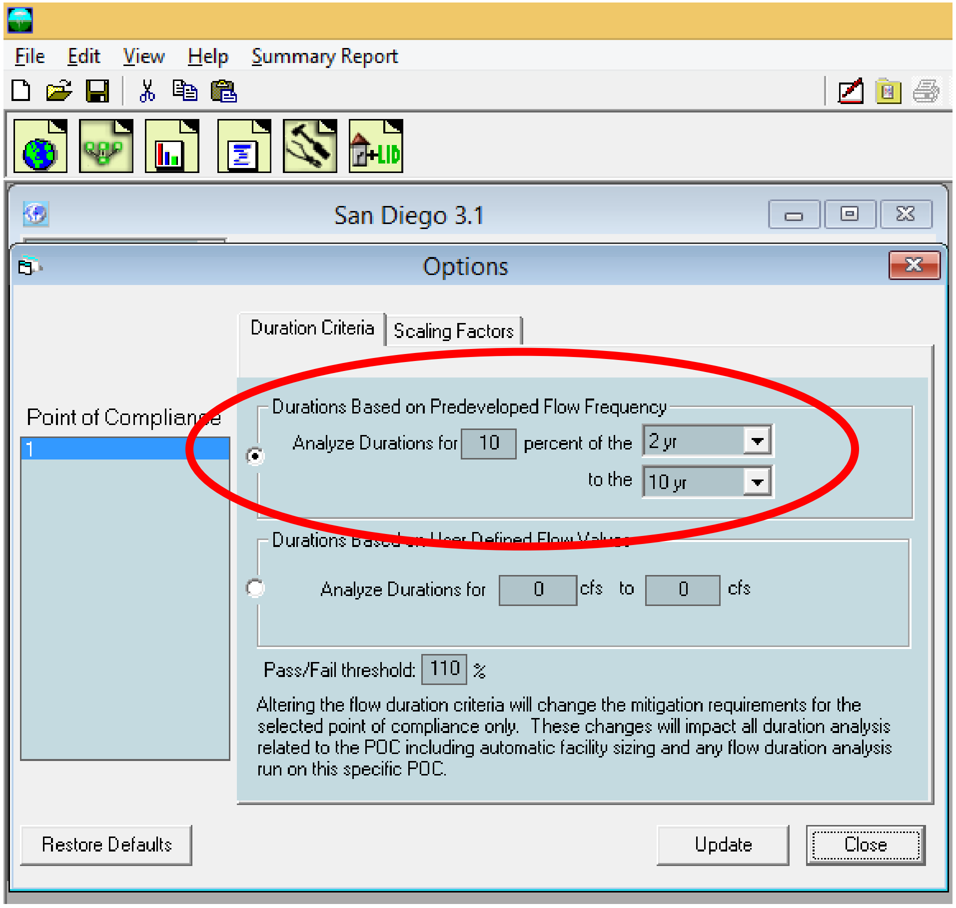
We can skip Step 7.

Step 7. Change thresholds (optional).

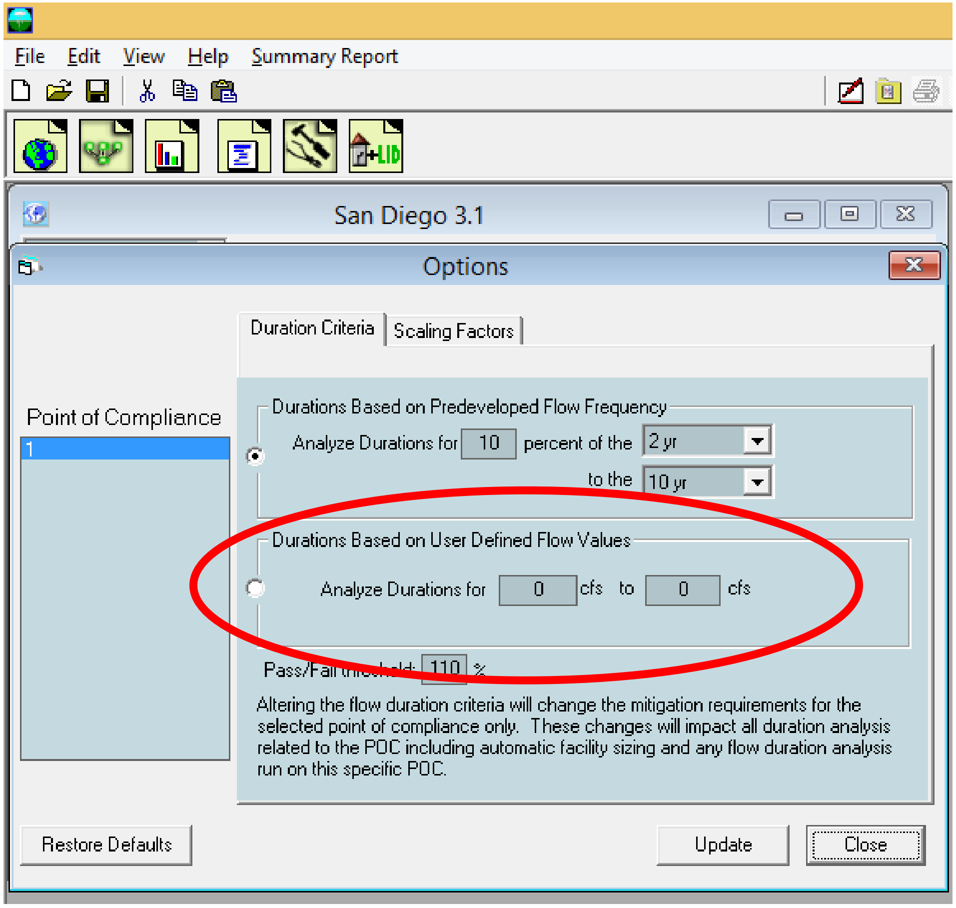
Note that when changing the default threshold value(s) this must be done for each point of compliance if there is more than one point of compliance.

Go to View, Options to change the threshold values.



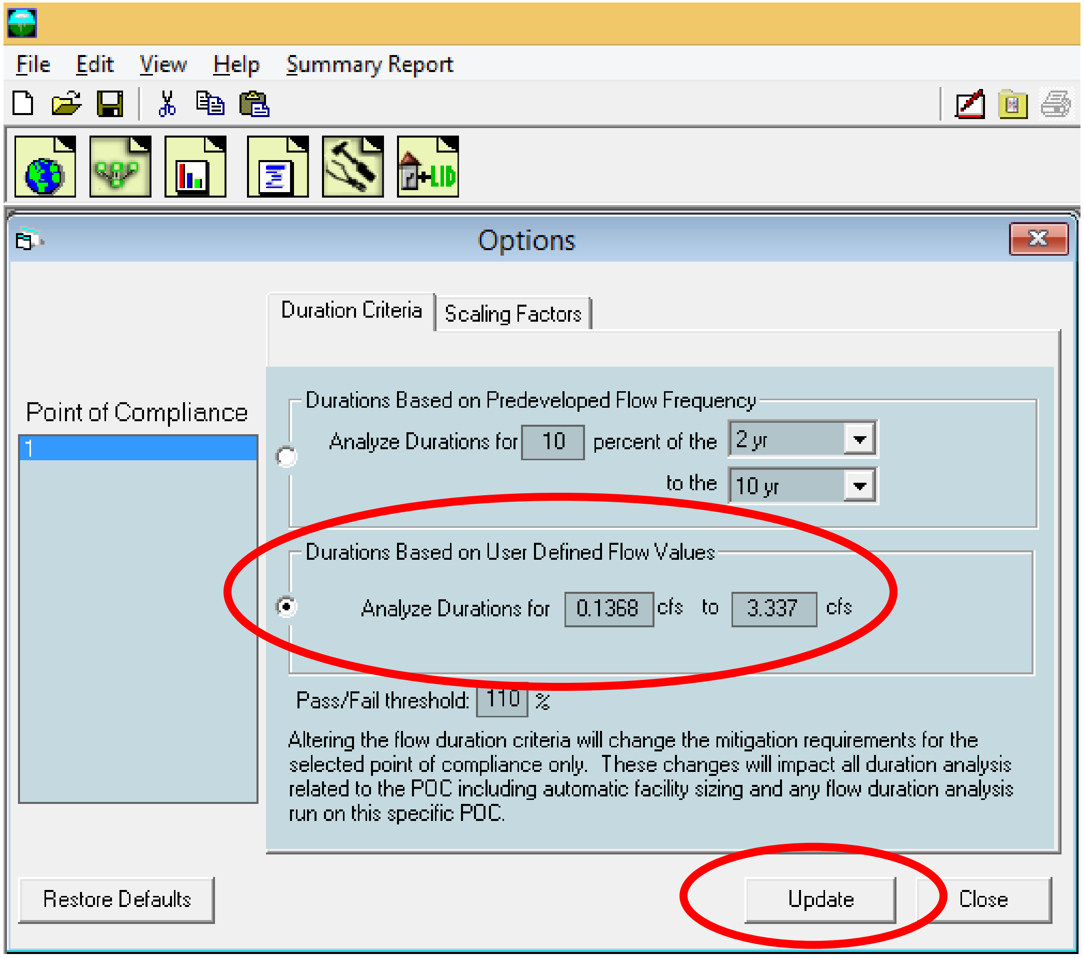


The Predevelopment Q2 and Q10 values are automatically calculated by SDHM based on the Predevelopment runoff computed in Step 2 above. However, the user has the option of using user-defined flow values for the lower and upper thresholds, if allowed by the reviewing agency. The process for calculating the user-defined flow values is described below.



The lower and upper thresholds can be set using specific user-defined flow values.

These user-defned flow values are calculated by the user outside of SDHM 3.1 and then input by the user as the new flow duration criteria.

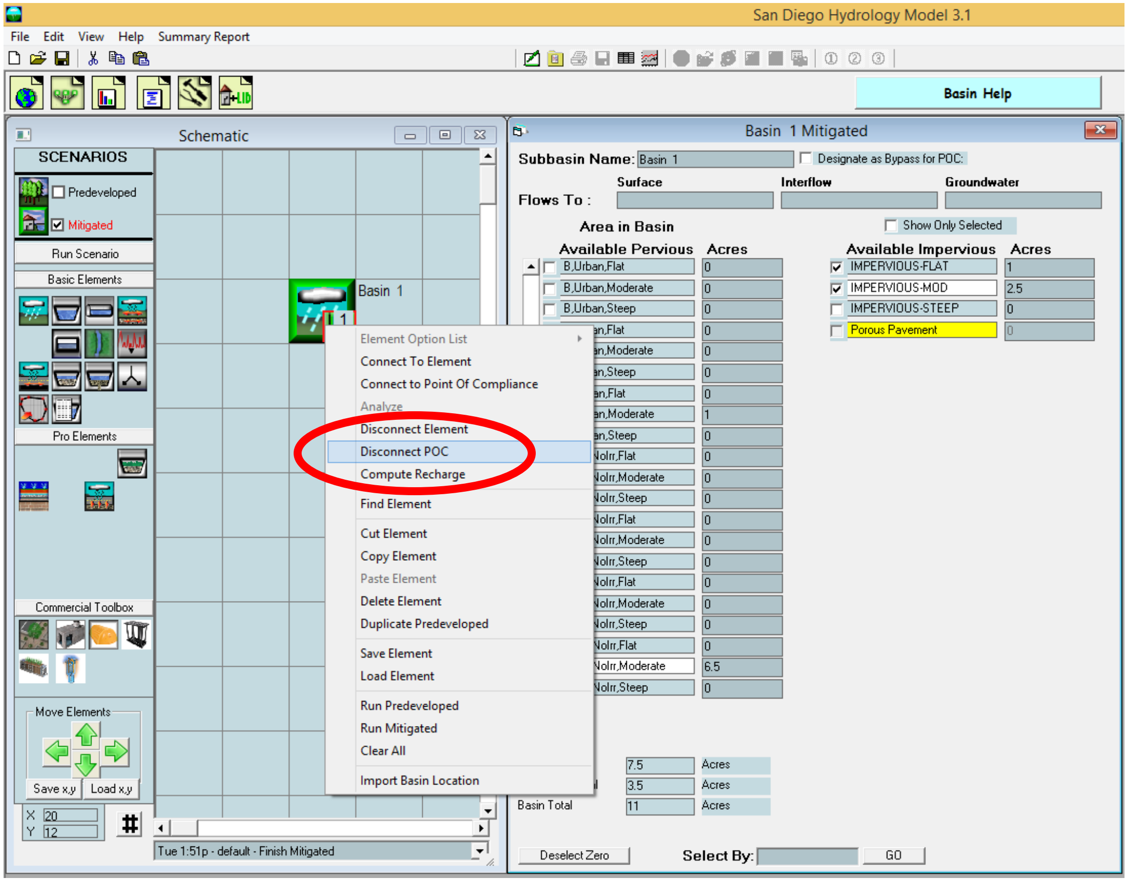


Lower threshold = 0.10Q2 = 0.1368 cfs
Upper threshold = Q10 = 3.337 cfs

Click the Update button when finished.

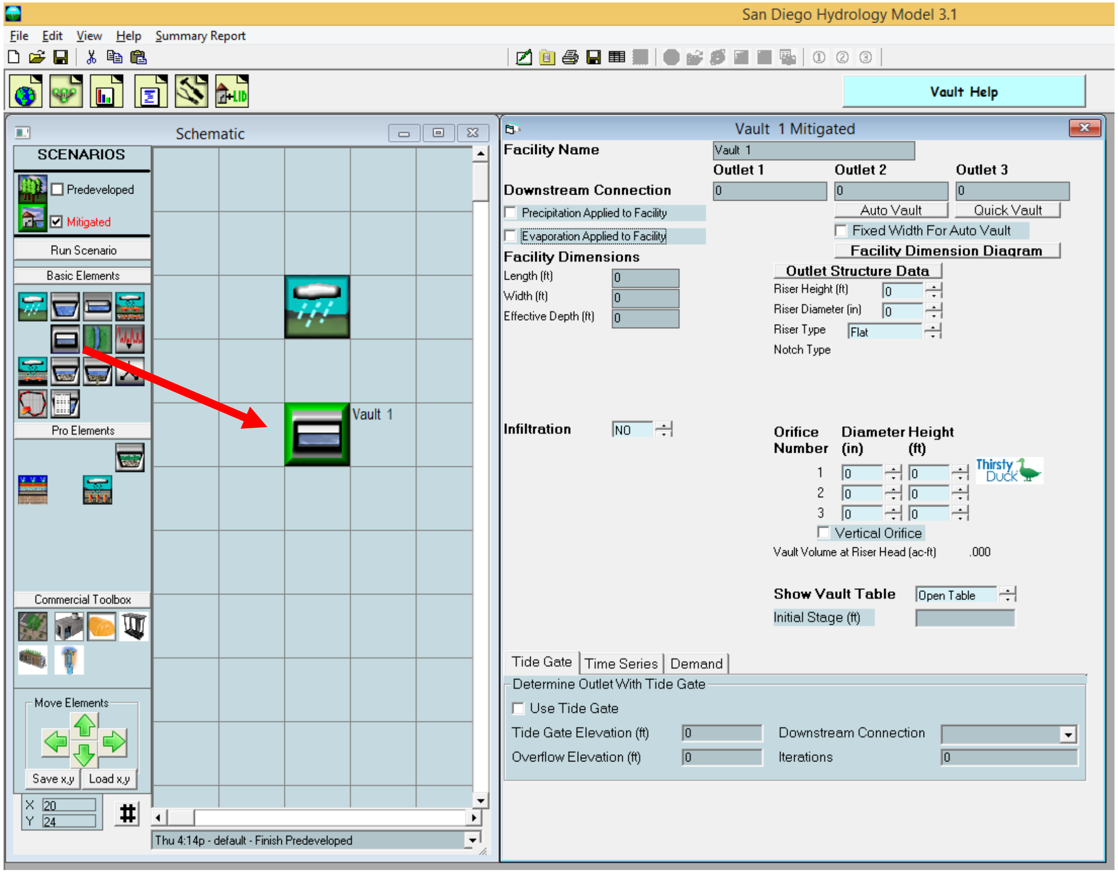
Note that for this example project we do not have to change the threshold values and can skip this step because we are using the default values computed by SDHM.

Step 8. Size Mitigated scenario HMP facility.

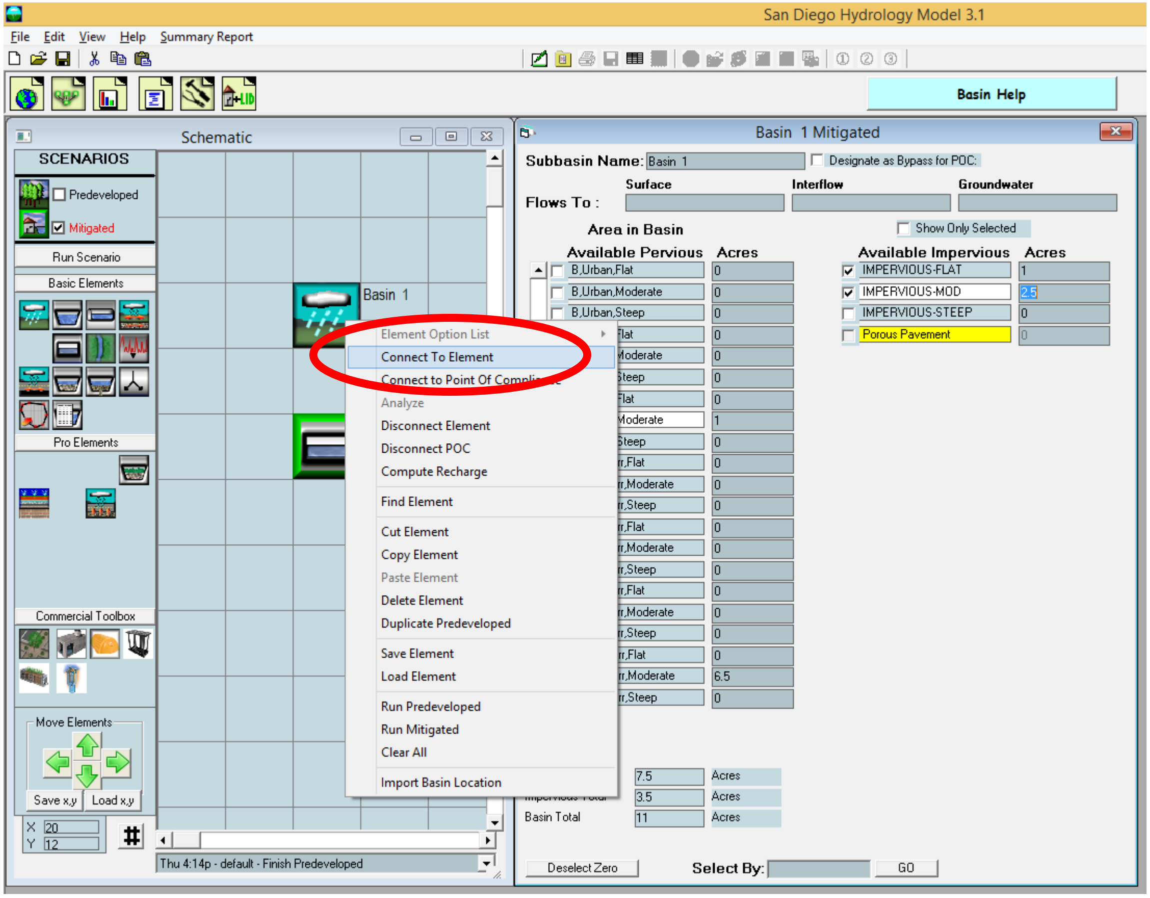


If, in Step 3, the Mitigated Landuse Basin element was connected to a POC then now we will disconnect the element from the POC in preparation of sizing the Mitigated scenario HMP facility. Later we will connect the POC to the Mitigated scenario HMP facility element.

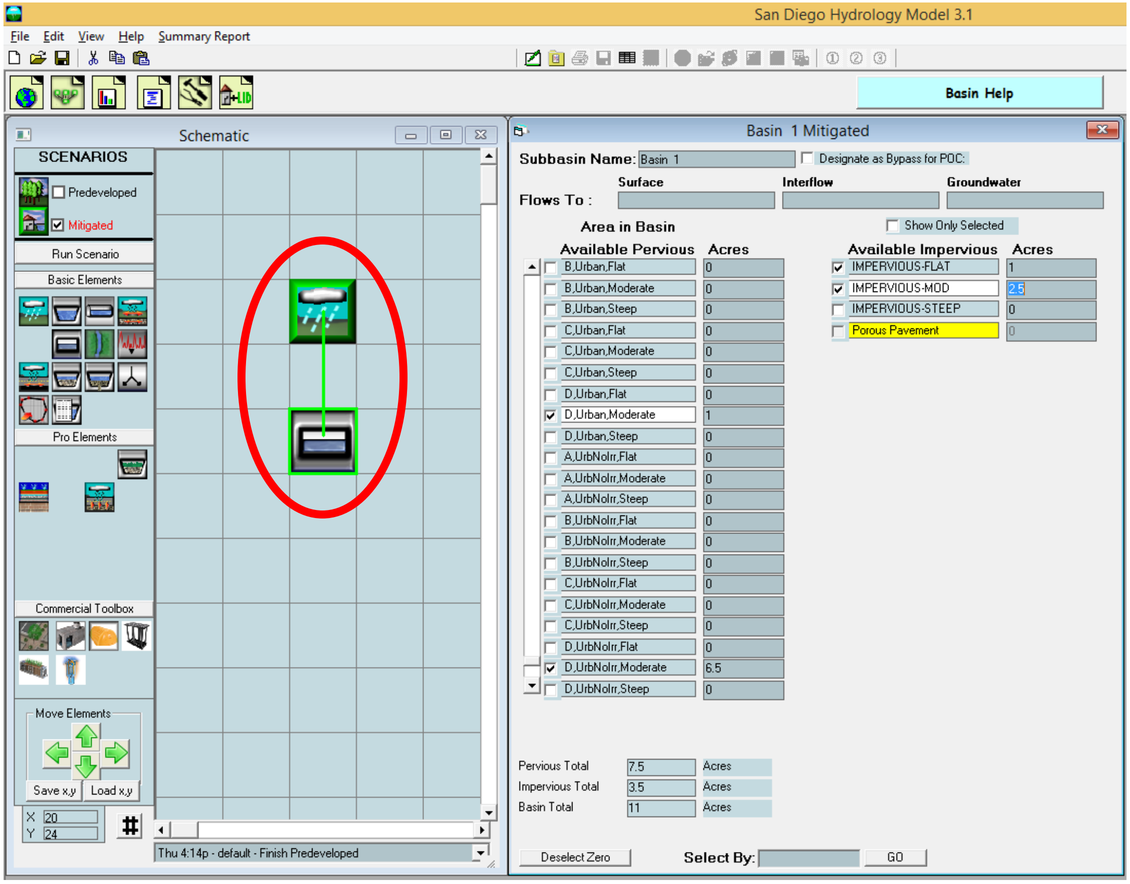
Right click on Basin 1 and select Disconnect POC. This will disconnect the POC from Basin 1.



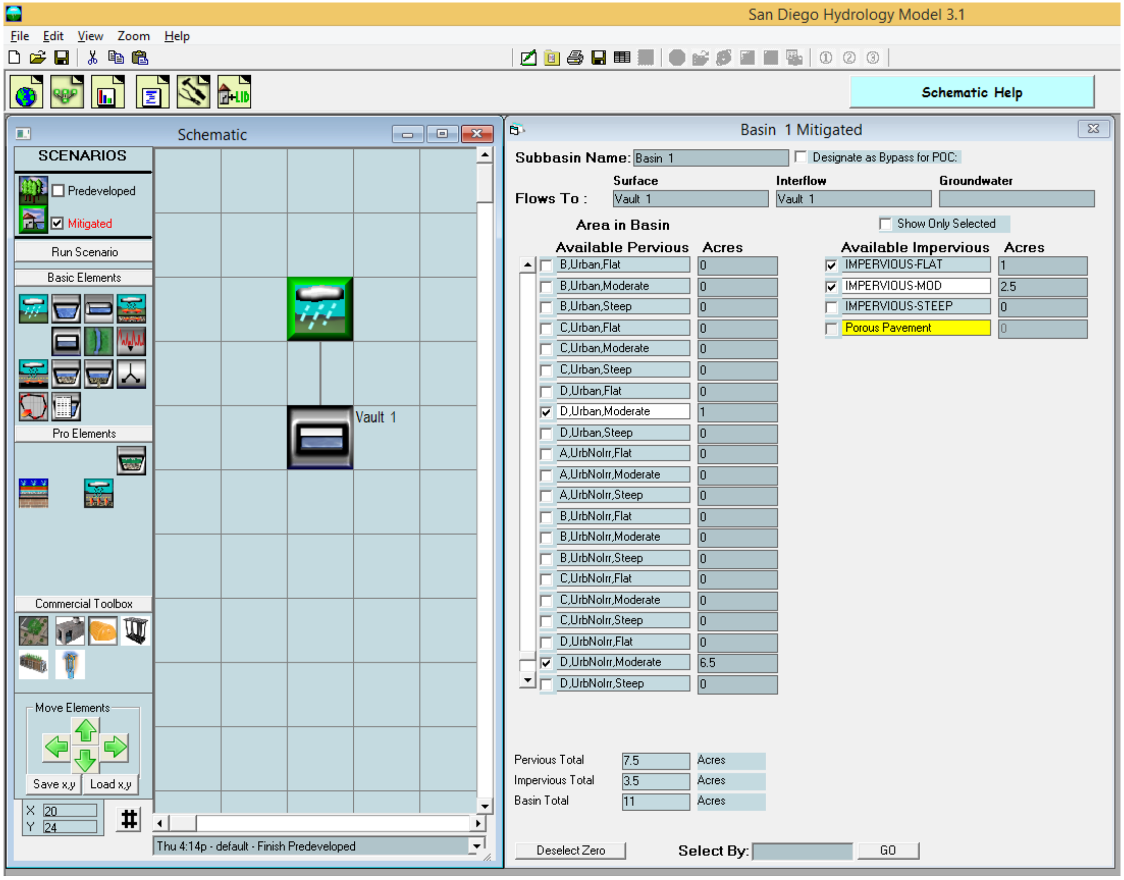
We can now add a Vault element at the downstream end of the Mitigated Landuse Basin element. For this example the vault will be the project HMP facility.



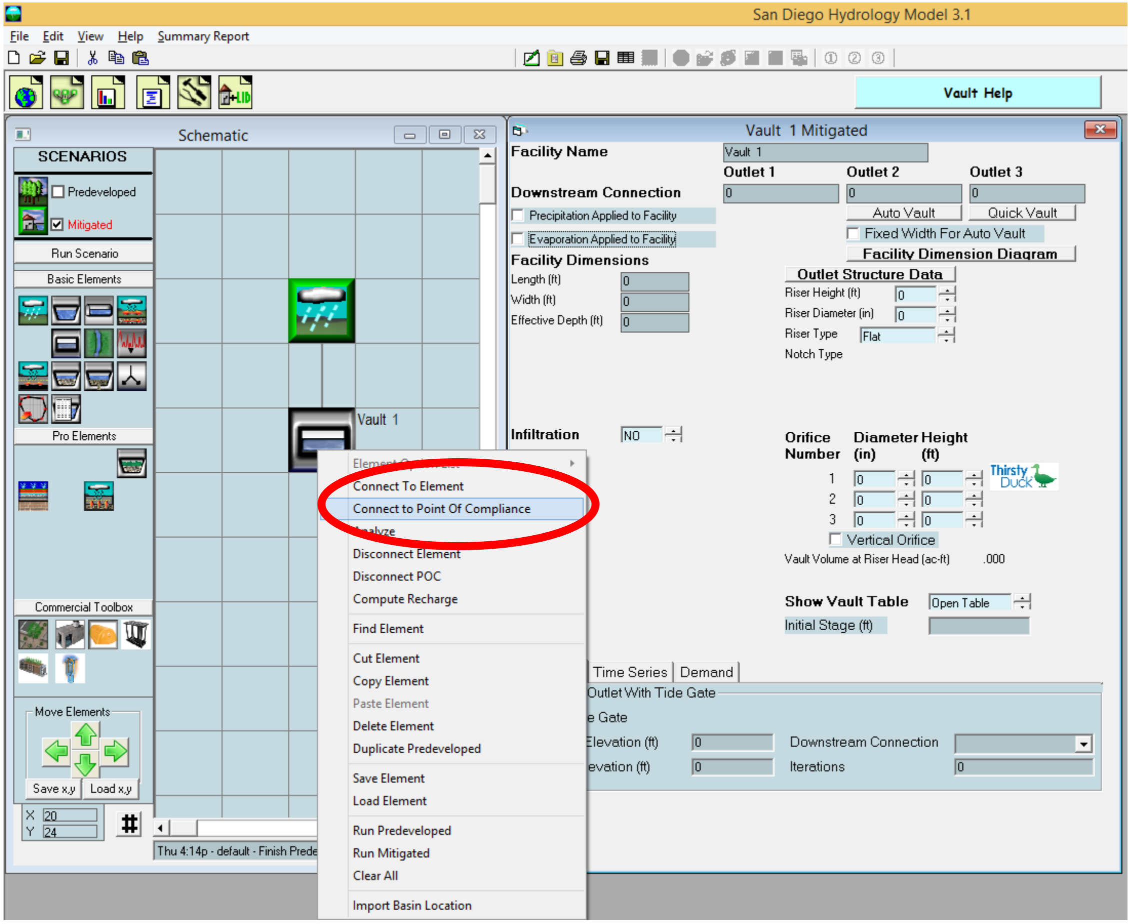
The Vault element is placed below the Landuse Basin element on the grid. Right click on the Landuse Basin element and select Connect To Element. A green line will appear with one end connected to the Landuse Basin element.



With the mouse pointer pull the other end of the line down to the Vault element and click on the Vault element box. That will connect the Landuse Basin element to the downstream Vault element.

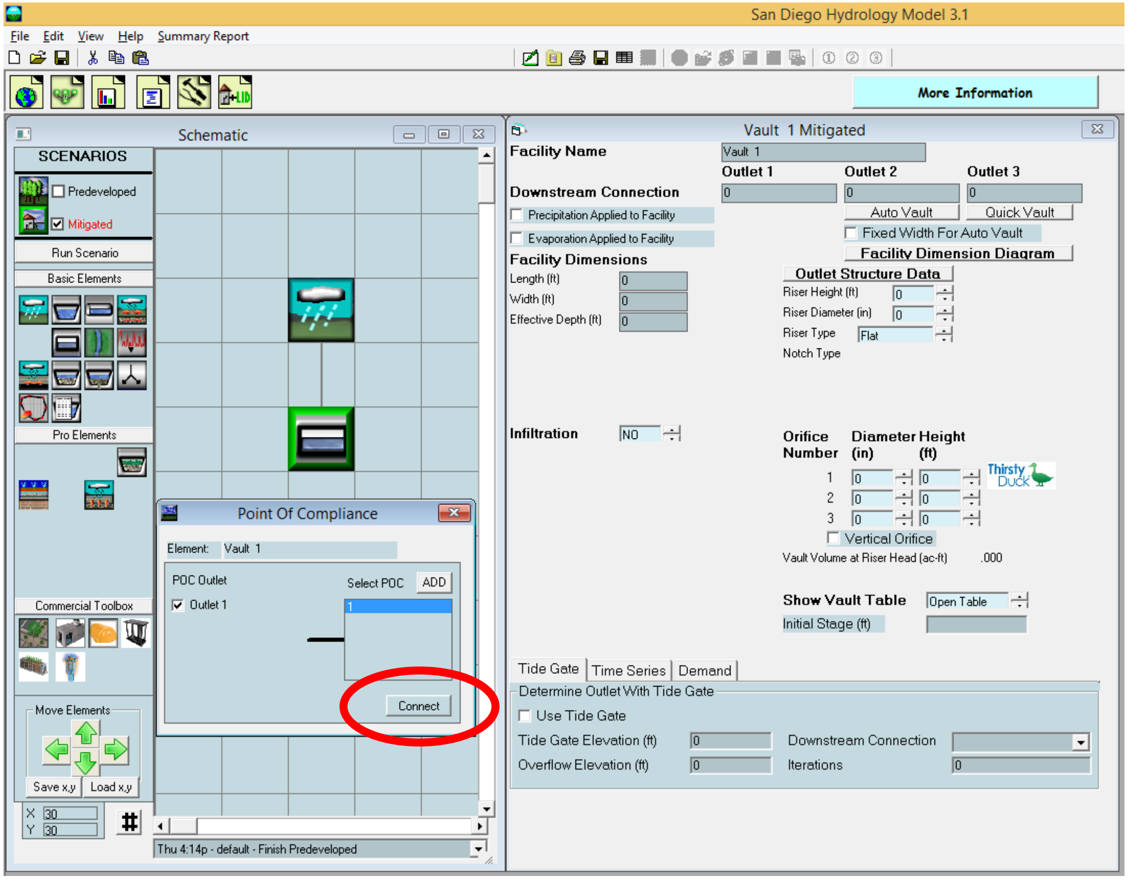


A line will connect the Landuse Basin element to the Vault element.

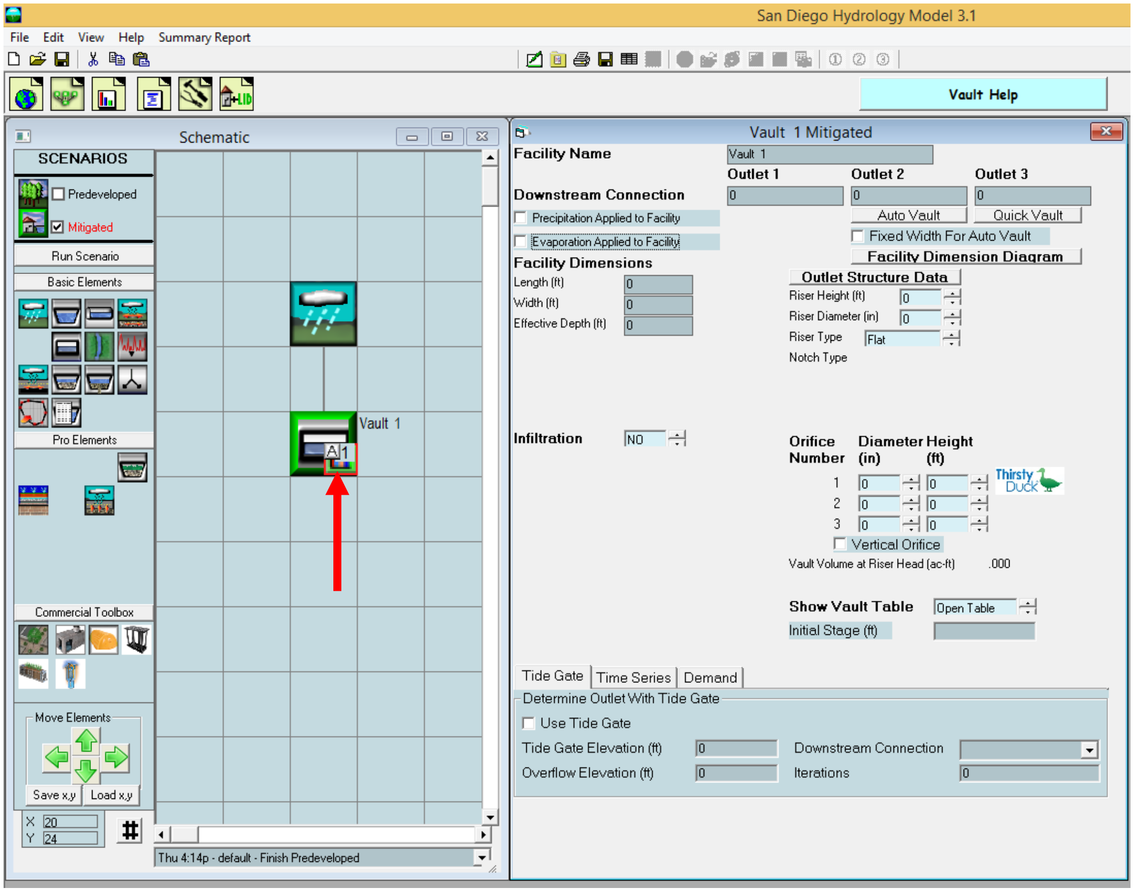


Next we will connect the vault's outlet to the Mitigated scenario point of compliance.

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



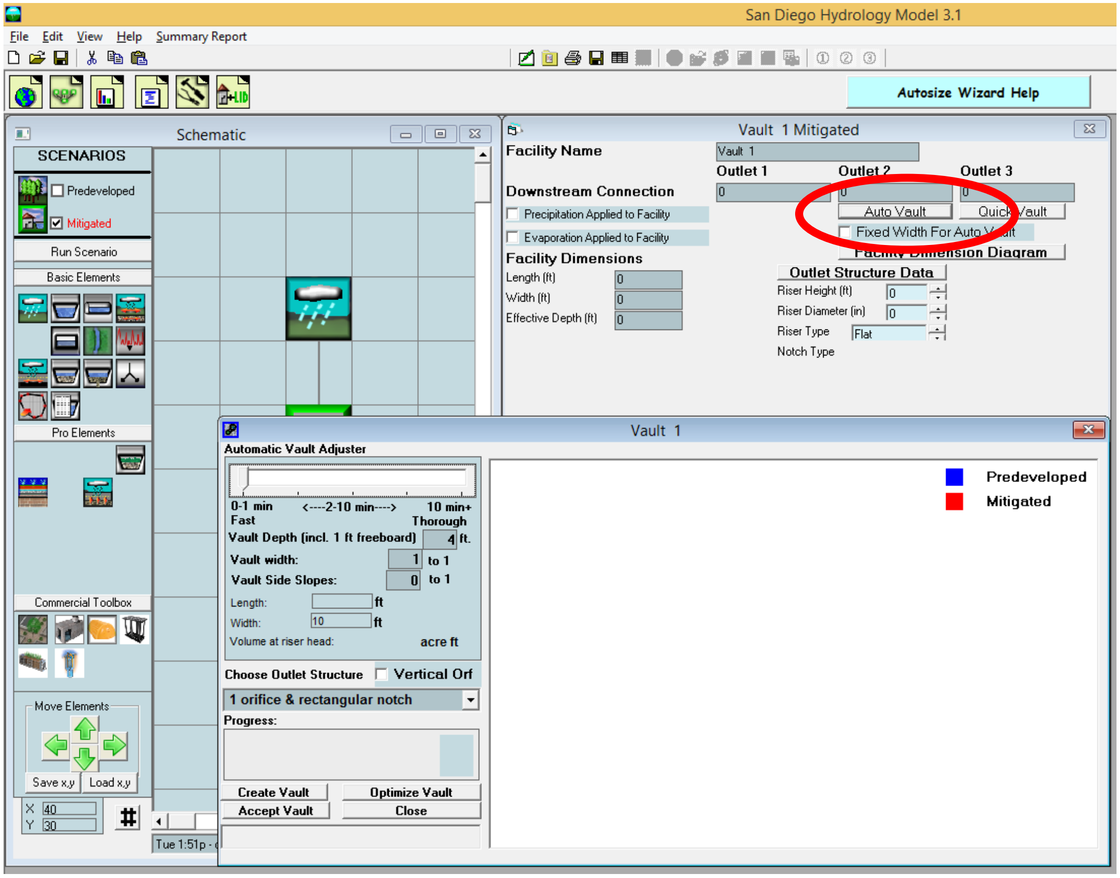
The Point of Compliance screen will be shown for the Vault element. The Vault element has one outlet (by default). The outflow from the vault will be compared with the Predeveloped runoff. The point of compliance is designated as POC 1 (SDHM 3.1 allows for multiple points of compliance). Click on the Connect button.



The point of compliance is shown on the Vault 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.

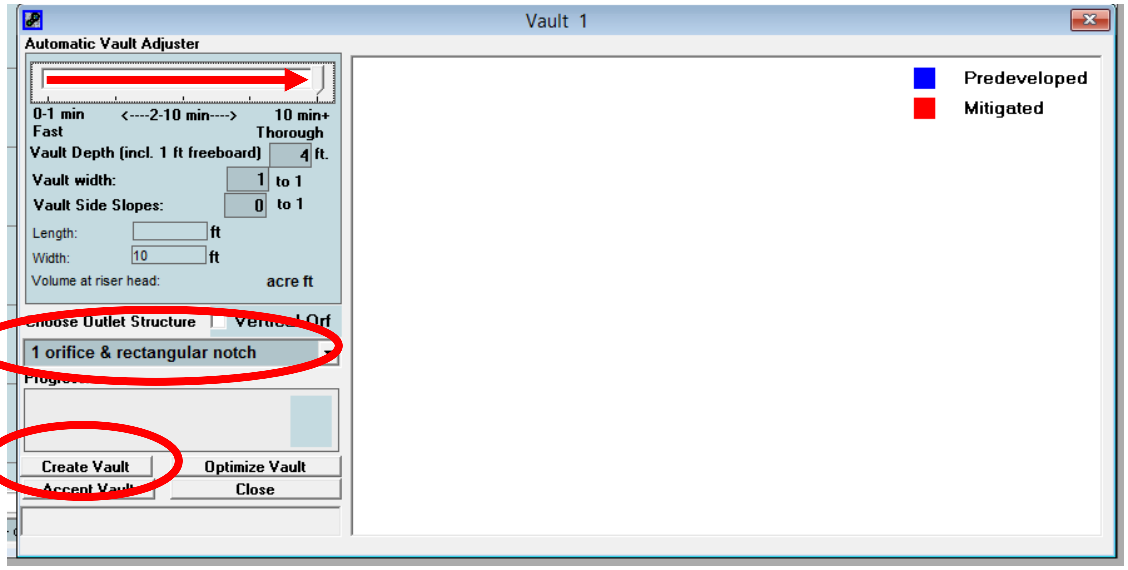
You can have an analysis location without having a point of compliance at the same location, but you cannot have a point of compliance that is not also an analysis location.



A stormwater vault can be sized either manually or automatically (using Auto Vault). For this example Auto Vault will be used. (Go to page 65 to find more information about how to manually size a vault or other HMP facility.)

Click on the Auto Vault button and the Auto Vault screen will appear. The user can set the vault depth (default: 4 feet), vault length to width ratio (default: 1 to 1), vault side slopes (limited to: 0 to 1), and the outlet structure configuration (default: 1 orifice and riser with rectangular notch weir).

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



Two outlet structure options are available in Auto Vault:

1. 1 orifice and a rectangular notch weir on the riser
2. 3 orifices and a flat weir on the riser

The orifices can be either horizontal (default) or vertical.

For this project example we will select the 1 orifice and a rectangular notch weir on the riser outlet structure option with the default horizontal orifice.

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

Running Auto Vault automates the following SDHM 3.1 processes:

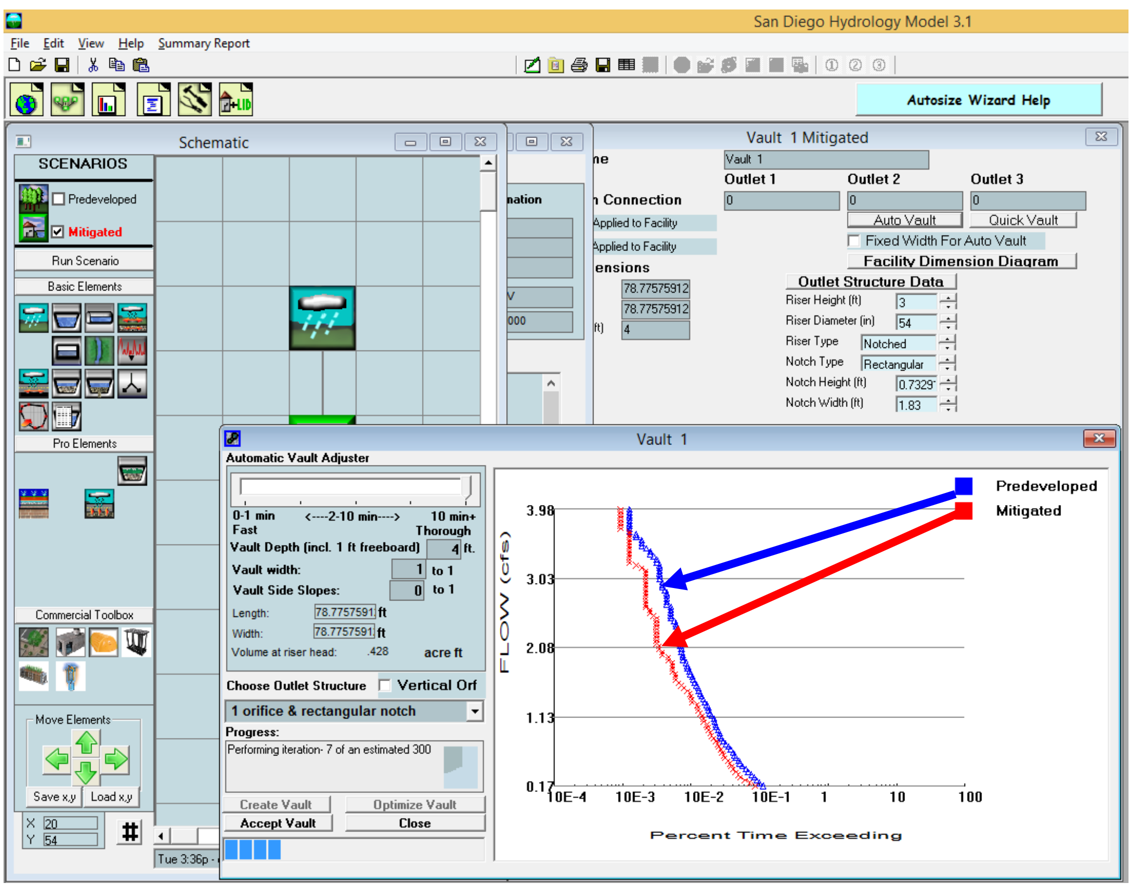
1. The hourly Predevelopment runoff is computed for the 30-50 years of record (depending on the rain gage selected).
2. The Predevelopment runoff flood frequency is calculated based on the partial duration peak flows to determine the lower and upper flow thresholds (Step 4) or the user has independently calculated the lower and upper flow thresholds using the USGS regional regression equations and pre-selected these values (Step 5).
3. The range of flows is selected for the flow duration based on the lower and upper flow thresholds.
4. This flow range is divided into 100 increments.
5. The number of hourly 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, SDHM 3.1 computes the development runoff (in the Mitigated scenario) and routes the runoff through the vault. But before the runoff can be routed through the vault the vault must be given dimensions and an outlet configuration. Auto Vault uses a set of rules based on the Predeveloped and Mitigated scenario land uses to give the vault an initial set of dimensions and an initial outlet bottom orifice diameter and riser height and diameter. This information allows SDHM 3.1 to compute a stage-storage-discharge table for the vault.

With this initial vault stage-storage-discharge table SDHM 3.1:

1. Routes the hourly development runoff through the vault for the 30-50 years of record (depending on the rain gage selected) to create to the Mitigated flow time series.
2. Counts the number of hourly Mitigated flow values that exceed each flow increment level (this is the Mitigated flow duration).
3. Computes the ratio of Mitigated flow values to Predeveloped flow values for each flow increment level (comparing the Predeveloped and Mitigated flow duration results).

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



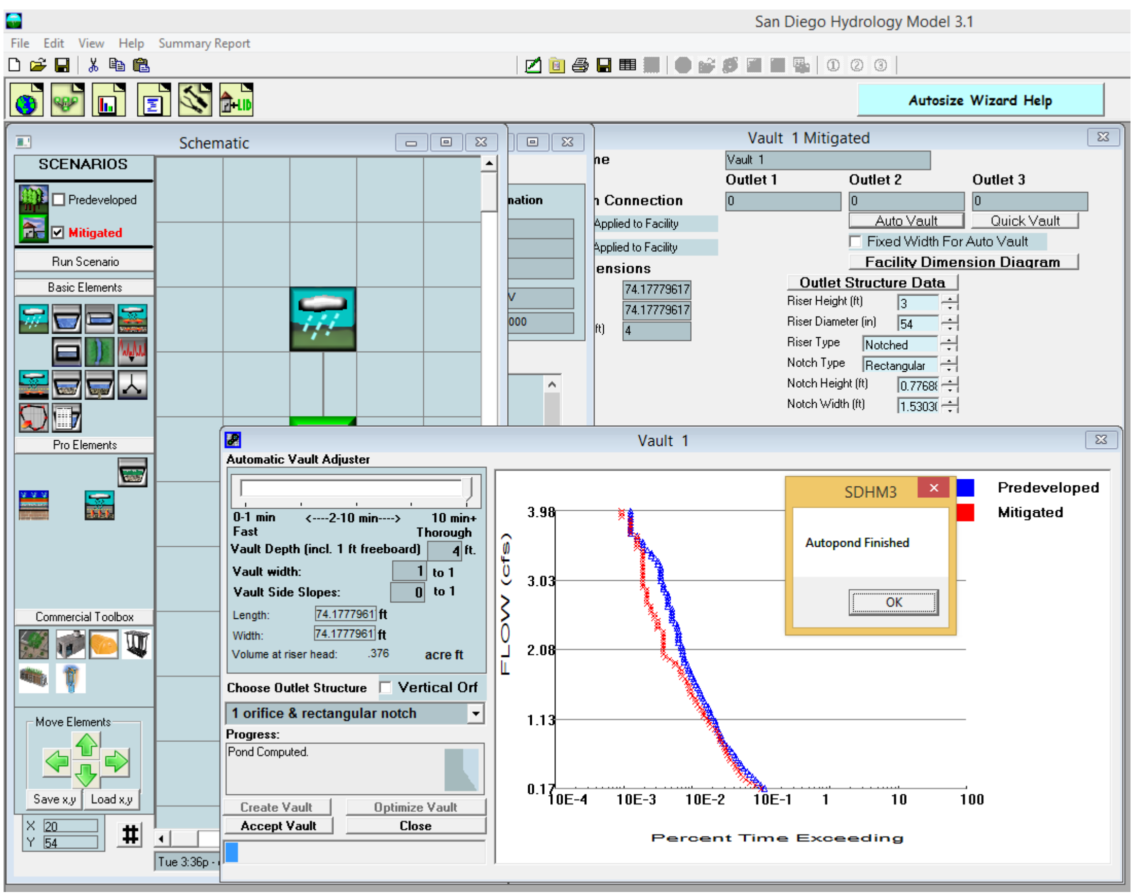
Flow duration results are shown in the plots above. The vertical axis shows the range of flows from 10% of the 2-year flow (0.174 cfs) to the 10-year flow (3.985 cfs). The horizontal axis is the percent of time that flows exceed a flow value. Plotting positions on the horizontal axis typical range from 0.001% to 1%, as explained below.

For the entire multiple-year simulation period all of the hourly time steps are checked to see if the flow for that time step is greater than the minimum flow duration criteria value (0.174 cfs, in this example). For a 30-year simulation period there are approximately 250 thousand hourly values to check. Many of them are zero flows. The 10% of the Predevelopment 2-year flow value is exceeded less than 0.1% 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).

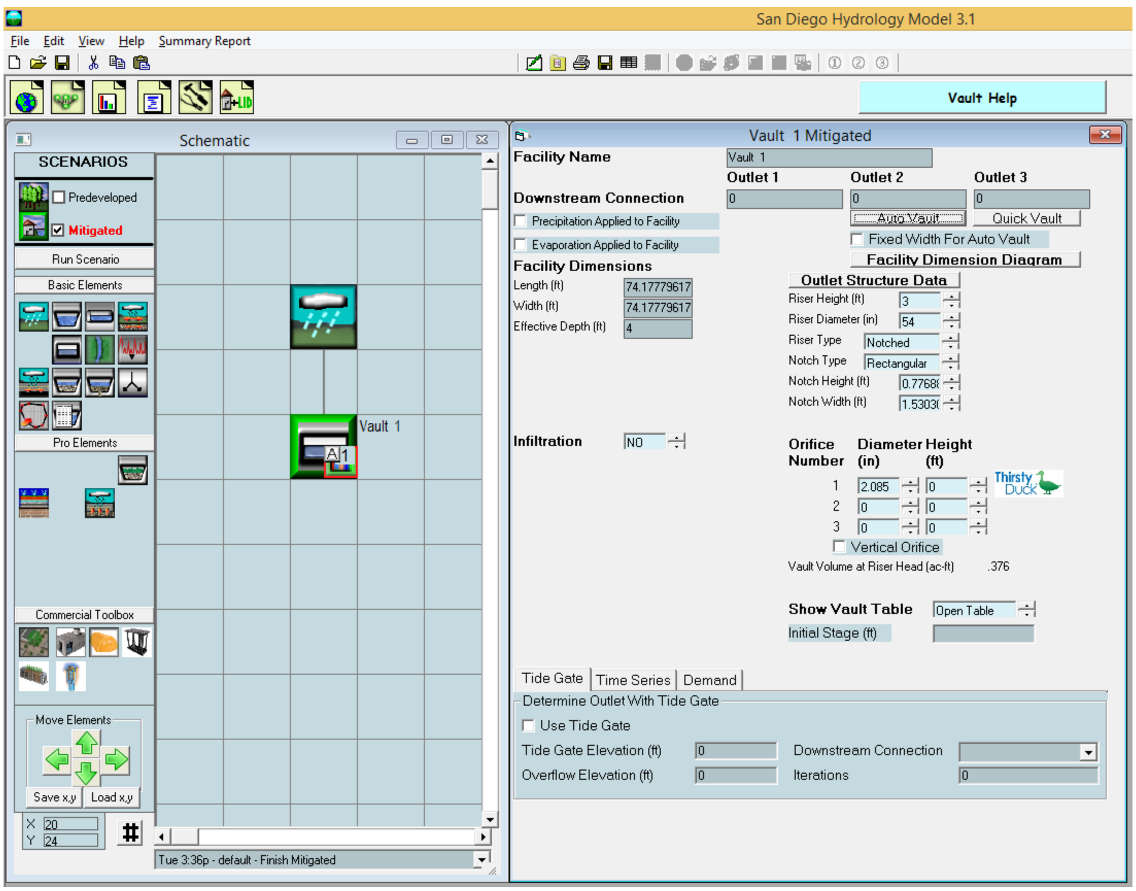
If all of the Mitigated flow duration values (in red) are to the left of the Predevelopment flow duration values (in blue) then the pond mitigates the additional erosive flows produced by the development.

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.



Auto Vault goes through an iteration process by which it changes the vault dimensions and outlet configuration, then instructs SDHM 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 Auto Vault 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).

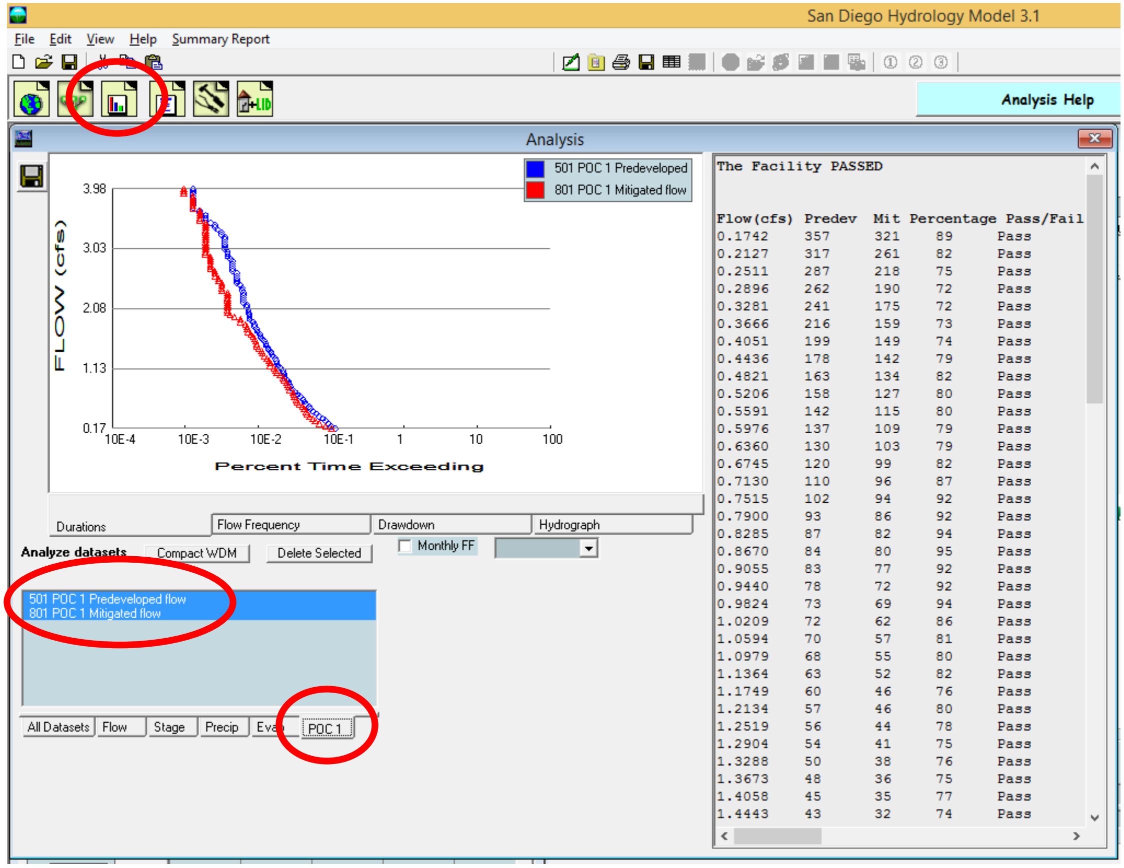
The user may continue to manually optimize the vault by manually changing vault dimensions and/or the outlet structure configuration. (Manual optimization is explained in more detail on page 65.) After making these changes the user should click on the Optimize Vault button to check the results and see if Auto Vault can make further improvements.



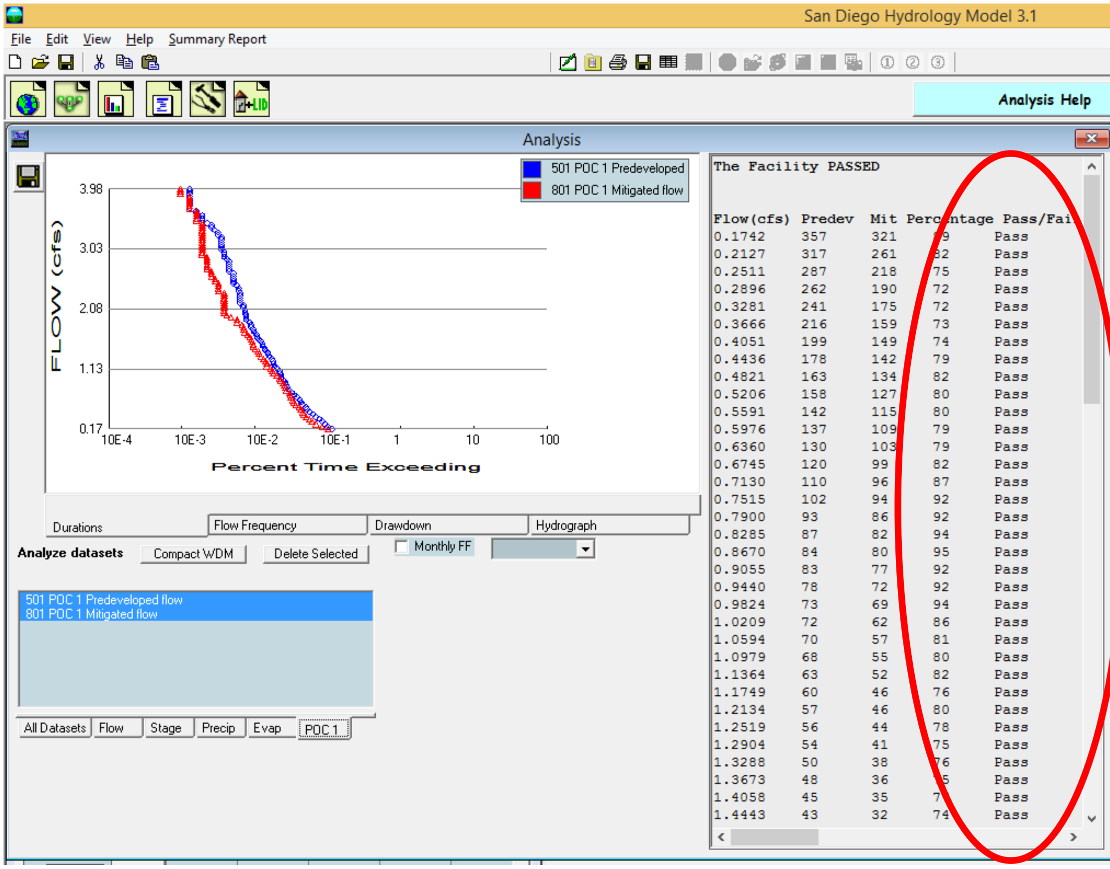
The final vault dimensions (bottom length, bottom width, and effective depth) and outlet structure information (riser height, riser diameter, riser weir type, and orifice diameter(s) and height(s)) are shown on the vault screen to the right of the Schematic grid.

NOTE: If Auto Vault selects a bottom orifice diameter smaller than the smallest diameter allowed by the local municipal permitting agency then the user should review the local municipal permitting agency's stormwater manual appendices C and D to determine an appropriate solution.

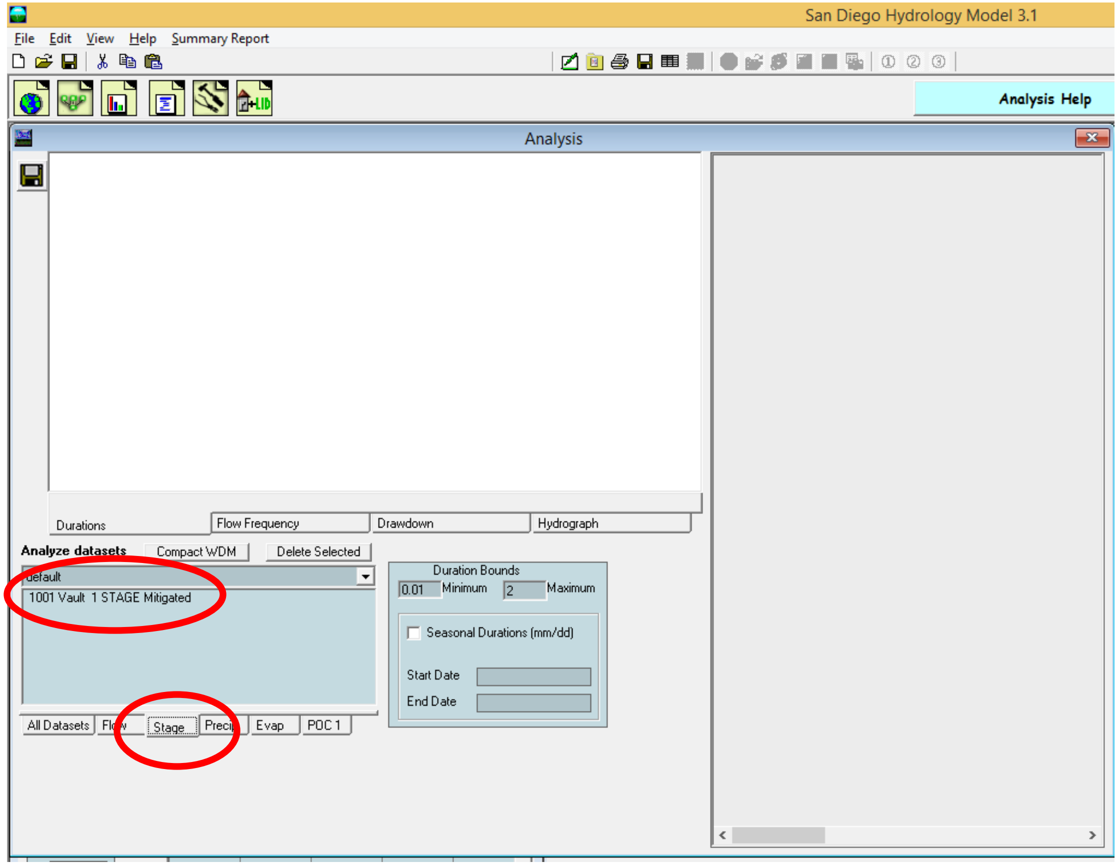
Step 9. Review analysis.



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 Predeveloped flow and 801 POC 1 Mitigated flow are highlighted.



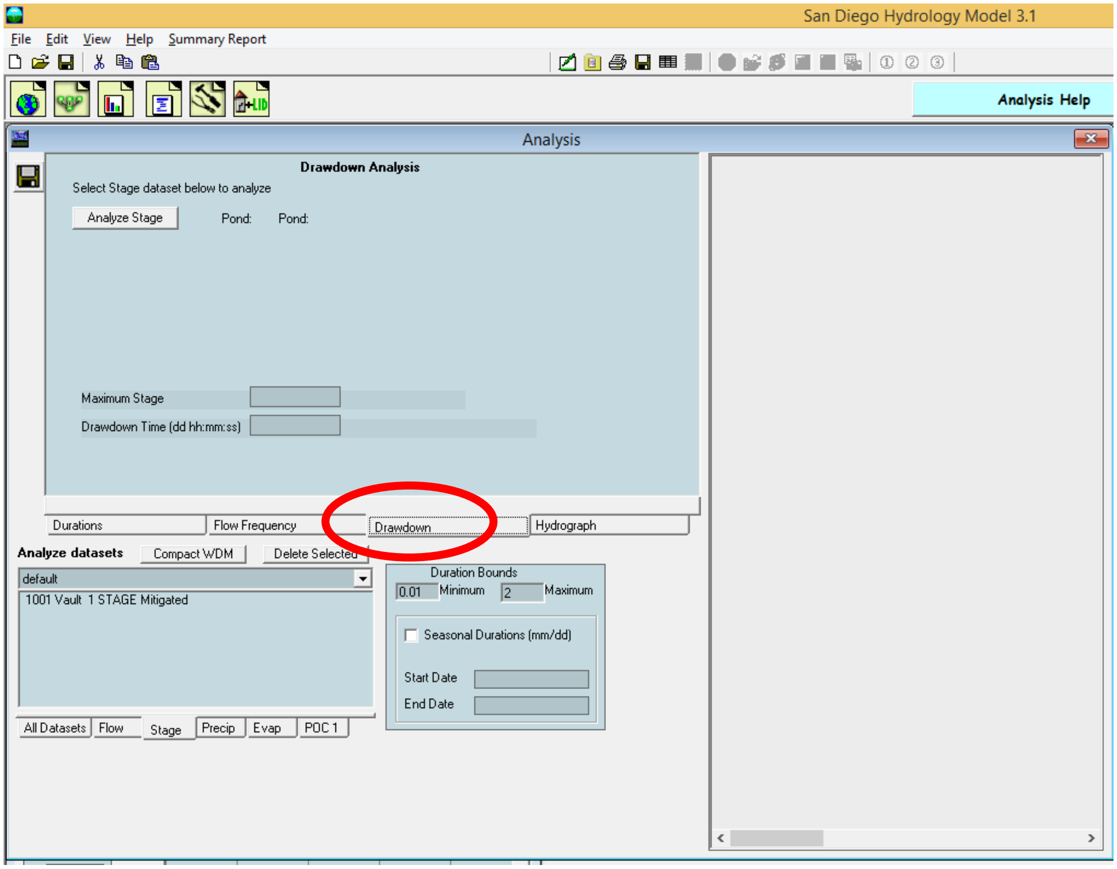
The flow duration plot for both Predeveloped and Mitigated flows will be shown along with the specific flow values and number of times Predeveloped and Mitigated flows exceeded those flow values. The Pass/Fail on the right indicates whether or not at that flow level the flow control standard criteria were met and the vault 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; one Fail fails the mitigation facility design.



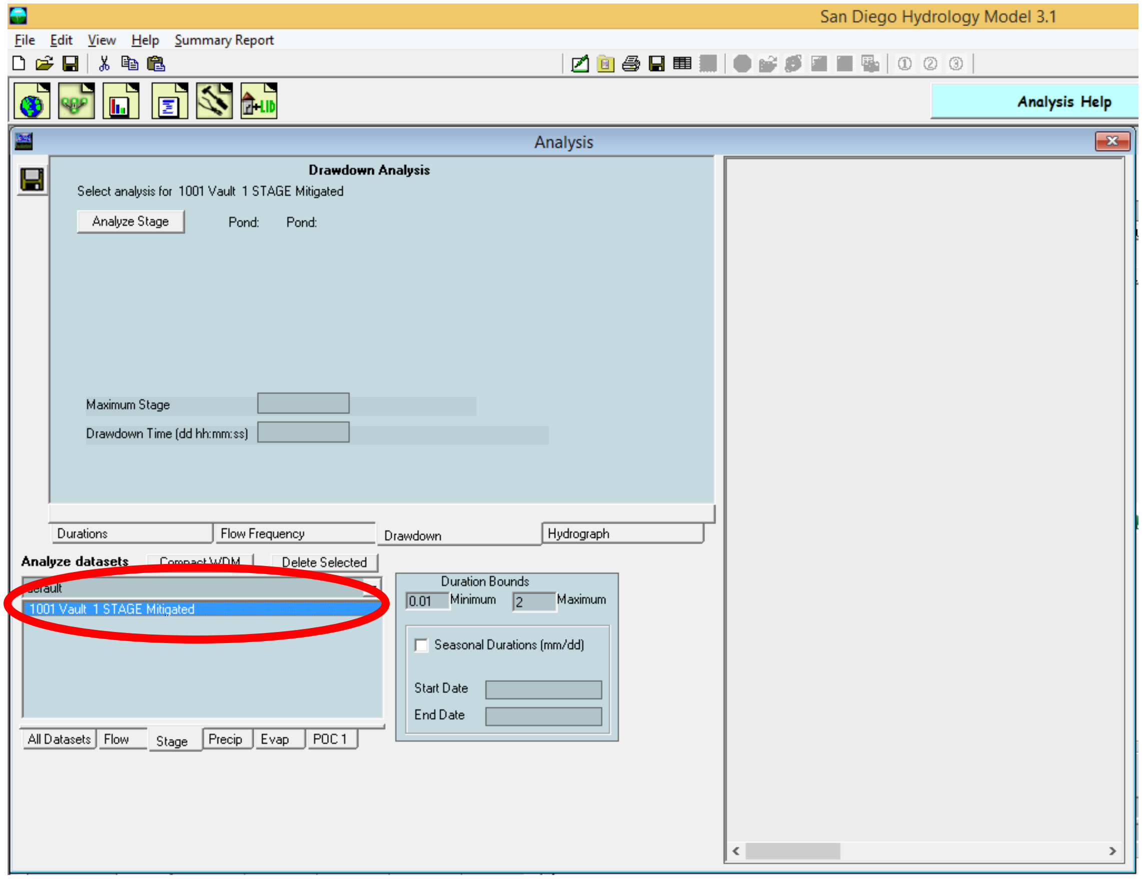
Vault drawdown/retention time is computed on the Analysis screen.

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

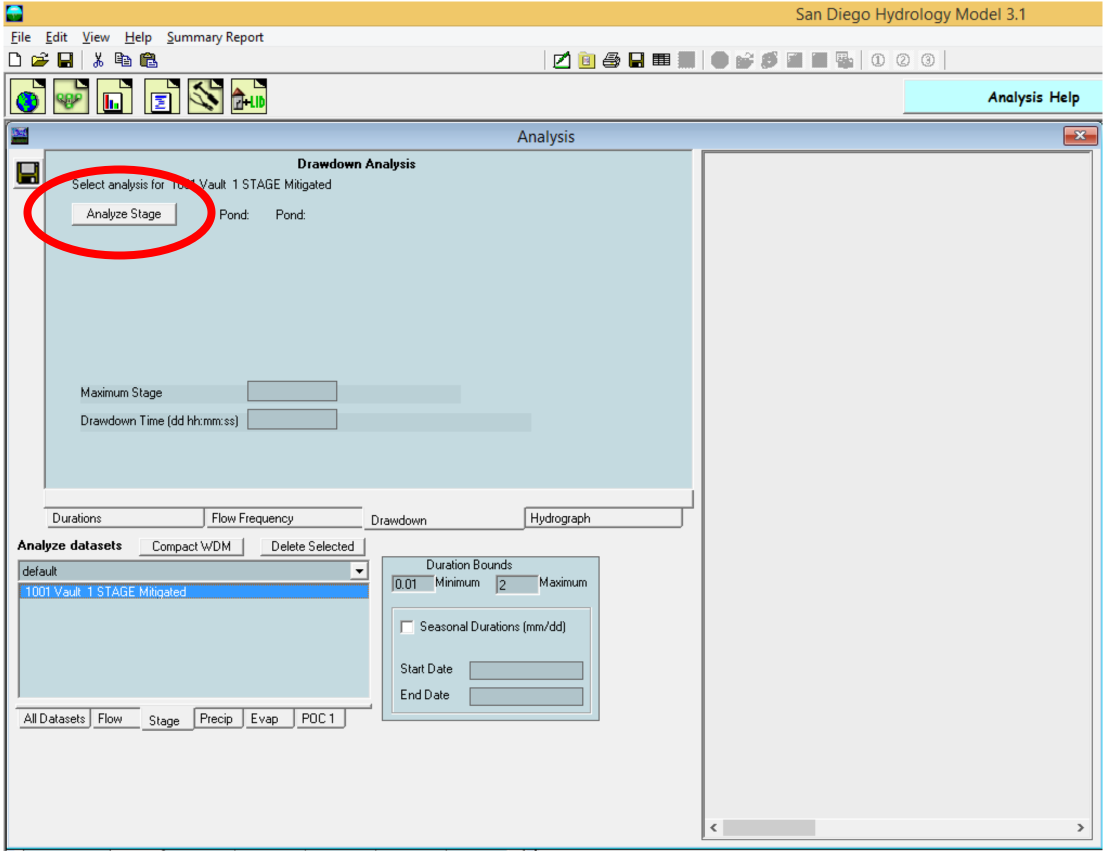
NOTE: This information is not required for basic sizing of the flow duration facility, but can assist the user in determining the overall suitability of the mitigated design in meeting additional, related requirements for treating stormwater runoff and minimizing risk of vector (mosquito) breeding problems. See page 141 for more descriptions of this SDHM feature and review the local municipal permitting agency's stormwater manual appendices C and D.



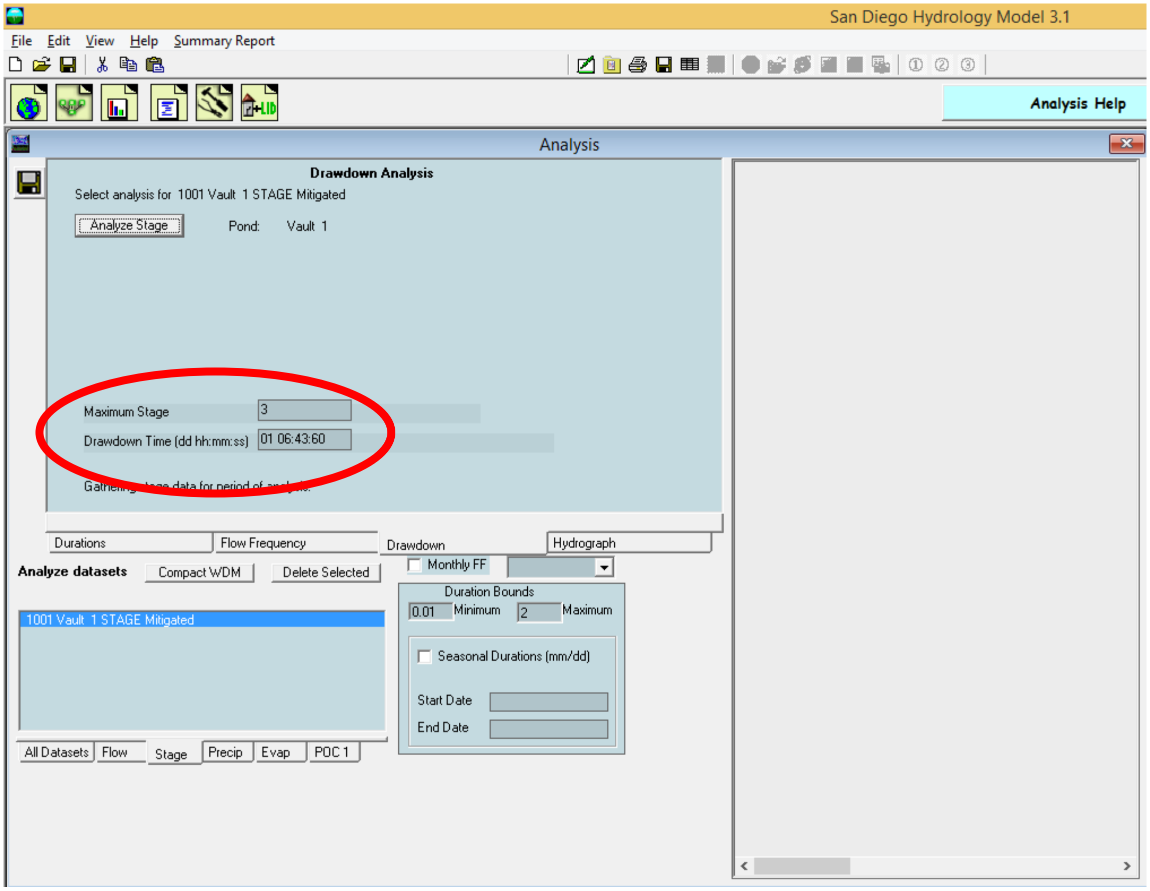
Click on the tab labeled Drawdown. This is where the vault drawdown/retention time results will be shown.



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



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

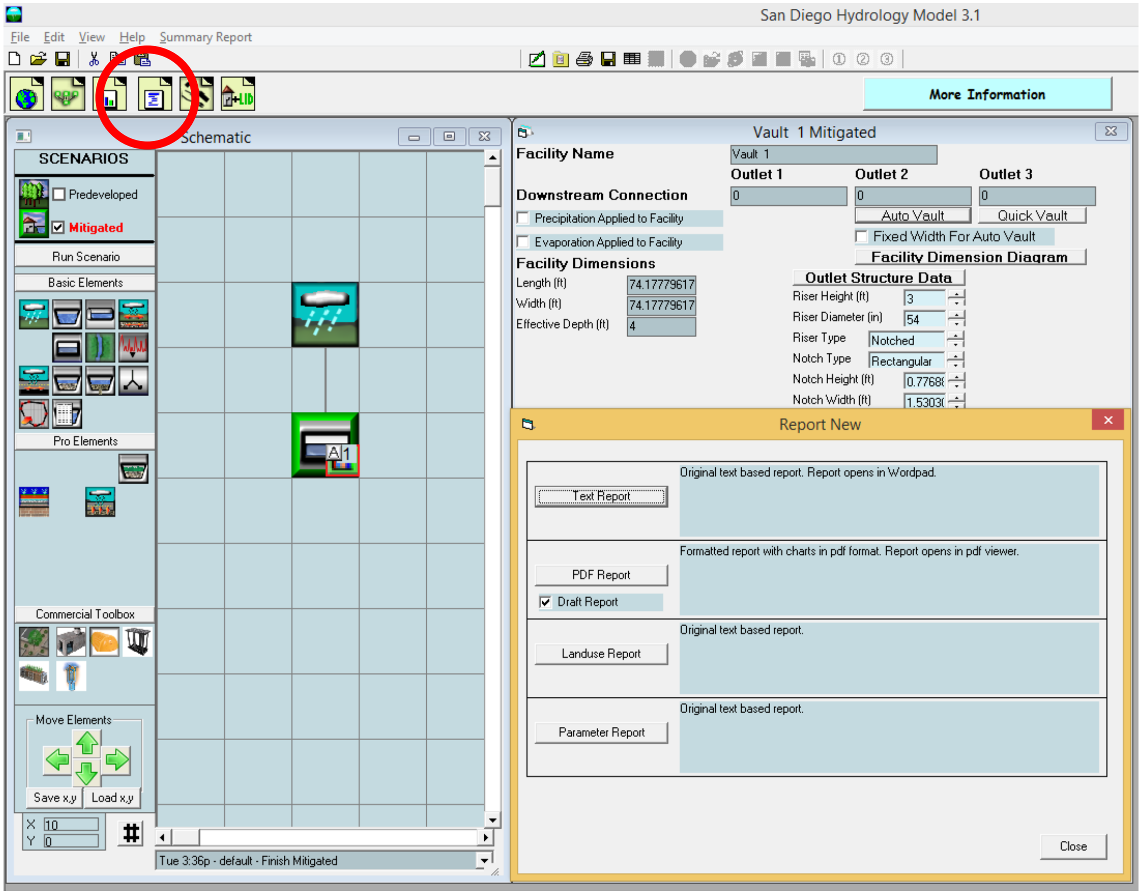


For this example, the stage (water depth in the vault) at the top of the riser is 3.0 feet. The vault has a drawdown time of 1 day, 6 hours, and 43 minutes. This is the time to drain the vault through the vault's outlet structure if the vault is full to the top of the riser (the vault may never have actually been this full in the simulation period).

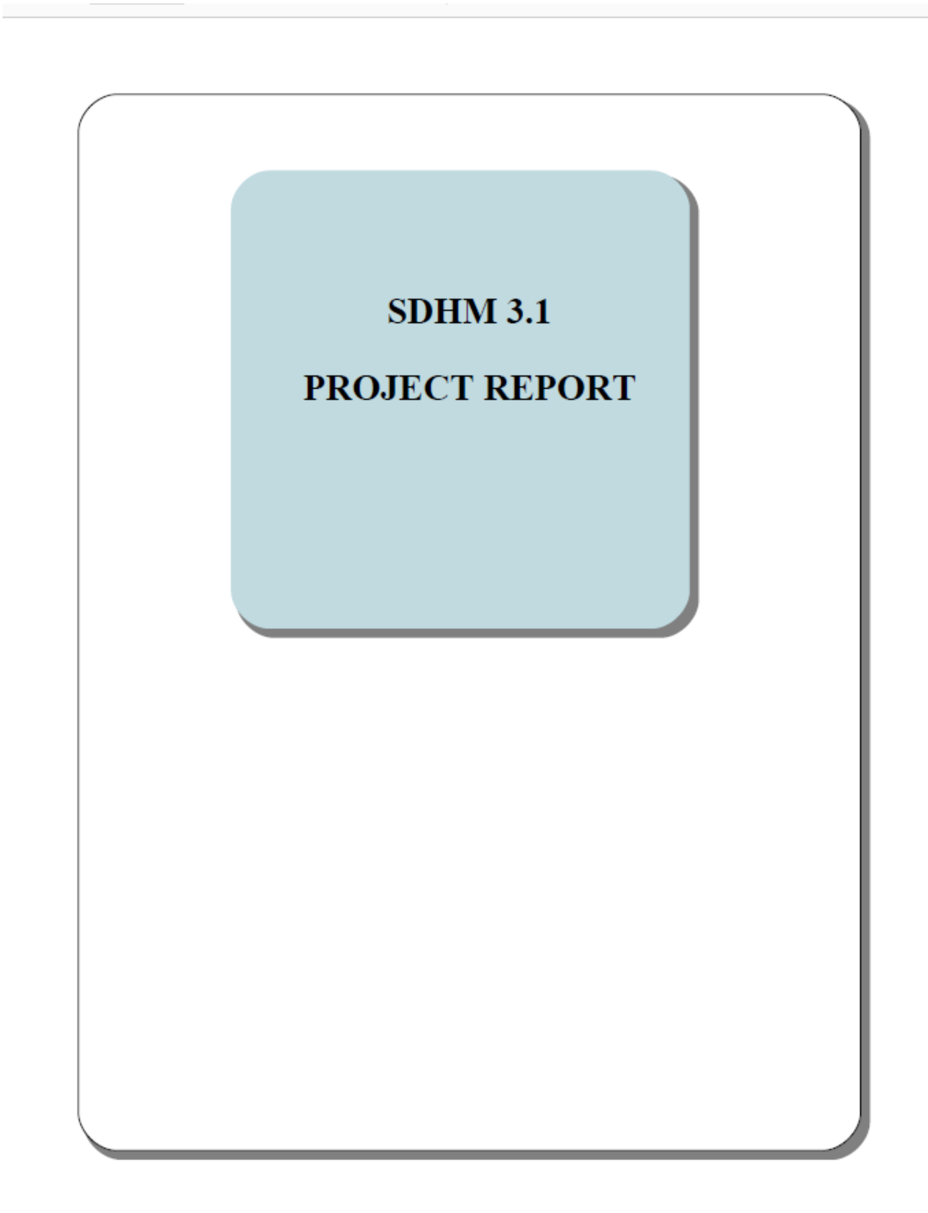
Stormwater storage facilities may have drain times in excess of the allowed maximum time. This can occur when a stormwater facility has a small bottom orifice. If this is not acceptable then the user needs to change the facility outlet configuration, manually run the Mitigated scenario, and repeat the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

NOTE: See the local municipal permitting agency's stormwater manual appendices C and D 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 user manual assumes that the flow duration criteria take precedence unless the user is instructed otherwise by the local municipal permitting agency.

Step 10. Produce report.

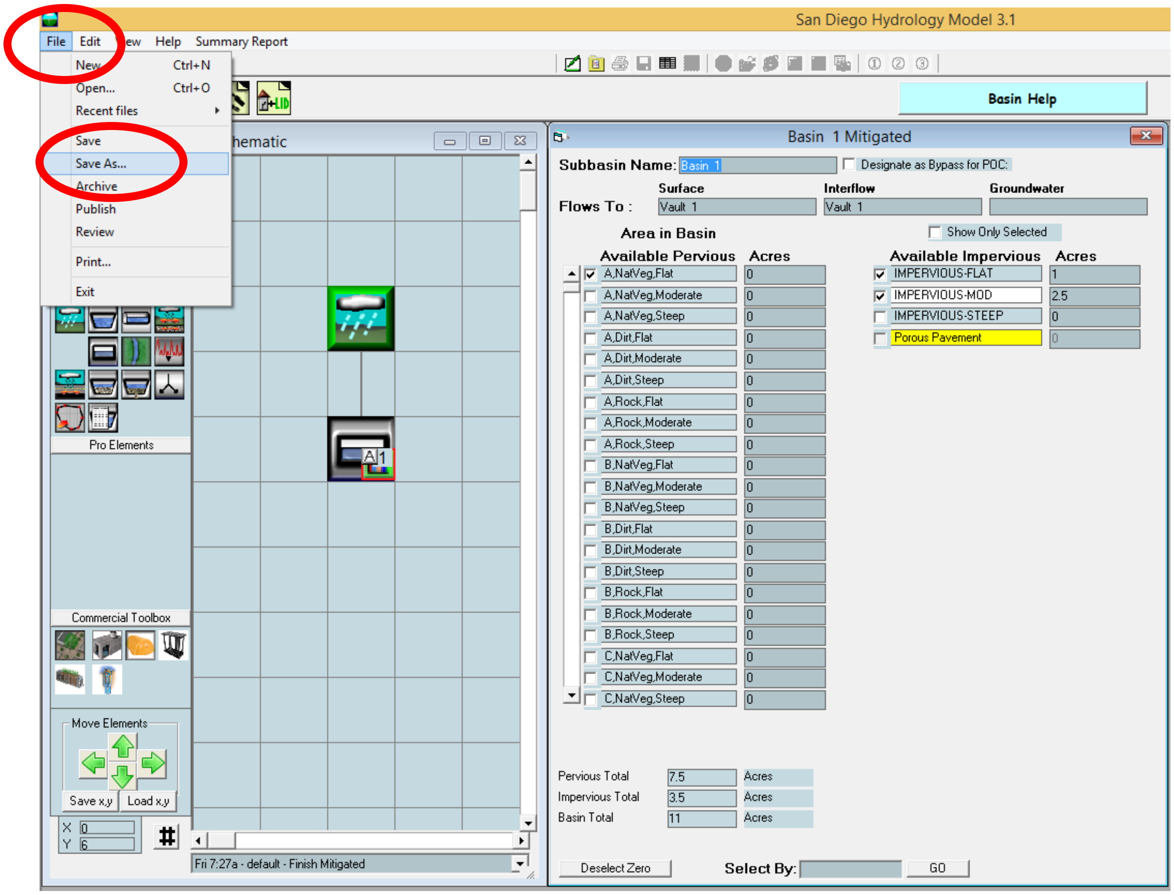


Click on the Reports tool bar button (fourth from the left) to generate a project report with all of the project information and results. Select either a Text Report (Word format) or a PDF Report.

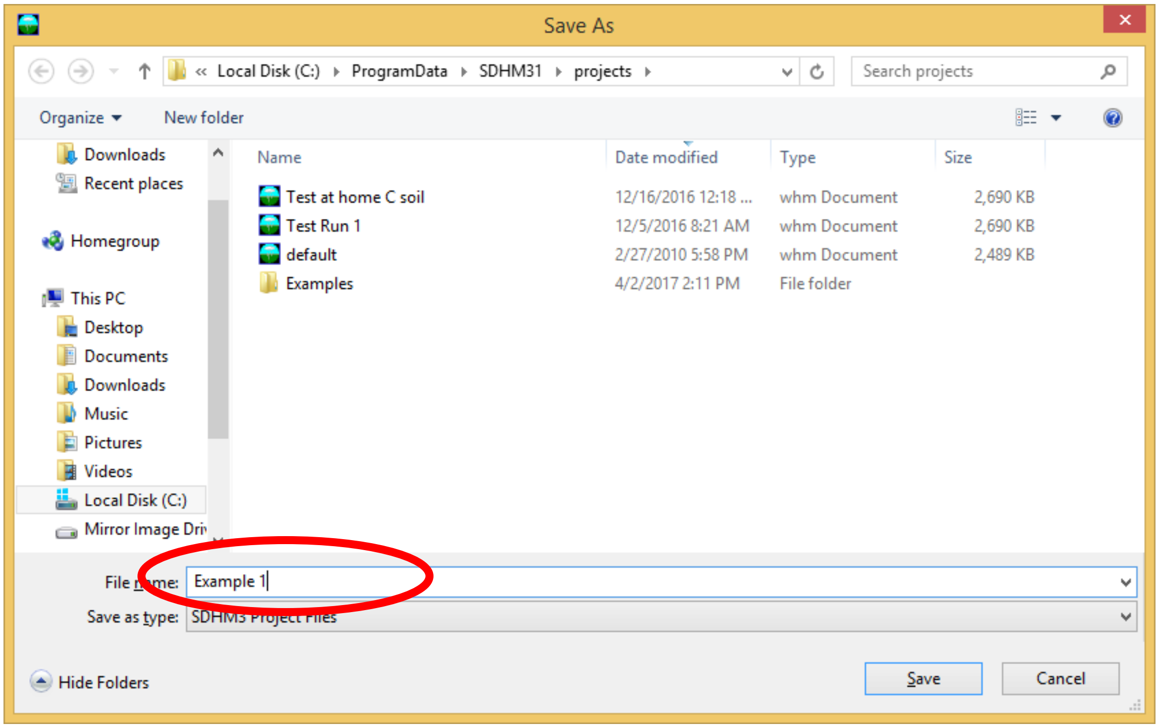


Scroll down the Report screen to see all of the results.

Step 11. Save project.

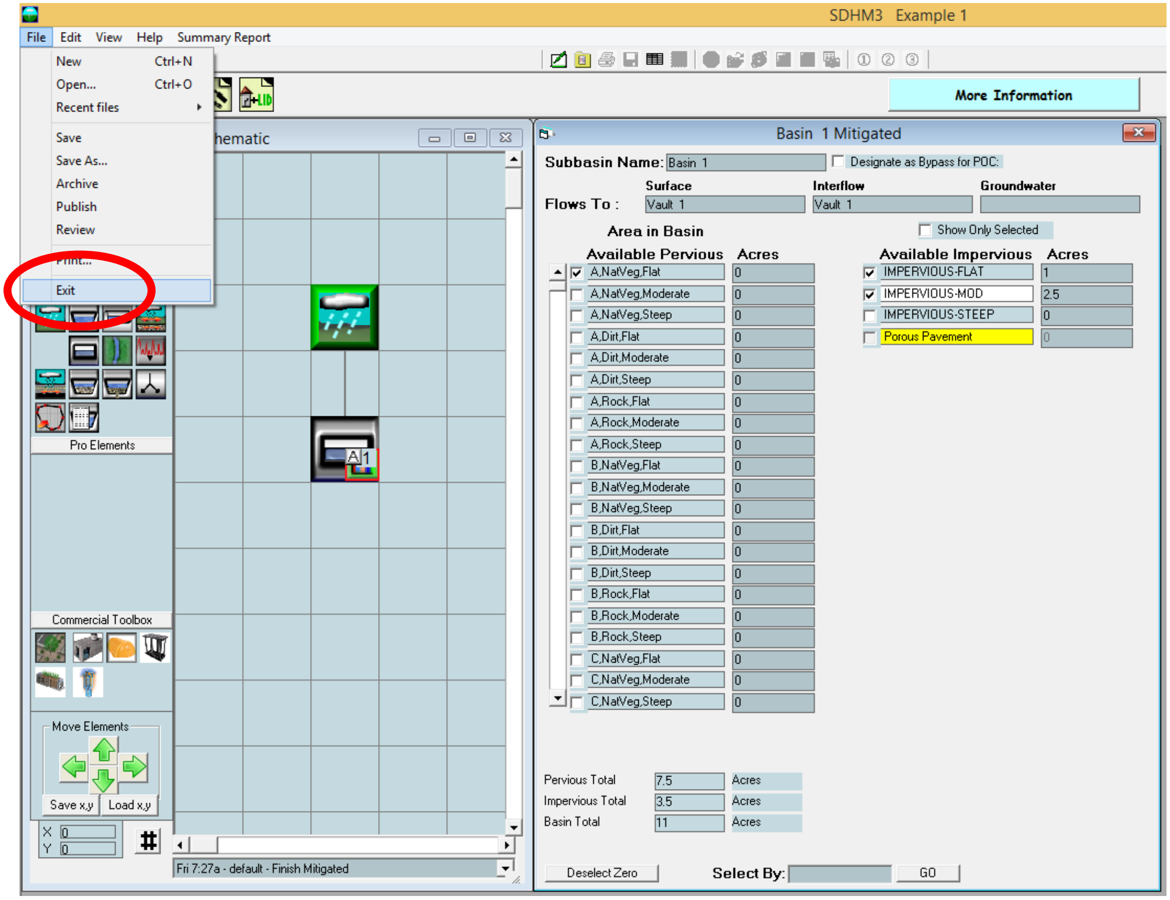


To save the project click on File in the upper left corner and select Save As.



Select a file name and save the SDHM 3.1 project file. The user can exit SDHM 3.1 and later reload the project file with all of its information by going to File, Open.

Step 12. Exit SDHM.



To exit SDHM 3.1 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.

NOTE: A more complex SDHM 3.1 example project is included in Appendix E.

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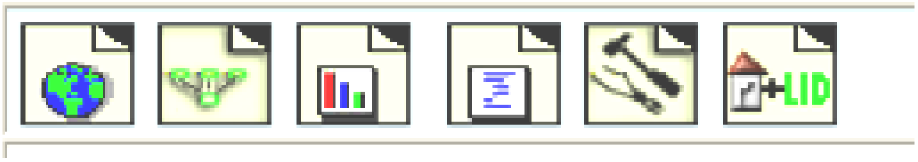
MAIN SCREENS



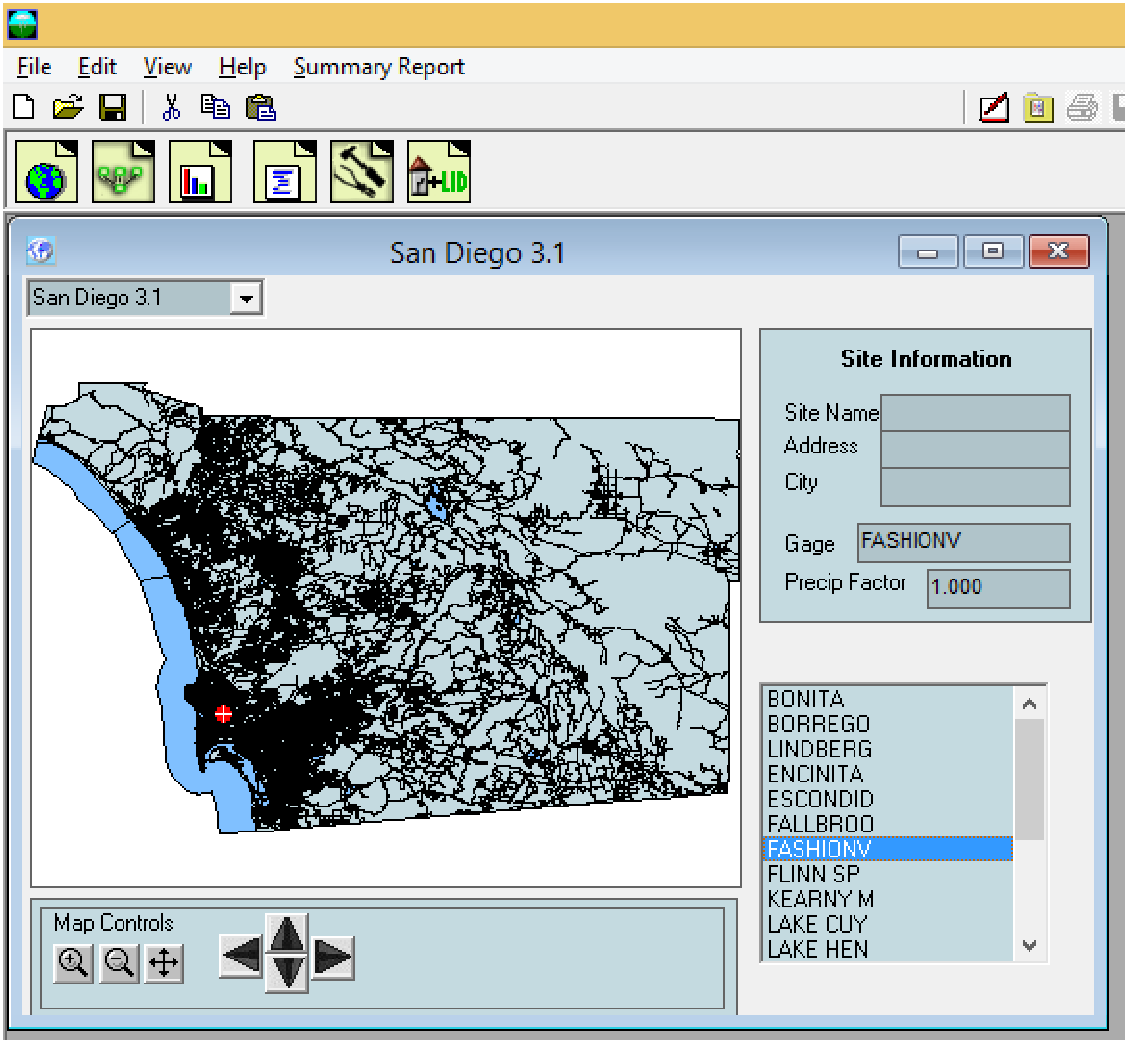
SDHM 3.1 has six main screens. These main screens can be accessed through the buttons shown on the tool bar above or via the View menu.

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

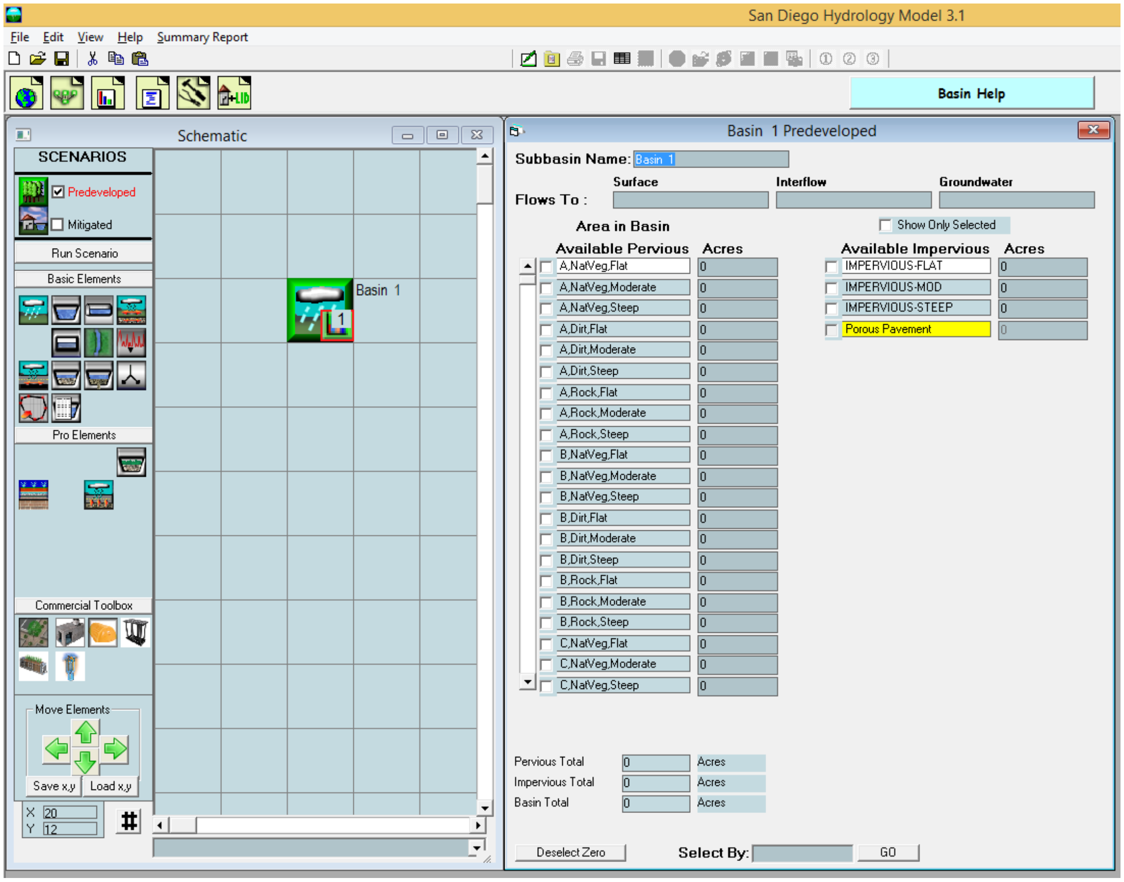


The Map Screen contains county information. The precipitation gage and precip factor are shown to the right of the map. The user selects the rainfall record from the list of precipitation stations shown in the lower right side of the screen. The precip factor will be 1.00.

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 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.

GENERAL PROJECT INFORMATION SCREEN



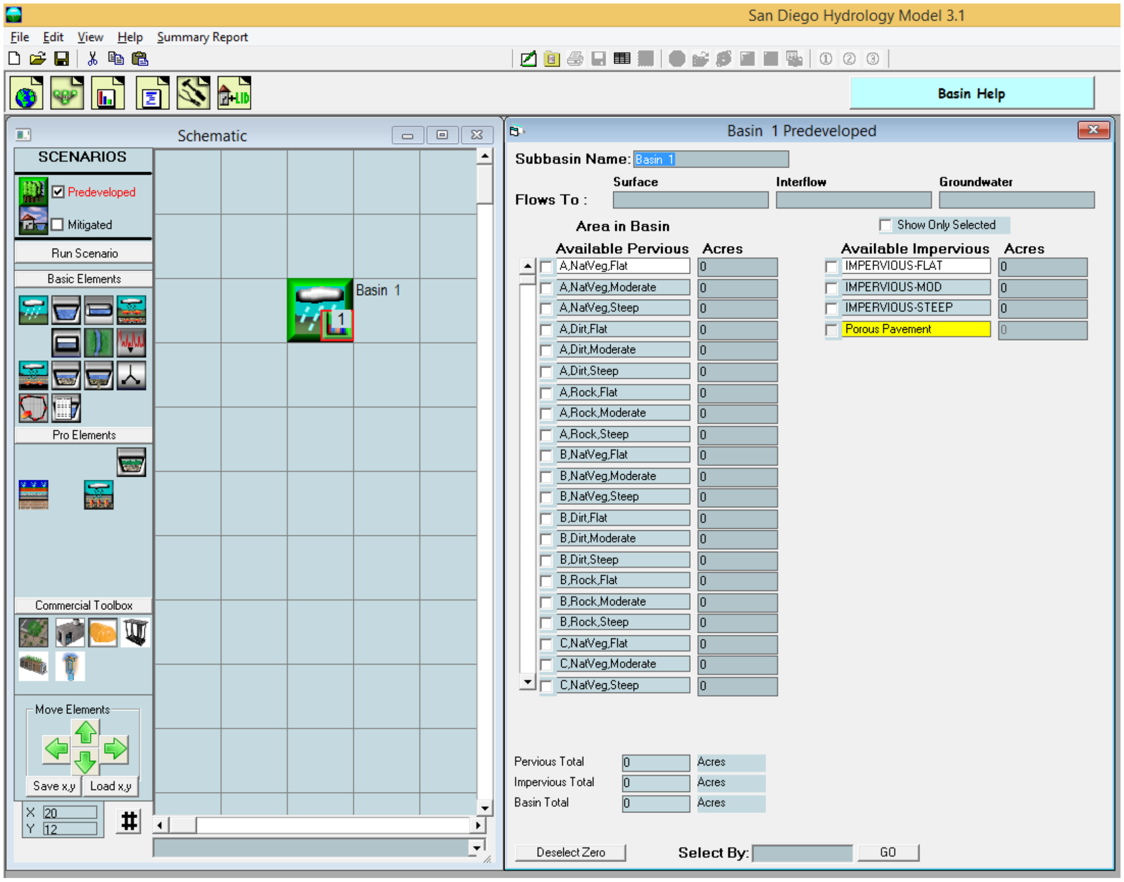
The project screen contains all of the information about the project site for the two land use scenarios: Predeveloped land use conditions and the Mitigated (developed) land use conditions. To change from one scenario to another check the box in front of the scenario name in the upper left corner of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

Predevelopment is defined as the natural conditions prior to the existing and proposed 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 Predeveloped 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.

It is recommended that all movement on the grid be from the top of the grid down, although it is no longer required.

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.

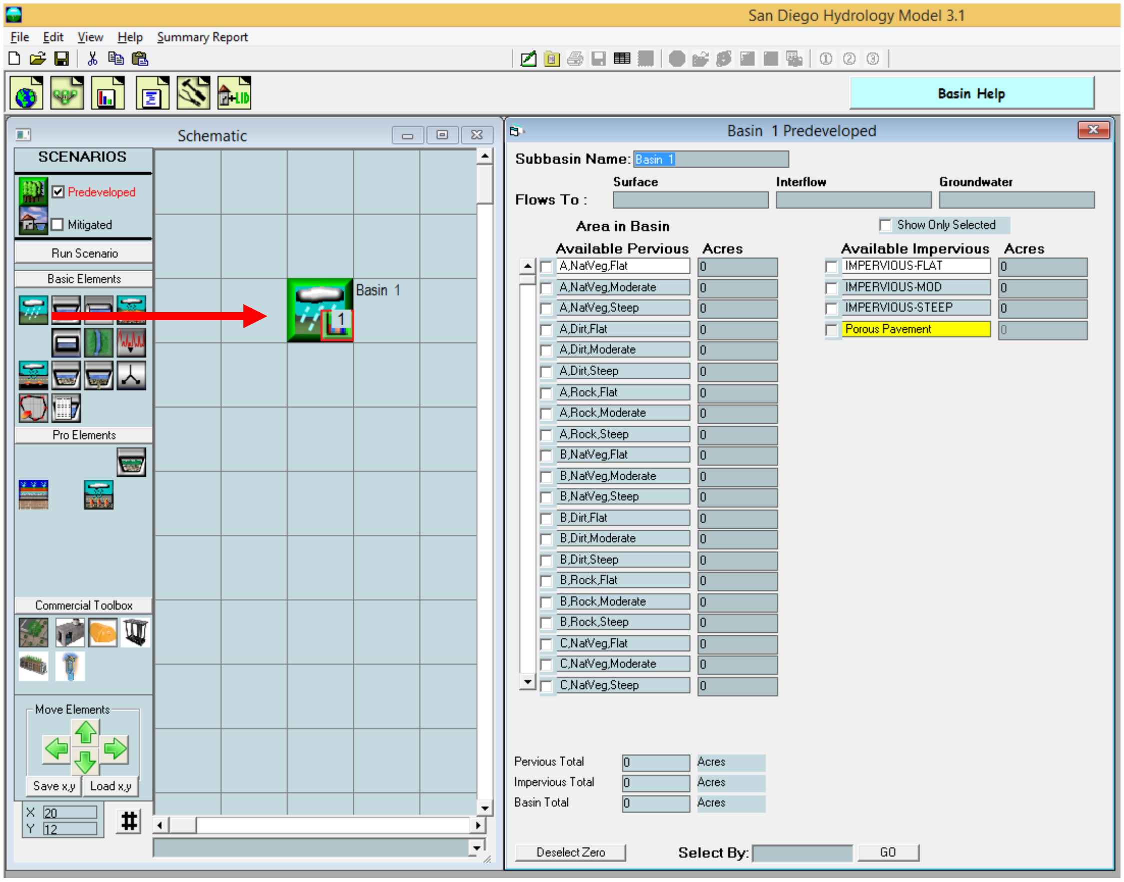
The grid coordinates from one project can be saved (Save x,y) and used for new projects (Load x,y).

BASIC ELEMENTS

The following pages contain information about these basic elements:

- Landuse Basin
- Trapezoidal Pond
- Storage Vault
- Storage Tank
- Irregular Shaped Pond
- Gravel Trench Bed
- Sand Filter
- Open Channel
- Flow Splitter
- Time Series
- SSD Table
- Lateral Flow Soil Basin
- Lateral Flow Impervious Area

LANDUSE BASIN ELEMENT



The Landuse Basin element represents a drainage area that can have any combination of soils, land cover, and land slopes. A land use 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 Landuse Basin element.

Table 1. SDHM 3.1 Pervious Land Types

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

41	B	Urban	Moderate (5-15%)
42	B	Urban	Steep (>15%)
43	C	Urban	Flat (0-5%)
44	C	Urban	Moderate (5-15%)
45	C	Urban	Steep (>15%)
46	D	Urban	Flat (0-5%)
47	D	Urban	Moderate (5-15%)
48	D	Urban	Steep (>15%)
49	A	Urban, No Irrigation	Flat (0-5%)
50	A	Urban, No Irrigation	Moderate (5-15%)
51	A	Urban, No Irrigation	Steep (>15%)
52	B	Urban, No Irrigation	Flat (0-5%)
53	B	Urban, No Irrigation	Moderate (5-15%)
54	B	Urban, No Irrigation	Steep (>15%)
55	C	Urban, No Irrigation	Flat (0-5%)
56	C	Urban, No Irrigation	Moderate (5-15%)
57	C	Urban, No Irrigation	Steep (>15%)
58	D	Urban, No Irrigation	Flat (0-5%)
59	D	Urban, No Irrigation	Moderate (5-15%)
60	D	Urban, No Irrigation	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 HSPF parameter values for each PERLND are listed in Appendix B.

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, Natural Vegetation (NatVeg), Flat" means NRSC soil type A, native grass/shrub 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 five basic land cover categories: natural vegetation, dirt, rock, urban irrigated landscaped vegetation, and urban non-irrigated landscaped vegetation..

Natural land cover has been divided into natural vegetation (NatVeg), dirt, and rock. Dirt and rock includes landscapes that are vegetated, but the majority of the surface cover is non-vegetation.

Urban vegetation consists of lawns, flowers, planted shrubs and trees. Urban vegetation may be irrigated (Urban) or non-irrigated (UrbNoIrr).

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

HSPF parameter values in SDHM 3.1 have been adjusted for the different soil, land cover, and land slope categories. SDHM 3.1 HSPF soil parameter values take into account the hydrologic effects of land development activities that result from soil compaction when "Urban" or "UrbNoIrr" is specified.

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

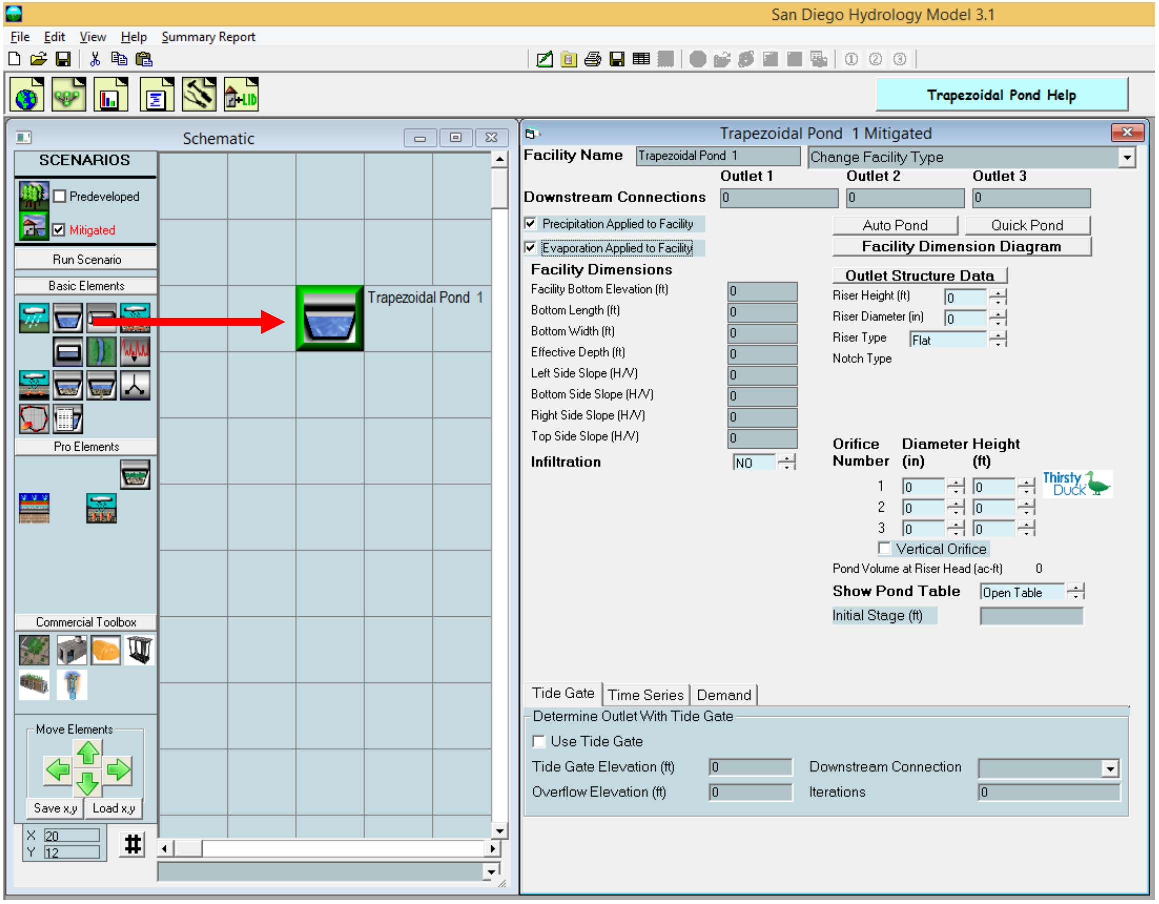
Table 2. SDHM 3.1 Impervious Land Types

IMPLND No.	Surface	Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-15%)
3	Impervious	Steep (>15%)

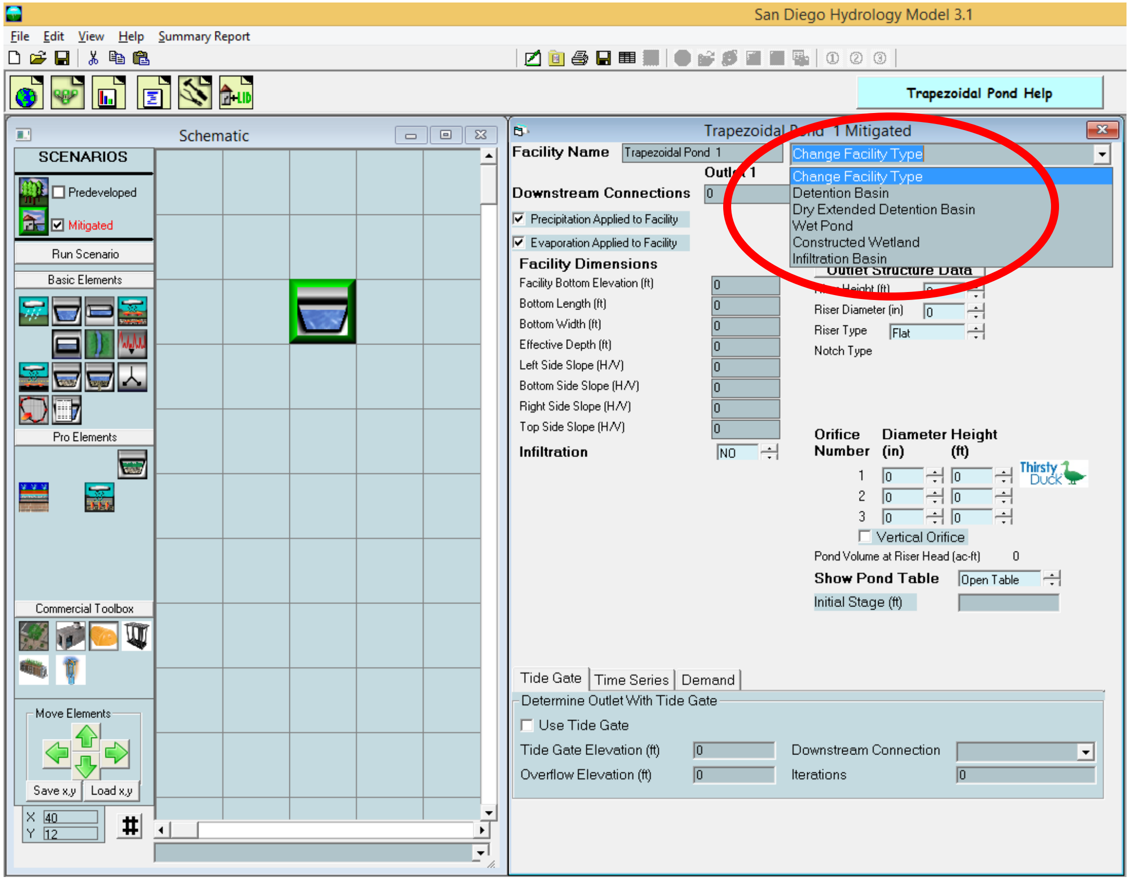
The user does not need to know or keep track of the HSPF IMPLND number. That number is used only for internal tracking purposes.

The HSPF parameter values for each IMPLND are listed in Appendix B.

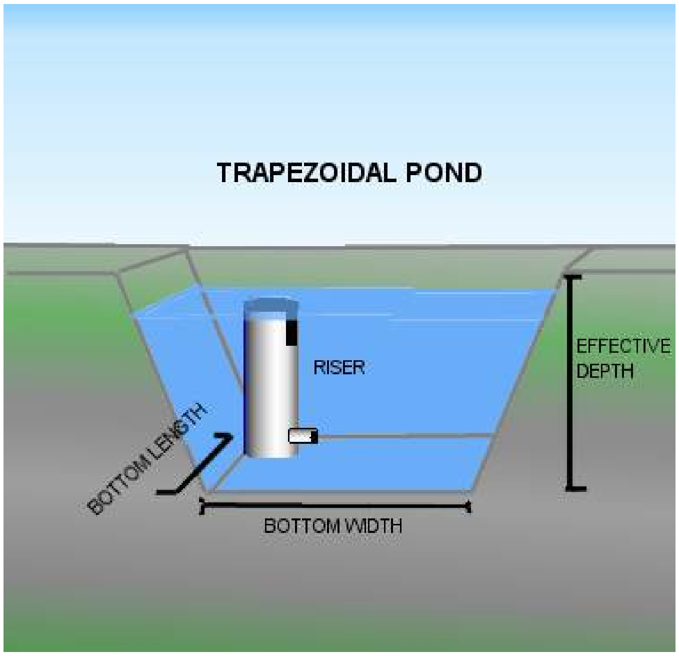
TRAPEZOIDAL POND ELEMENT



The Trapezoidal Pond element is a rectangular-shaped stormwater storage facility with an outlet structure. This element can be used to model a detention basin, dry extended detention basin, wet pond, constructed wetland, and/or infiltration basin.



The Change Facility Type pulldown menu can be used to document the type of facility being modeled and change the facility type name from trapezoidal pond to one of the other options listed in the pulldown menu. For the purposes of documenting this element in the SDHM 3.1 User Manual, the term “trapezoidal pond” or “pond” will be used to include all of the above-mentioned variations of this BMP element.



In SDHM 3.1 there is a stormwater storage element for each type of stormwater control facility. The pond element shown above is for a trapezoidal pond. This is the most common type of stormwater storage.

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.

Auto-Sizing

For the Trapezoidal Pond element auto-sizing of the pond is done using Auto Pond. Auto Pond will automatically size a trapezoidal pond to meet the required flow duration criteria. Auto Pond is available only in the Mitigated scenario.

Quick Pond can be used to instantly add pond dimensions and an outlet configuration without checking the pond for compliancy with flow duration criteria. Quick Pond is sometimes used to quickly create a scenario and check the model linkages prior to sizing the pond. Multiple clicks on the Quick Pond 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 orifices are assumed to have horizontal openings, but they can be changed to vertical by checking the Vertical Orifice box. If there are multiple orifices they all must be either all horizontal or all vertical. A combination of vertical and horizontal is not allowed.

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 defines the pond's hydraulic characteristics.

Manual Sizing

The user can also 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 (Pond 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 125).
- 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 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D 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.

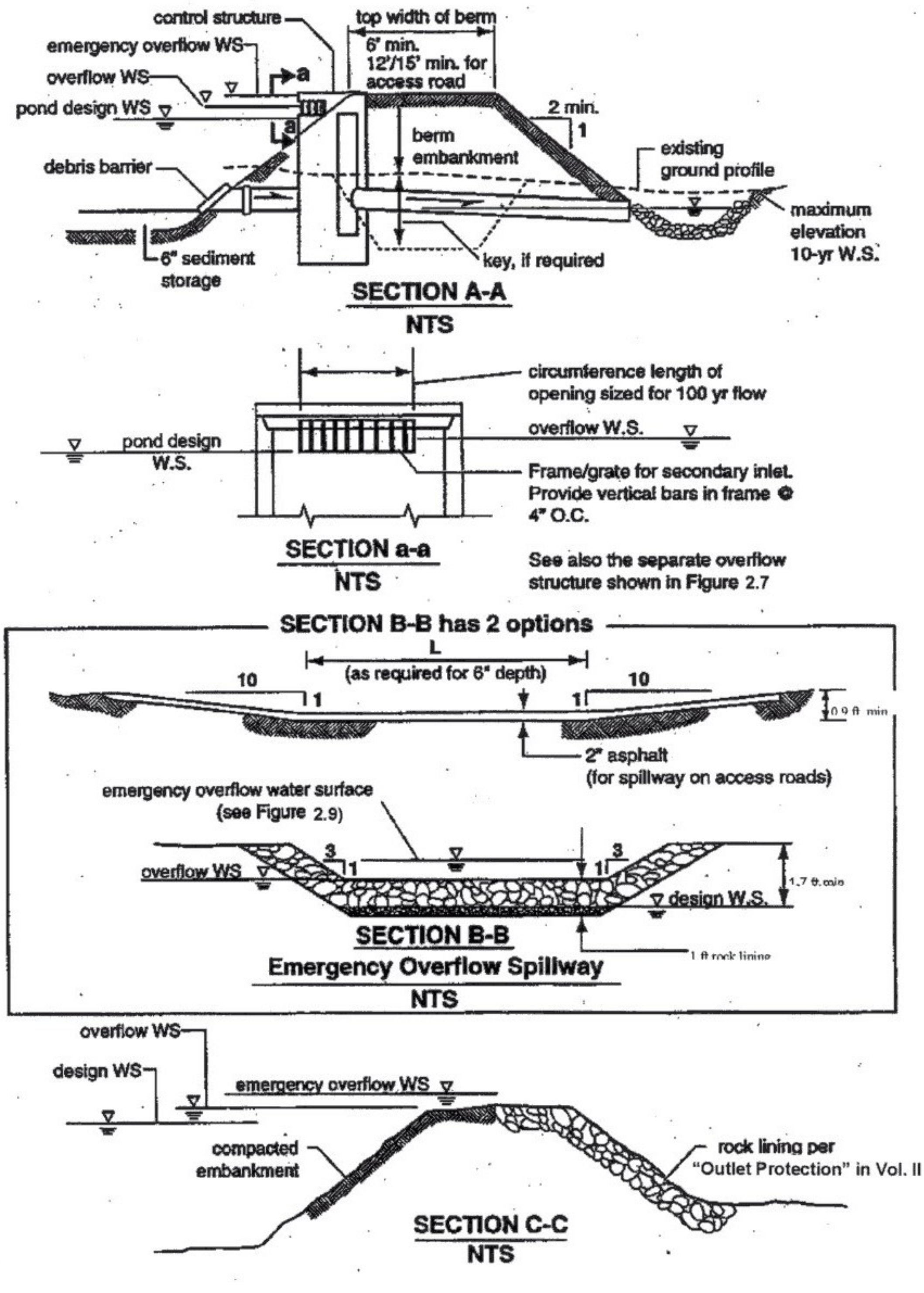
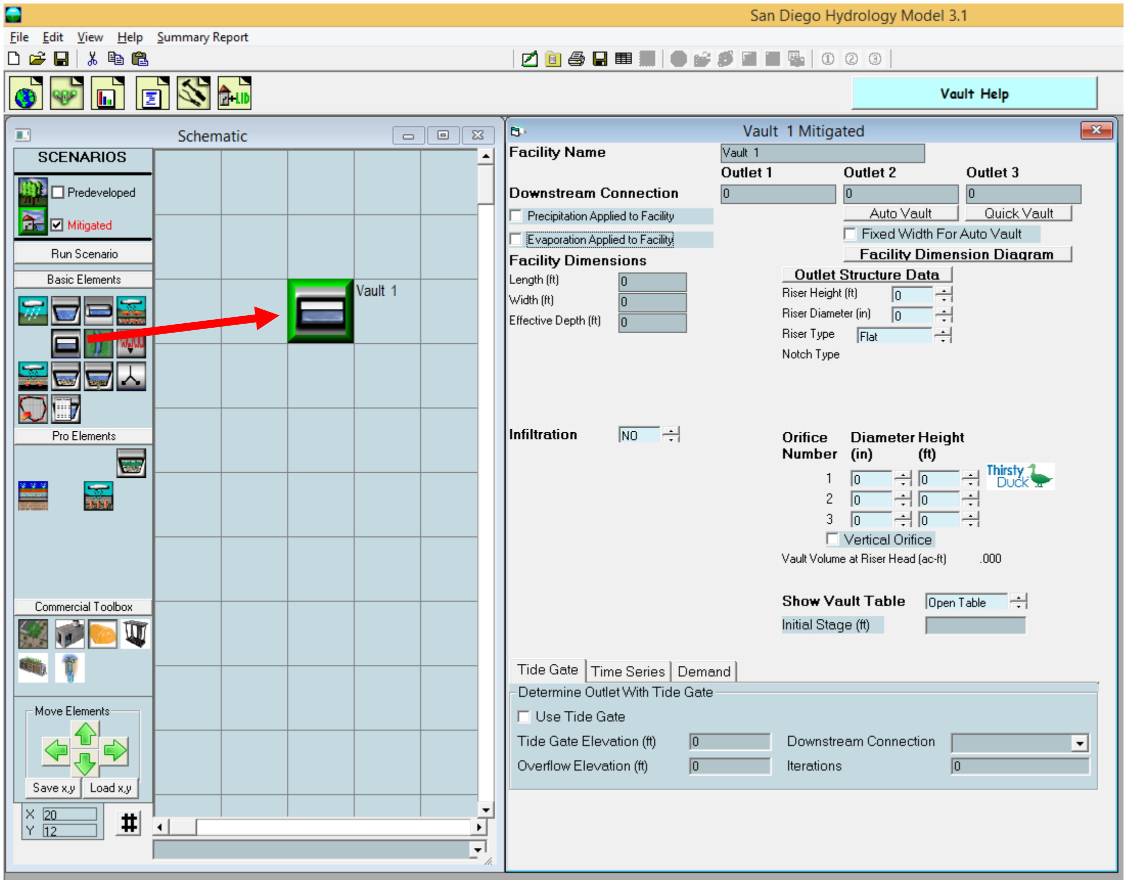


Figure 3.10 Typical Detention Pond Sections

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 2014 Stormwater Management

Manual for Western Washington. *Consult with your local municipal permitting agency on specific design requirements for your project site.*

STORAGE VAULT ELEMENT

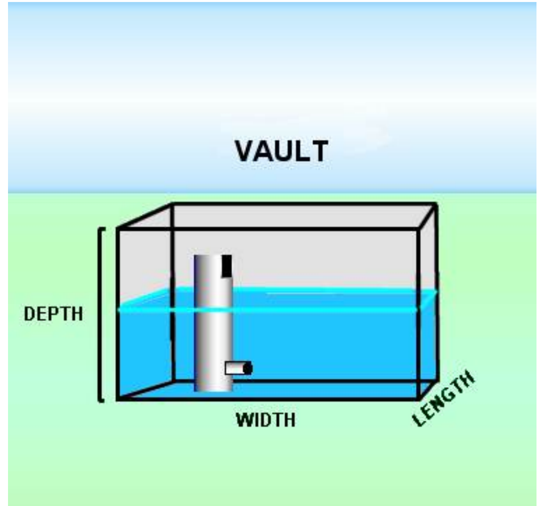


The Storage Vault element has the same characteristics as the Trapezoidal Pond element, except that the user does not specify the side slopes (by definition they are zero) and the vault is assumed to have a lid (no precipitation or evaporation).

Auto Vault and Quick Vault work the same way as Auto Pond and Quick Pond. Go to page 65 to find information on how to manually size a vault or other HMP facility.

Auto Vault is available only in the Mitigated scenario.

Storage Vault element 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 125).
- Use Wetted Surface Area (sidewalls): Yes, if infiltration through the vault sides is allowed.

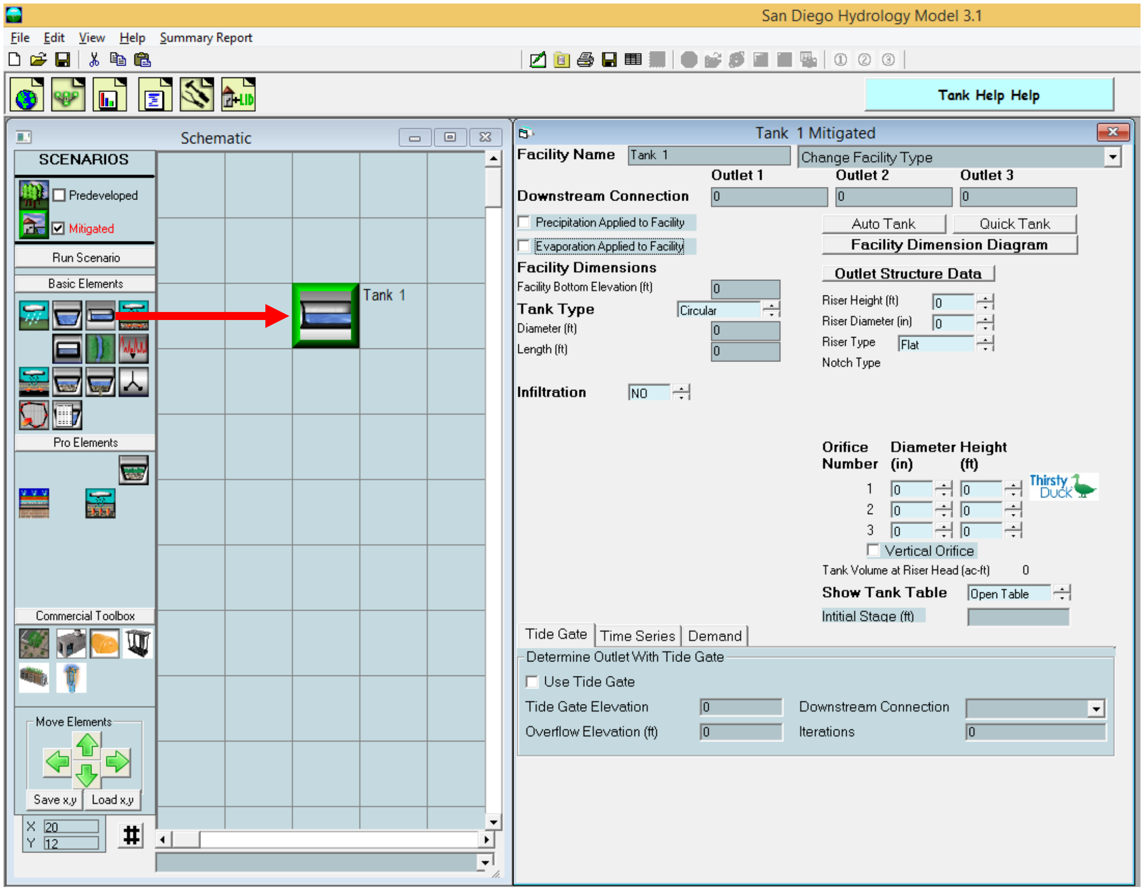
If infiltration is used then the user should consult the Infiltration discussion on page 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D 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.

The Storage Vault element can represent a cistern or rain barrel or other storage with a circular base by converting the base area (square feet) into equivalent length and width dimensions or vice versa.

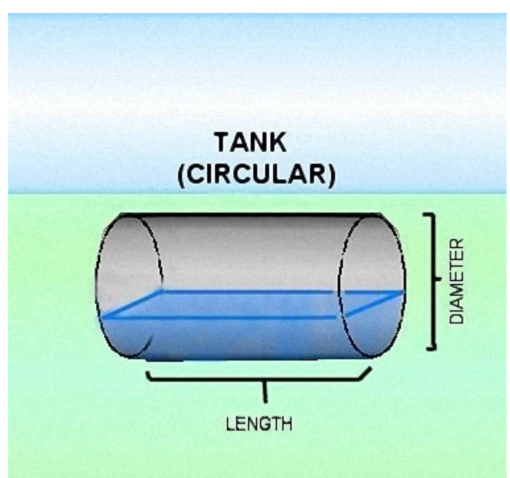
STORAGE TANK ELEMENT



The Storage Tank element can be thought of as a cylinder placed on its side. The user specifies the tank's diameter and length.

Auto Tank and Quick Tank work the same way as Auto Pond and Quick Pond.

Auto Tank is only available in the Mitigated scenario.



The Quick Tank option creates a tank, but does not check for compliance with the flow duration criteria.

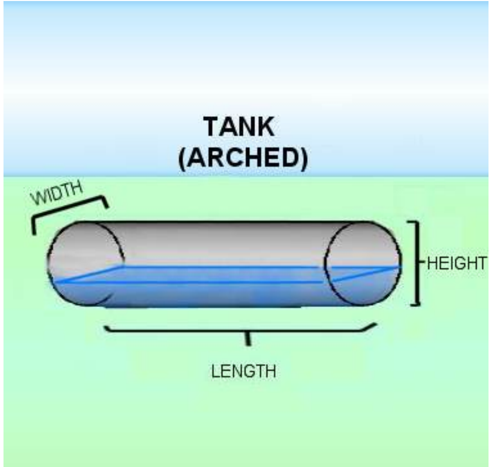
Tank input information:

- 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.

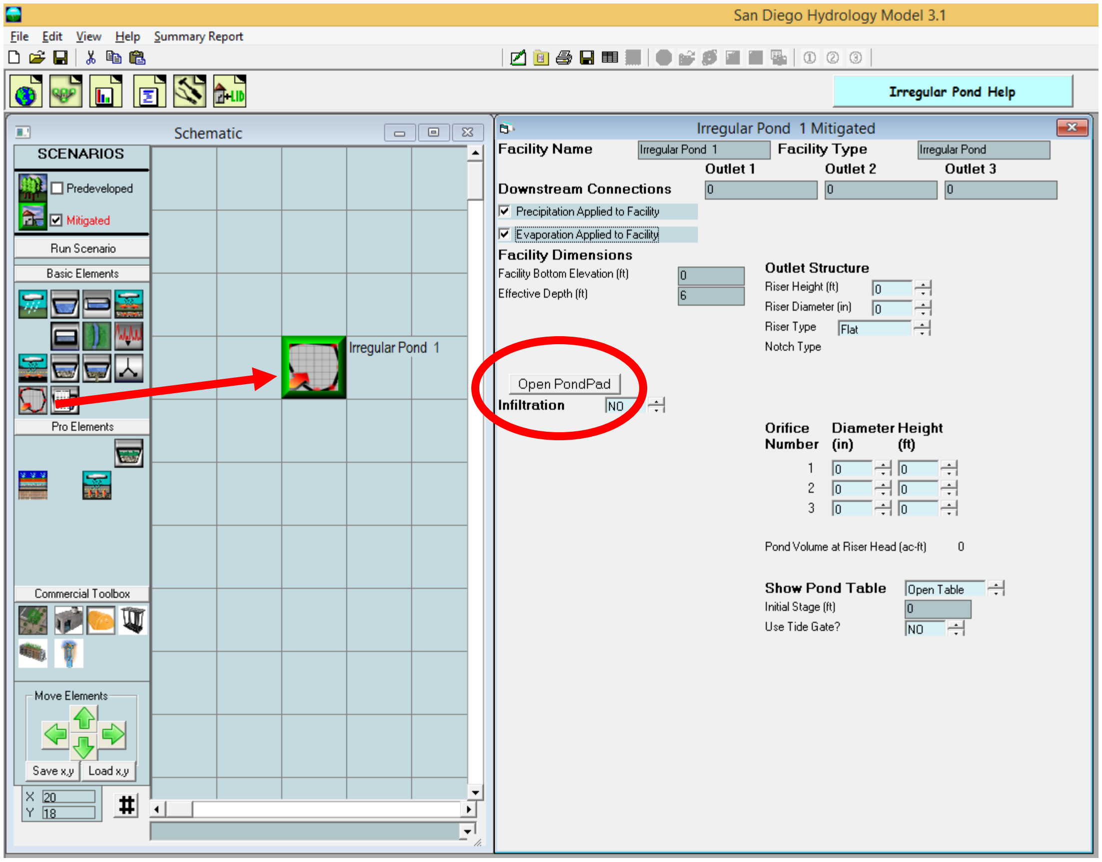
- Infiltration: Yes (infiltration into the underlying native soil)
- Measured Infiltration Rate (in/hr): Native soil infiltration rate.
- Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 125).
- Use Wetted Surface Area (sidewalls): Yes, if infiltration through the tank sides is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D 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 SHAPED POND ELEMENT

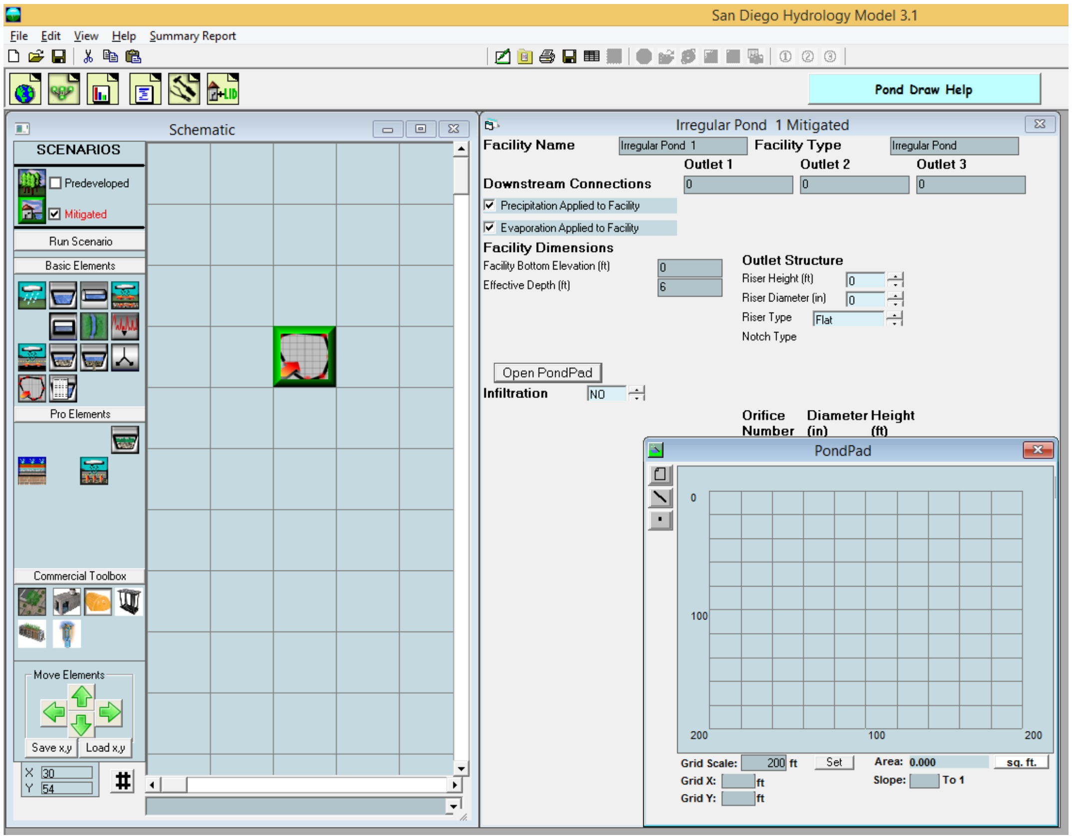


The Irregular Shaped Pond element is for any pond with a shape that differs from the rectangular top of a trapezoidal pond. An irregular-shaped pond has all of the same characteristics of a trapezoidal pond, but its shape must be defined by the user.

The Auto Pond option is not available in the Irregular Shaped Pond element. Go to page 65 to find information on how to manually size an irregular pond or other HMP facility.

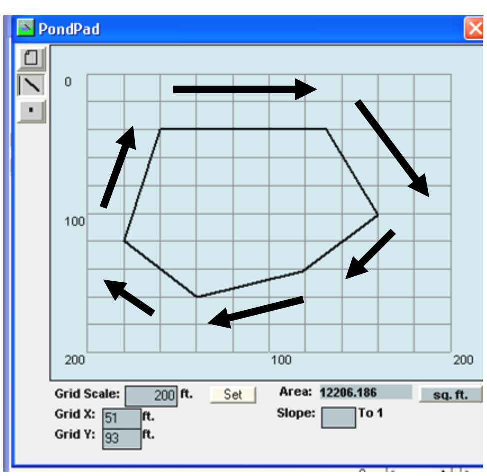
To create the shape of an irregular pond the user clicks on the "Open PondPad" button. This allows the user to access the PondPad interface (see below).

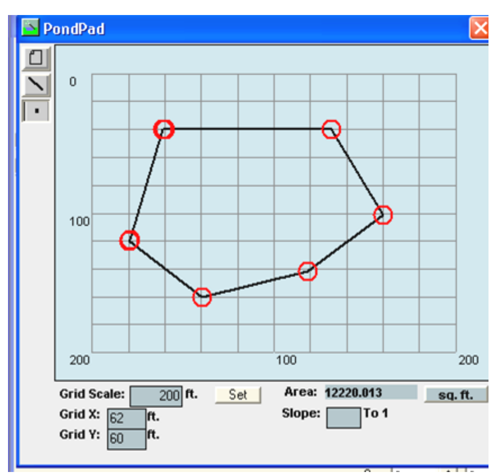
PondPad Interface



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.





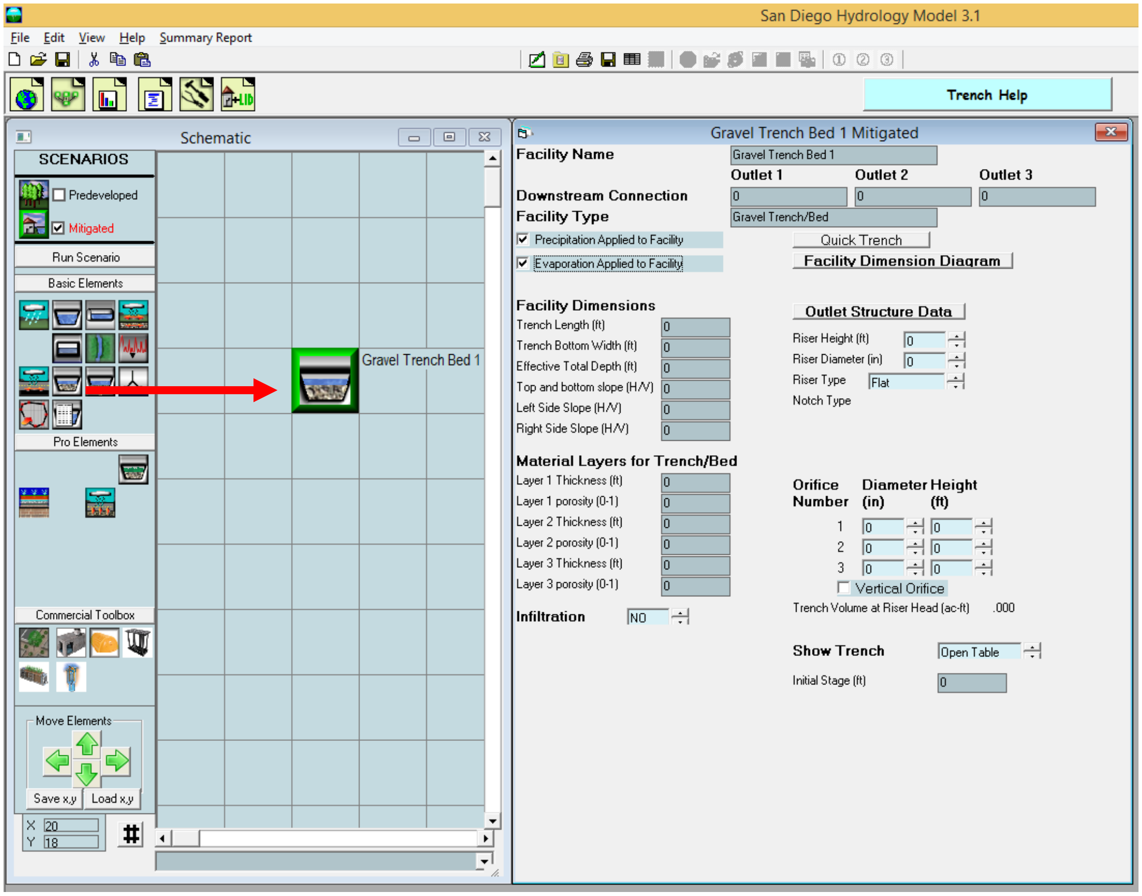
The default side slope value is 3 (3:1). The side slopes can be individually changed by right clicking on the specific side (which changes the line color from black to red) and then entering the individual side slope value in the slope text box.

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

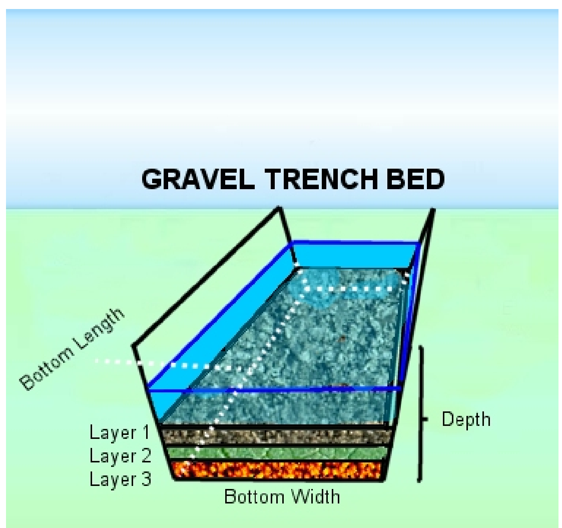
PondPad Controls and Numbers

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 element represents a gravel trench or gravel bed. These gravel-filled facilities are typically 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).

Quick Trench 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.

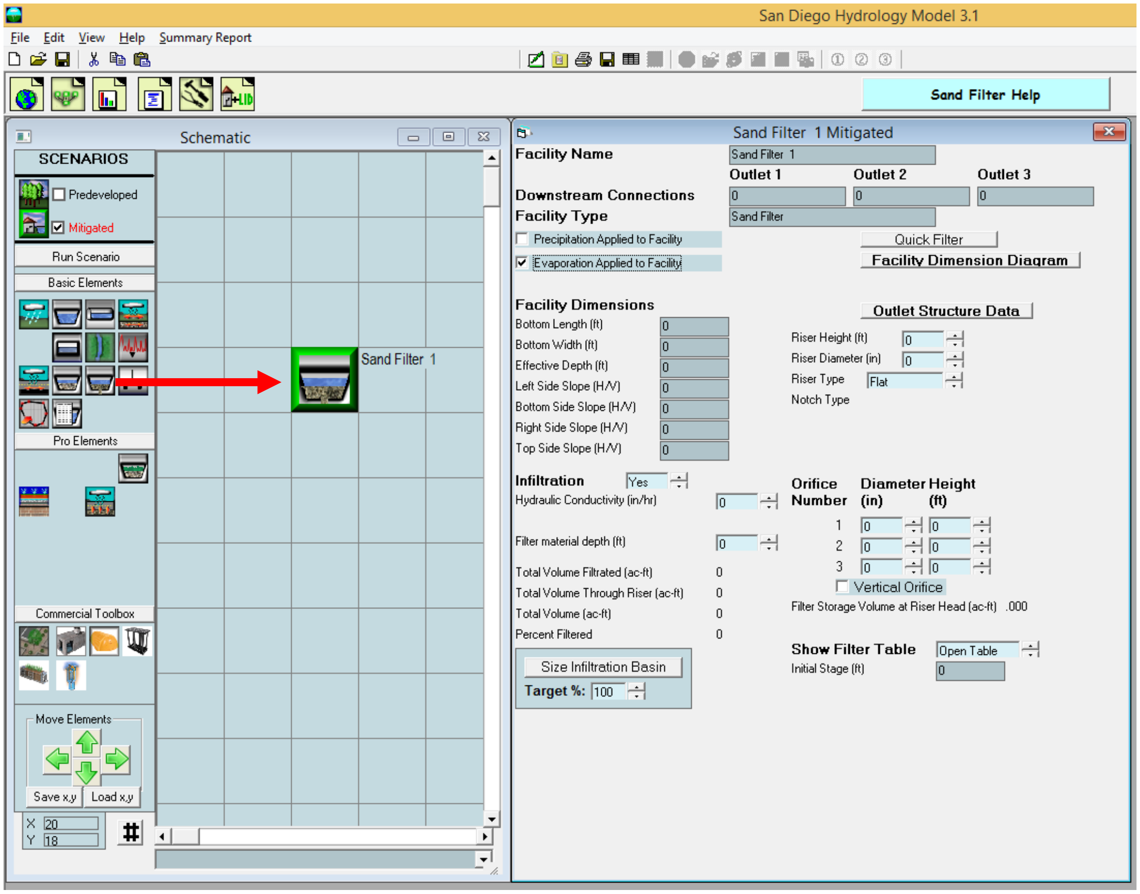
- Native Infiltration: Yes (infiltration into the underlying native soil)
- Measured Infiltration Rate (in/hr): Native soil infiltration rate.
- Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 125).
- Use Wetted Surface Area (sidewalls): Yes, if infiltration through the trench side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D 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.

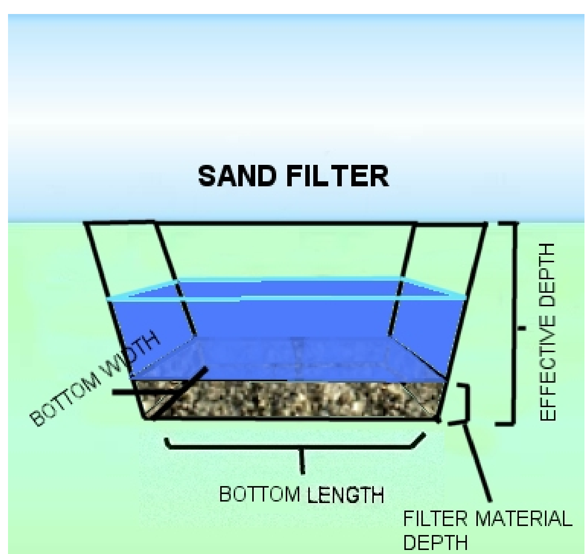
SAND FILTER ELEMENT



The Sand Filter element is used to model a water quality facility. A sand filter does not infiltrate runoff into the native soil, but is used to filter runoff through a medium and send the filtered runoff 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 review the local municipal permitting agency's stormwater manual appendices C and D 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:

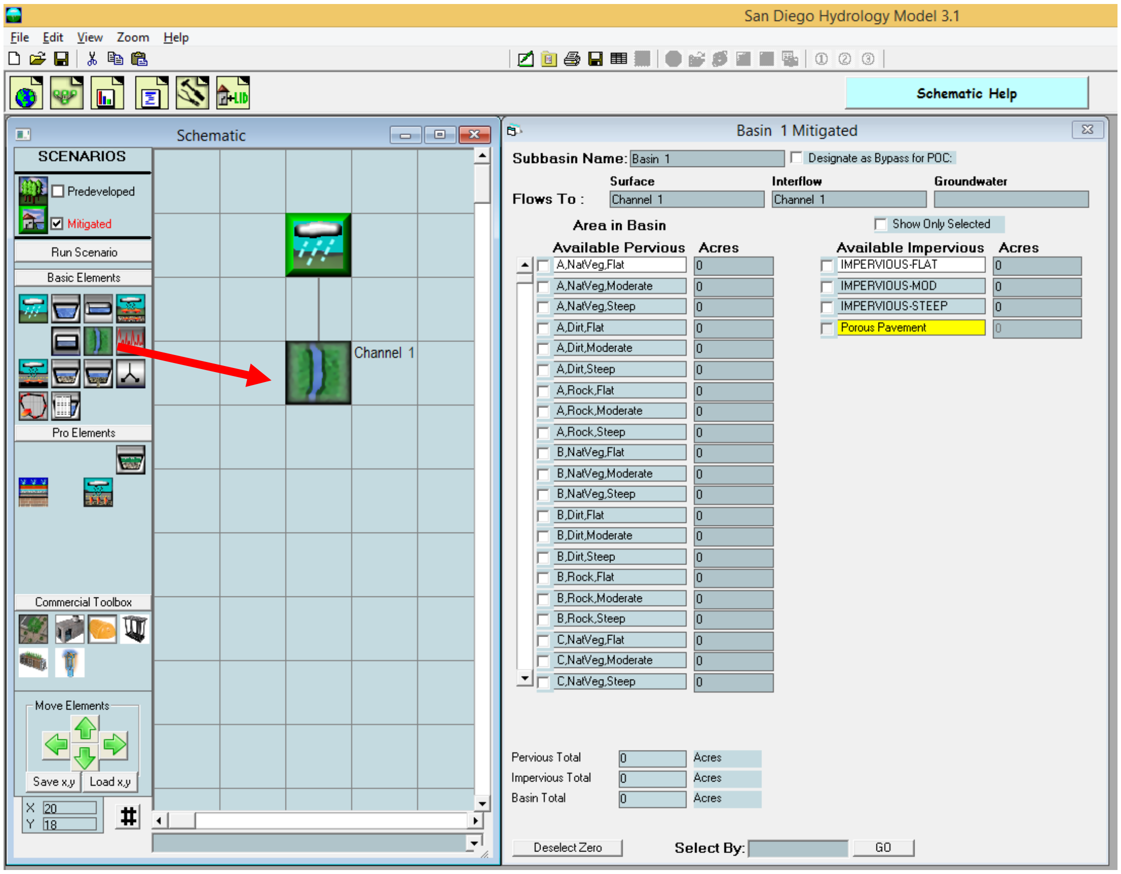
- Notch Height (feet): distance from the top of the weir to the bottom of the notch.
- Notch Width (feet): width of notch; cannot be larger than the riser circumference.

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

- Infiltration: Yes (infiltration through the filter material); infiltration into the native soil is not allowed in this element.
- Hydraulic Conductivity (in/hr): Filtration rate through the sand filter.
- Filter material depth (ft): Depth of sand filter material (for runoff filtration).

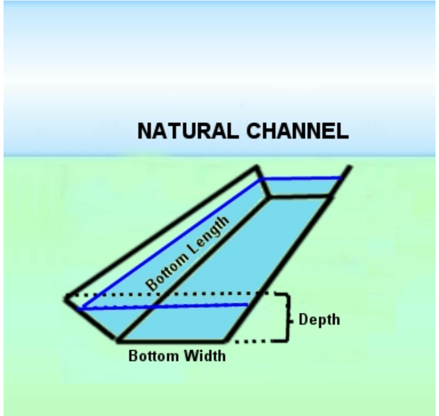
Sand filter receives precipitation on and evaporation from the sand filter surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

OPEN CHANNEL ELEMENT



The Open Channel element represents any open channel, natural or man-made. The Open Channel element allows the user to route runoff from a land use basin or stormwater 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:

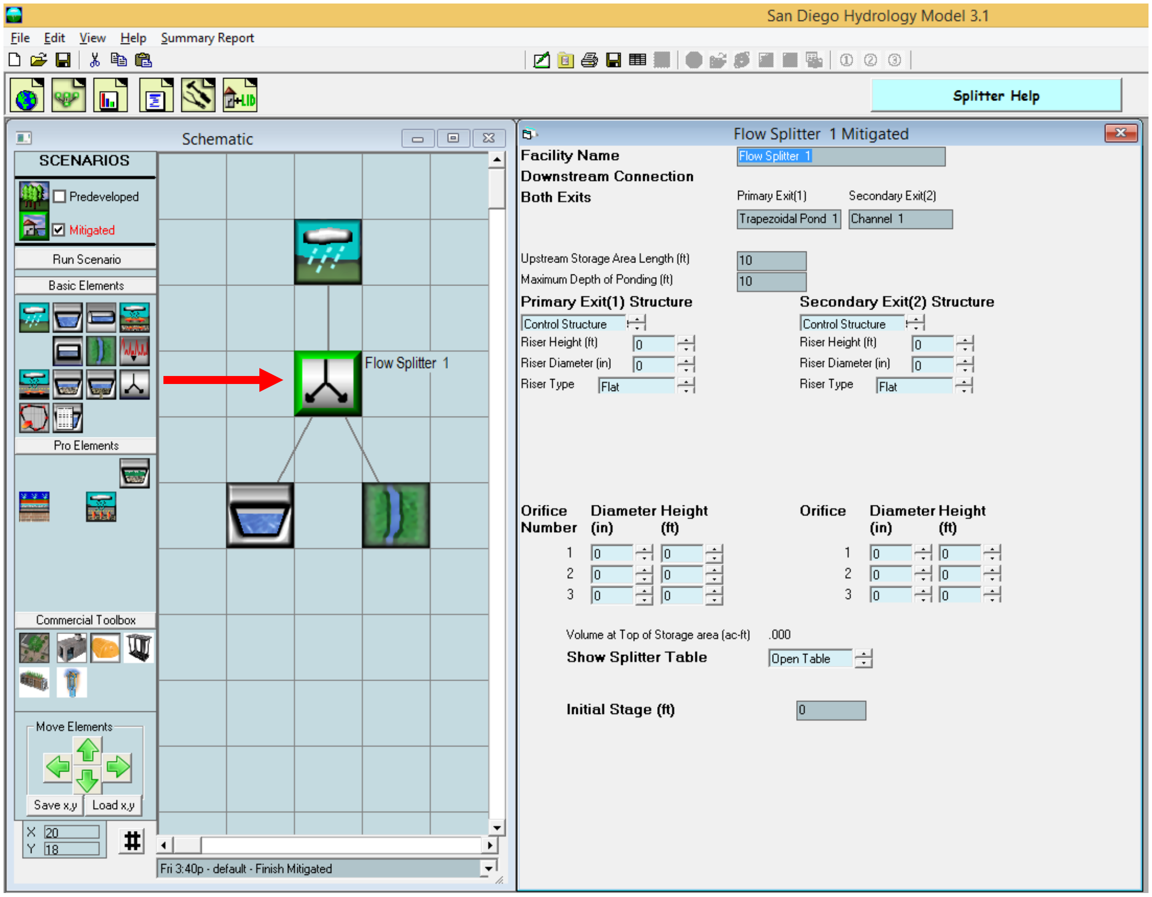
- Channel Bottom Width (ft): Open channel bottom width.
- Channel Length (ft): Open channel length.
- Manning's n coefficient: Open channel roughness coefficient (user menu selected or input).
- Slope of Channel (ft/ft): Open channel bottom slope.
- Left Side Slope of Channel (ft/ft): H/V ratio of horizontal 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 125).
- 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 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

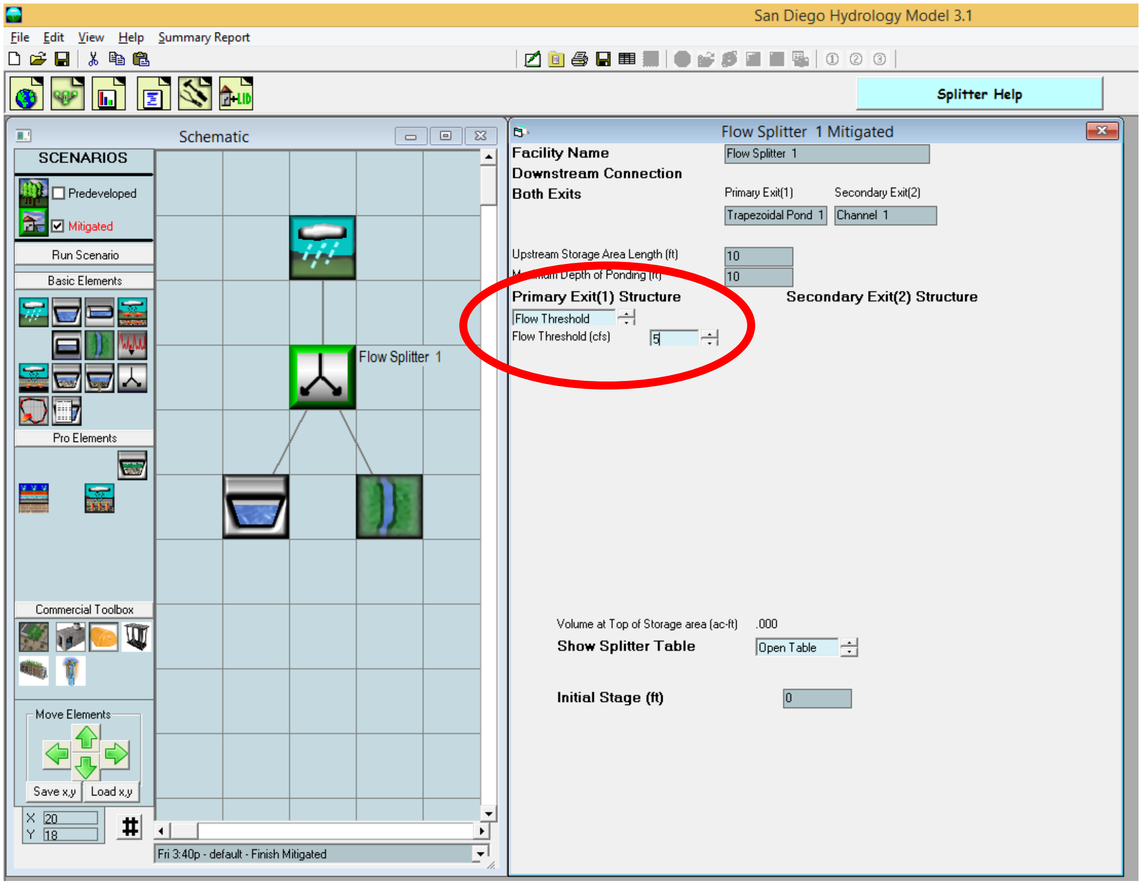
FLOW SPLITTER ELEMENT



The Flow Splitter element divides the runoff and sends it to two different 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.

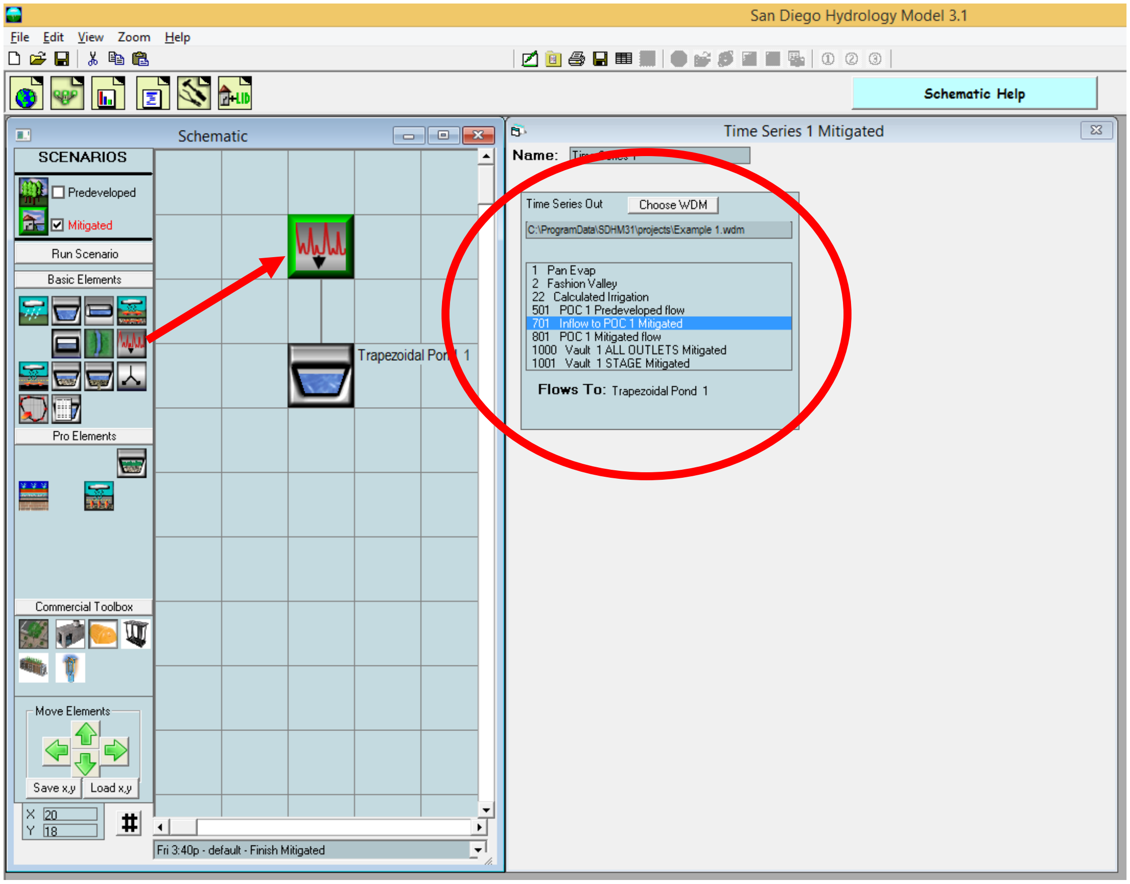
The user can define a flow control structure with a riser and one to three orifices for each exit. The flow control structure works the same way as the pond outlet structure, with the user setting the riser height and diameter, the riser weir type (flat, rectangular notch, V-notch, or Sutro), and the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

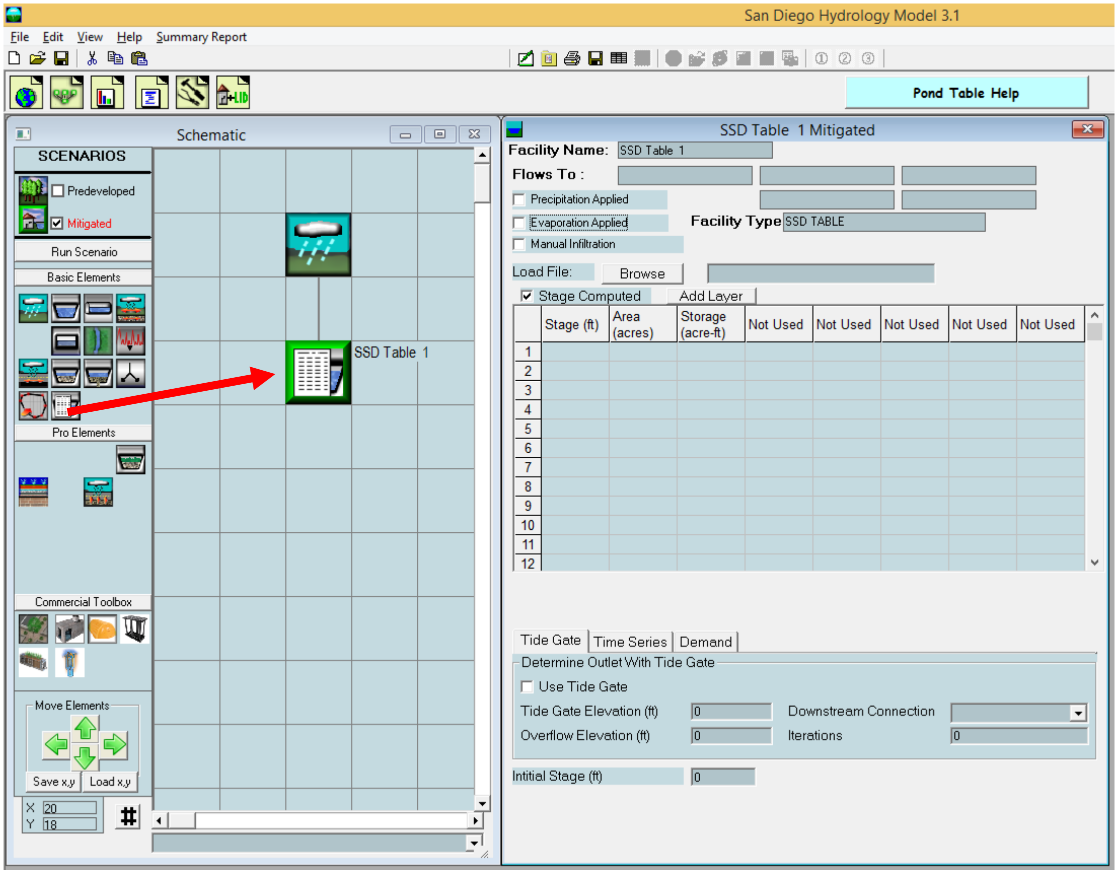
TIME SERIES ELEMENT



The Time Series element is used to input an external runoff or streamflow time series (from an old project) into a new project. The Time Series element accesses runoff and streamflow data stored in a SDHM database (HSPF WDM file). The user also has the option to create or use a time series file external from SDHM in SDHM. 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 SDHM data and the same simulation time step (hourly) then it can be linked to SDHM model using the Time Series element.

To link the external time series to SDHM 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 SDHM.

SSD TABLE ELEMENT



The SSD Table element can be used to represent any routing/storage feature that is not represented by another SDHM 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 SDHM for ponds, vaults, tanks, and channels.

The easiest way to create a SSD Table outside of SDHM 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 (.csv). A text file (.txt) 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 SDHM. These rules are:

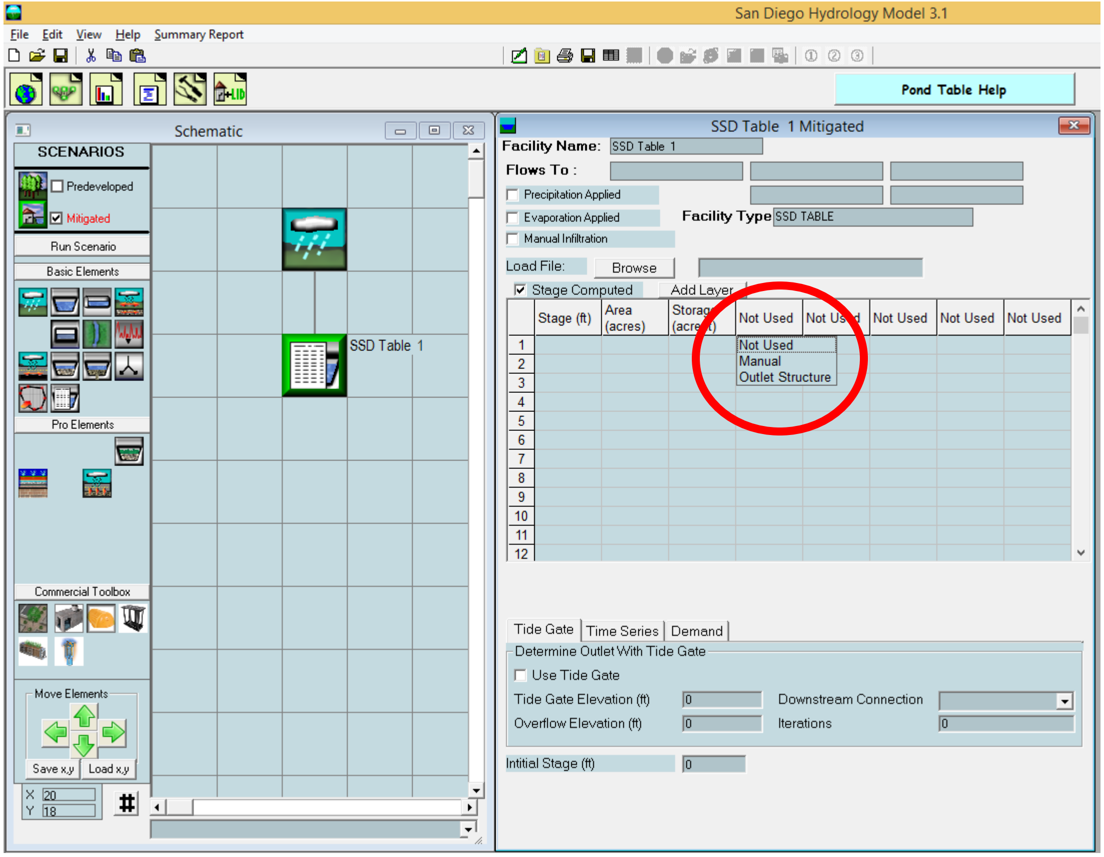
1. Stage (feet) must start at zero and increase with each row. The incremental increase does not have to be consistent.

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 SDHM does not check externally generated storage values.

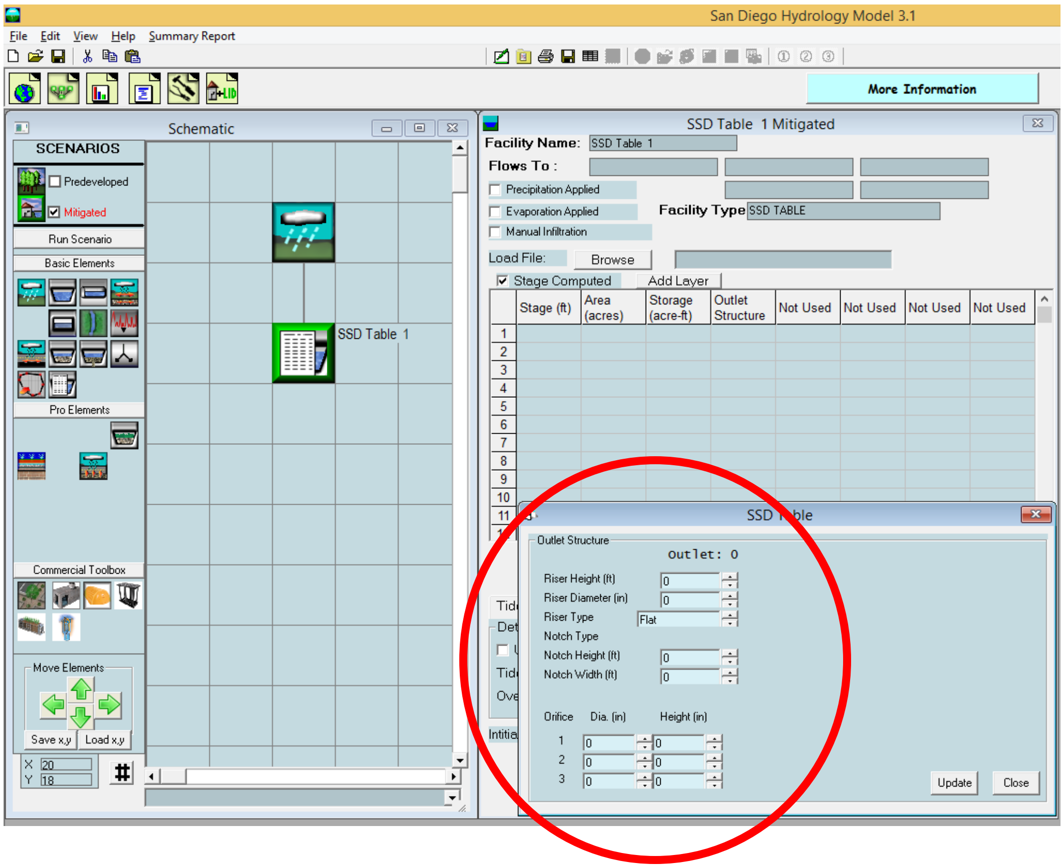
3. Discharge (cfs) must start at zero. Discharge does not have to increase with each row. It can stay constant or even decrease. Discharge cannot be negative. Discharge should be based on the outlet structure's physical dimensions and characteristics, but SDHM does not check externally generated discharge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

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

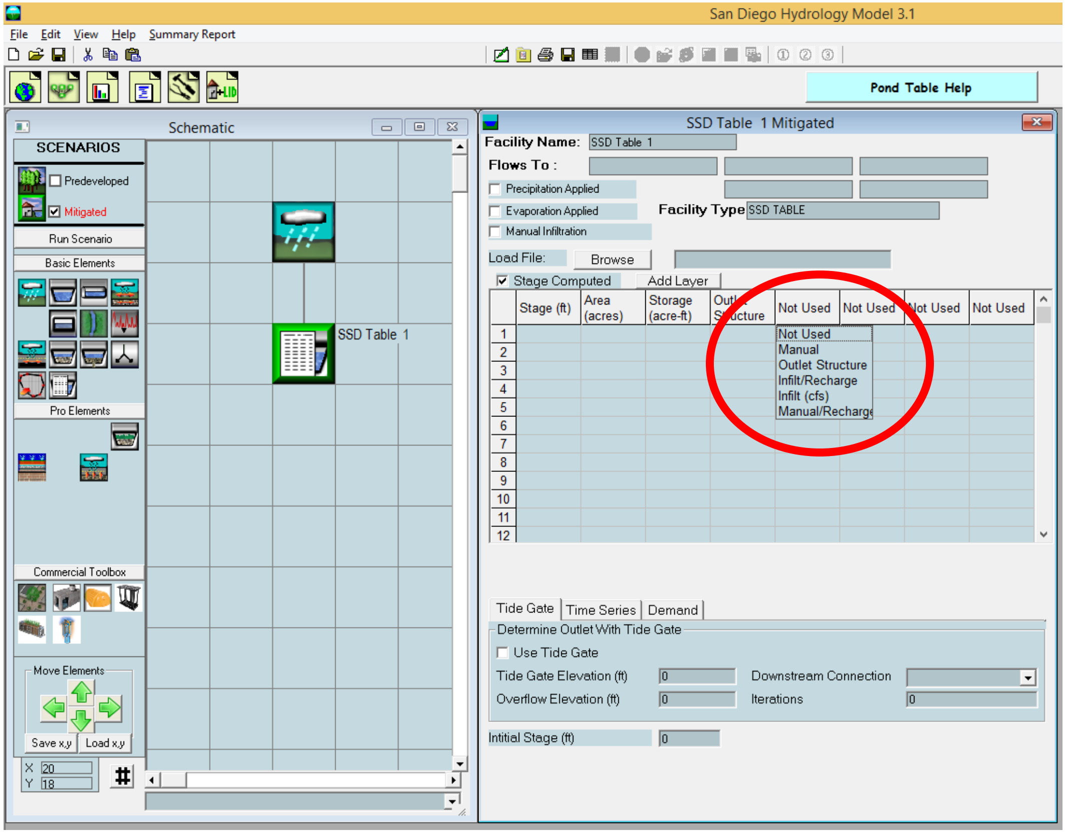
To input an externally generated SSD Table, first create and save the table outside of SDHM. Use the Browse button to locate and load the file into SDHM.



To input columns of values beyond (to the right of) the Storage column click on the "Not Used" title and select the appropriate option. Use "Manual" when the discharge has been included in the external spreadsheet.

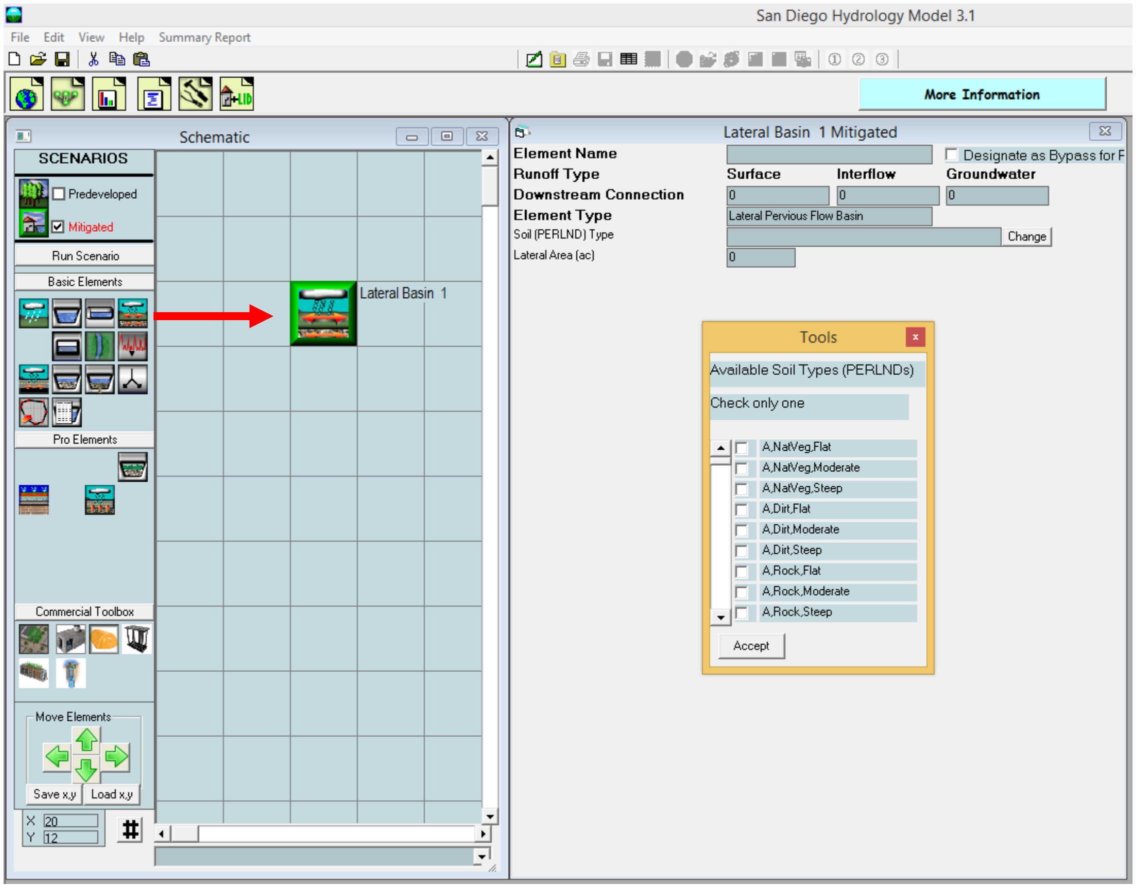


Use "Outlet Structure" to input riser and orifice dimensions.



The fifth column can be used for a second surface outlet (manual or outlet structure), infiltration, or aquifer recharge. Aquifer recharge differs from infiltration in how the model separately accounts for it.

LATERAL FLOW SOIL BASIN ELEMENT



The Lateral Flow Soil Basin element represents a pervious area that drains onto another adjacent pervious or impervious area before the runoff is connected into a stormwater conveyance system.

Typically the Lateral Flow Soil Basin element and the Lateral Flow Impervious Area element are used together to model runoff dispersion from impervious surfaces onto adjacent pervious land. Examples of this type of runoff dispersion are an impervious parking lot that is sloped so that the impervious area runoff sheet flows onto an adjacent lawn prior to draining into a stormwater conveyance system, and an impervious roof with downspouts that disperse the roof runoff onto an adjacent lawn or landscape area. In both cases the flow from the impervious area onto the adjacent pervious area slows the impervious area runoff and allows for some limited infiltration into the pervious lawn soil prior to discharging into a conveyance system. One lateral flow soil basin can connect to another lateral flow soil basin, but there is less justification for doing this.

The Lateral Flow Soil Basin element is similar to the Landuse Basin element except that the lateral soil basin contains only a single pervious land type. Impervious area is handled separately with the Lateral Flow Impervious Area element.

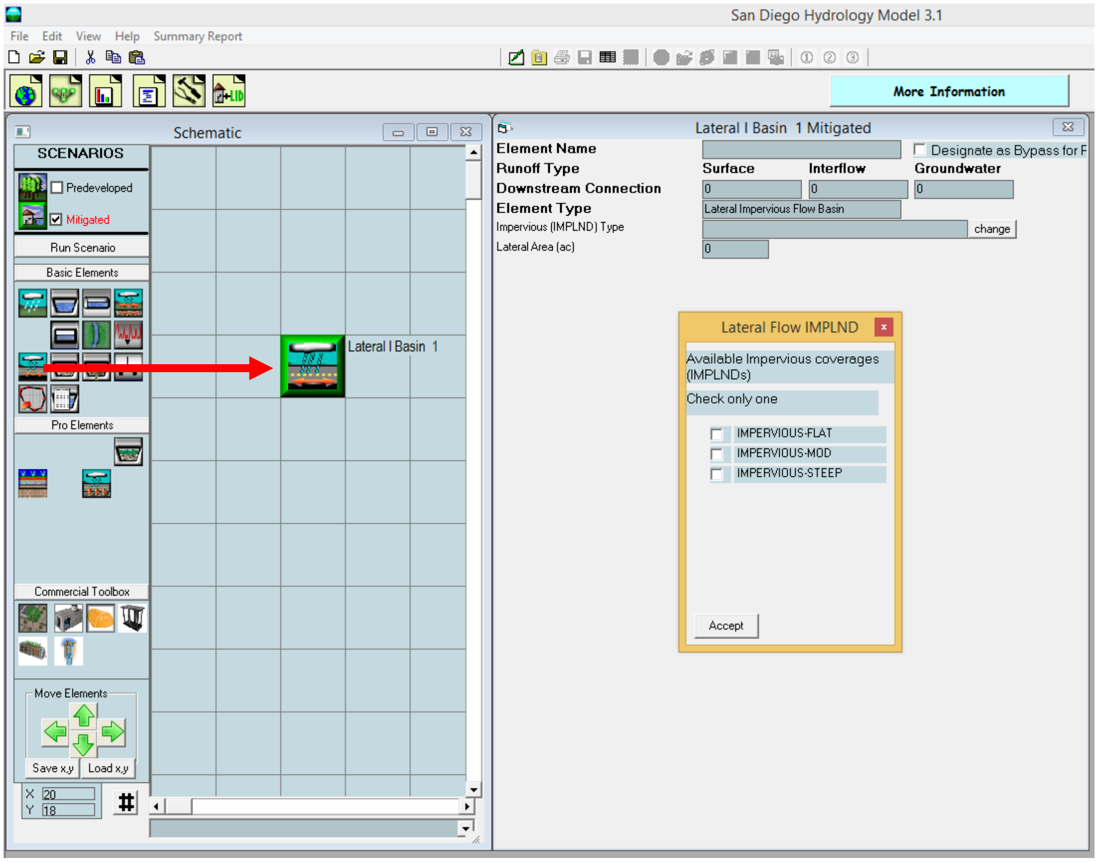
The user selects the pervious lateral basin land type by checking the appropriate box on the Available Soil Types Tools screen. This information is automatically placed in the

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 Flow Soil Basin element for each.

Note that the Lateral Flow Soil Basin element can be connected directly to any storage/routing element, including the Porous Pavement and Biofiltration elements.

LATERAL FLOW IMPERVIOUS AREA ELEMENT



The Lateral Flow Impervious Area element represents an impervious area that drains onto another adjacent pervious or impervious area before the runoff is connected into a stormwater conveyance system.

Typically the Lateral Flow Impervious Area element and the Lateral Flow Soil Basin element are used together to model runoff dispersion from impervious surfaces onto adjacent pervious land. Examples of this type of runoff dispersion are an impervious parking lot that is sloped so that the impervious area runoff sheet flows onto an adjacent lawn prior to draining into a stormwater conveyance system, and an impervious roof with downspouts that disperse the roof runoff onto an adjacent lawn or landscape area. In both cases the flow from the impervious area onto the adjacent pervious area slows the impervious area runoff and allows for some limited infiltration into the pervious lawn soil prior to discharging into a conveyance system. One lateral flow impervious area can connect to another lateral flow impervious area, but there is less justification for doing this.

The Lateral Flow Impervious Area element is similar to the Landuse Basin element except that the lateral impervious area contains only a single impervious land type. Pervious area is handled separately with the Lateral Flow Soil Basin element.

The user selects the impervious lateral basin land type by checking the appropriate box on the Available Impervious Coverages (IMPLNDs) 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 impervious land type.
If the lateral impervious area contains two or more impervious land use types then the user should create a separate Lateral Flow Impervious Area element for each.

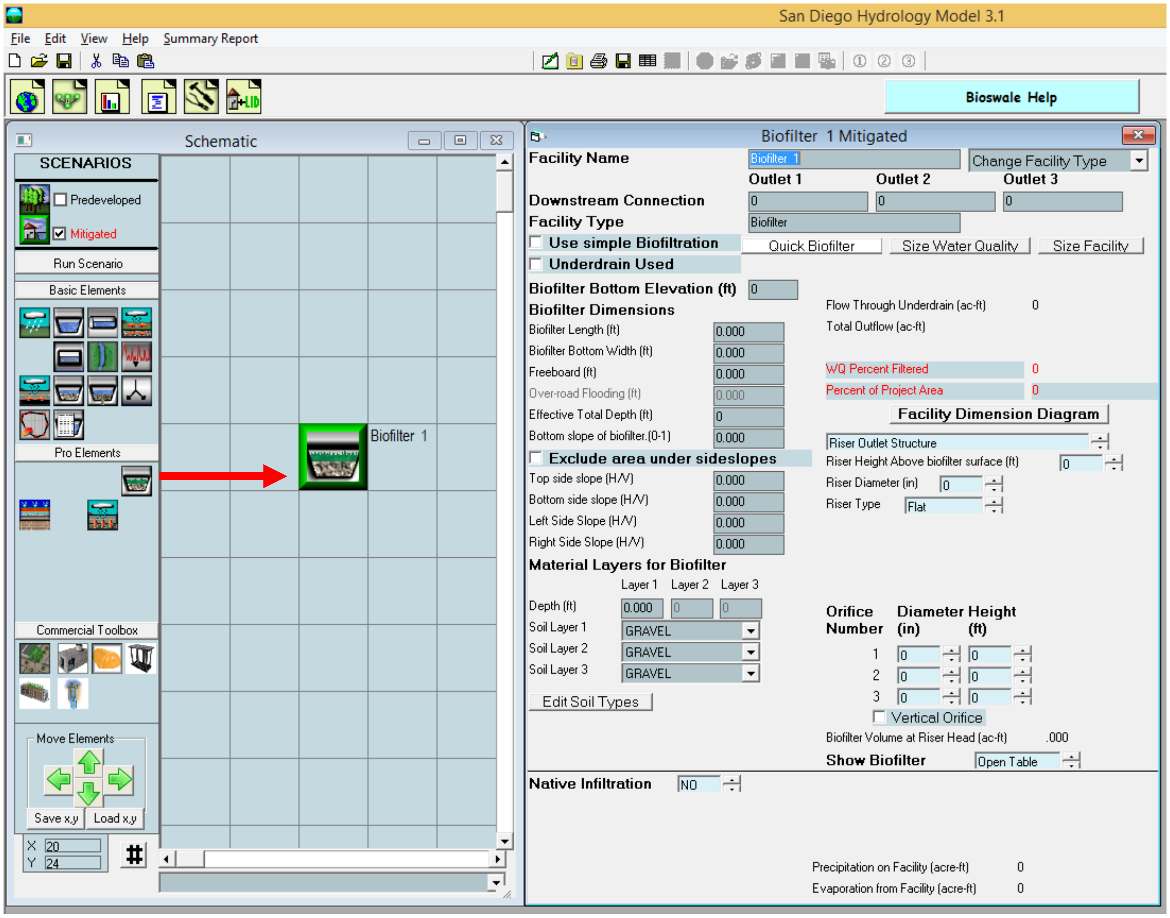
Note that the Lateral Flow Impervious Area element can be connected directly to any storage/routing element, including the Porous Pavement and Biofiltration elements.

PRO ELEMENTS

The following pages contain information about these PRO elements, which represent different types of low impact development (LID) stormwater facilities:

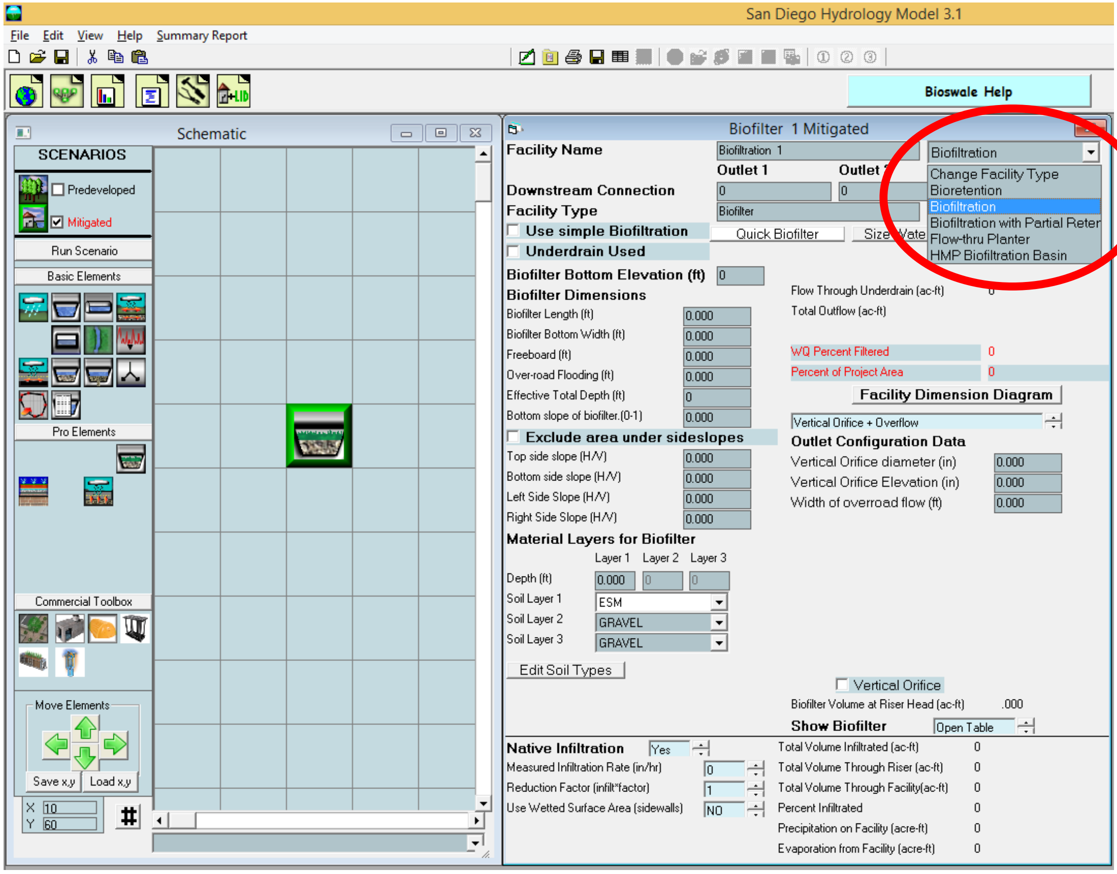
- Biofiltration
- Porous Pavement
- Green Roof

BIOFILTRATION ELEMENT



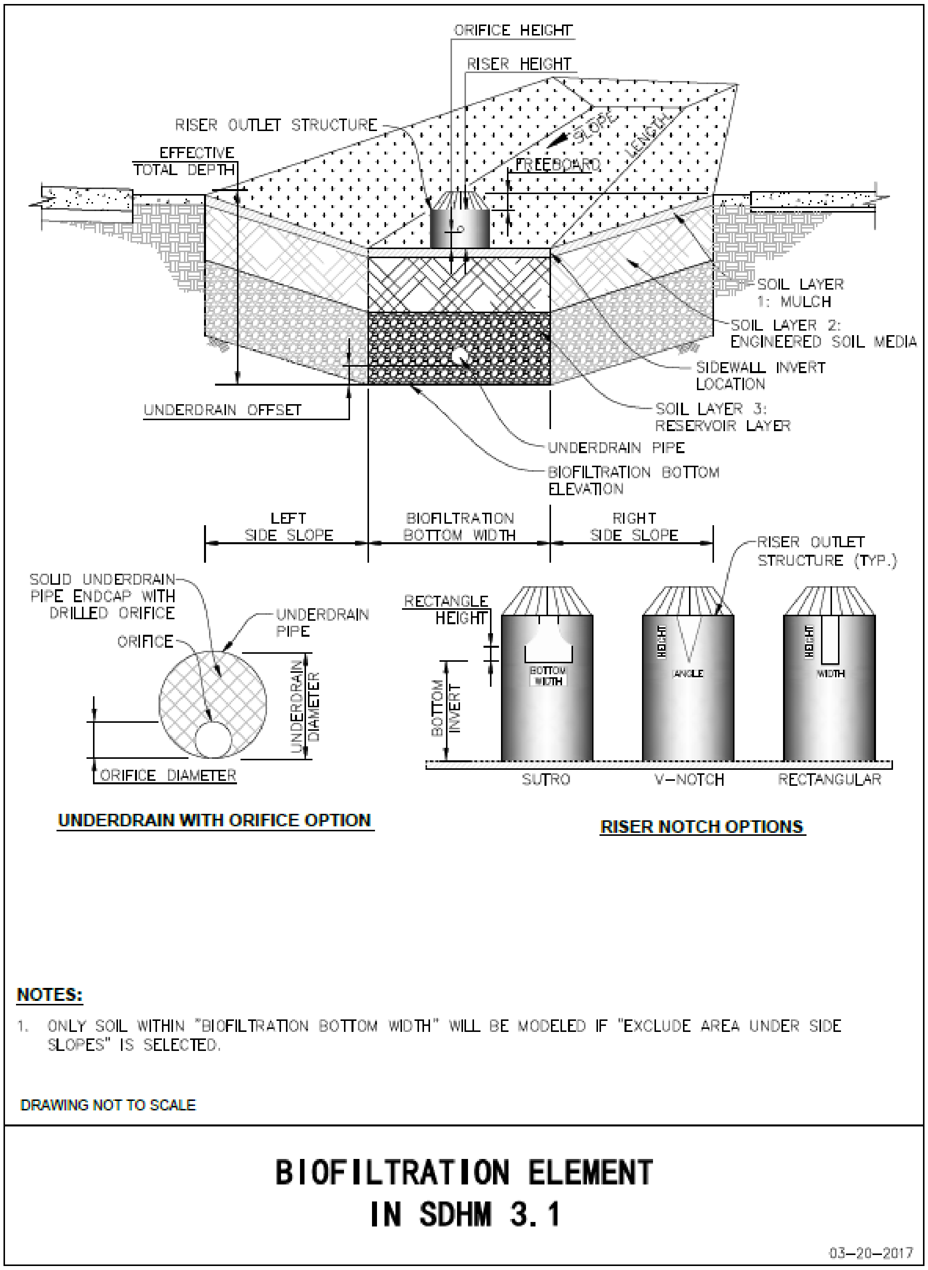
The Biofiltration element is a BMP and can be used to model biofiltration, biofiltration with partial retention, bioretention, flow-through planter box, and/or HMP biofiltration basin. The only difference between each of these stormwater facilities in the Biofiltration element is the options turned on by the user and the user input values.

The biofiltration surface area automatically receives rainfall and produces evapotranspiration. Due to this automatic application, input of the biofiltration surface area should be excluded from the Landuse Basin element's total surface area.



The Change Facility Type pulldown menu can be used to document the type of BMP facility being modeled. For the purposes of documenting this element in the SDHM 3.1 User Manual, the term "biofiltration" or "biofilter" will be used to include all of the above-mentioned variations of this BMP element.

The Biofiltration 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 element and the element's soil capacity to absorb additional runoff. HSPF Special Actions is used to check the element's soil capacity to determine the appropriate routing option. More technical details on how the Biofiltration element is modeled in SDHM are included in Appendix D.



As shown in the above drawing, the Biofiltration element is a BMP in which the native soils have been excavated and replaced with mulch (optional), engineered soil media, and gravel. The surface discharge can be either through a riser (Riser Outlet Structure) or via a weir (Vertical Orifice + Overflow). Water ponds on the surface of the biofiltration facility prior to becoming either surface discharge or moving vertically through the biofiltration material layers (mulch, engineered soil media, and gravel). Infiltration from the gravel layer to the native soil is an option, depending on the properties of the native soil. Biofiltration can also include an underdrain pipe.

The biofiltration material layers placed in the BMP have storage capacities equal to their individual porosities and volumes. Runoff infiltrates from the surface of the BMP to the top material layer at an infiltration rate computed by SDHM. The infiltration rate cannot exceed the available storage capacity of the material layer. The available storage capacity is determined each time step by HSPF Special Actions. Once the biofiltration material layers are saturated then water has the opportunity to infiltrate into the underlying native soil at the native soil's infiltration rate if Native Infiltration is set to Yes. The native soil infiltration is input by the user and is assumed to be constant throughout the year.

Inflow to the BMP can exceed the top material layer infiltration rate. When this occurs the extra water ponds on the surface of the BMP. The extra water can then infiltrate into the soil during the next time step or can flow out of the BMP through its surface outlet if the ponding depth exceeds the surface outlet's control height (riser or weir height).

Water in both the surface storage and material layer storages is available for evapo-transpiration. Surface storage evapotranspiration is set to the potential evapo-transpiration rate; the biofiltration material layers' evapotranspiration is set to 50% of the potential evapotranspiration rate to reflect reduced evapotranspiration from the material layers.

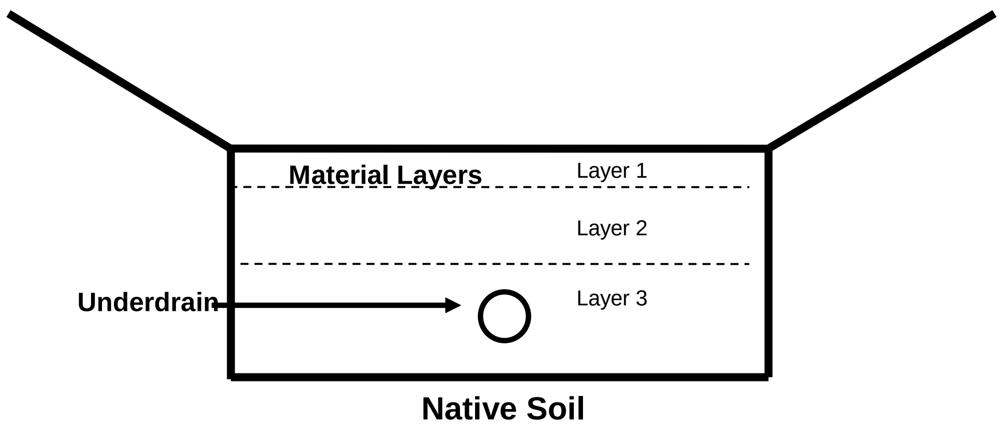
The user is required to enter the following physical dimensions for the Biofiltration element:

- Biofilter Length (ft): length dimension of biofiltration surface bottom.
- Biofilter Bottom Width (ft): width dimension of biofiltration surface bottom.
- Freeboard (ft): height from top of riser to top of facility (for facilities with Riser Outlet Structure) or depth of surface ponding before weir/street overflow occurs (for facilities with Vertical Orifice + Overflow).
- Over-road Flooding (ft): maximum depth of flow over weir/street (only required for Vertical Orifice + Overflow).
- Effective Total Depth (ft): the total depth of the material layer(s) plus riser height plus freeboard (for facilities with Riser Outlet Structure) or the total depth of the material layer(s) plus freeboard plus vertical orifice elevation plus vertical orifice diameter plus over-road flooding (for facilities with Vertical Orifice + Overflow); for either option the effective total depth is automatically computed by SDHM.
- Bottom Slope of Biofilter (ft/ft): the slope of the biofiltration bottom based on length.
- Top Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sides. Top, bottom, left, and right side slopes are based on viewing the side slopes from a plan view. Top is at the top of the plan, bottom on the bottom of the plan, etc.
- Bottom Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sides. Top, bottom, left, and right side slopes are based on viewing the side slopes from a plan view. Top is at the top of the plan, bottom on the bottom of the plan, etc.
- Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sides. Top, bottom, left, and right side slopes are based on viewing the

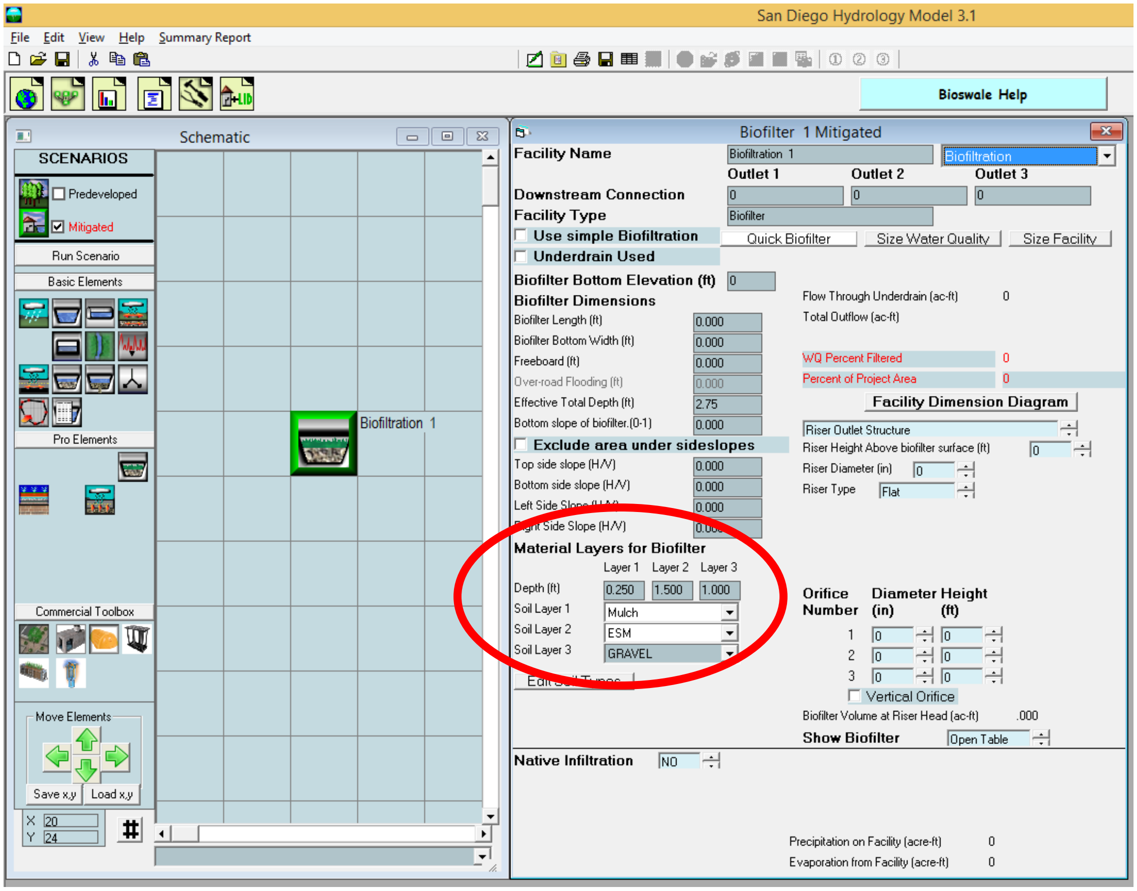
side slopes from a plan view. Top is at the top of the plan, bottom on the bottom of the plan, etc.

- Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sides. Top, bottom, left, and right side slopes are based on viewing the side slopes from a plan view. Top is at the top of the plan, bottom on the bottom of the plan, etc.

The "Exclude area under side slopes" box should be checked when the BMP has non-vertical side slopes for the above-ground side slopes but vertical side slopes for the material layers, as shown in the diagram below.



In the material layers water movement through the soil column is dependent on layer characteristics and saturation rates for different discharge conditions. Details of how biofiltration water movement is modeled in SDHM are presented in Appendix D.



The material layers user inputs:

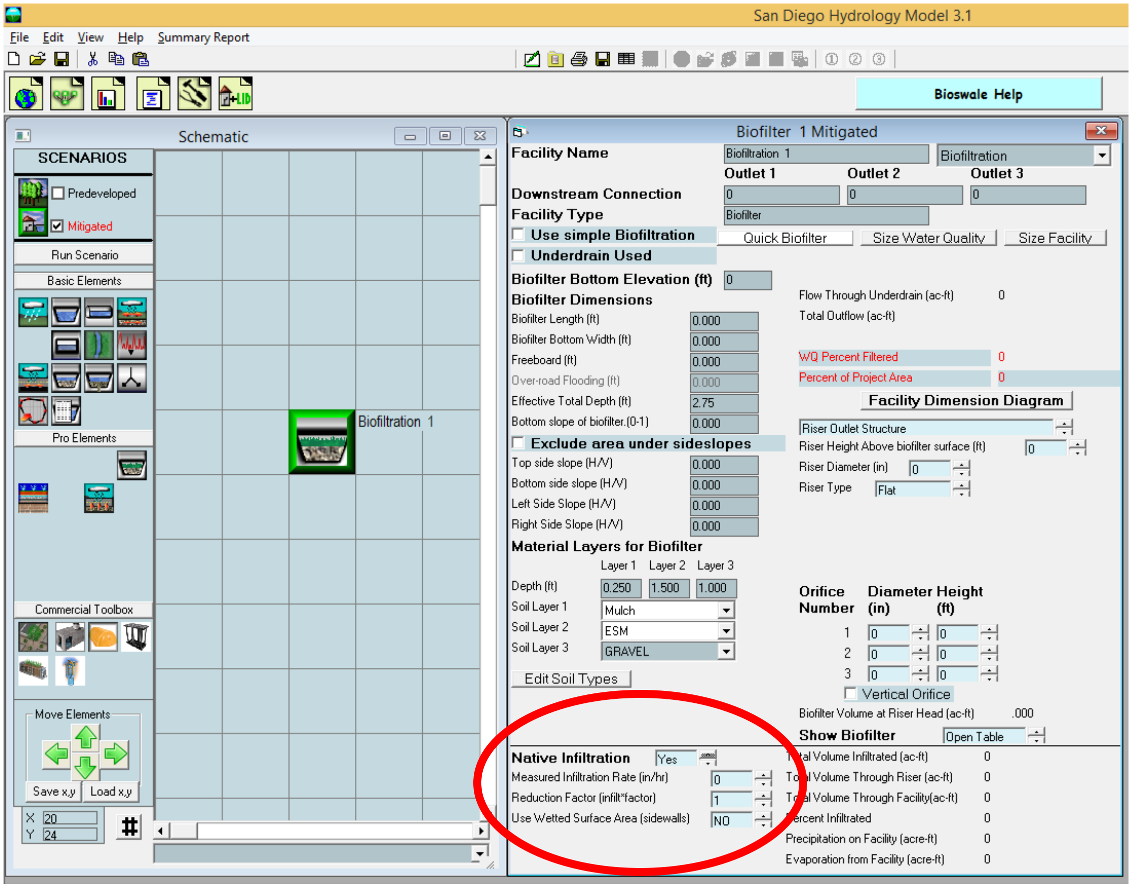
- Layer Thickness (feet): depth of amended soil.
- Type of amended soil: three different soil types are included (mulch, engineered soil media (ESM), and gravel).

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

Typically Layer 1 is mulch, with a minimum depth of 3 inches (0.25 ft); mulch may be optional, depending on the requirements of the local permitting agency.

The next layer (Layer 2) is ESM (Engineered Soil Media), as specified by the local permitting agency; minimum depths range from 18 inches (1.5 ft) to 24 inches (2.0 ft).

The bottom layer (Layer 3) is gravel. The practical minimum depth is 12 inches (1.0 ft).



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

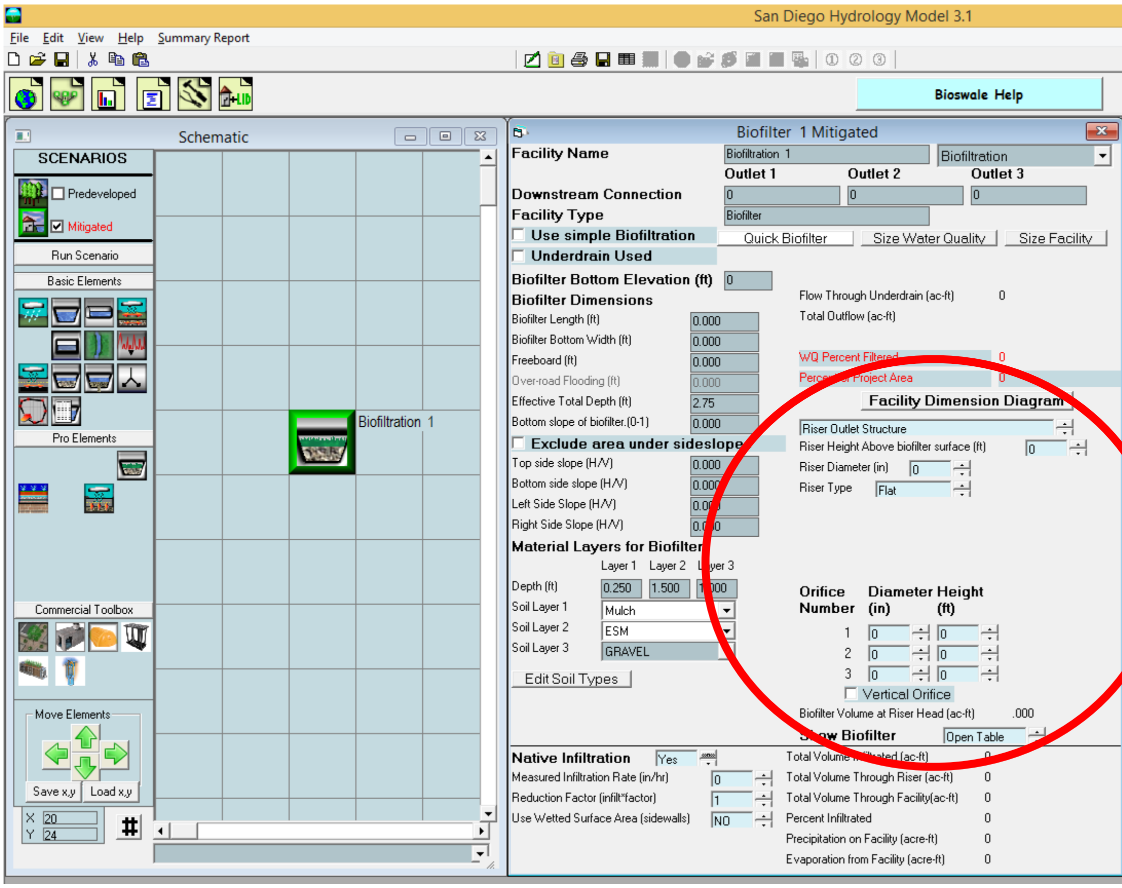
- Measured Infiltration Rate (inches per hour): infiltration rate of the native soil.
- Infiltration Reduction Factor: between 0 and 1 (1/Native soil infiltration rate safety factor (see page 125).
- Use Wetted Surface Area (sidewalls): YES or NO; YES allows infiltration to the native soil through the sidewalls of the BMP; otherwise all infiltration is through the bottom only.

If infiltration is used then the user should consult the Infiltration discussion on page 125.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

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

Riser outlet structure option:



The input information required for the riser outlet structure is:

- Riser Height above Biofilter 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:

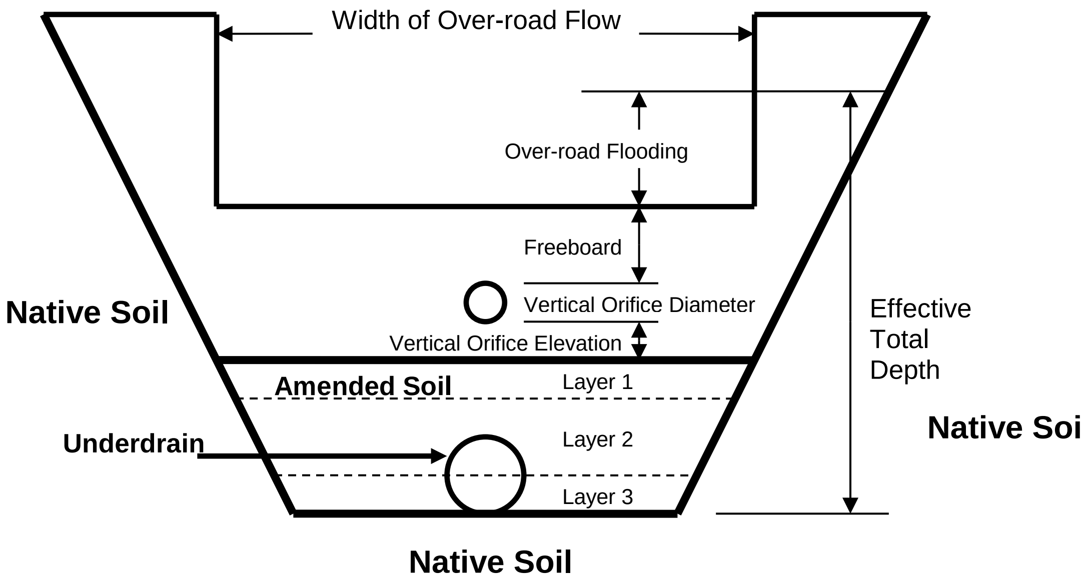
- Notch Height (feet): distance from the top of the weir to the bottom of the notch.
- Notch Width (feet): width of notch; cannot be larger than the riser circumference.

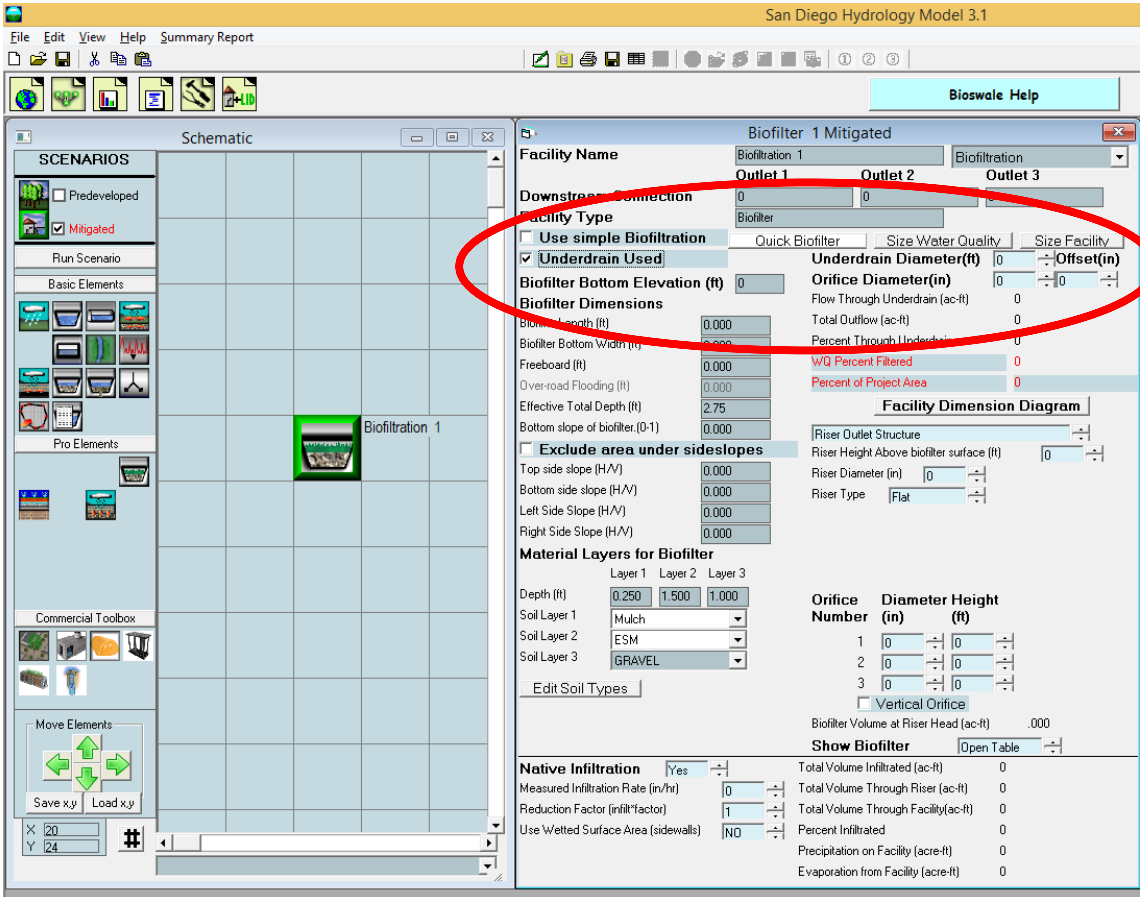
For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

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 biofiltration with vertical orifice plus overflow:





To use the underdrain click the Underdrain Used box and input the following underdrain related information:

- Underdrain Diameter (feet): diameter of the underdrain pipe diameter.
- Orifice Diameter (inches): diameter of the underdrain outlet orifice (cannot be larger than the underdrain diameter and should not be zero; if no orifice is to be included with the underdrain then set to the underdrain diameter in inches).
- Underdrain offset (inches): height of the bottom of the underdrain pipe above the bottom of the lowest material layer.

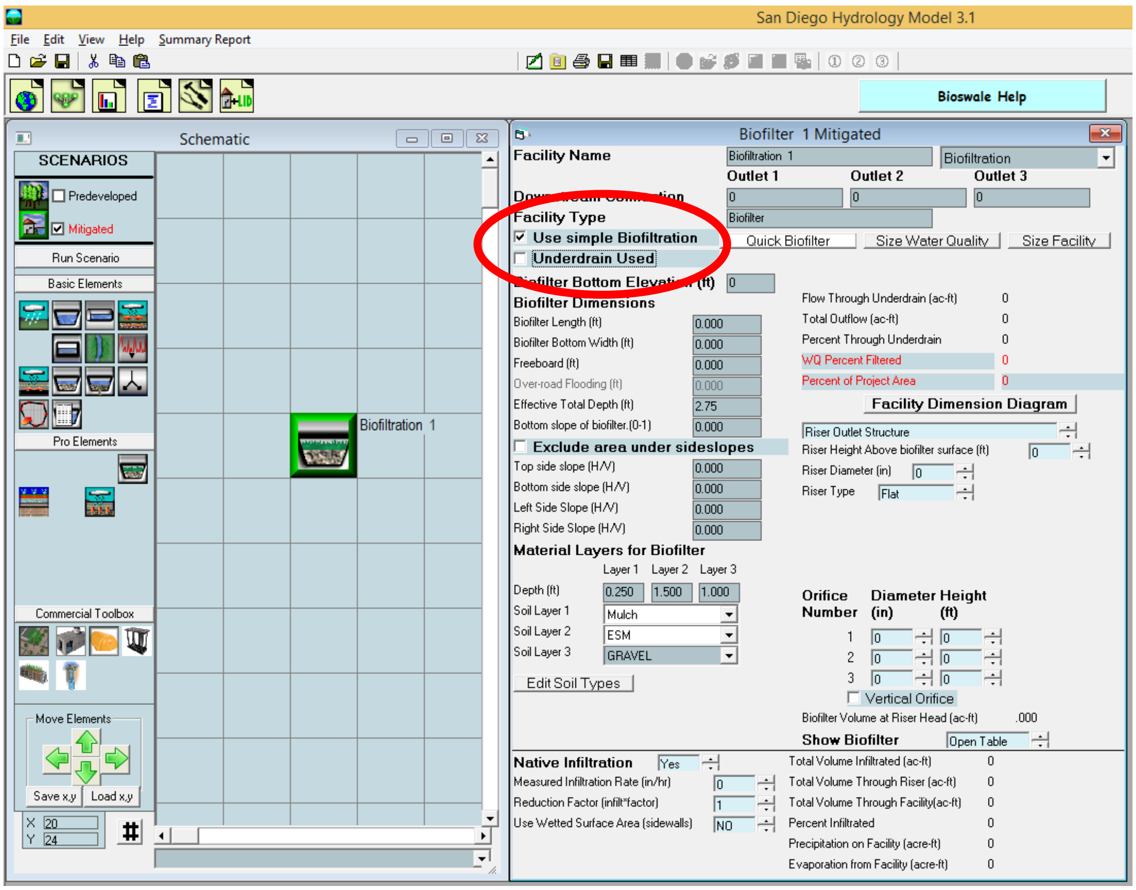
The material layer fills with stormwater from the top on down to where the water can drain to the native soil (if Native Infiltration is set to YES) and/or the underdrain pipe (if Underdrain Used box is checked).

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 material layer saturation. When the material layer 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).

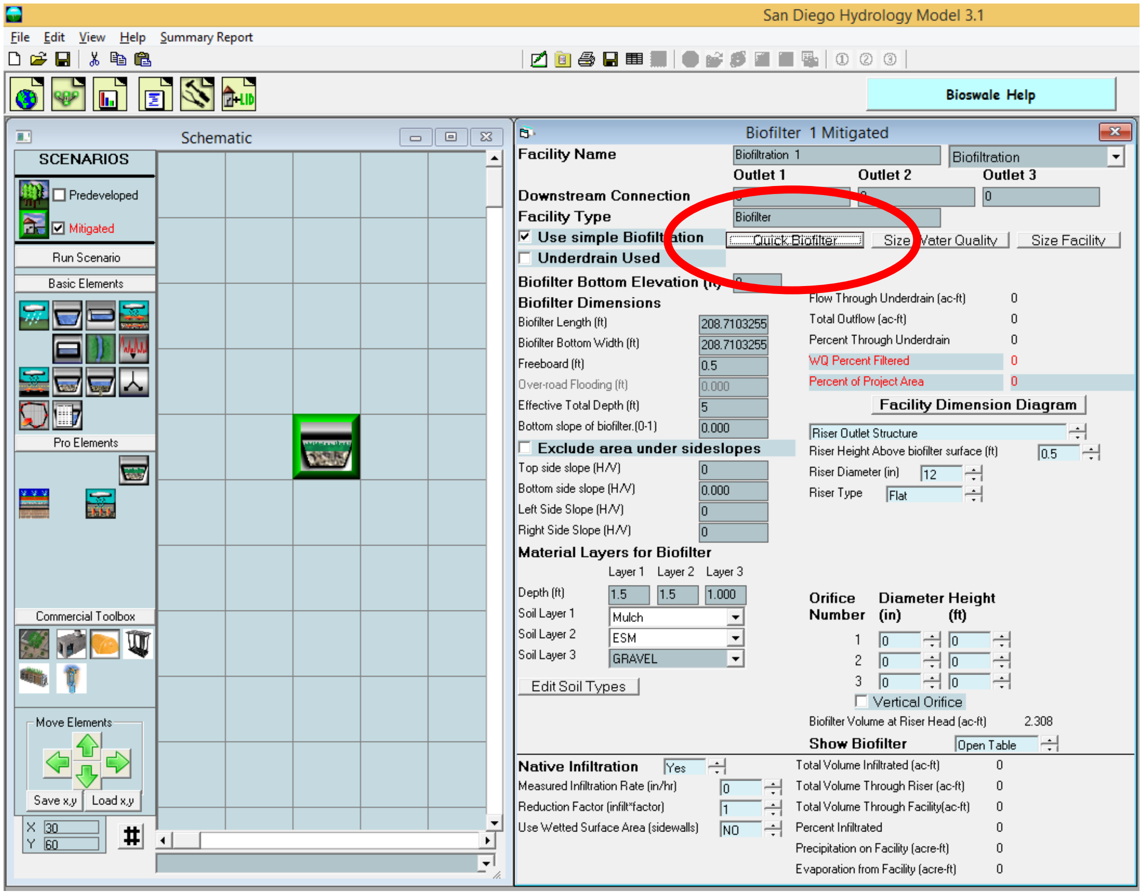
2. Water enters the material layer (if Use Wetted Surface Area (sidewalls) is set to YES).
3. Water saturates the material layer(s) to 2/3rds of the total material depth (if there is no underdrain and Wetted Surface Area is set to NO).



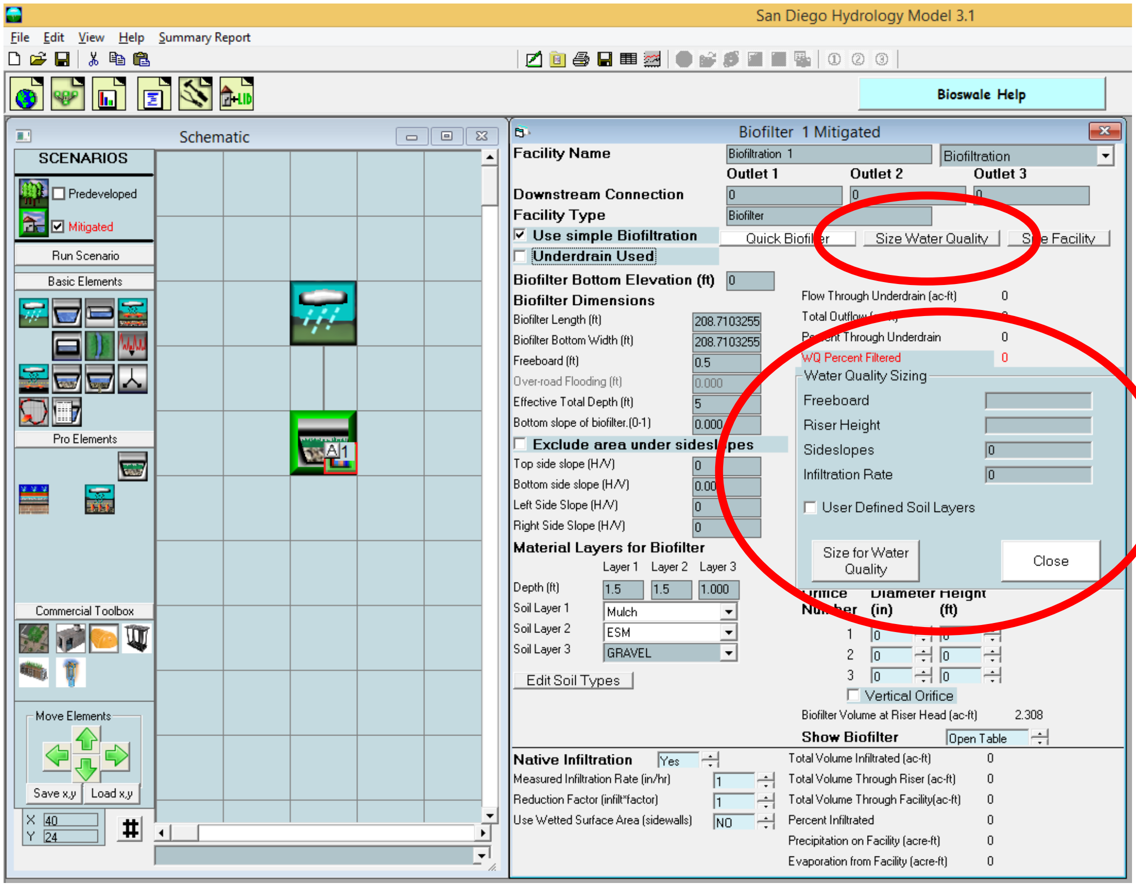
Checking the Use Simple Biofiltration box turns on the simple biofiltration option. It is computationally much faster than the standard biofiltration element.

As previously noted, the standard biofiltration routine uses HSPF Special Actions to check the available material layer storage and compares it with the inflow rate. Because the check is done by HSPF Special Actions, simulations using the Biofiltration element take much longer than simulations not using this element. Simulations that normally take only seconds may take multiple minutes when one or more Biofiltration elements are added, depending on the computational speed of the computer used.

One solution to this problem is to use the Simple Biofiltration option. The Simple Biofiltration option does not include HSPF Special Actions. It is less accurate than the standard Biofiltration calculations. Tests have shown that the simple option may produce slightly larger facilities. If appropriate, model the Biofiltration element both ways and see how close the simple answer is to the standard method. The standard method will always be more accurate than the simple option.



The Quick Biofilter button can be used to quickly fill the Biofiltration element with some dummy values. The user can then change these values, as needed.



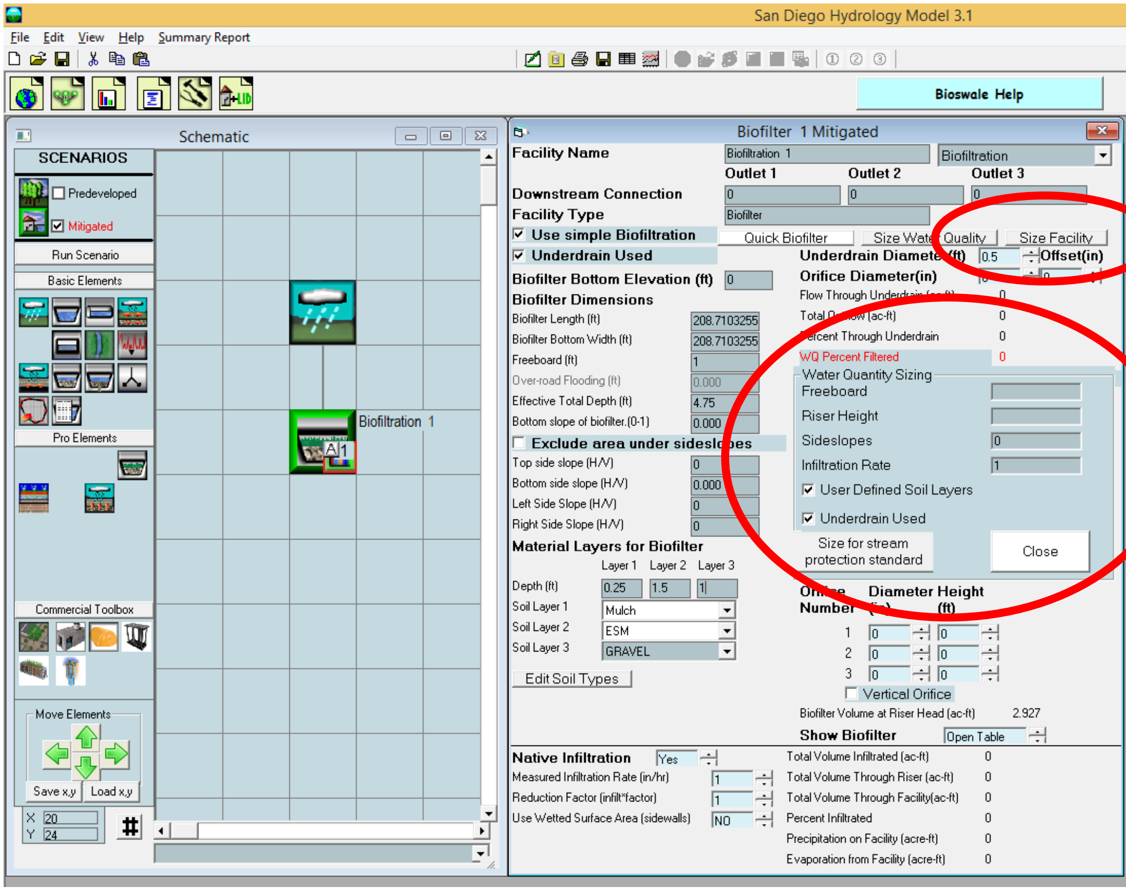
The Size Water Quality button is used to size a biofiltration facility to filter the total runoff volume to meet or exceed a specified percentage.

The user inputs:

- Freeboard (ft)
- Riser Height (ft)
- Side Slopes (H:V)
- Infiltration Rate (in/hr) to the native soil

If the user has defined the three material layers and their individual depths then the user should check the User Defined Soil Layers box.

Click on the Size for Water Quality button to start the iterative facility sizing process. SDHM will change the BMP bottom length and width until the facility passes the water quality standard with the smallest size possible.



The Size Facility button is used to size a biofiltration facility to meet the HMP flow duration standard.

The user inputs:

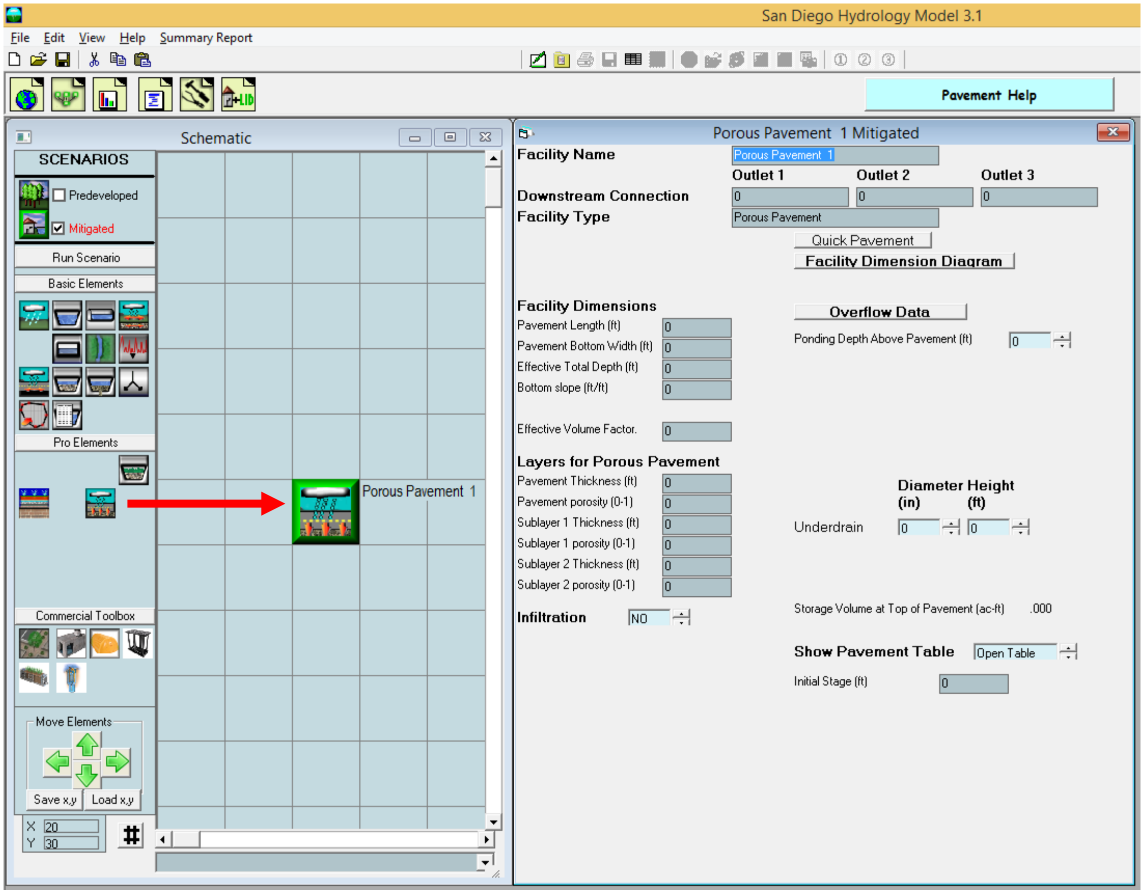
- Freeboard (ft)
- Riser Height (ft)
- Side Slopes (H:V)
- Infiltration Rate (in/hr) to the native soil

If the user has defined the three material layers and their individual depths then the user should check the User Defined Soil Layers box.

If an underdrain is included then the user should check the Underdrain Used box.

Click on the Size for Stream Protection Standard button to start the iterative facility sizing process. SDHM will change the BMP bottom length and width and the underdrain orifice diameter until the facility passes the HMP flow duration standard with the smallest size possible.

POROUS PAVEMENT ELEMENT



The Porous Pavement element is used to represent porous asphalt or concrete, grid/lattice systems (non-concrete), and paving blocks.

The use of any of these 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: Porous pavement can be used in place of conventional pavement for roadways, sidewalks, driveways, and parking lots. Review the local municipal permitting agency's stormwater manual appendices C and D to find out under what conditions porous pavement is allowed.

Porous pavement can be represented by the Porous Pavement element in SDHM if the following three conditions are met:

1. The infiltration rate of the porous pavement is greater than the peak rainfall rate.
2. The infiltration rate of the porous pavement is greater than the underlying native soil.

3. There is subgrade layer of crushed rock/gravel between the porous pavement and the native soil.

The Porous Pavement element is an impervious land use basin element that drains directly to storage layer similar to a gravel trench bed.

The Porous Pavement element dimensions and parameters are:

- Pavement Length (ft): Roadway length.
- Pavement Bottom Width (ft): Roadway width.
- Effective Total Depth (ft): Height from bottom of porous pavement subgrade to top of pavement plus at least 0.5 feet extra.
- Bottom Slope (ft/ft): Gravel layer slope or grade.

- The effective volume factor is a value between zero and 1.00. It is only used when the bottom slope is greater than 2%. The effective volume factor is the fraction ratio of the average maximum water depth behind a check dam in the gravel layer (Sublayer 1) compared to the maximum gravel layer depth (Sublayer 1). For example, if the average maximum water height is 6 inches and the gravel depth is 9 inches then the Effective Volume Factor = 0.67 (6/9). The effective volume factor is multiplied by the Sublayer 1 storage volume to determine the actual maximum volume available for stormwater storage before the check dam is overtopped and the water in the gravel layer depth (Sublayer 1) proceeds to a downstream conveyance facility.

- Pavement Thickness (ft): Porous pavement layer depth.
- Pavement Porosity: Porous pavement porosity.
- Layer 1 Thickness (ft): Subgrade gravel layer depth.
- Layer 1 Porosity: Subgrade gravel porosity.
- Layer 2 Thickness (ft): Sand layer depth (if appropriate).
- Layer 2 Porosity: Sand porosity.

- Ponding Depth Above Pavement (ft): Ponding depth on the surface of the pavement at which sheet flow starts to occur.

- Underdrain Diameter (in): Set to zero if there is no underdrain.
- Underdrain Height (ft): Height of the bottom of the underdrain above the bottom layer.

- 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 125).

If infiltration is used then the user should consult the Infiltration discussion on page 125.

The porous pavement layers represent the pavement layer and two subgrade layers and their design characteristics (thickness and porosity). The subgrade layers (Sublayer 1 and Sublayer 2) are available to provide storage prior to discharge through infiltration to the native soil or discharge via an underdrain.

Quick Pavement will create a porous pavement feature with default values without checking it for compliancy with flow duration standards.

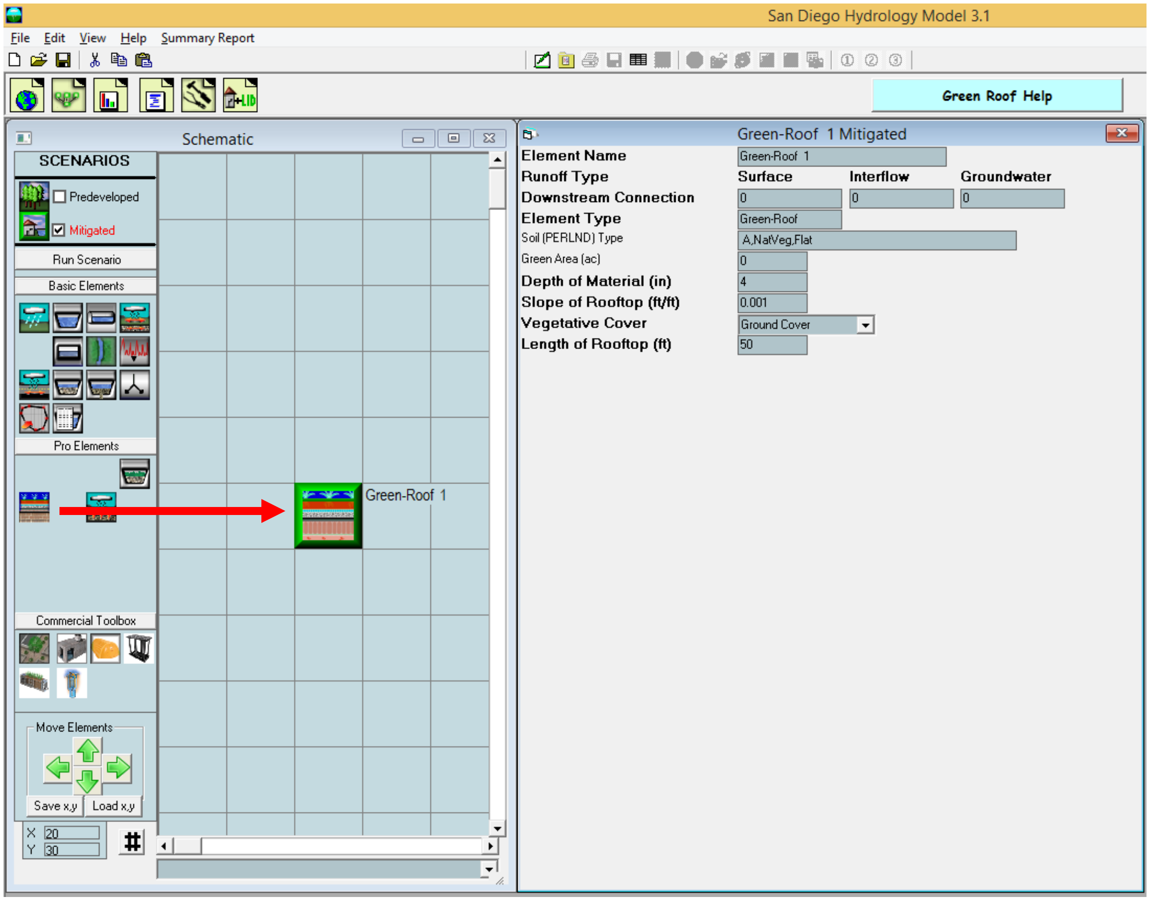
The porous pavement surface area automatically receives rainfall and produces evapotranspiration. Due to this automatic application, input of the porous pavement surface area should be excluded from the Landuse Basin element's total surface area.

If ponding is not allowed then the ponding depth above pavement value should be set to zero.

NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D to determine if ponding on the surface of the pavement is allowed.

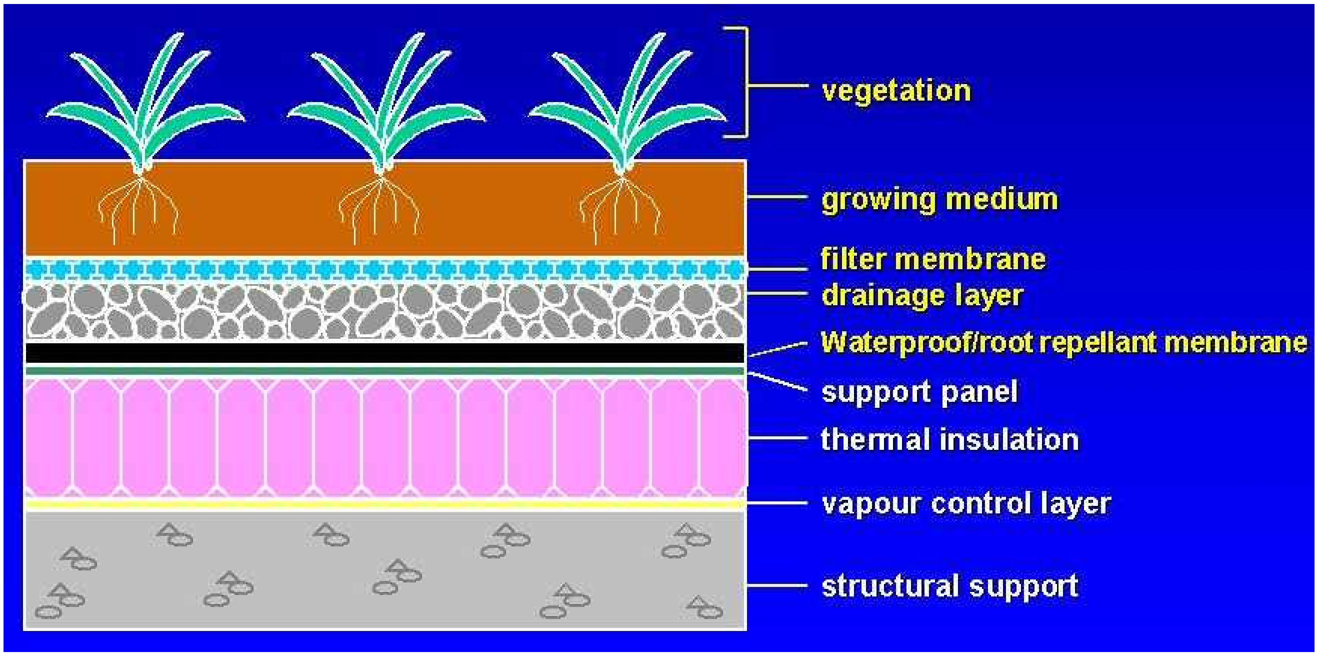
NOTE: The user should review the local municipal permitting agency's stormwater manual appendices C and D for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

GREEN ROOF ELEMENT



The Green Roof element is used to represent any 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.

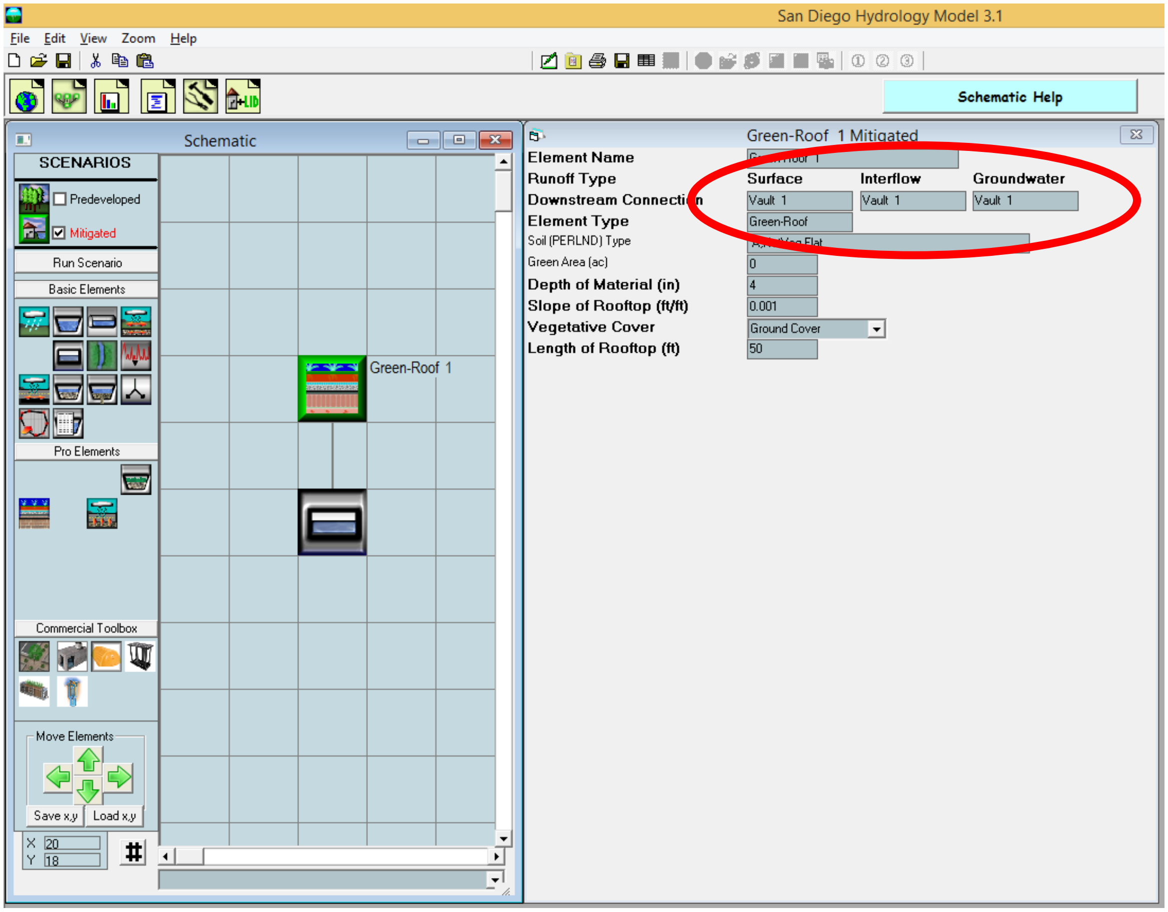


The dimensions and parameters to adjust to represent a green roof are:

- Green Area (ac): Size of the green roof.
- Depth of Material (in): Growing media/soil depth.
- Slope of Rooftop (ft/ft): Roof surface slope.
- Vegetative Cover: Type of vegetation on green roof (choices are: ground cover, shrubs, or trees).
- Length of rooftop (ft): Length of the longest runoff path to reach a roof drain.

Default input values are automatically included with the element. They should be changed to reflect actual roof conditions.

The green roof surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the green roof surface area should be excluded from the Landuse Basin element's total surface area.



If the Green Roof element is connected to a downstream element or is selected as a point of compliance then the green roof's groundwater runoff is automatically included. Unlike the other drainage area elements (Landuse Basin element, etc.), the green roof groundwater always contributes to the total runoff. The green roof groundwater has nowhere else to go.

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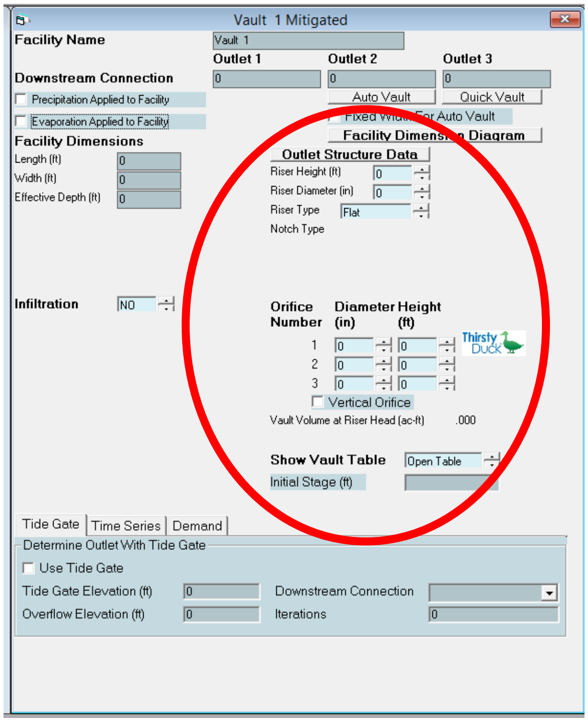
ADDITIONAL INFORMATION

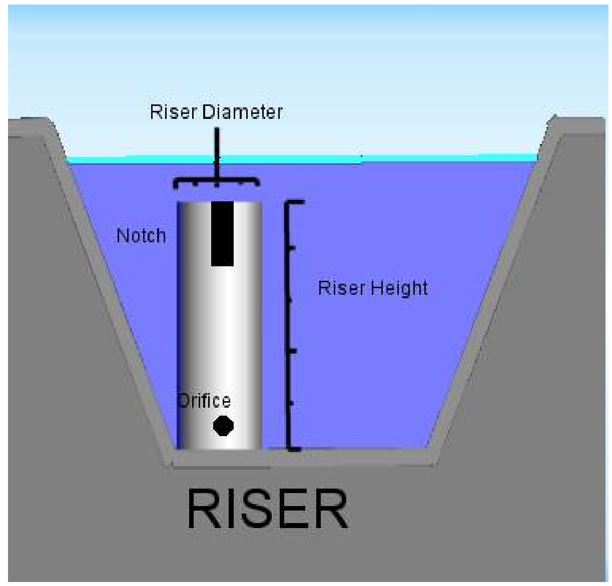
The following pages contain additional information about these features:

- Outlet Structure Configurations
- Infiltration
- Auto Sizing for HMP Flow Duration
- Stage-Storage-Discharge Table
- Point of Compliance
- Connecting Elements

OUTLET STRUCTURE CONFIGURATIONS

The Trapezoidal Pond element, the Storage Vault element, the Storage Tank element, the Irregular Shaped Pond element, the Gravel Trench Bed element, the Sand Filter element, and the Biofiltration element all use a riser for the outlet structure to control discharge from the facility.



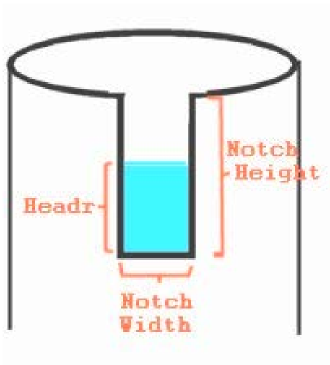


The riser is a vertical pipe with a height above pond bottom (typically one foot less than the effective depth). The user specifies the riser height and diameter. If the riser has a square cross-section (instead of circular) then the user should convert the cross-section area into an equivalent circular diameter.

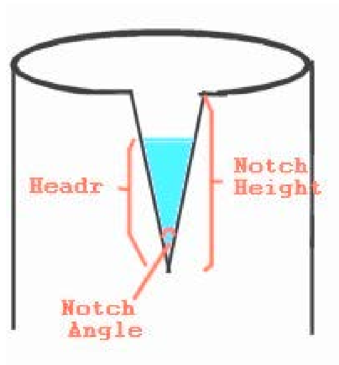
The riser can have up to three round orifices. The bottom orifice is usually located at the bottom of the pond and/or above any dead storage in the facility. The user can set the diameter and height of each orifice.

The default orifice is a horizontal orifice. This can be changed to vertical orifice opening by checking the Vertical Orifice box. For a single outlet structure the orifice openings must be all horizontal or all vertical.

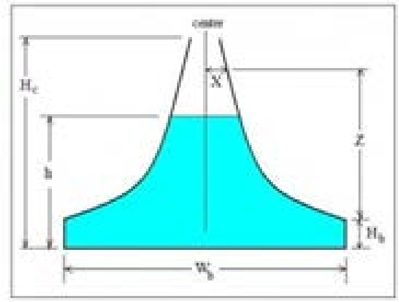
The user specifies the riser type as either flat or notched. The weir notch can be either rectangular, V-notch, or a Sutro weir. The shape of each type of weir is shown below.



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 SDHM are provided below.

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

Riser Head Discharge:

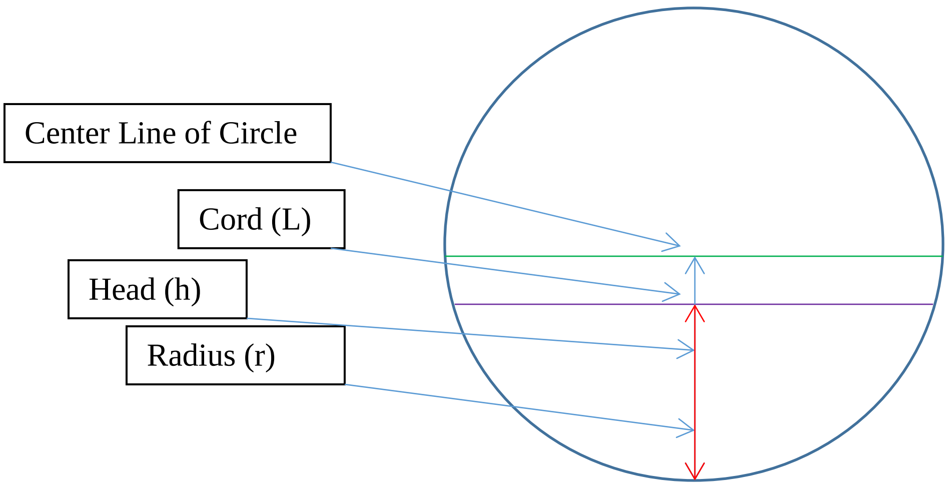
Head = water level above riser
q = 9.739 * Riser Diameter * Head ^ 1.5

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

Vertical Orifice Equation:

The equations differ depending on the depth of flow in the orifice.

If the water surface is below the middle line of the orifice (r-h > 0) then compute the flow using equation # 4



Vertical orifice flow:

Equation #1: Q = constg * Area * (Head ^ 0.5) where:

Equation #2: constg = C * (64.4^0.5) = 4.975

Where:

C = 0.62

Head = elevation of water surface or h where h can also be defined as = height from edge of circle to center of cord.

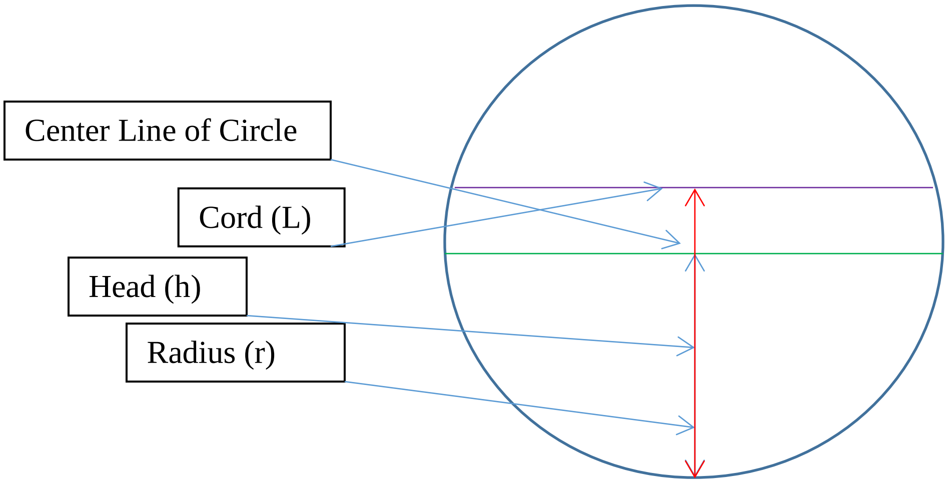
Equation #3: Area = (0.5 * (r ^ 2) * 2) * (arccos - L * x)

x = radius of orifice – h
L = length of cord = ((r ^ 2) – (X ^ 2)) ^ 0.5
r = radius
arccos = Atn(-arcangle / ((-arcangle * arcangle + 1) ^ 0.5)) + (2 * Atn(1))
Atn = Arc Tangent
arcangle = x / r

Which results in:

Equation #4: Q = constg*(0.5*(r^2))*(2*arccos(x/r))-(l/2)*(r-h))

If the water surface is between the middle line of the orifice and the top of the orifice (r-h < 0) then compute the flow using equation #4 above where:

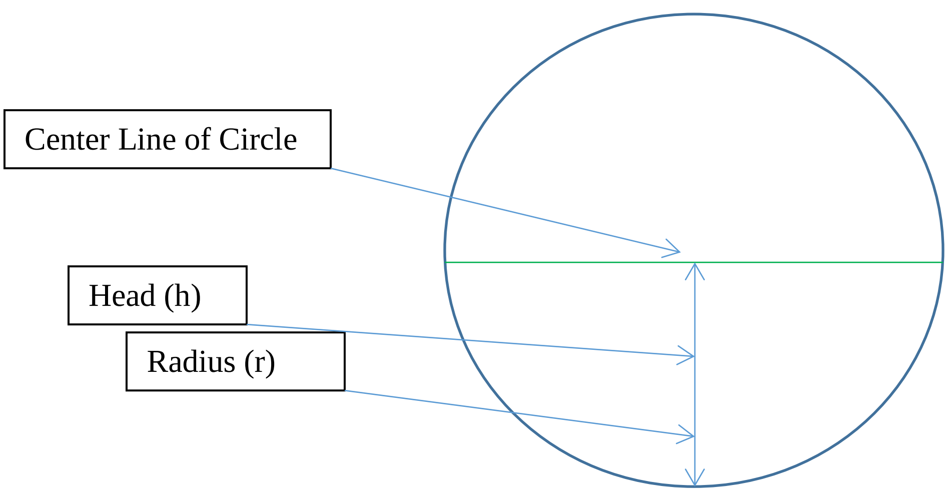


x = distance between top of orifice and head or (h-r).
The area is equal to the area of the full orifice – the area of the unused part of the orifice.

Equation #5: Area = (*PI * (r^2)) - ((0.5 * (r ^ 2) * 2) * (arccos - L * x))

If the water surface is greater than top of orifice then compute the flow using equation #1 above where:

Equation #6: Area = PI * (r^2)



Rectangular Notch:

b = NotchWidth *- (1- 0.2 * Headr)

where b >= 0.8

q = 3.33 * b * Headr ^ 1.5

Sutro:

Hb = Notch Height

Hc = Riser Height – Notch Height

Wb = Bottom Width

Q = Cd * Wb * (h – Hb/3) * SQRT(2g * Hb)

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 2014 *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.

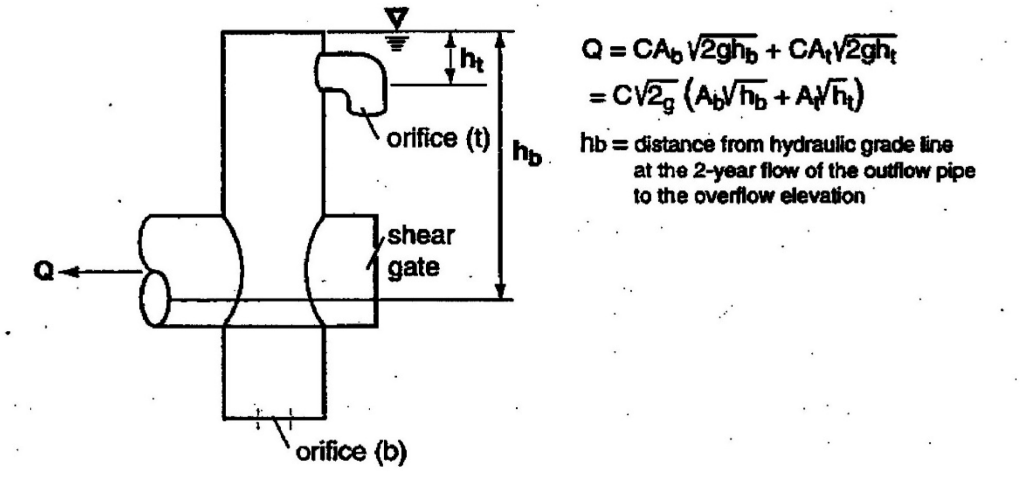


Figure 3.20 Simple Orifice

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)

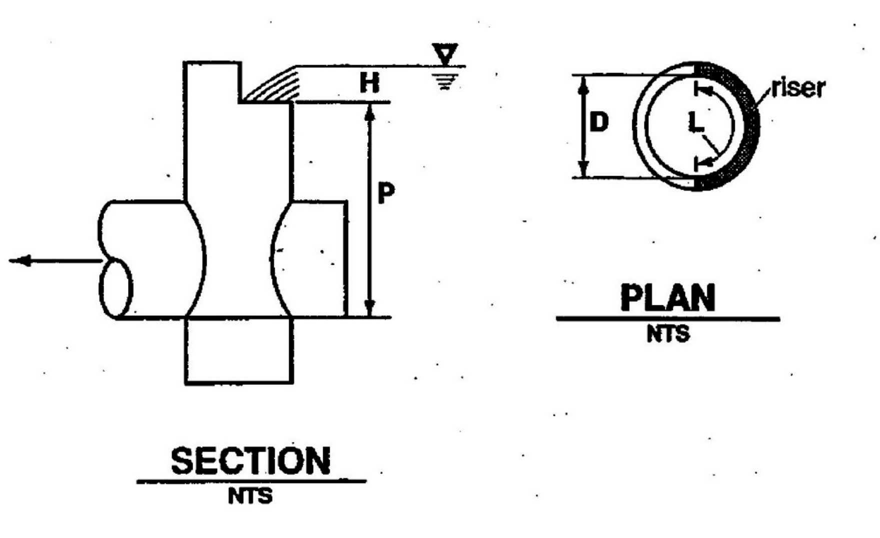


Figure 3.21 Rectangular, Sharp-Crested Weir

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

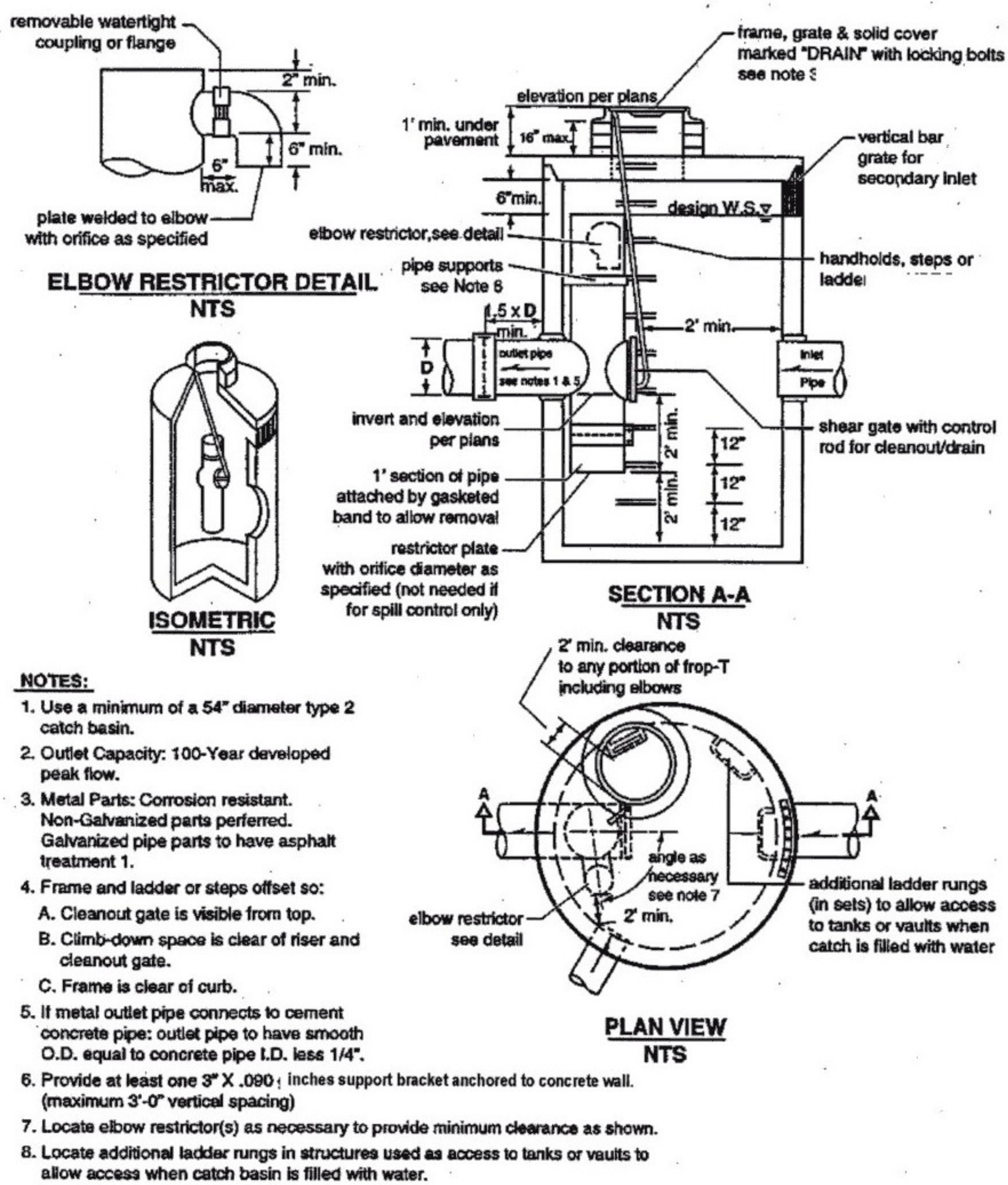


Figure 3.17 Flow Restrictor (TEE)

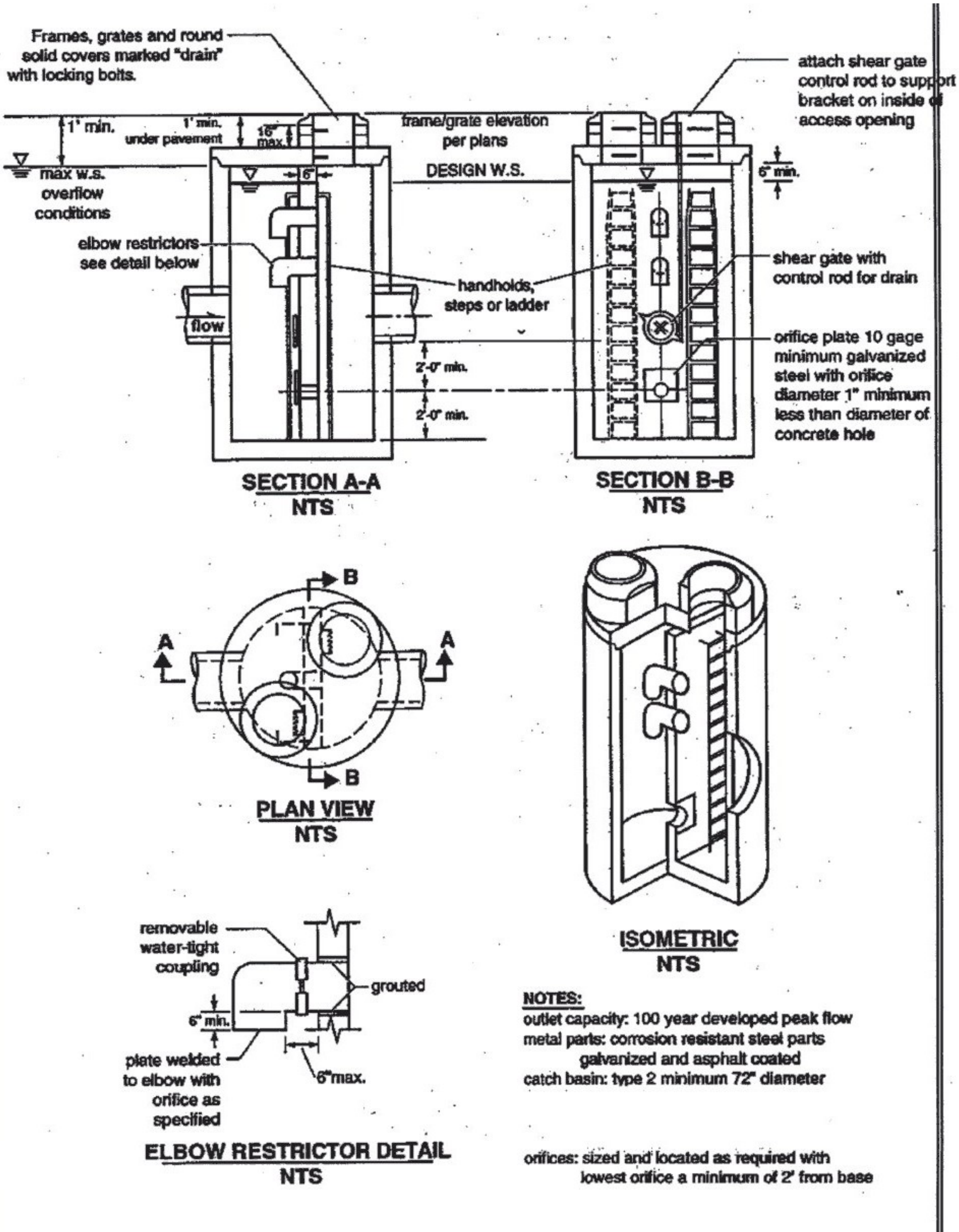
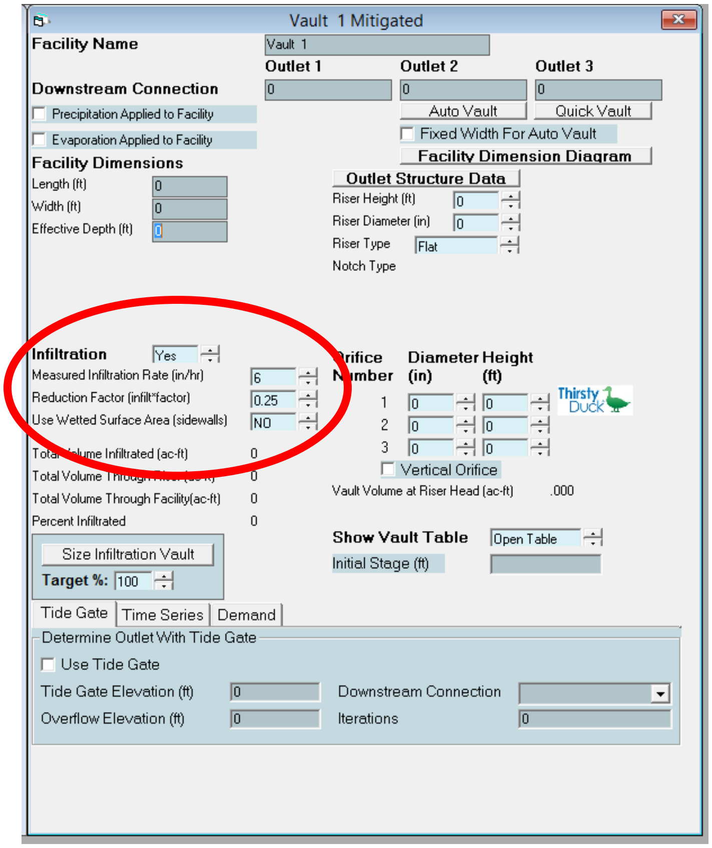


Figure 3.18 Flow Restrictor (Baffle)

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: The user should review the local municipal permitting agency's stormwater manual appendices C and D for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

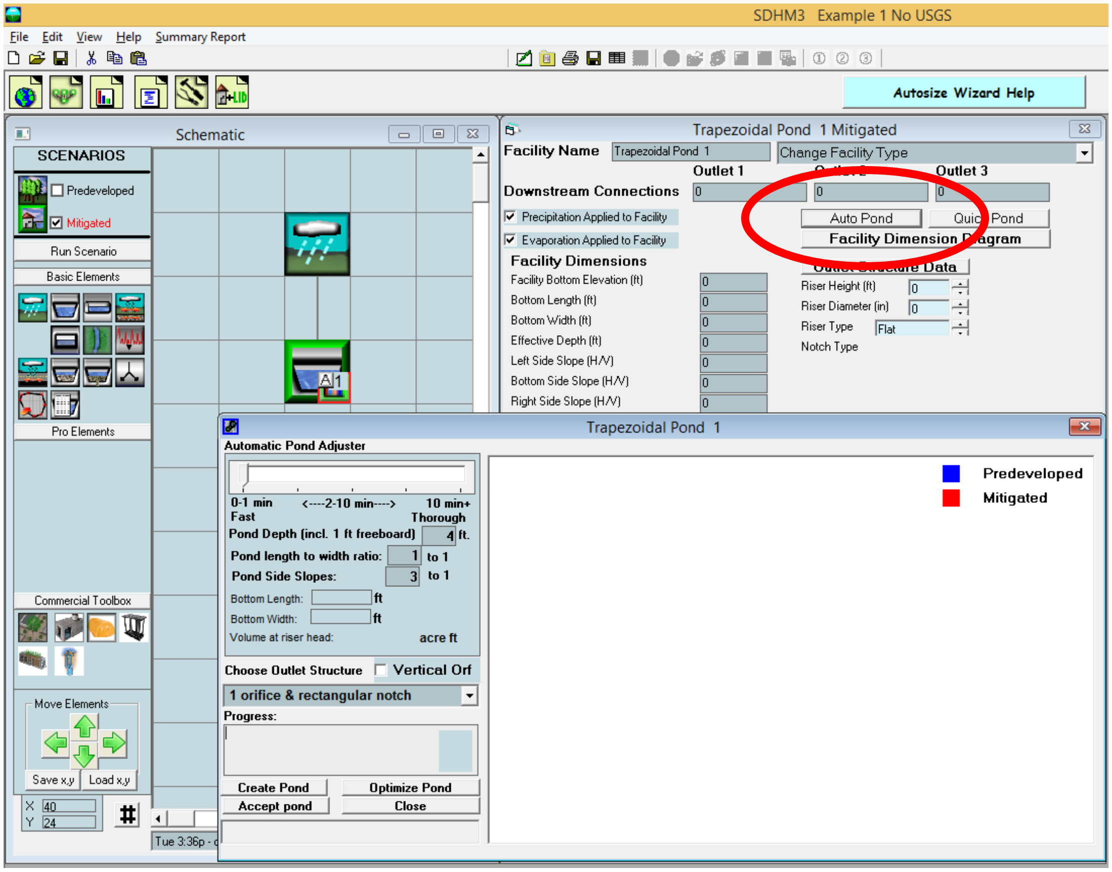
The user clicks on the Infiltration option arrow to change infiltration from NO to YES. This activates the infiltration input options: measured infiltration rate, infiltration reduction factor, and whether or not to allow infiltration through the wetted side slopes/walls.

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.

AUTO SIZING FOR HMP FLOW DURATION



SDHM includes a HMP flow duration auto-sizing option for the Trapezoidal Pond element (Auto Pond), Storage Vault element (Auto Vault), Storage Tank element (Auto Tank), and Biofiltration element (Size Facility). The first three all work the same.

Each auto-sizing routine automatically creates a pond, vault, tank, or biofiltration size and designs the outlet structure to meet the HMP flow duration criteria. For each type of above-mentioned facility (except biofiltration) the user can either create the facility from scratch or optimize an existing design.

The following information applies to the following three auto-sizing routines (Auto Pond, Auto Vault, and Auto Tank); the biofiltration sizing information is included in the Biofiltration element description. For the purposes of simplification, the term "Auto Pond" as used below applies equally to Auto Vault and Auto Tank.

Auto Pond requires that the Predeveloped and Mitigated Landuse Basin elements be defined prior to using Auto Pond. Clicking on the Auto Pond button brings up the Auto Pond window and the associated Auto Pond controls.

Auto Pond controls:

Automatic Pond Adjuster: The slider at the top of the Auto Pond 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: Auto Pond 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.

Vertical Orf: Check this box to use vertical orifices instead of default horizontal orifices.

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

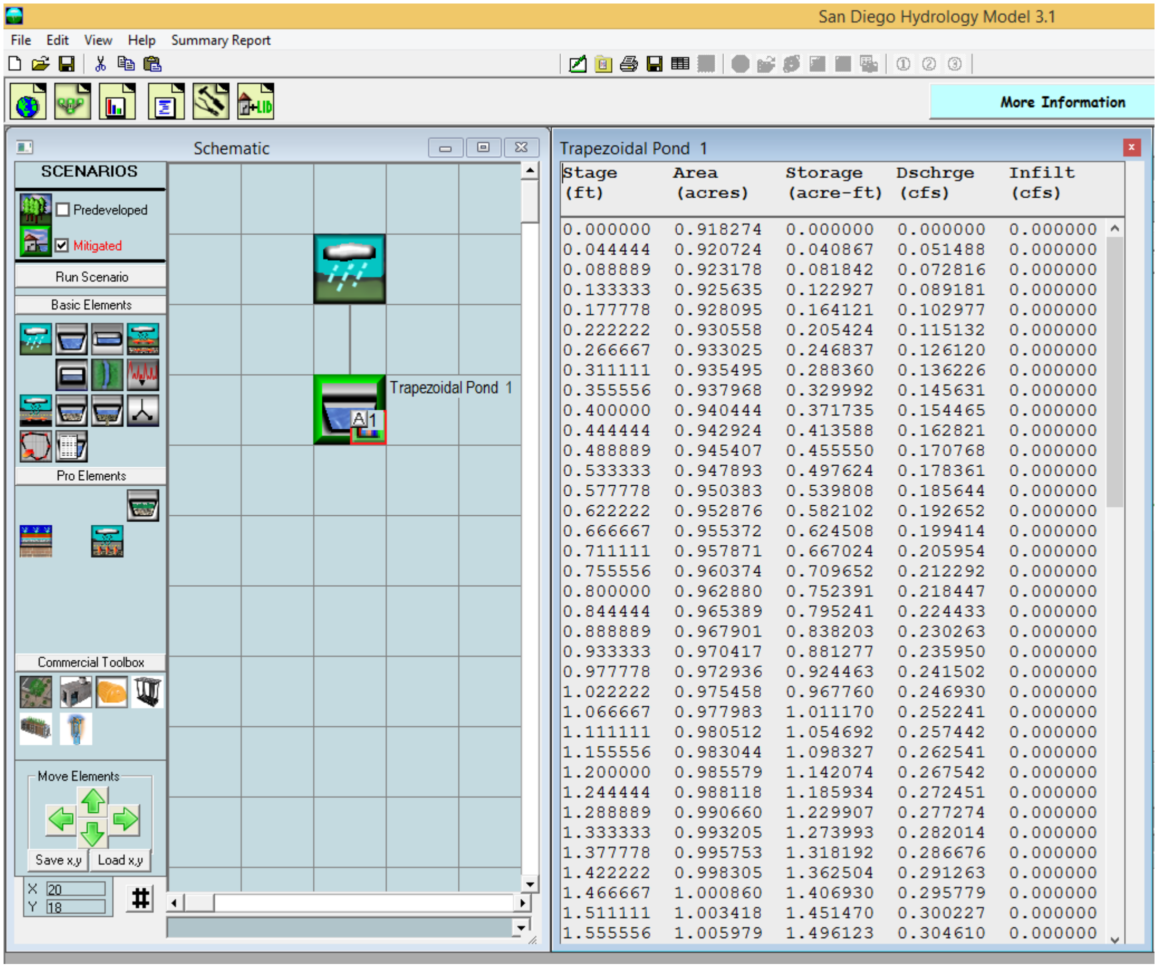
The bottom length and width and volume at riser head will be computed by Auto Pond; they cannot be input by the user.

Auto Vault and Auto Tank operate the same way as Auto Pond.

There are some situations where Auto Pond (or Auto Vault) will not work. These situations occur when complex routing conditions upstream of the pond make it difficult or impossible for Auto Pond 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 65 to find information on how to manually size a pond or other HMP facility.

NOTE: If Auto Pond 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 review local municipal permitting agency's stormwater manual appendices C and D for more details. For manual sizing information see page 65.

STAGE-STORAGE-DISCHARGE TABLE



Stage (ft)	Area (acres)	Storage (acre-ft)	Dschrge (cfs)	Infilt (cfs)
0.000000	0.918274	0.000000	0.000000	0.000000
0.044444	0.920724	0.040867	0.051488	0.000000
0.088889	0.923178	0.081842	0.072816	0.000000
0.133333	0.925635	0.122927	0.089181	0.000000
0.177778	0.928095	0.164121	0.102977	0.000000
0.222222	0.930558	0.205424	0.115132	0.000000
0.266667	0.933025	0.246837	0.126120	0.000000
0.311111	0.935495	0.288360	0.136226	0.000000
0.355556	0.937968	0.329992	0.145631	0.000000
0.400000	0.940444	0.371735	0.154465	0.000000
0.444444	0.942924	0.413588	0.162821	0.000000
0.488889	0.945407	0.455550	0.170768	0.000000
0.533333	0.947893	0.497624	0.178361	0.000000
0.577778	0.950383	0.539808	0.185644	0.000000
0.622222	0.952876	0.582102	0.192652	0.000000
0.666667	0.955372	0.624508	0.199414	0.000000
0.711111	0.957871	0.667024	0.205954	0.000000
0.755556	0.960374	0.709652	0.212292	0.000000
0.800000	0.962880	0.752391	0.218447	0.000000
0.844444	0.965389	0.795241	0.224433	0.000000
0.888889	0.967901	0.838203	0.230263	0.000000
0.933333	0.970417	0.881277	0.235950	0.000000
0.977778	0.972936	0.924463	0.241502	0.000000
1.022222	0.975458	0.967760	0.246930	0.000000
1.066667	0.977983	1.011170	0.252241	0.000000
1.111111	0.980512	1.054692	0.257442	0.000000
1.155556	0.983044	1.098327	0.262541	0.000000
1.200000	0.985579	1.142074	0.267542	0.000000
1.244444	0.988118	1.185934	0.272451	0.000000
1.288889	0.990660	1.229907	0.277274	0.000000
1.333333	0.993205	1.273993	0.282014	0.000000
1.377778	0.995753	1.318192	0.286676	0.000000
1.422222	0.998305	1.362504	0.291263	0.000000
1.466667	1.000860	1.406930	0.295779	0.000000
1.511111	1.003418	1.451470	0.300227	0.000000
1.555556	1.005979	1.496123	0.304610	0.000000

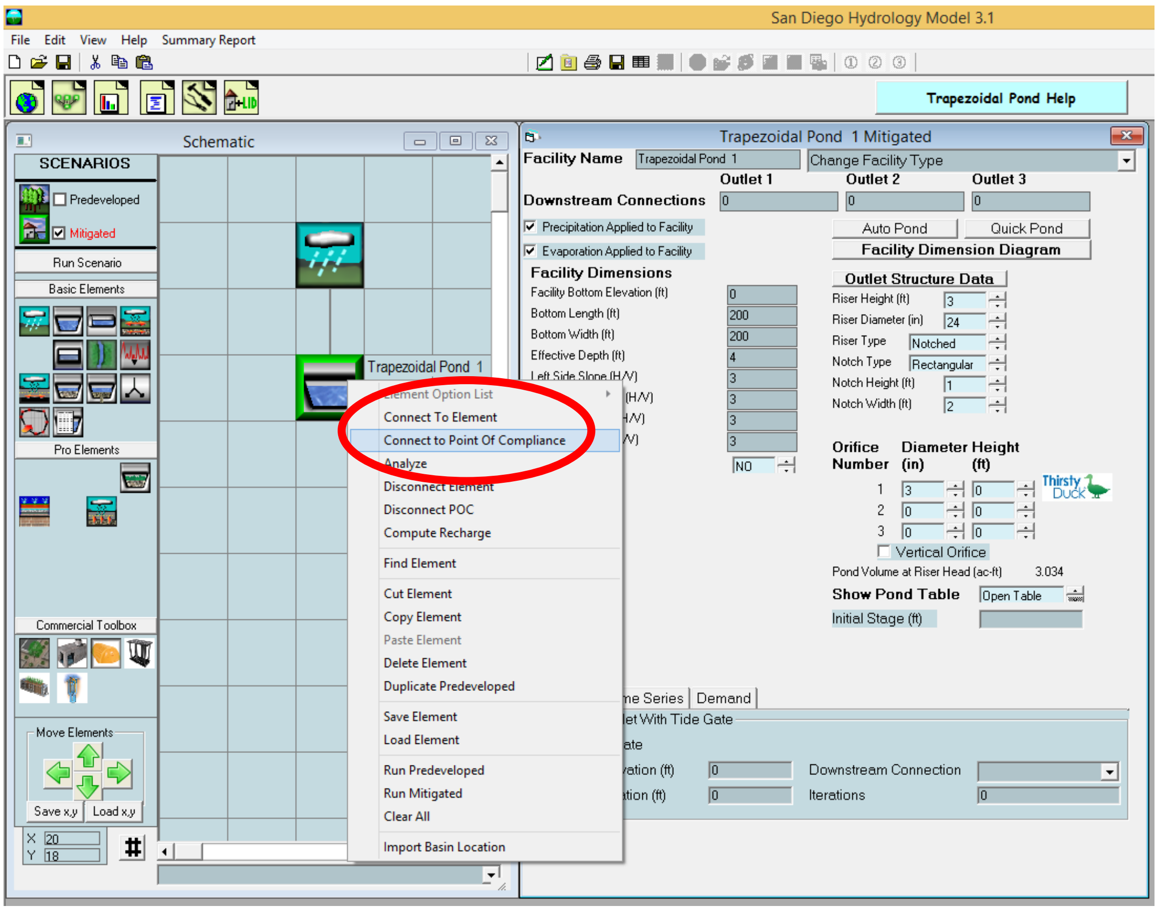
The stage-storage-discharge table hydraulically represents any facility that requires stormwater routing. The table is automatically generated by SDHM when the user inputs storage facility dimensions and outlet structure information. SDHM generates 91 lines of stage, surface area, storage, surface discharge, 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 SDHM changes a facility dimension (for example, bottom length) or an orifice diameter or height the program immediately recalculates the stage-storage-discharge table.

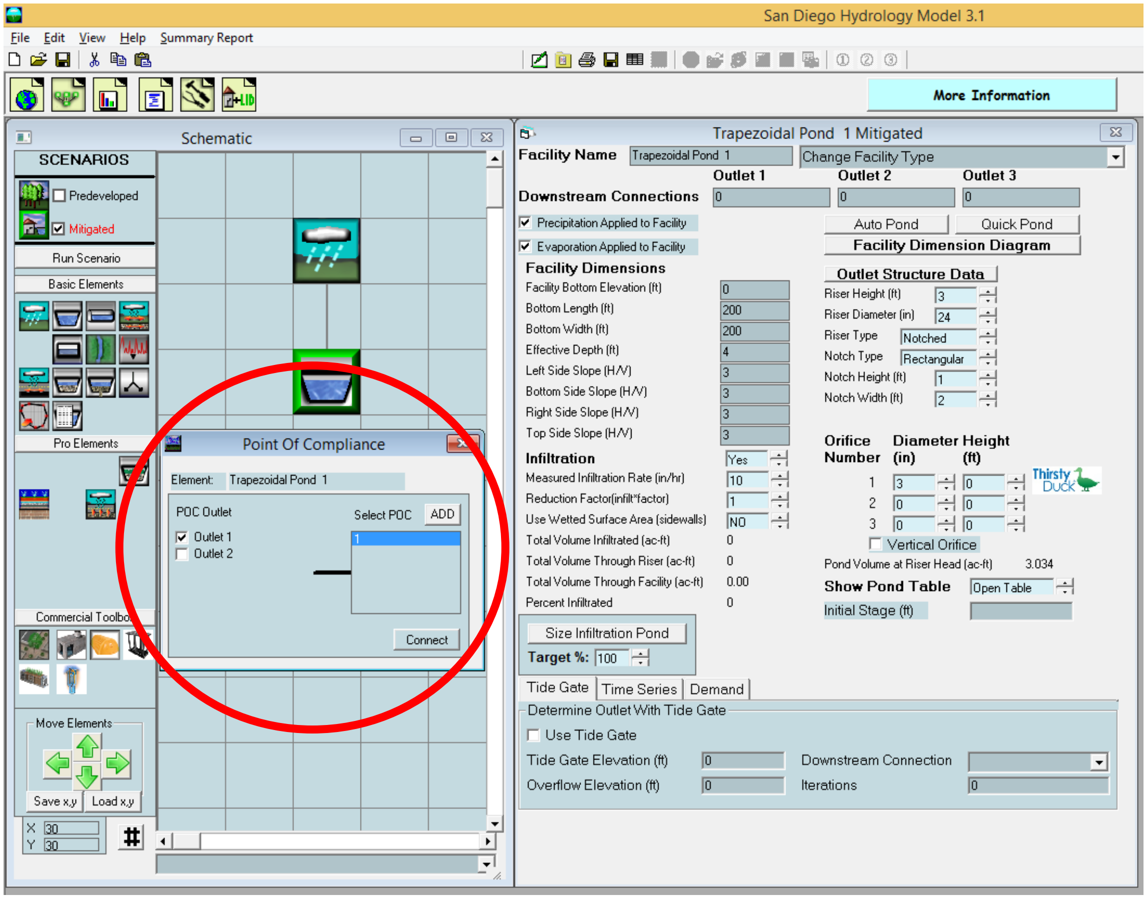
The user can input to SDHM a stage-storage-discharge table created outside of SDHM. To use a stage-storage-discharge table created out of SDHM the SSD Table element is required. See the SSD Table element description above for more information on how to load such a table to SDHM.

POINT OF COMPLIANCE

SDHM allows for multiple points of compliance (maximum of 50) in a single project. A point of compliance is defined as the location at which the Predeveloped and Mitigated flows will analyzed for compliance with the HMP 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.



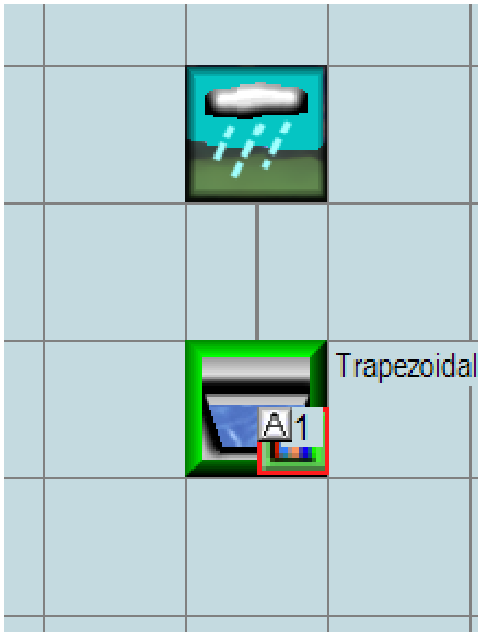
A Point of Compliance (POC) box will allow the user to specify which outlet (if there is more than one) to connect to the point of compliance and corresponding number for the POC.

In the above example, there are two outlets shown (Outlet 1 and Outlet 2). Outlet 1 represents the surface discharge through the outlet structure. Outlet 2 is the infiltration discharge through the bottom of the facility. Only the surface discharge (Outlet 1) should be connected to the POC.

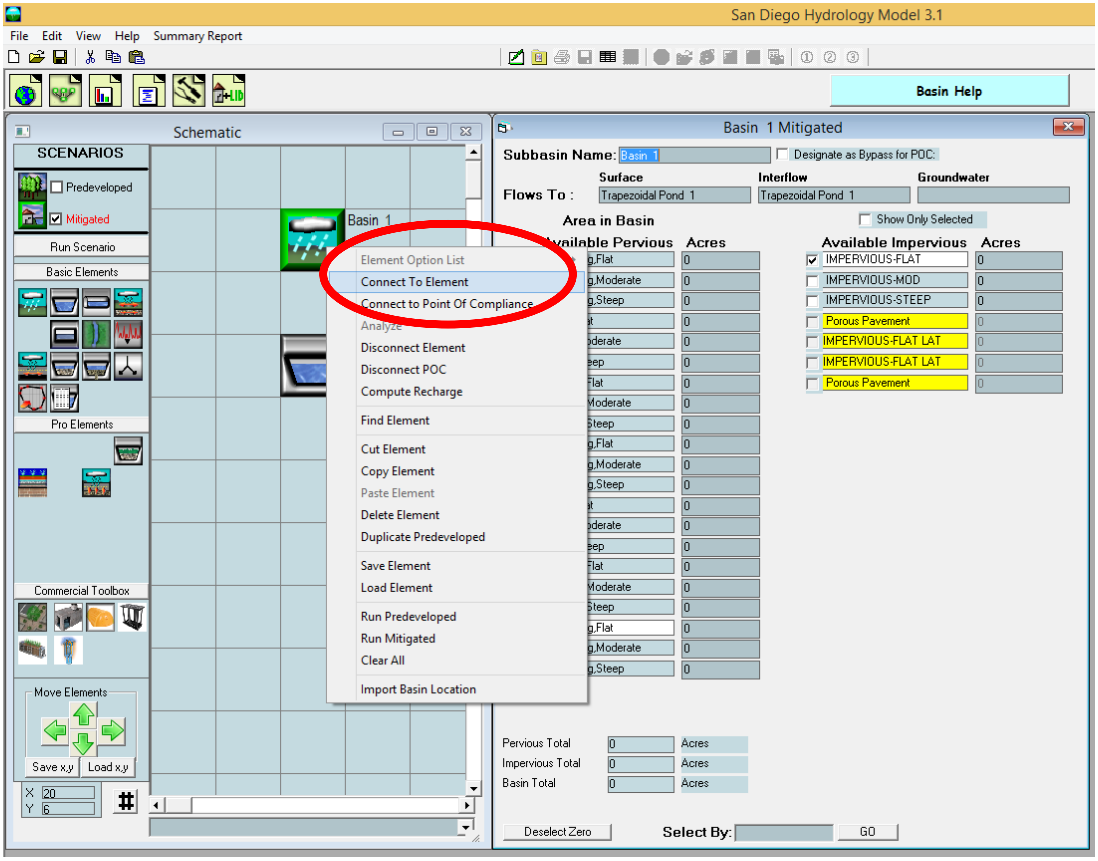
When an underdrain is included in the facility (biofiltration or porous pavement) the discharge from the underdrain will be considered part of the Outlet 1 total discharge.

A sand filter should include the discharge from both Outlet 1 (surface discharge not filtered by the sand filter) and Outlet 2 (surface discharge filtered by the sand filter) connected to the POC, assuming that the POC is immediately downstream of the sand filter.

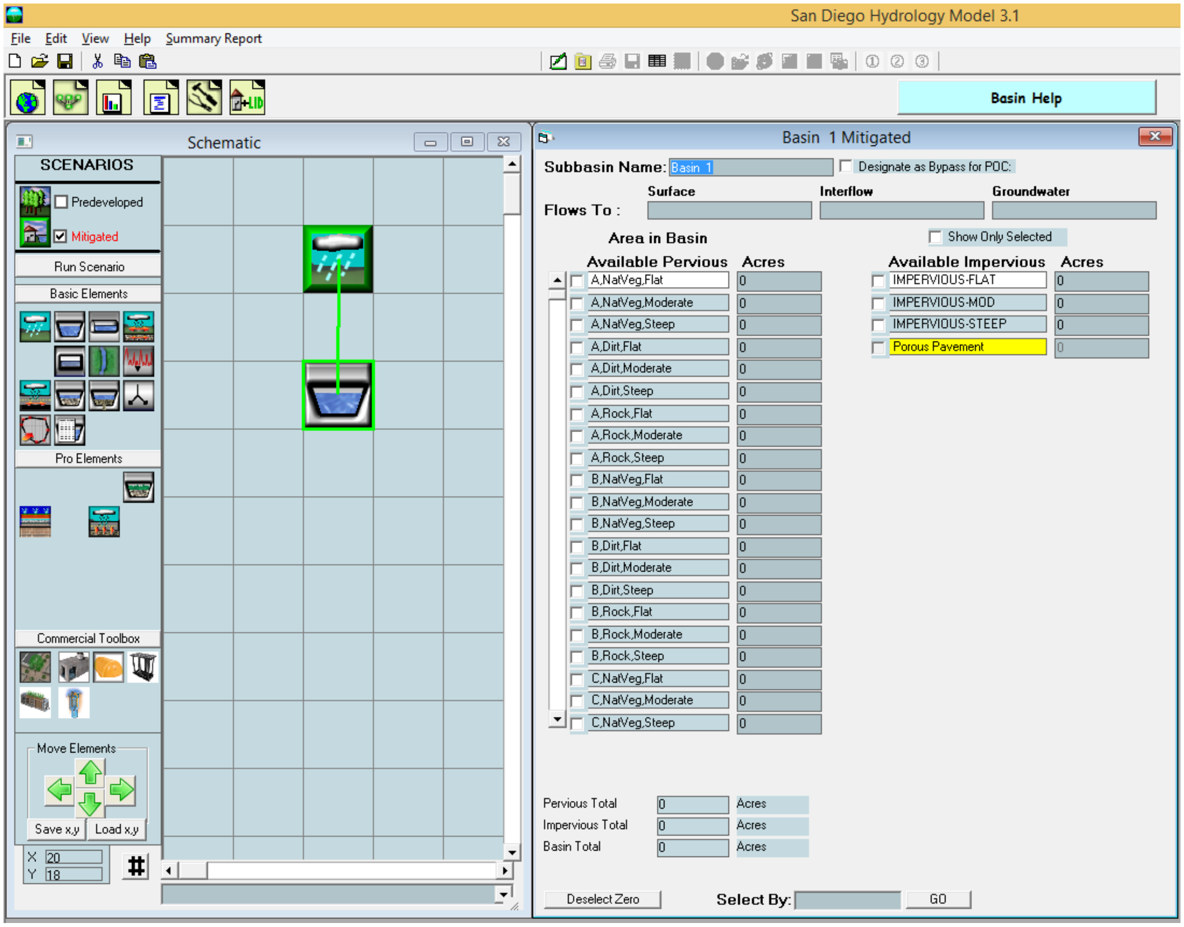
Once the point of compliance has been selected the element is modified on the Schematic screen to include a small box with the POC number (1 in this example) and the letter “A” (for Analysis) in the lower right corner. This identifies the outlet from this element as a point of compliance.



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 SDHM 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 automatically connects the surface runoff and interflow components from the Landuse Basin element to the downstream element.

Stormwater runoff is defined as surface flow plus interflow. Groundwater/base flow is computed but is not included for HMP flow duration analysis.

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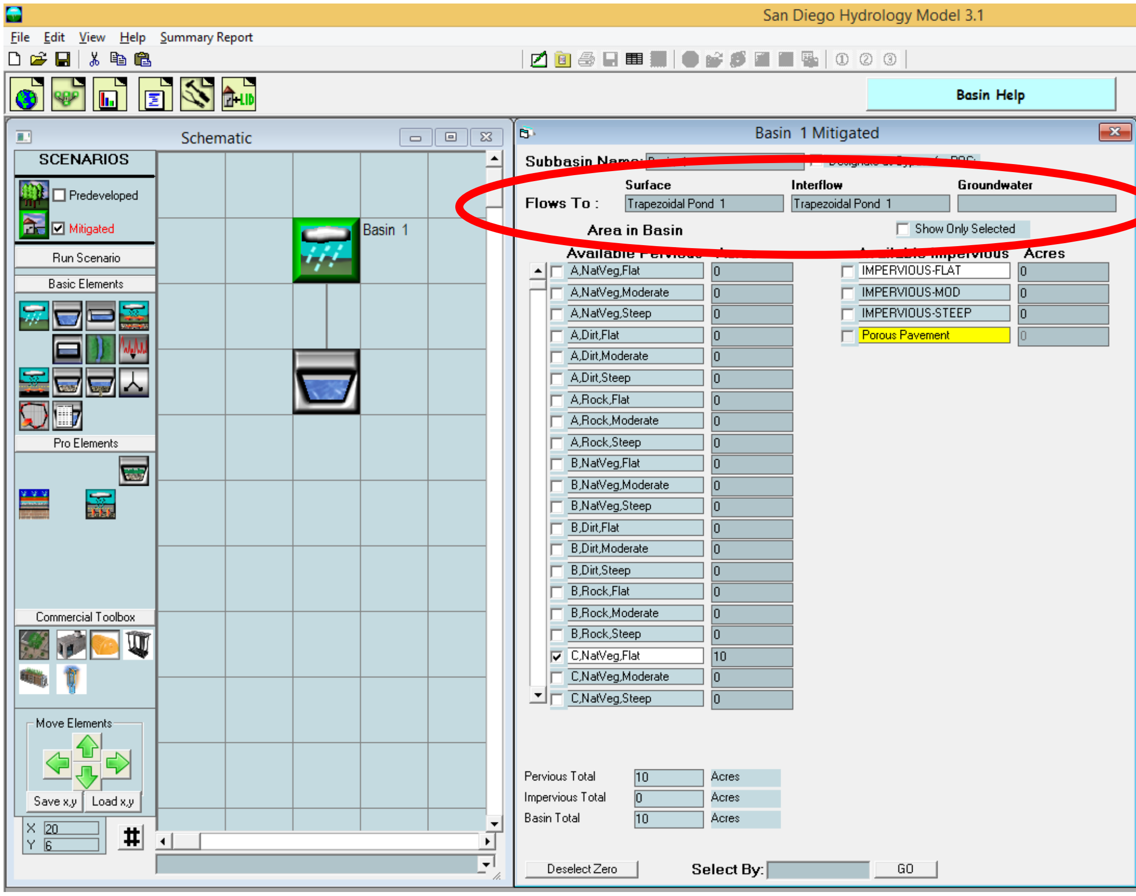

The final screen will look like the above screen. The Landuse Basin element information screen on the right will show that Basin 1 surface runoff and interflow flows to Trapezoidal Pond 1 (groundwater is not connected).

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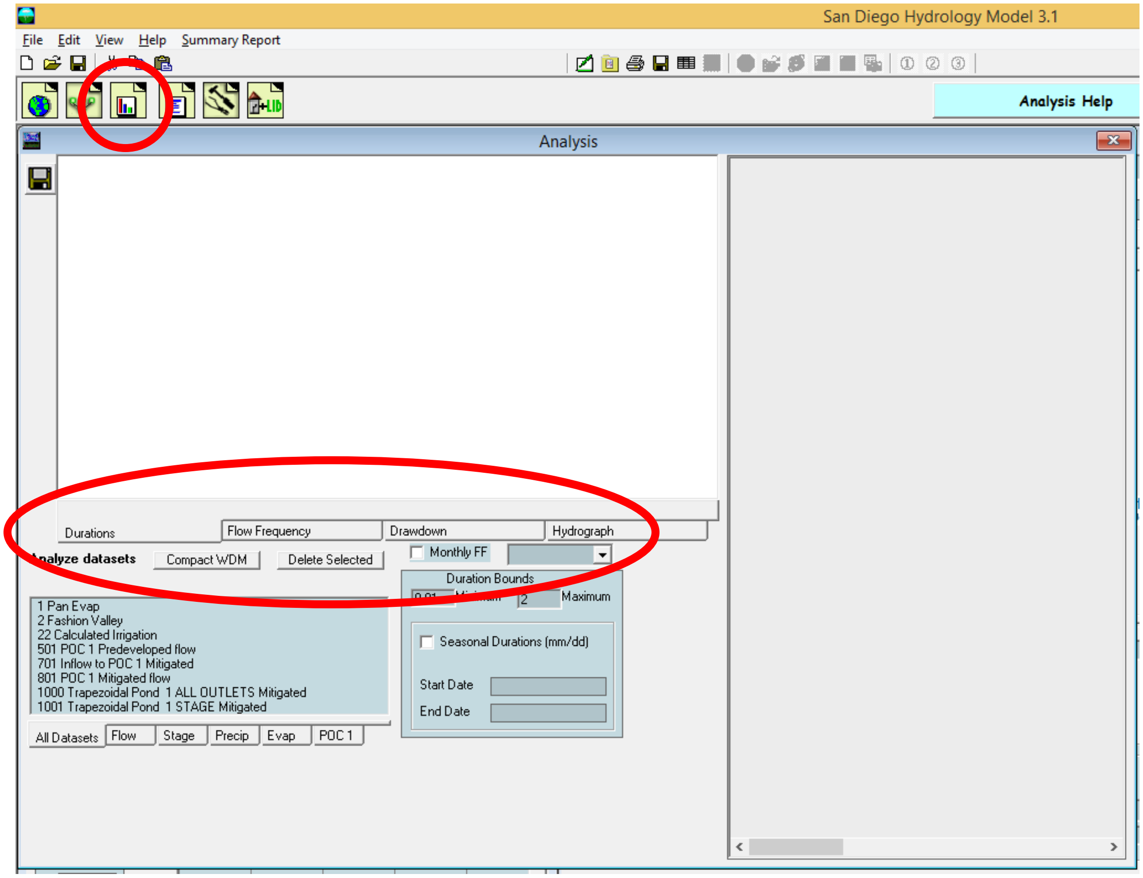
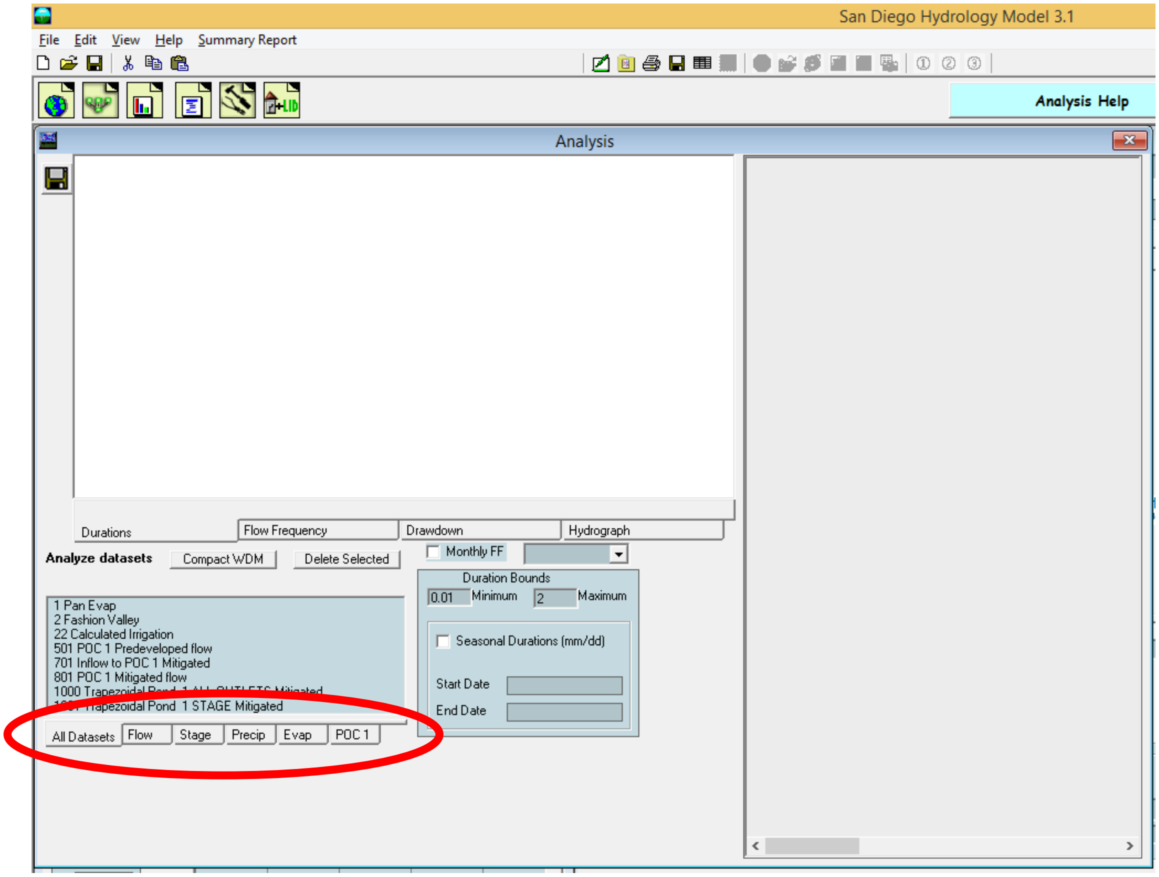
ANALYSIS SCREEN

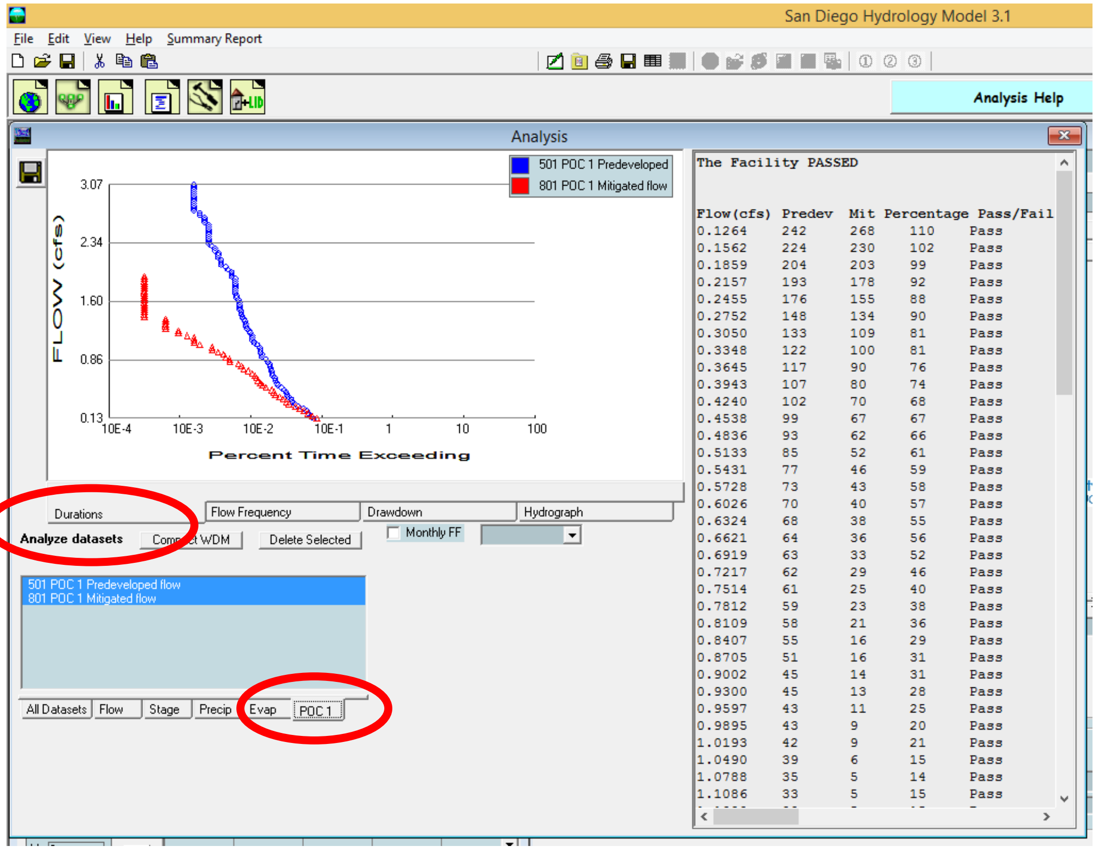


The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results of the Predeveloped and Mitigated scenarios. The Analysis screen allows the user to analyze and compare flow durations, flow frequency, drawdown times, and hydrographs.



The user can analyze any or all of the time series datasets in the database 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

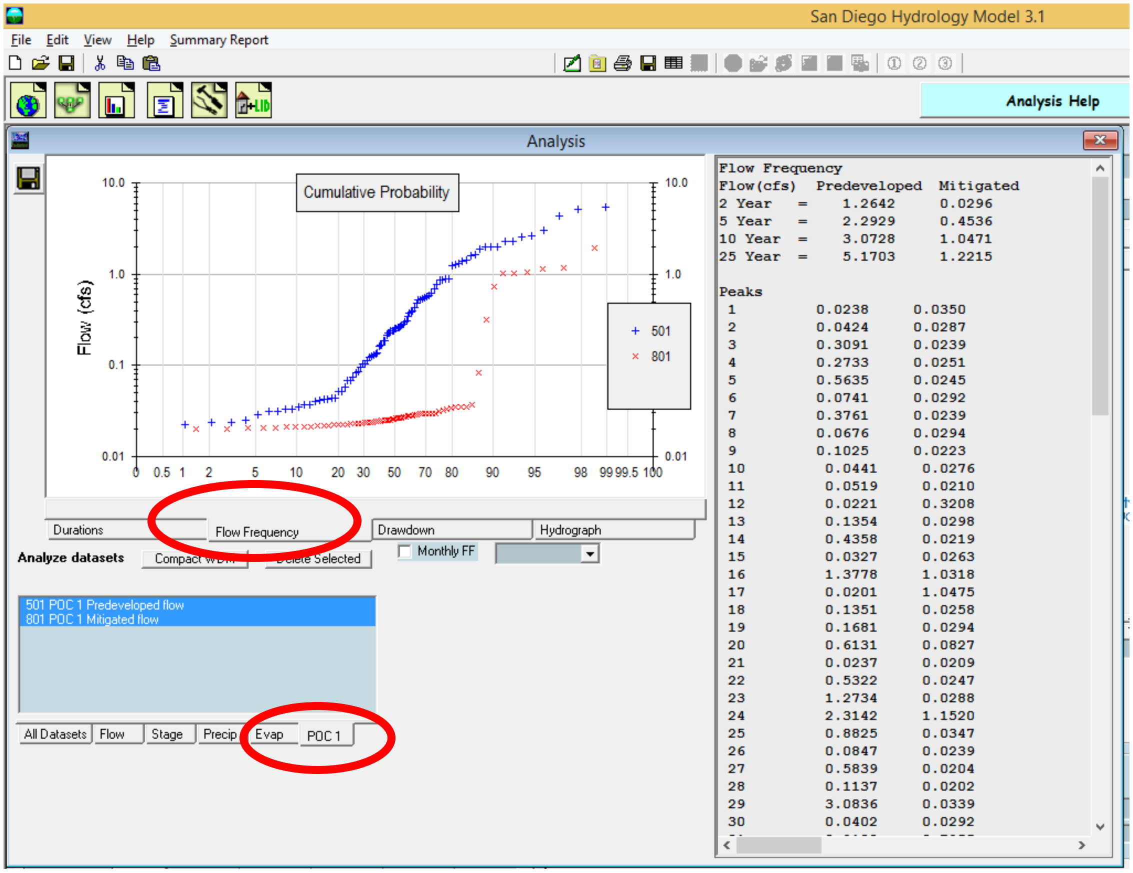


HMP flow duration at the point of compliance (POC 1) is the most common analysis. A plot of the flow duration values is shown on the left, the flow values on the right.

The flow duration flow range is from the lower threshold flow frequency value (in this example 10% of the 2-year flow value) to the upper threshold value (the 10-year flow 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). For each flow level/value SDHM counts the number of times that the flow at the Point of Compliance for the Predevelopment scenario (Predev) exceeds that specific flow level/value. SDHM does the same count for the Mitigated scenario flow (Mit). The total number of counts is the number of simulated hourly intervals 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% 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 upper threshold value) then the Pass/Fail column shows a Pass for that flow level. If they are exceeded then a Fail is shown. One Fail and the facility fails the HMP 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 Weibull Plotting Position.

The Weibull Plotting Position formula is:

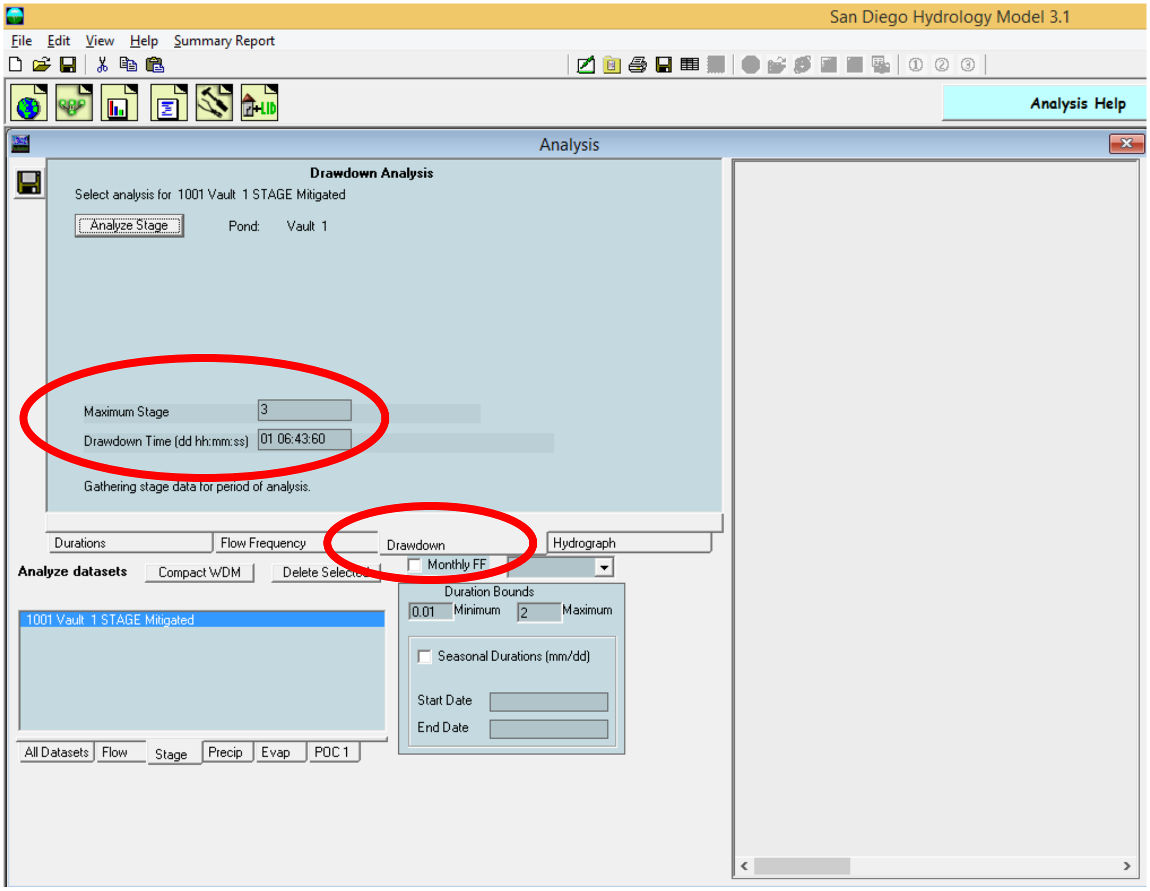
Tr = (N+a)/(m-b) where Tr = return period (years)
m = rank (largest event, m = 1)
N = number of simulation years
a = 1.0
b = 0.0

Probability = 1/Tr

The return period value, Tr, is used in SDHM 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 Weibull.

Note: The flow frequency should only be run using the POC tab. Frequency values are only valid for these POC tab time series.

DRAWDOWN



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

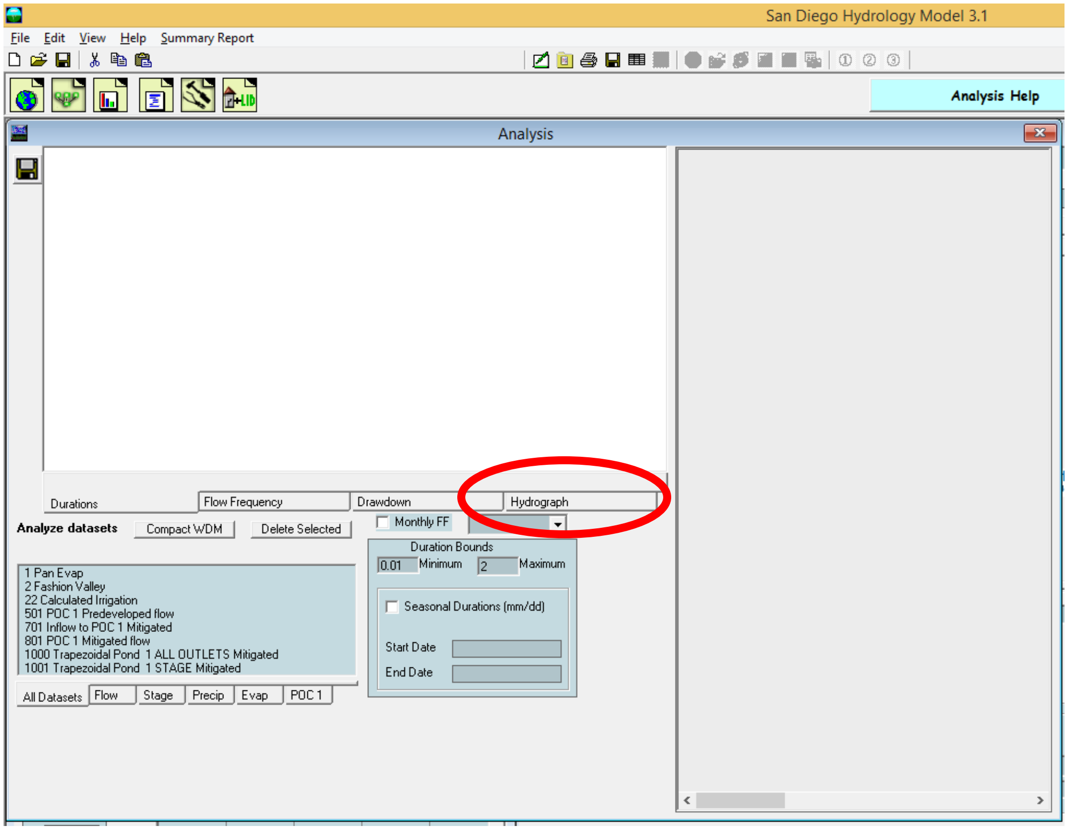
For this example, the maximum stage (based on the top of riser height) is 3.00 feet.

The stage for this maximum depth has a drawdown time of 1 day, 6 hours, 43 minutes.

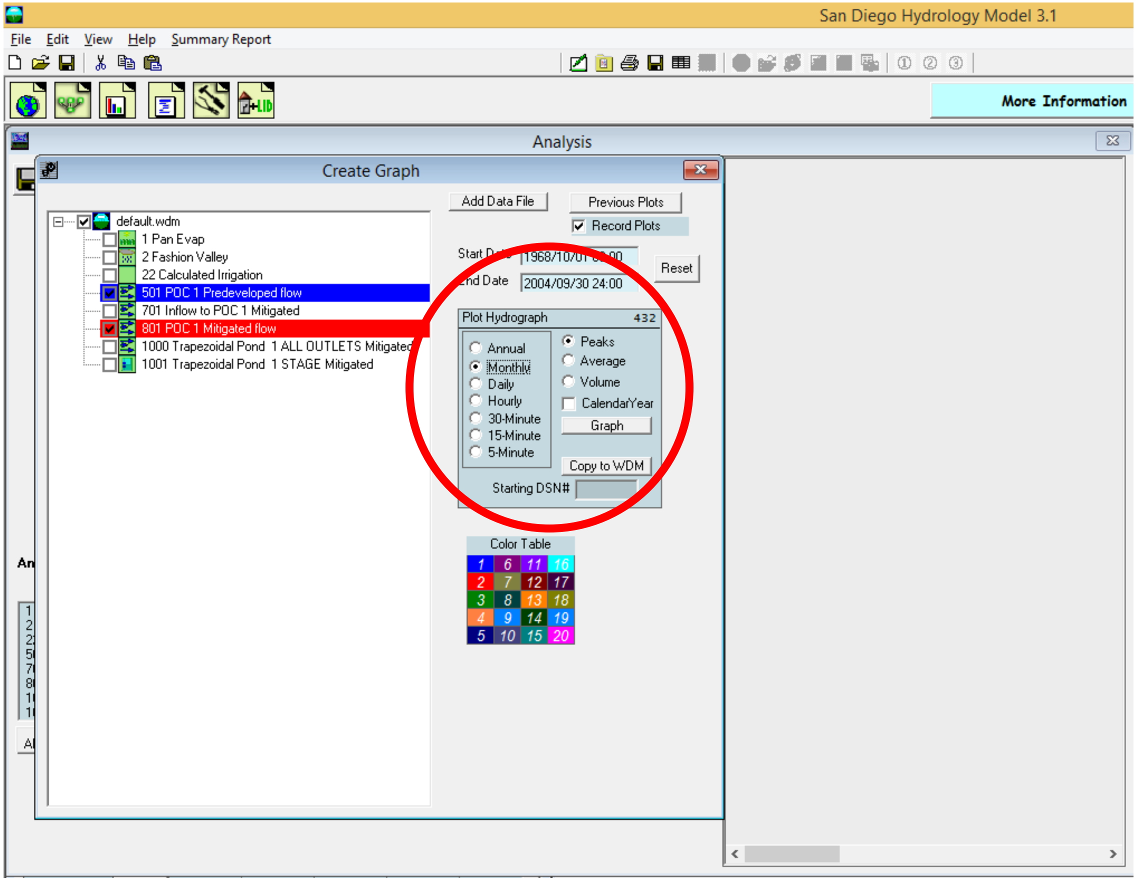
HMP facilities may have drain times in excess of the allowed maximum of 96 hours (4 days). This can occur when a facility has a small bottom orifice. If this is not acceptable then the user needs to change the facility outlet configuration, manually run the Mitigated scenario, and repeat the analyze stage computations. A situation may occur where it is not possible to have both an acceptable facility drawdown/ retention time and meet the flow duration criteria.

NOTE: The flow duration criteria take precedence unless the user is instructed otherwise requirements specified in the local municipal permitting agency's stormwater manual appendices C and D.

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 hourly), and type of data (peaks, average, or volume).

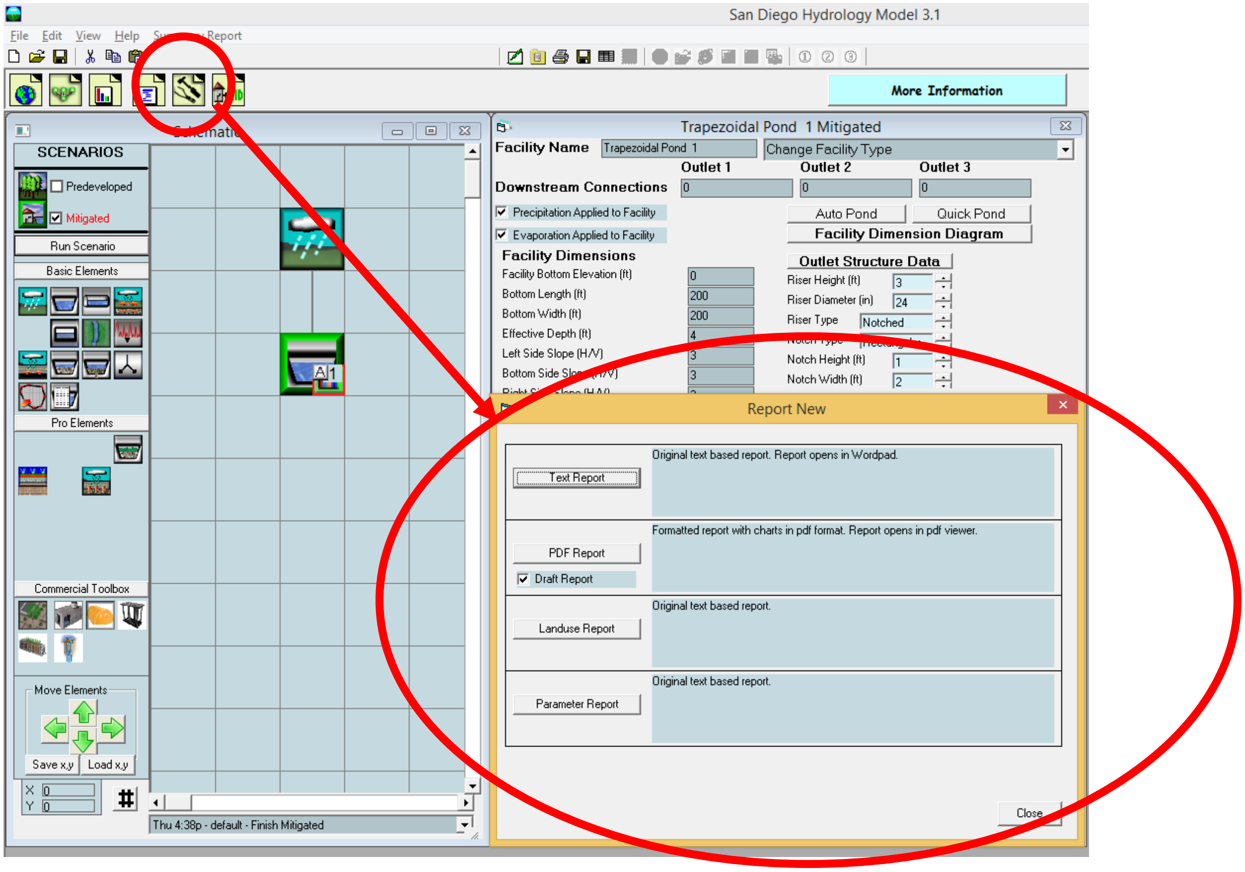
The following numbering system is used for the flow time series:
500-599: Predeveloped flow (Predeveloped scenario)
700-799: Inflow to the POC (Mitigated runoff entering the BMP facility)
800-899: POC flow (Mitigated flow exiting the BMP facility)
1000-1999: Other POC related time series (flow and stage)

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

The hydrograph shows the monthly maximum/peak flow values for each time series for the entire simulation period (in this example, from 1968 through 2004).

The graph can be either saved, printed, or copied to Windows Clipboard. From the Clipboard the individual values plotted can be pasted into an Excel spreadsheet for further analysis.

REPORTS SCREEN



Click on the Reports tool bar button (fourth from the left) to generate a project report.

The project report is a separate file that contains all of the user-provided input and a summary of the model output. The project report file can be saved or printed.

The user has the option of producing the report file in two different formats.

Click on “Text Report” button to generate the report file in WordPad RTF format.

SDHM 3.1
PROJECT REPORT

Project Name: default
Site Name:
Site Address:
City :
Report Date: 4/21/2017
Gage : FASHIONV
Data Start : 10/01/1968
Data End : 09/30/2004
Precip Scale: 1.00
Version Date: 2017/04/14

Low Flow Threshold for POC 1 : 10 Percent of the 2 Year

High Flow Threshold for POC 1: 10 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
C,NatVeg,Flat	10
Pervious Total	10

Impervious Land Use	acre
Impervious Total	0
Basin Total	10

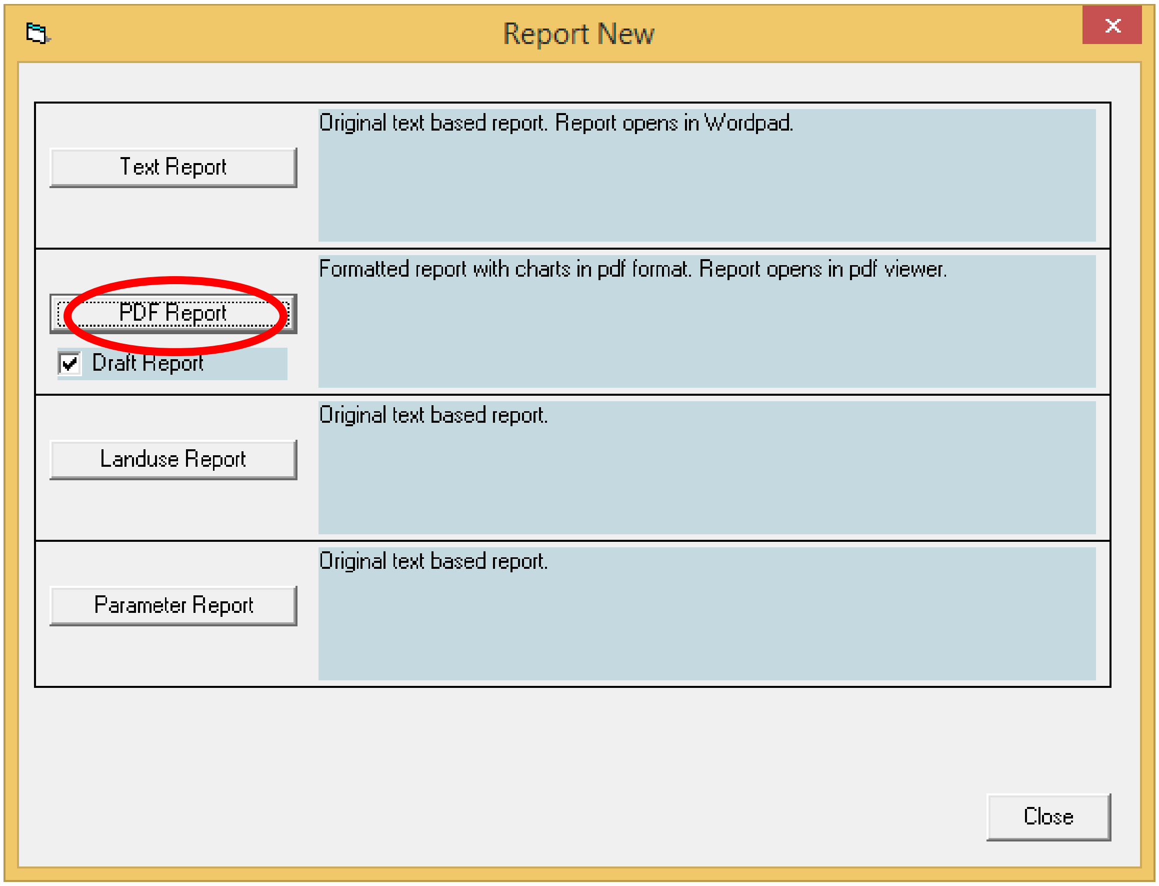
Element Flows To:

Surface	Interflow	Groundwater

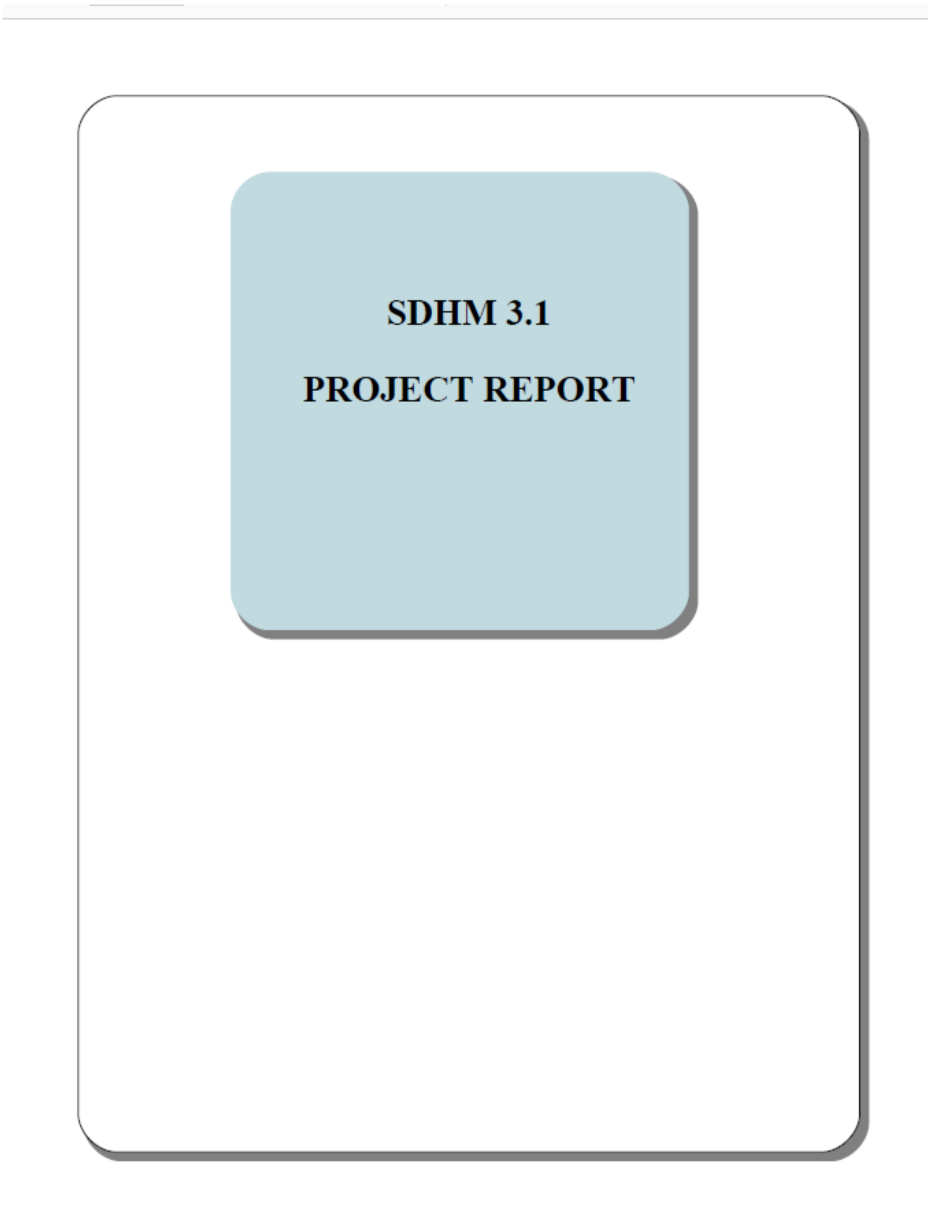
MITIGATED LAND USE

Name : Basin 1
Bypass: No

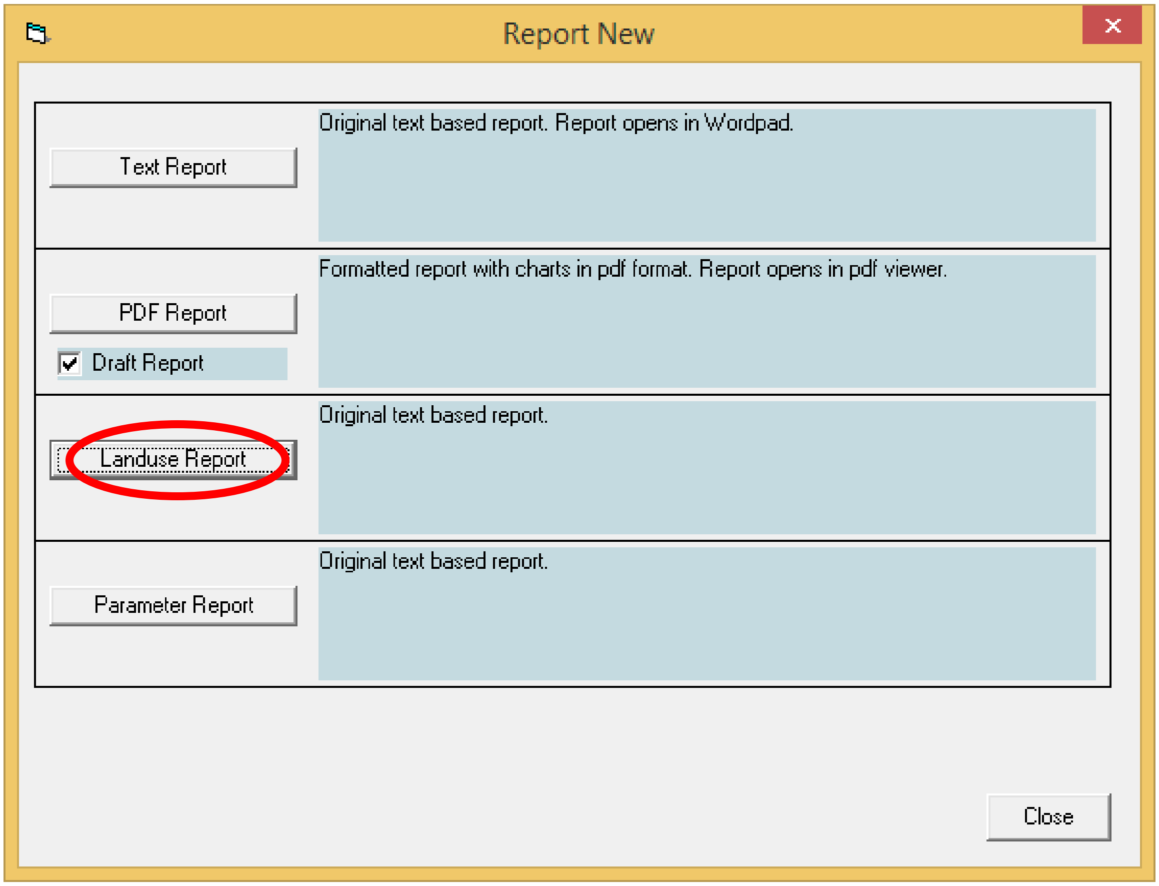
Scroll down the WordPad screen to see all of the results.



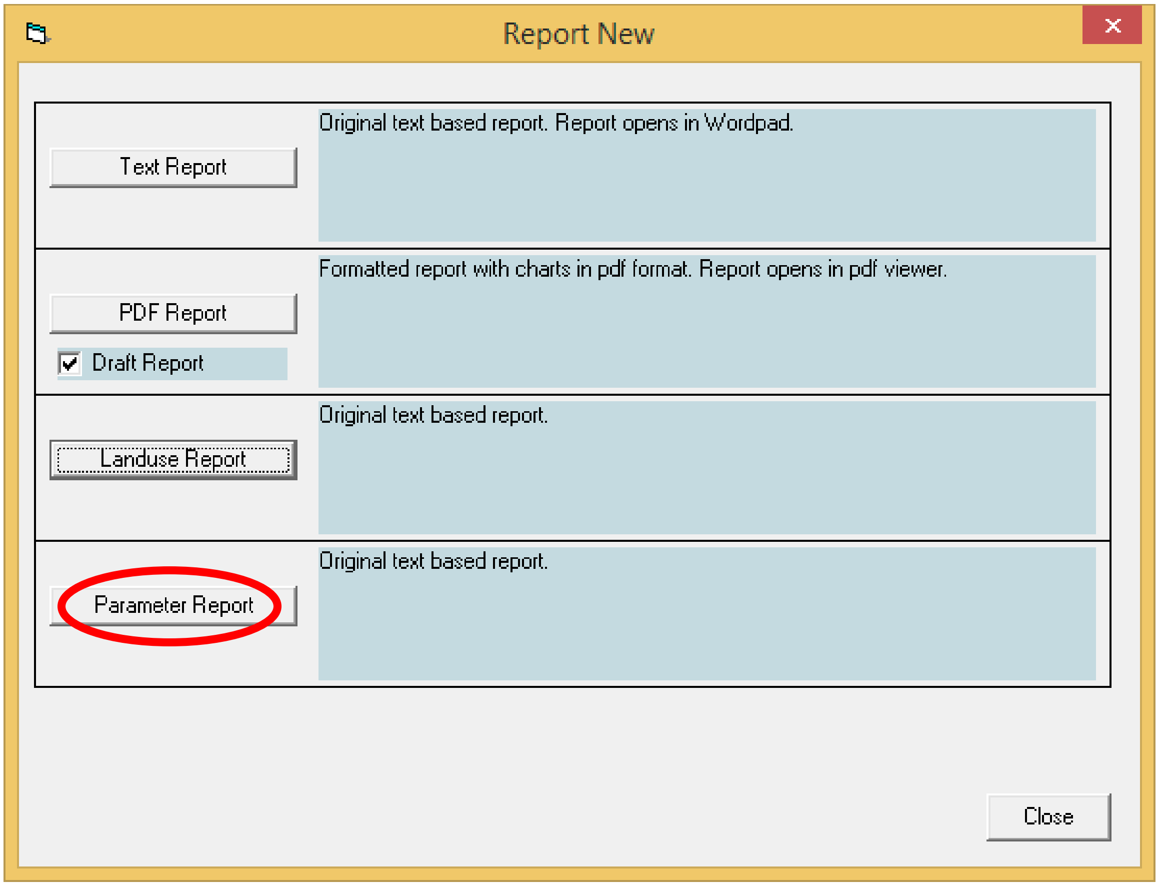
Click on “PDF Report” button to generate the report file in PDF format.



Scroll down the PDF screen to see all of the results or select specific sections using the bookmarks at the left.

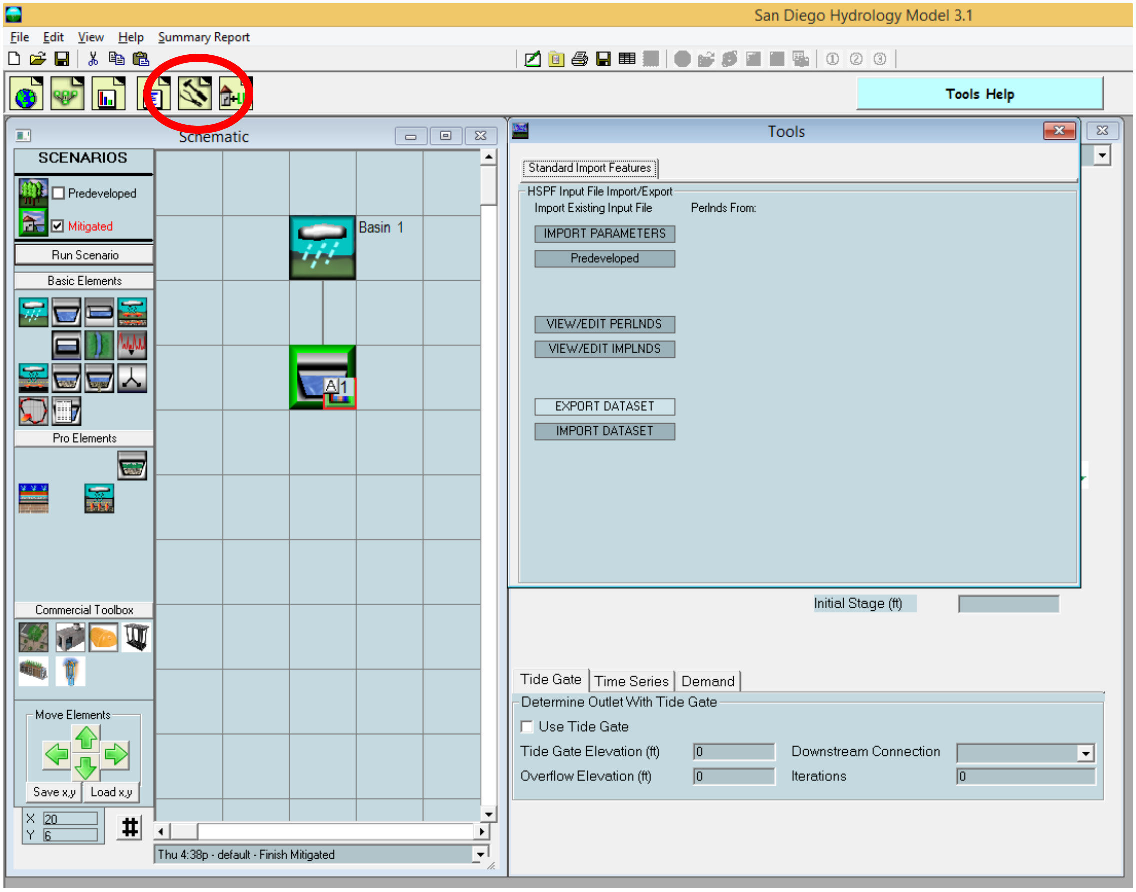


Click on “Landuse Report” button to generate a listing of the input basin land use data in WordPad RTF format.



Click on “Parameter Report” button to generate a listing of the HSPF input parameter values that have been changed from their default values. The listing is in WordPad RTF format. If the listing is blank then there have been no HSPF input parameter value changes made.

TOOLS SCREEN

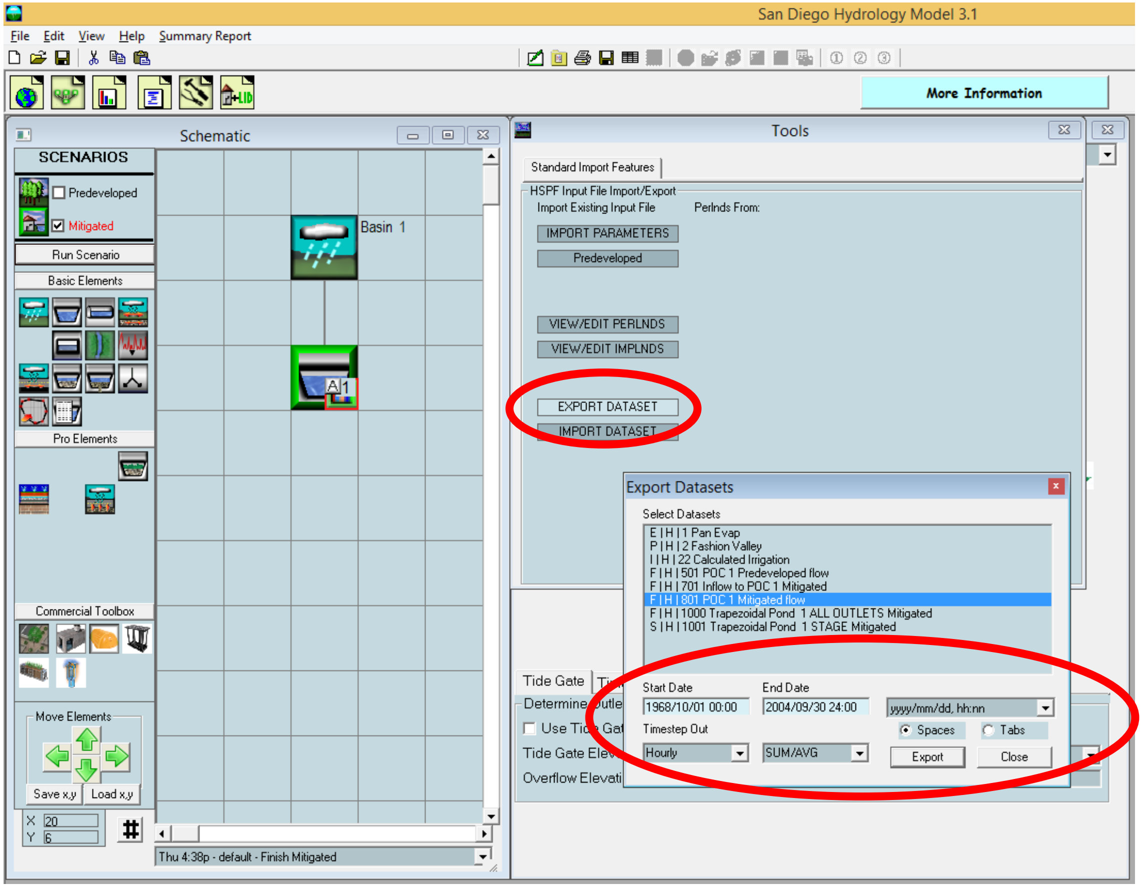


The Tools screen is accessed with the Tools tool bar (second from the right). The two purposes of the Tools screen are:

(1) To allow users to import HSPF PERLND parameter values from existing HSPF UCI files and/or view and edit SDHM 3.1 PERLND parameter values.

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

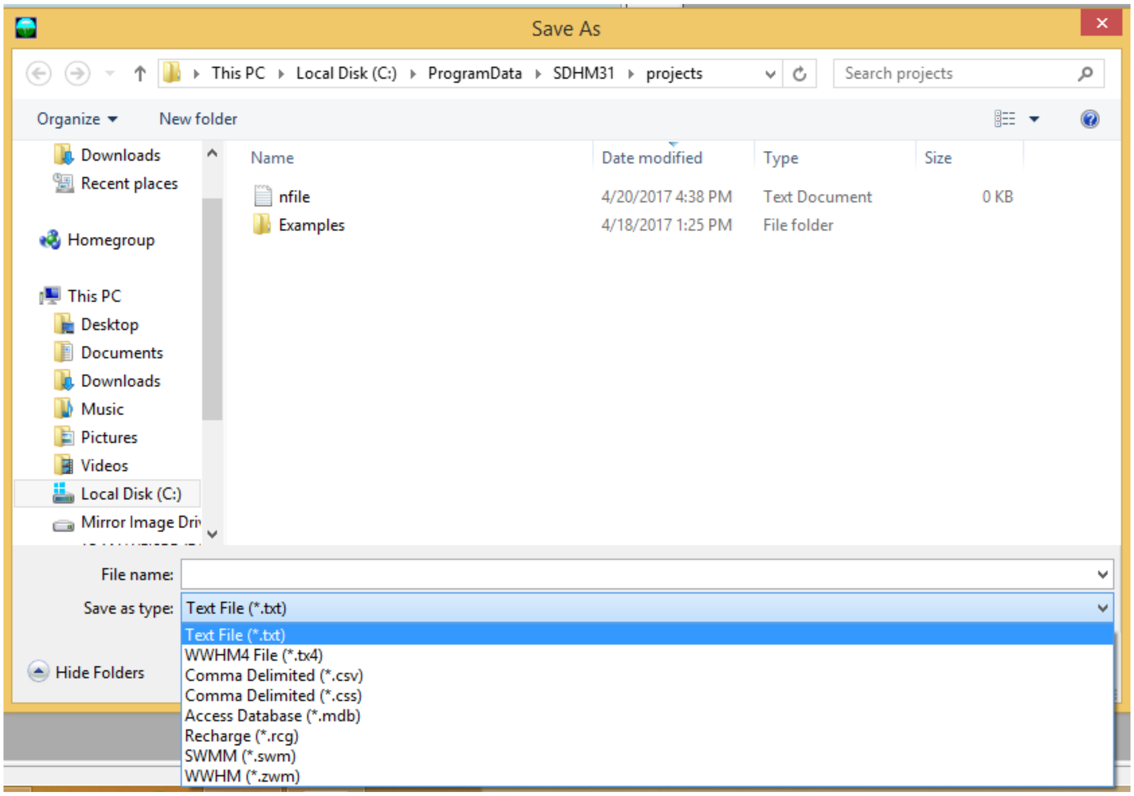
To export a time series dataset click on the Export Dataset box.



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 (hourly, 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 hourly 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.

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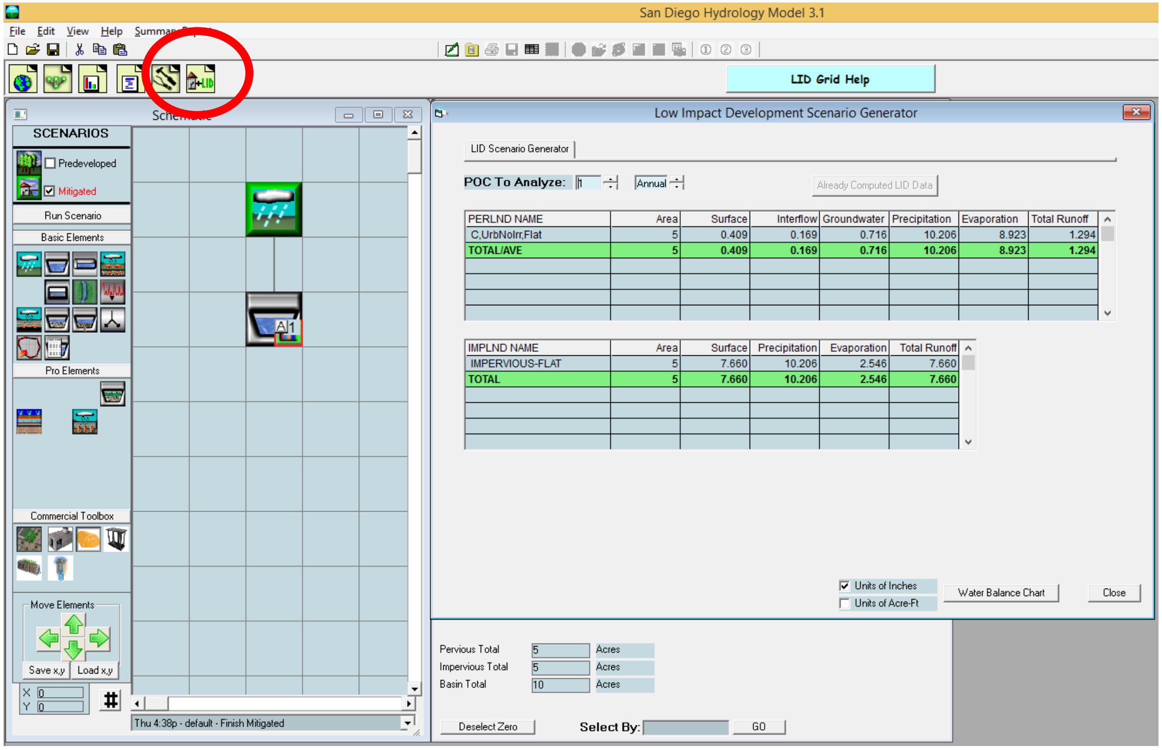
LID ANALYSIS SCREEN

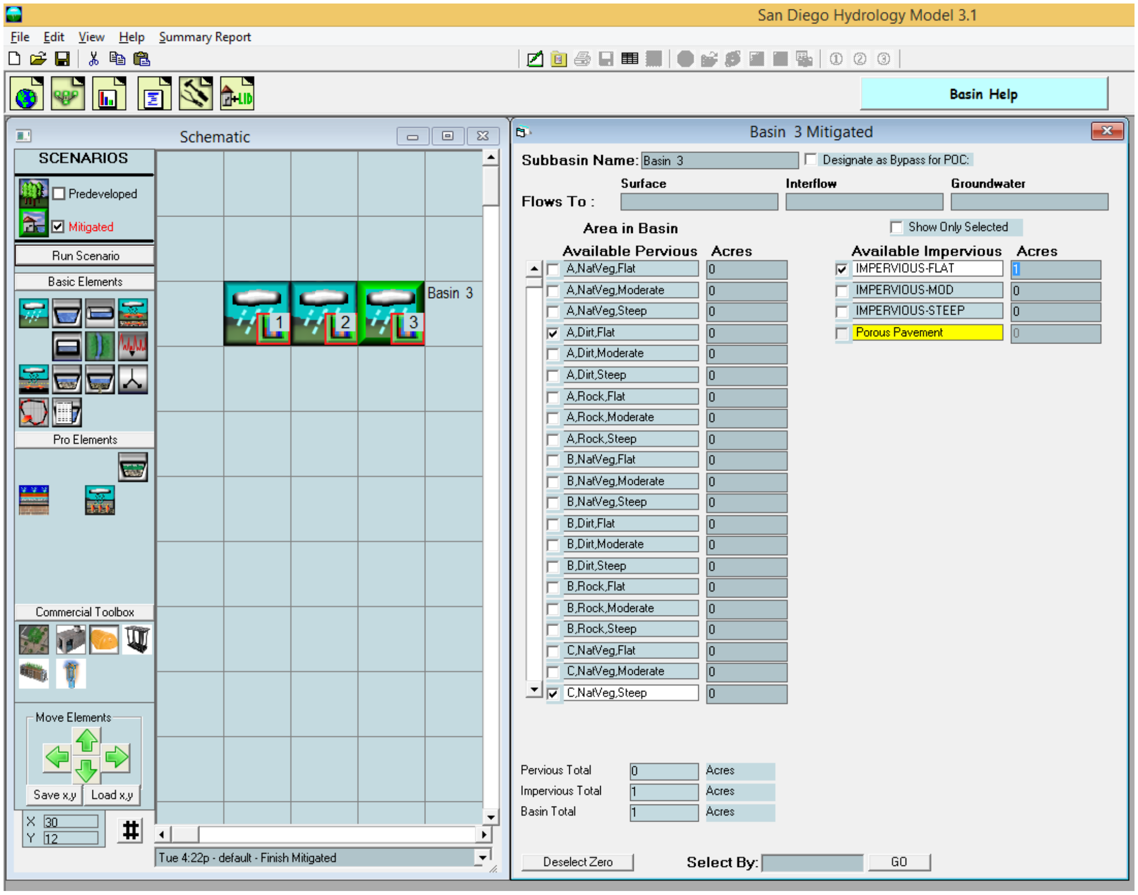


The LID tool bar button (farthest on the right) brings up the Low Impact Development Scenario Generator screen.

The LID scenario generator is a completely optional tool and is not needed for HMP sizing. It provides additional information that may be of interest to the user, but is not required for a project permit submittal.

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.

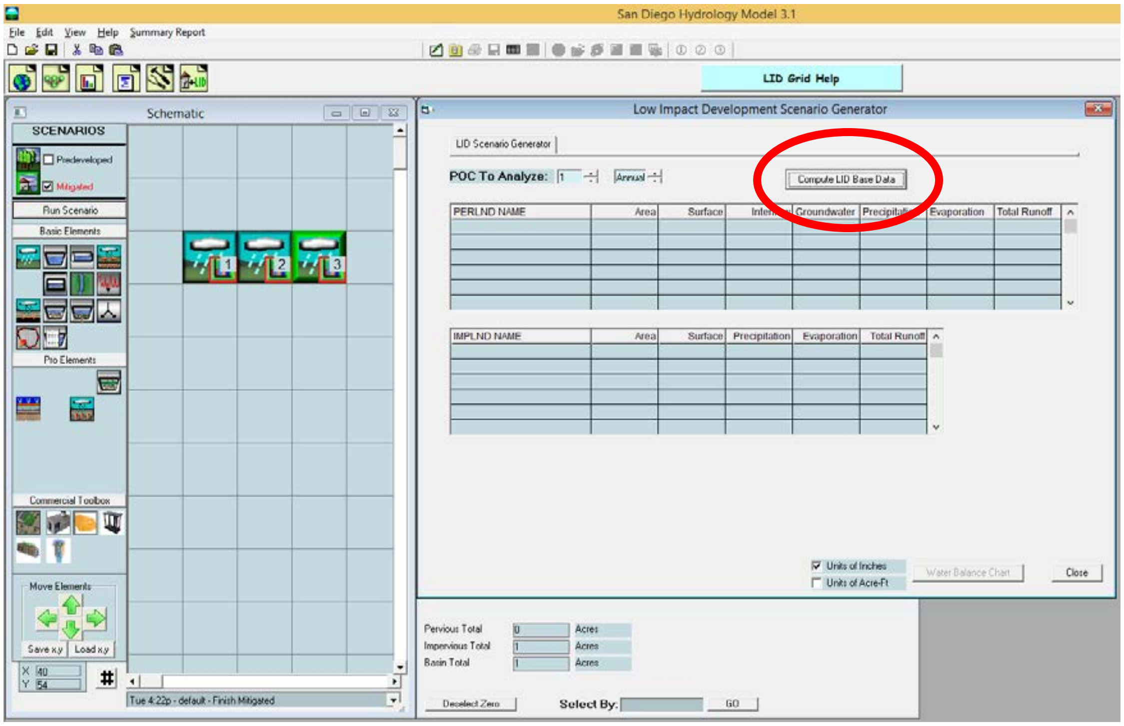
NOTE: The LID scenario generator works only in the Mitigated scenario.



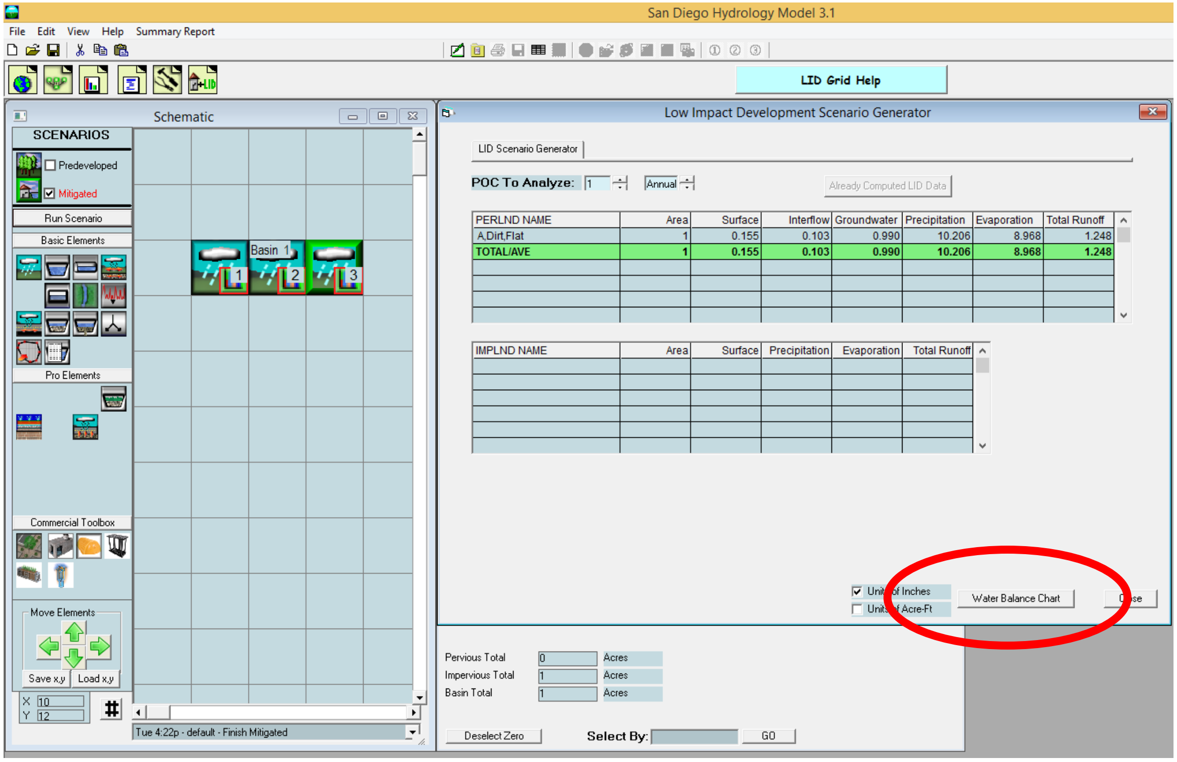
The easiest way to compare different land use conditions is to place all of them on the same Schematic Editor screen grid in the Mitigated scenario. Each basin can then represent a different land use condition. Because the LID scenario generator only compares runoff volume there is no need to do any 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, Dirt, Flat
Basin 2: 1 acre C, NatVeg, 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 based on its POC number.



For Basin 1 (1 acre of A, Dirt, Flat) the distribution of the precipitation is:
Surface runoff = 0.155 inches per year
Interflow = 0.103 inches per year
Groundwater = 0.990 inches per year
Evaporation = 8.968 inches per year

The sum of the surface runoff + interflow + groundwater + evaporation equals 10.216 inches per year. The precipitation at this site equals 10.206 inches per year. The difference is the initial storage in the soil column.

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 Water Balance Chart button.

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 dirt 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 C soil with natural vegetation 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.

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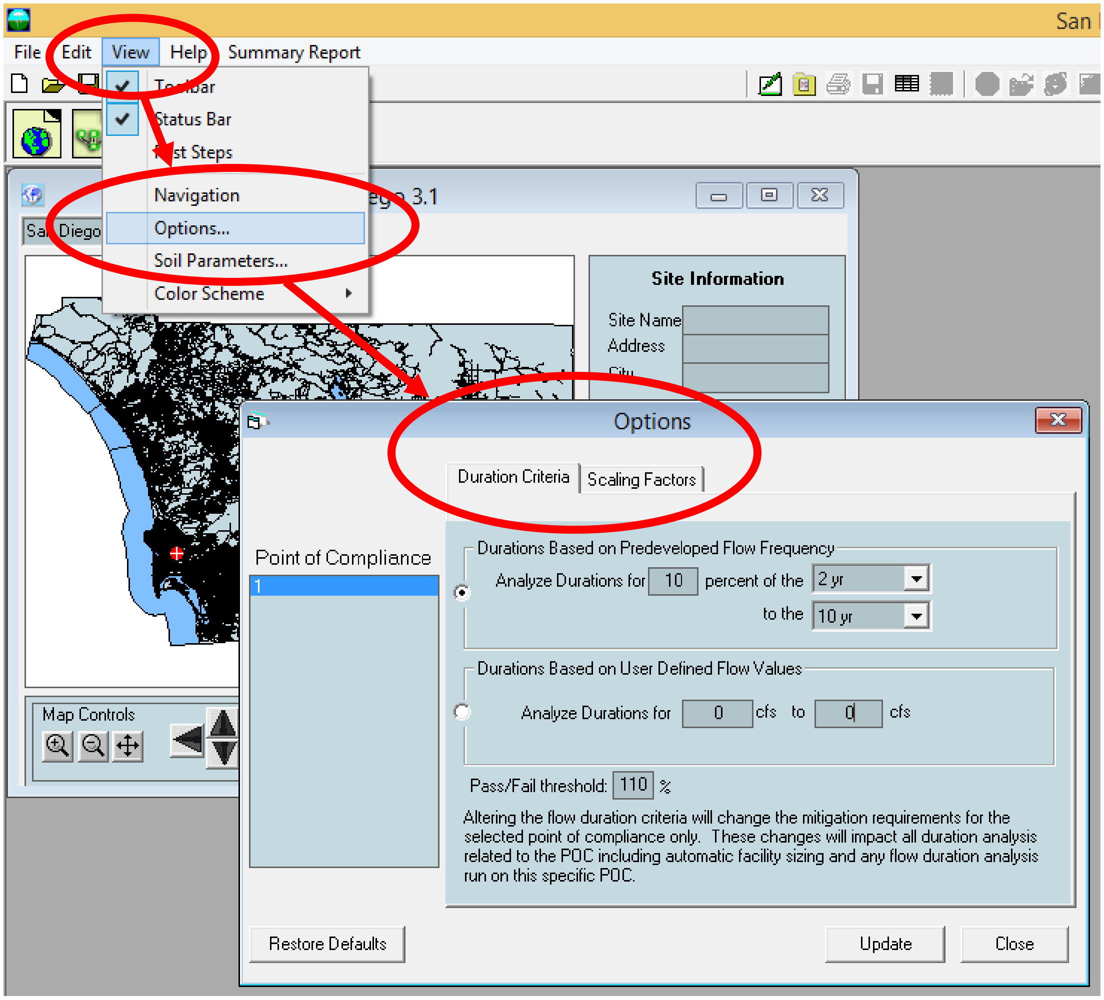
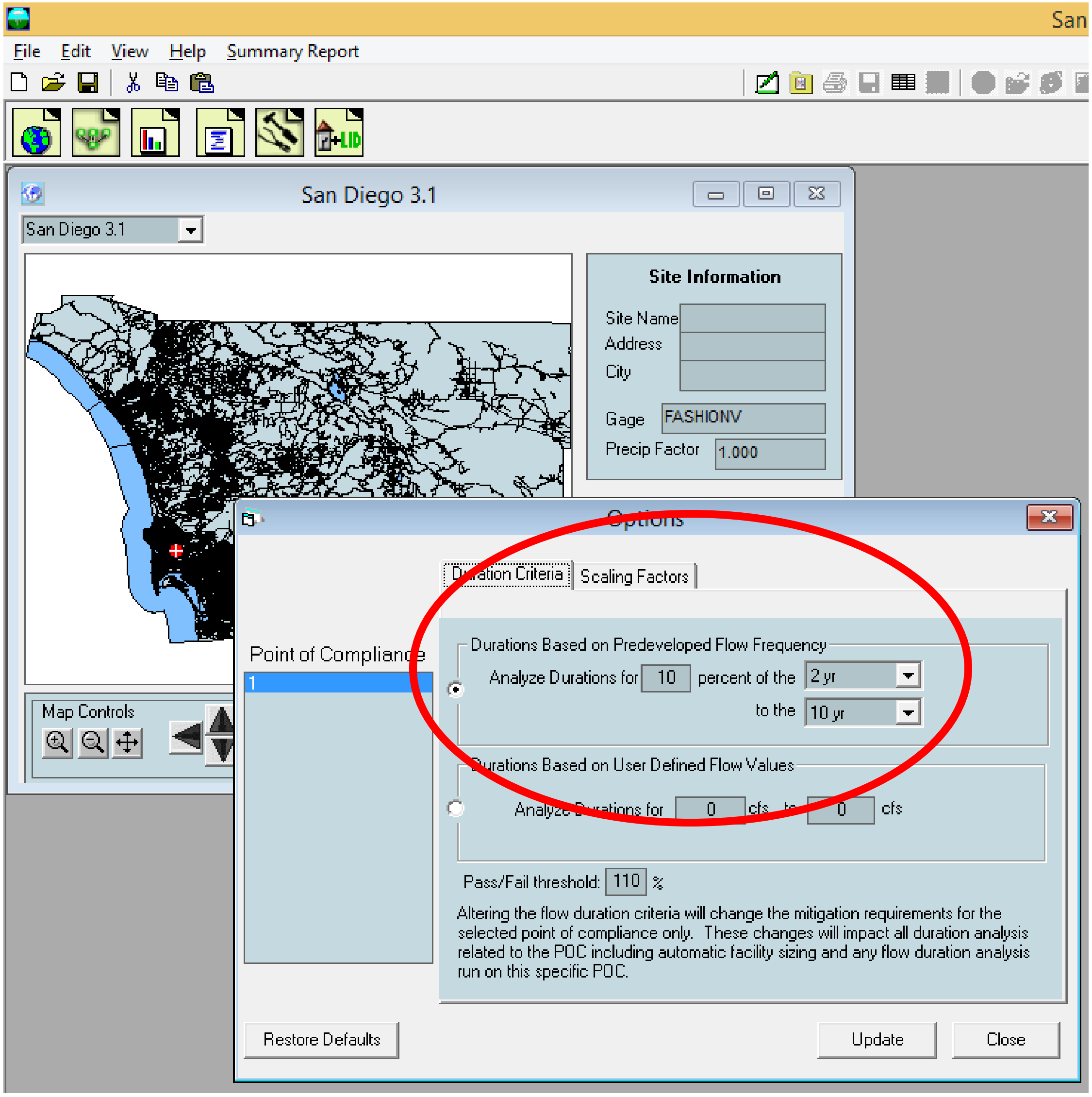
OPTIONS



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 HMP flow duration matching and scaling factors for climate variables.

DURATION CRITERIA



The HMP flow duration criterion is:

1. If the post-development flow duration values exceed any of the Predevelopment flow levels between the lower threshold (x% of the two-year) and 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.

The duration criteria in SDHM 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 (Weibull calculated) flow frequency, or (2) durations based on user defined flow values. The Predevelopment (Weibull calculated) flow frequency is the default method in SDHM 3.1.

If using durations based on Predevelopment (Weibull) flow frequency then the percent of the lower limit can be changed from the default (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 then the user should click on that option and input the lower and upper flow values.

The user has the option of changing the lower and upper thresholds based on the following USGS regional regression equations:

Q2 = 3.60*(A^0.672)*(P^0.753)
Q10 = 6.56*(A^0.783)*(P^1.07)

Where A = drainage area (sq. miles)
P = mean annual precipitation (inches)

The lower threshold equals 0.10Q2.

Mean annual precipitation values for the standard 18 San Diego County rain gages included in SDHM 3.1 are shown below.

Rain Gage	Mean Annual Precipitation (in)
Bonita	8.9
Borrego	3.2
CCDA Lindbergh	9.9
Encinitas	10.3
Escondido	13.9
Fallbrook	15.3
Fashion Valley	10.4
Flinn Springs	13.2
Kearny Mesa	11.1
Lake Cuyamaca	30.9
Lake Henshaw	22.4
Lake Wohlford	17.0
Lower Otay	10.5
Oceanside	11.8
Poway	12.2
Ramona	14.4
San Onofre	11.6
San Vicente	12.7
Santee	13.1

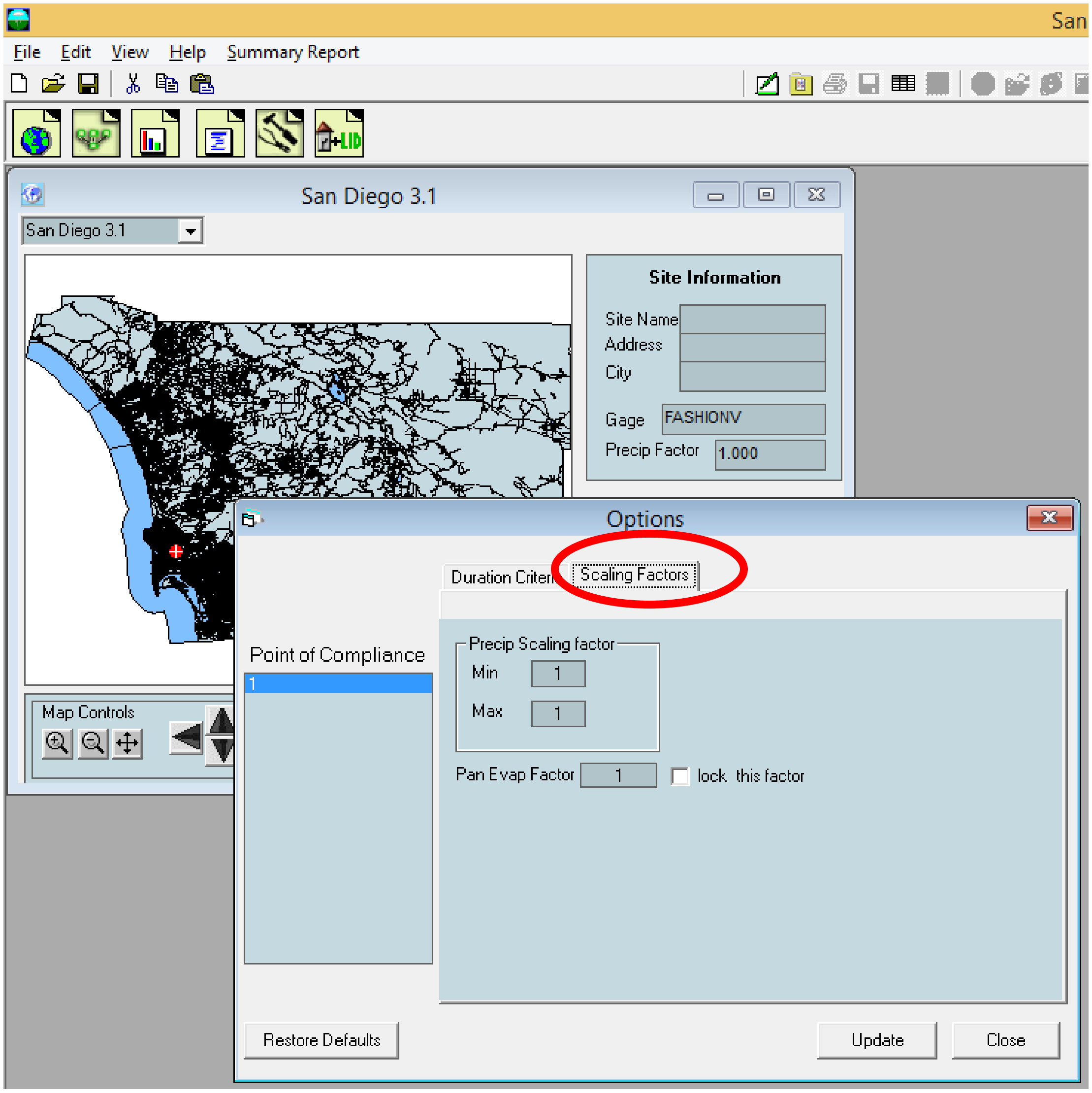
Note that when changing the default threshold value(s) this must be done for each point of compliance if there is more than one point of compliance.

The default pass/fail threshold is 110%. This value cannot 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.

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.

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.

Reselect the project location on the county map to apply the new scaling factor even if the actual project location has not changed.

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APPENDIX A: SAN DIEGO BMP DESIGN MANUAL EXAMPLES

The following Appendix A design manual examples and descriptions have been provided by Rick Engineering.

USING SDHM 3.1 TO MODEL BMPS PRESENTED IN THE FEBRUARY 2016 MODEL BMP DESIGN MANUAL SAN DIEGO REGION

This Appendix provides guidance for modeling BMPs presented in the February 2016 Model BMP Design Manual San Diego Region (Model BMP DM). Throughout this Appendix, references to other Appendices (e.g., Appendix B, D, E, or G) are referencing appendices of the Model BMP DM, and also apply to local permitting agencies' BMP DMs that follow the format of the Model BMP DM.

A project's storm water quality management plan (SWQMP) must document calculations showing that each drainage management area (DMA) has implemented a BMP or a series of BMPs to meet both pollutant control and flow control requirements, unless the DMA meets criteria to be excluded from these calculations (see Chapter 5 of the local permitting agency's BMP DM for exclusion criteria). Users must refer to the local permitting agency's BMP Fact Sheets for jurisdictionally specific guidance related to design of BMPs. BMPs must meet the local permitting agency's *Design Criteria and Considerations* presented in the BMP Fact Sheets. Follow the *Conceptual Design and Sizing Approach when Storm Water Flow Control is Applicable* presented in the BMP Fact Sheet when sizing a BMP for combined flow control and pollutant control.

For BMPs used in series (e.g., runoff is directed into site design BMPs upstream of a structural BMP, or overflow from a structural BMP designed for pollutant control requires additional flow control in a separate structural BMP) the BMPs can be linked together in SDHM. Refer to the guidance sections in this Appendix for guidance for each BMP applied in the project.

Guidance is provided for the BMPs listed in Table A-1.

Table A-1
Model BMP DM BMP Fact Sheets and Applicable Guidance Section in this Appendix

BMP Fact Sheet	Applicable Guidance Section
SD-1: Street Trees (a.k.a. Tree Wells)	A.1 Modeling Tree Wells
SD-5: Impervious Area Dispersion	A.2 Modeling Impervious Area Dispersion
SD-6B: Permeable Pavement (Site Design)	A.3 Modeling Permeable Pavement
SD-8: Rain Barrels	A.4 Modeling Rain Barrels
HU-1: Cistern	A.5 Modeling Cisterns
INF-1: Infiltration Basins	A.6 Modeling Infiltration Basins
INF-2: Bioretention	A.7 Modeling Bioretention, Biofiltration with Partial Retention, and Biofiltration BMPs
INF-3: Permeable Pavement (Pollutant Control) (Structural BMP)	A.3 Modeling Permeable Pavement
PR-1: Biofiltration with Partial Retention	A.7 Modeling Bioretention, Biofiltration with Partial Retention, and Biofiltration BMPs
BF-1: Biofiltration	A.7 Modeling Bioretention, Biofiltration with Partial Retention, and Biofiltration BMPs
FT-4: Dry Extended Detention Basin	A.8 Modeling Dry Extended Detention Basins

Green roofs (SD-6A) are not covered in this Appendix because there is no San Diego specific detail for a green roof. Green roof designs are variable and must be evaluated case by case.

Nutrient sensitive media design for biofiltration (BF-2) does not introduce additional modeling variables beyond those applied in biofiltration with partial retention (PR-1) or biofiltration (BF-1). Therefore, no additional modeling guidance is applicable. Proprietary biofiltration (BF-3), vegetated swale (FT-1), media filter (FT-2), sand filter (FT-3), and proprietary flow-thru treatment control (FT-5) are excluded because they are not flow control BMPs for hydromodification management.

A.1 MODELING TREE WELLS (SD-1)

Tree wells as site design and/or pollutant control and/or flow control BMPs are trees planted in configurations that allow storm water runoff to be directed into the soil immediately surrounding the tree. The tree may be contained within a planter box or structural cells. The surrounding area will be graded to direct runoff to the tree well. Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements. Tree wells may be modeled using the SDHM Pro Element "Biofiltration". See Figure A-1 for an example of element setup for tree wells.

- Enter the required Biofiltration Element data. This is project-specific depending on the configuration of the tree well. If mulch is used, select "Mulch" for Soil Layer 1 and enter the depth consistent with the tree well design. Select "ESM" for the tree well soil (Layer 2 if mulch is used, or Layer 1 if mulch is not used) and enter the depth consistent with the tree well design. If the tree well design includes aggregate storage below the tree well soil, select "GRAVEL" for the next layer (Layer 3 if mulch is used, or Layer 2 if mulch is not used) and enter the depth consistent with the tree well design.

- If the design includes an underdrain, enter the underdrain diameter. Although not specified in BMP Fact Sheet SD-1, typically the minimum underdrain diameter is at least 6 inches (check local jurisdiction requirements). The underdrain offset is the invert elevation of the underdrain measured from the bottom of all layers.

- If infiltration is applicable, select "Yes" for "Infiltration". Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, "Reduction Factor" will be 1. Select "No" for "Use Wetted Surface Area (sidewalls)".

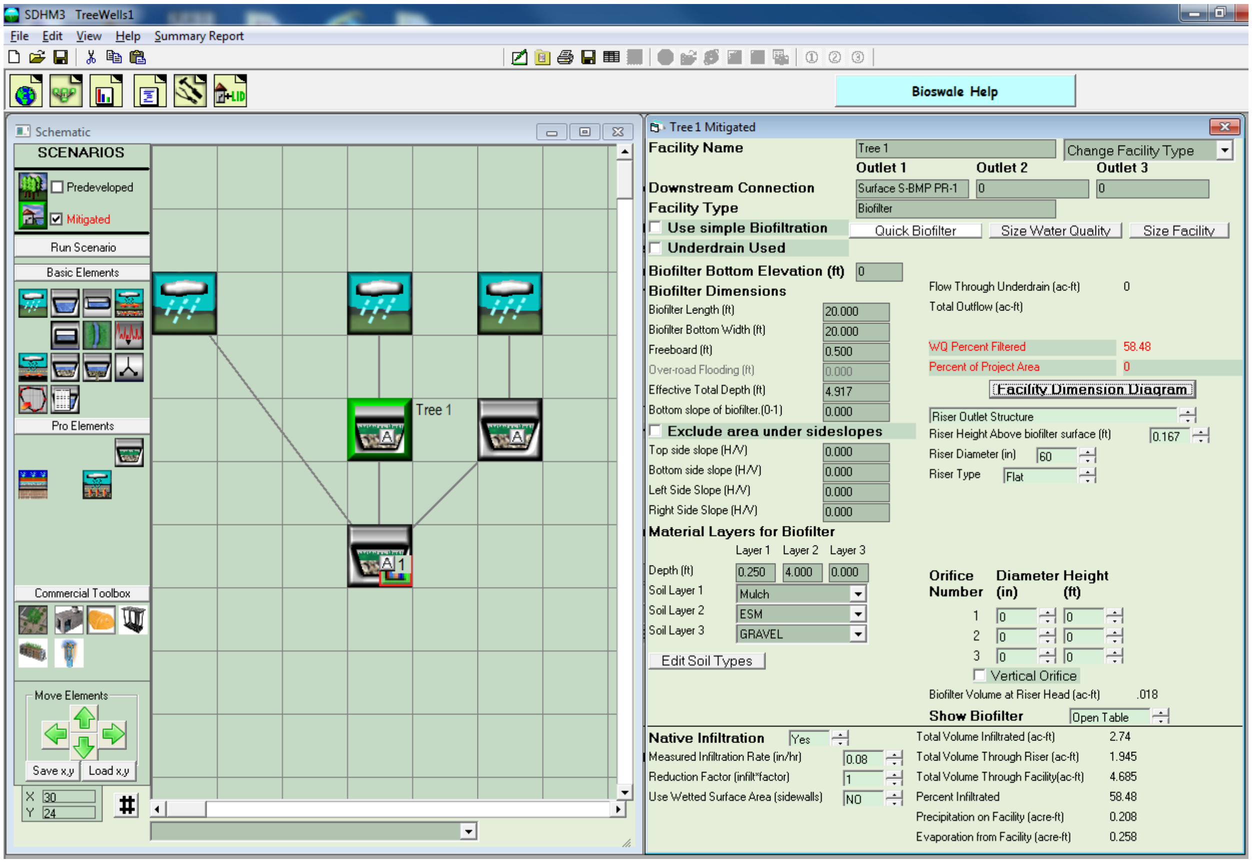

Figure A-1
Example of Tree Well Setup in SDHM 3.1

A.2 MODELING IMPERVIOUS AREA DISPERSION (SD-5)

Impervious area dispersion (dispersion) refers to the practice of effectively disconnecting impervious areas from directly draining to the storm drain system by routing runoff from impervious areas such as rooftops (through downspout disconnection), walkways, and driveways onto the surface of adjacent pervious areas. Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements. Generally there are limits to the ratio of impervious area dispersed to pervious area for the purpose of reducing DCV for pollutant control. However, for the purpose of flow control for hydromodification management, any ratio of impervious area dispersed to pervious area may be modeled, and the model will determine the benefit with respect to flow control. Impervious area dispersion may be modeled using the SDHM Basic Elements for Lateral Basins. See Figure A-2 for an example of element setup for impervious area dispersion.

- Use the “Lateral flow impervious area” element to represent the impervious area that will drain across pervious area. Select the applicable impervious area type (e.g., “IMPERVIOUS-FLAT”).
- Use the “Lateral flow soil basin” element to represent the pervious area that will receive runoff from the impervious area. Select the applicable pervious area soil type, consistent with the requirements for pervious area rainfall loss parameters in post-project condition according to Appendix G.1.4.3 of the BMP Design Manual for the local jurisdiction (e.g., based on the February 2016 Model BMP Design Manual, fill soils shall be modeled as hydrologic soil group Type D soils, but may be modeled as Type C soils if plans indicate the area to be re-tilled and/or amended in the post-project condition).
- Connect the impervious Lateral Basin element to the pervious Lateral Basin element. The pervious Lateral Basin element may subsequently connect to a downstream BMP, along with any other land use basin areas as applicable for the project.

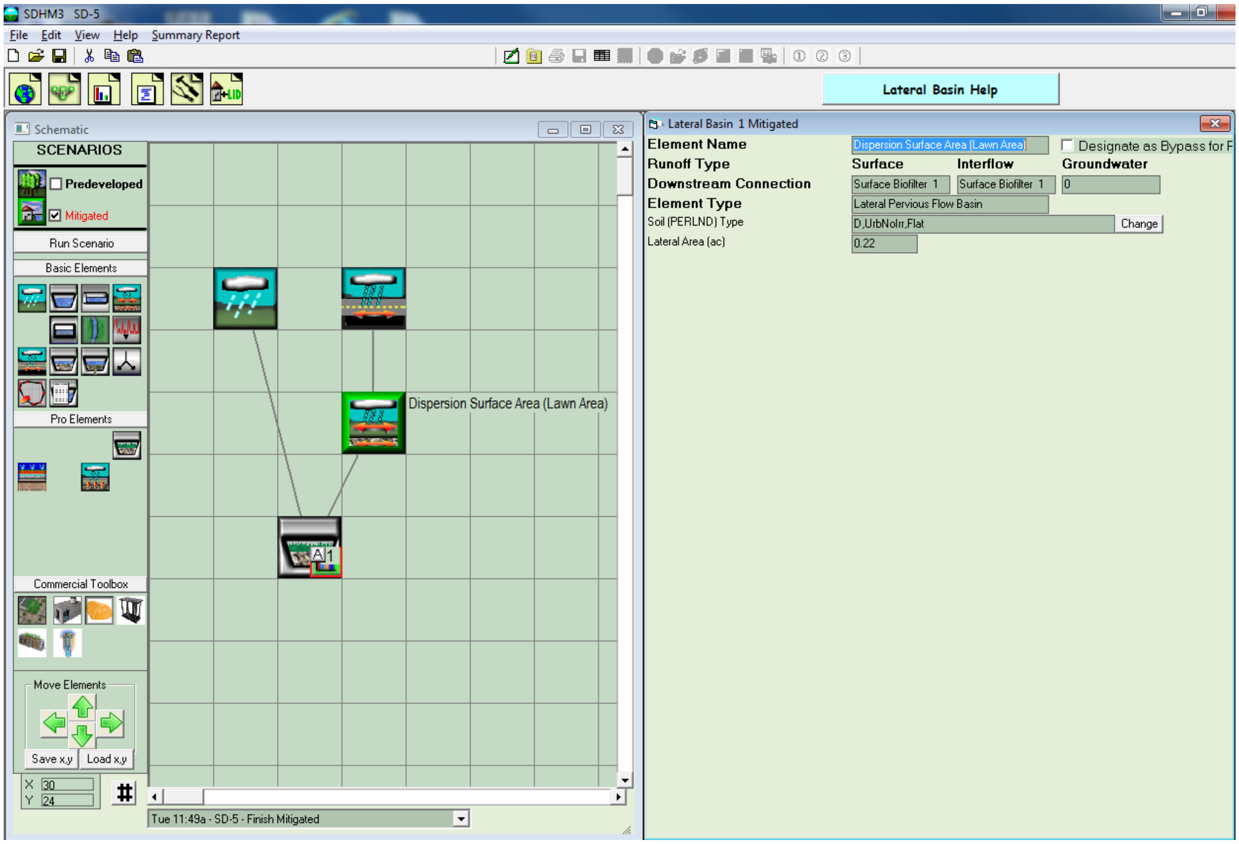

Figure A-2
Example of Impervious Area Dispersion Setup in SDHM 3.1

A.3 MODELING PERMEABLE PAVEMENT (SD-6B and INF-3)

Permeable pavement is pavement that allows for percolation through void spaces in the pavement surface into subsurface layers. There are many types of permeable pavement (e.g., modular paver units or paver blocks, pervious concrete, porous asphalt, and turf pavers). Varying levels of storm water treatment and flow control can be provided depending on the size of the permeable pavement system relative to its drainage area, the underlying infiltration rates, and the configuration of outflow controls. Permeable pavement may be used as a site design BMP (SD-6B) or as a structural BMP (INF-3).

Permeable pavement may be modeled using the SDHM Pro Element "Porous Pavement," provided 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.

Permeable pavement receives direct rainfall, and can receive runoff from additional tributary area. If additional tributary area drains to the permeable pavement, use the applicable SDHM Basic Element for a Lateral Basin (e.g., "Lateral Flow Impervious Area" and/or "Lateral Flow Soil Basin") to represent the tributary area and connect the Lateral Basin Element to the Porous Pavement Element.

Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements, including restrictions or other criteria applicable to additional tributary area.

Additional Considerations for Permeable Pavement as a Site Design BMP (SD-6B)

Permeable pavement as a site design BMP does not have a liner. It may have an underdrain that is elevated within the subsurface storage layer. As a site design BMP permeable pavement can be used to reduce impervious area and DCV. It can be used as a self-retaining area to meet pollutant control BMP sizing requirements. However, reductions in DCV realized through site design BMPs are applicable to pollutant control only and do not relax hydromodification management requirements. To quantify the flow control benefit, the area must be included in the hydromodification management analysis. Typically the area will drain to a structural BMP downstream of the permeable pavement surface. See Figure A-3 for an example of element setup for permeable pavement as a site design BMP.

- Enter the required Porous Pavement Element data. This is project-specific and the layers depend on the type of permeable pavement used. The modeler is responsible to provide documentation of the proposed permeable pavement cross section (corresponding to the layers entered in the model) and the permeable pavement infiltration rate (for confirmation that the proposed permeable pavement meets the three conditions required for the model element).

- Select "Yes" for "Infiltration". Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, "Reduction Factor" will be 1. Select "No" for "Use Wetted Surface Area (sidewalls)".

- If the design includes an underdrain, enter the underdrain diameter. Although not specified in BMP Fact Sheet SD-6B, typically the minimum underdrain diameter is at least 6 inches (check local jurisdiction requirements). The "Height" is the invert elevation of the underdrain measured from the bottom of all layers. Enter the underdrain height, consistent with Appendix B.2.1.3 and any other local jurisdiction requirements (typically the underdrain height is a minimum of 3 inches from the bottom of the aggregate storage layer).

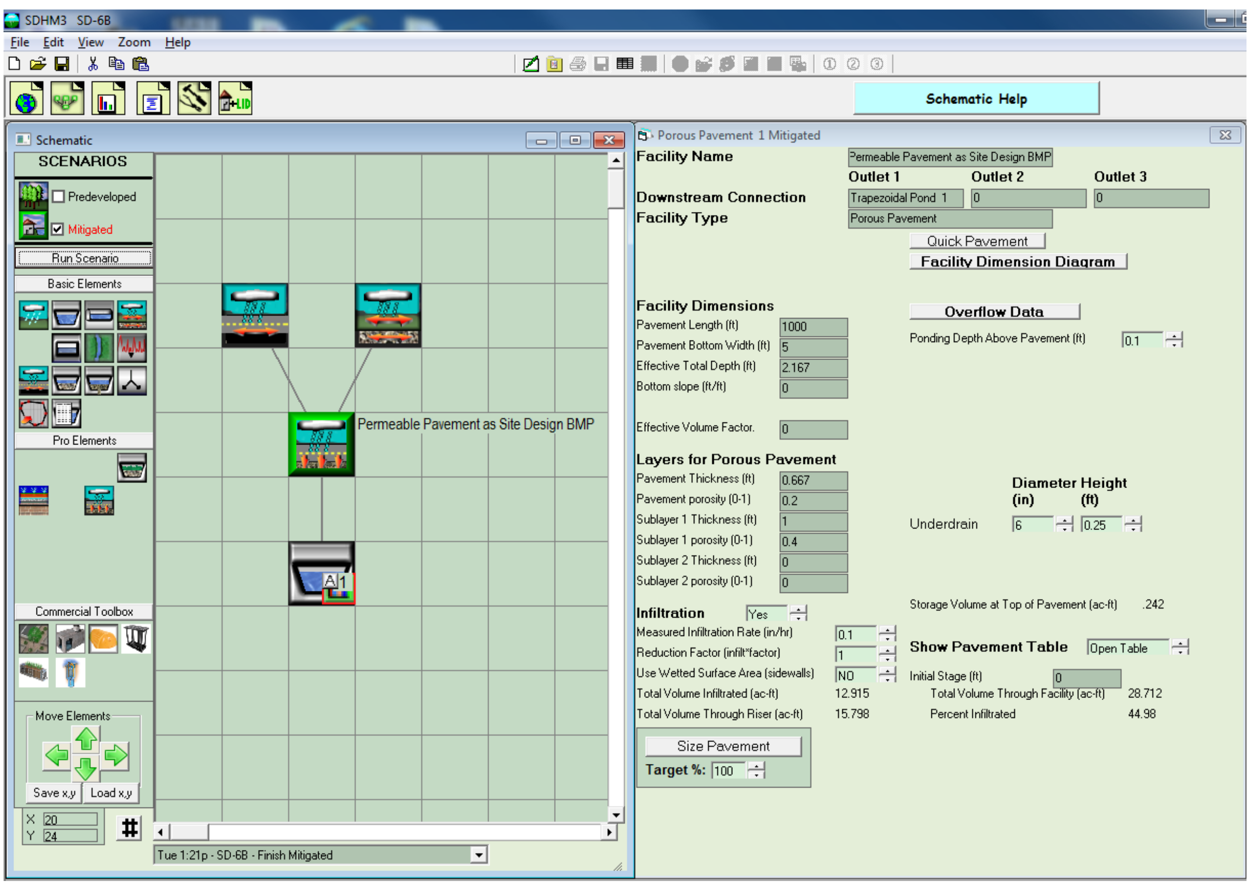

Figure A-3
Example of Permeable Pavement as Site Design BMP (SD-6B) Setup in SDHM 3.1

Additional Considerations for Permeable Pavement as a Structural BMP (INF-3)

There are several ways to use permeable pavement as a structural BMP. It may be a full infiltration BMP, partial infiltration BMP, flow-thru treatment BMP, or flow control BMP (see BMP Fact Sheet INF-3 in Appendix E).

When using permeable pavement as a combined pollutant control and flow control BMP, prior to performing hydromodification management calculations, determine the minimum surface area and cross section for the BMP to meet pollutant control performance standards. From this starting point, the surface area and volume may be increased to meet hydromodification management performance standards.

- Enter the required Porous Pavement Element data. This is project-specific and the layers depend on the type of permeable pavement used. The modeler is responsible to provide documentation of the proposed permeable pavement cross section (corresponding to the layers entered in the model) and the permeable pavement infiltration rate (for confirmation that the proposed permeable pavement meets the three conditions required for the model element).

- If infiltration is applicable, select “Yes” for “Infiltration”. Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, “Reduction Factor” will be 1. Select “No” for “Use Wetted Surface Area (sidewalls)”.

- If the design includes an underdrain, enter the underdrain diameter consistent with the applicable BMP Fact Sheet in Appendix E. If the underdrain will include a flow control orifice, set the underdrain diameter to the size of the outlet orifice diameter for the purpose of calculating the orifice flow rate. The “Height” is the invert elevation of the underdrain measured from the bottom of all layers. Enter the underdrain height, consistent with the applicable BMP Fact Sheet in Appendix E.

See Figure A-4 for an example of element setup for permeable pavement as a structural BMP.

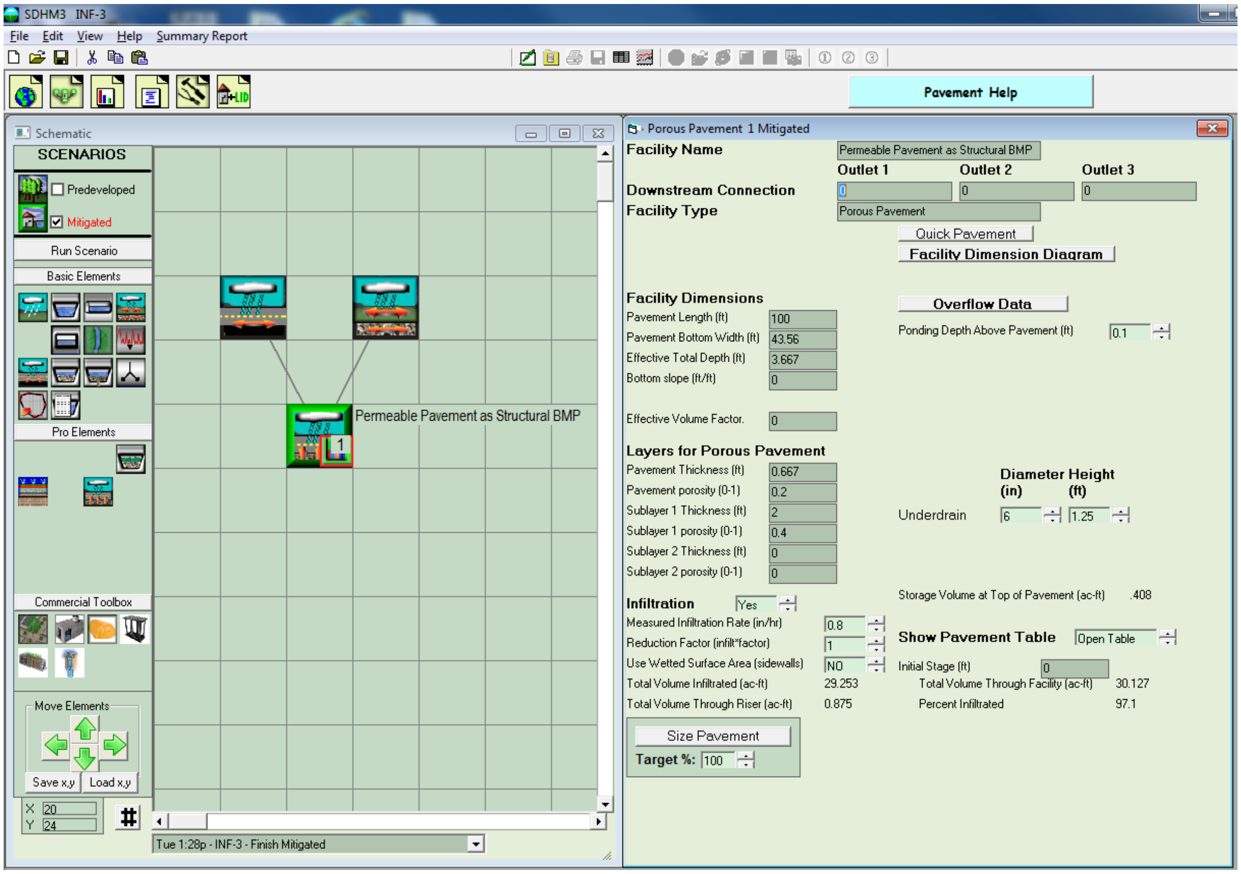

Figure A-4
Example of Permeable Pavement as a Structural BMP (INF-3) Setup in SDHM 3.1

A.4 MODELING RAIN BARRELS (SD-8)

Rain barrels are containers that can capture rooftop runoff and store it for future use such as irrigation or alternative grey water between storm events. Rain barrels tend to be smaller systems, 100 gallons or less, and are used as site design BMPs to remove a portion of the roof runoff from the site discharge (for larger systems serving as a structural BMP, see HU-1 Cisterns). Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements for rain barrels. Rain barrels may be modeled using the SDHM Basic Elements "Trapezoidal Pond," "Storage Tank," "Storage Vault," or "SSD Table". See Figure A-5 for an example of element setup for rain barrels.

- Select the element that best represents the configuration of the rain barrel and enter dimensions that cause the element volume to match the rain barrel volume.
- De-select "Precipitation Applied to Facility."
- De-select "Evaporation Applied to Facility."
- Create an overflow outlet that will allow unrestricted overflow when the rain barrel volume is full, such as a weir that will convey a large flow at a low head (e.g., a 36-inch riser or a 10-foot weir). The purpose of this is to cause the model to send excess flow to the next downstream element without storage.
- Select "Yes" for "Infiltration". Enter an infiltration rate that will cause the volume of the rain barrel to drain in approximately 96 hours. Enter "1" for the "Reduction Factor". Select "No" for "Use Wetted Surface Area (sidewalls)". Note for the purpose of modeling rain barrels, the infiltration rate entered is not a true infiltration rate supported by onsite testing and documented with Worksheet D.5-1. The purpose of using infiltration in the model rather than a low flow outlet is to remove the rain barrel volume from draining downstream. Therefore the infiltration rate is calculated to represent manual drawdown of the rain barrel volume.
- Use the "Analyze" option on the element that represents the rain barrel (right-click the element and select "Analyze," so an "A" appears in the element). This will make the element stage and outflow data available in the Analysis Window so the user and/or reviewer may verify that the overflow outlet conveyed excess flow to the next downstream element without storage.

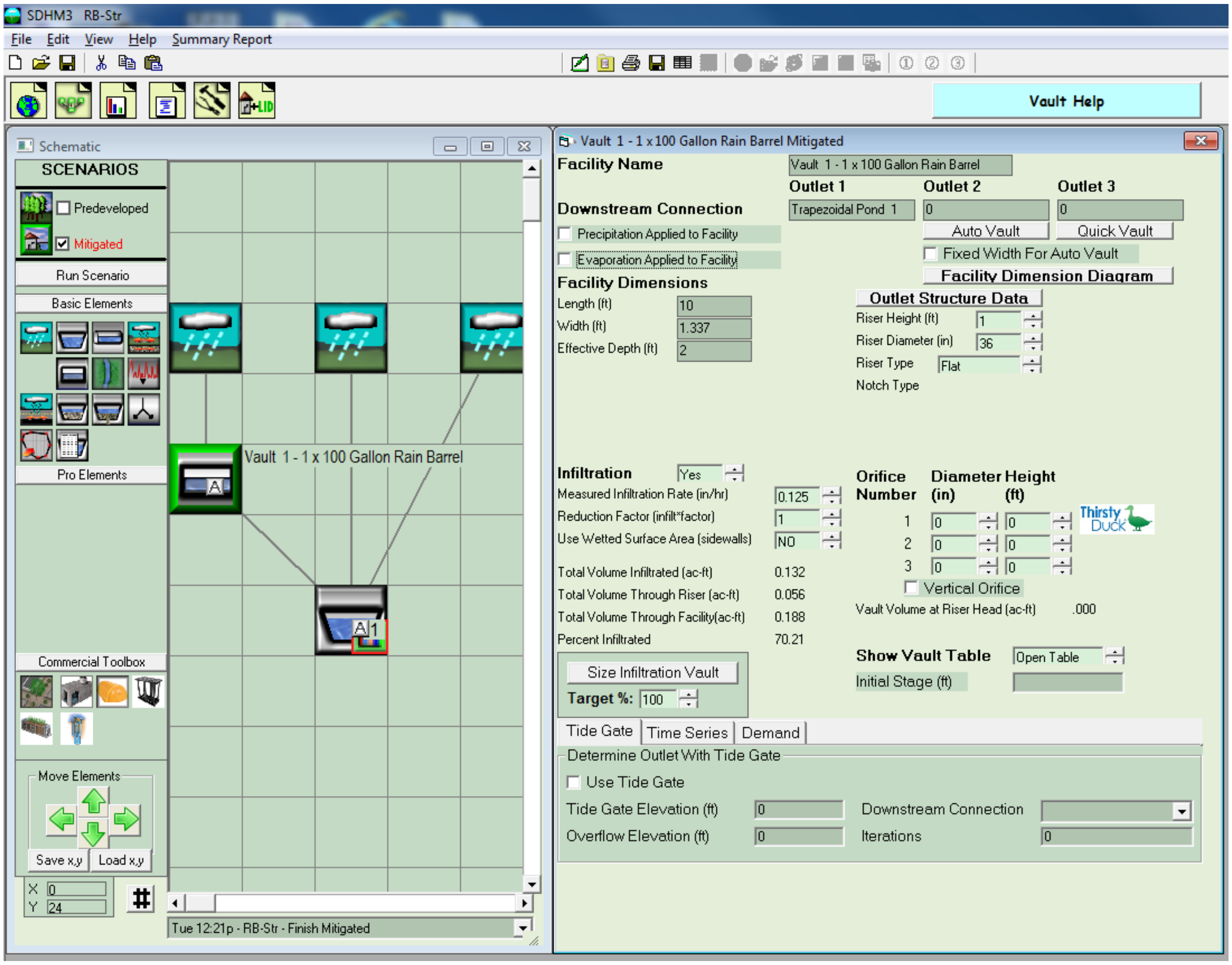

Figure A-5
Example of Rain Barrel (SD-8) Setup in SDHM 3.1

A.5 MODELING CISTERNS (HU-1)

Cisterns are containers that capture runoff (typically rooftop runoff) and store it for future use such as irrigation or alternative grey water between storm events. Cisterns can be aboveground or below ground systems. Cisterns are structural BMPs that can provide pollutant control and/or flow control for a project. For rain barrels or other smaller systems used as site design BMPs, see SD-8 Rain Barrels. Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements for cisterns. Cisterns may be modeled using the SDHM Basic Elements "Trapezoidal Pond," "Storage Tank," "Storage Vault," or "SSD Table".

- Select the element that best represents the configuration of the cistern and enter dimensions that cause the element volume to match the cistern volume.
- De-select "Precipitation Applied to Facility."
- De-select "Evaporation Applied to Facility."
- For harvest and use applications in which a portion of the stored runoff will be used onsite, select "Yes" for "Infiltration". Enter an infiltration rate that will mimic the rate of use of the stored runoff. Enter "1" for the "Reduction Factor". Select "No" for "Use Wetted Surface Area (sidewalls)". Note for this purpose, the infiltration rate entered is not a true infiltration rate supported by onsite testing and documented with Worksheet D.5-1. The purpose of using infiltration in the model is to remove the harvest and use volume from the model and not route this volume downstream. Therefore the infiltration rate is calculated to represent the controlled release of the stored runoff for onsite use.

Additional Considerations for Cistern Used as Pollutant Control BMP Located Upstream of Flow Control BMP

When the cistern is designed for pollutant control only and does not provide complete flow control for the project, the overflow may be routed to a downstream BMP for flow control. See Figure A-6 for an example element setup for a pollutant control only cistern draining to a downstream BMP for flow control.

- If the cistern configuration includes an internal bypass structure with room to build head above the overflow outlet (e.g., an internal standpipe or weir), create the overflow outlet in the model consistent with the proposed overflow outlet (e.g., an 8-inch riser or 2-foot weir, with freeboard as available in the structure).
- If the cistern configuration includes a bypass structure at the cistern entrance that activates bypass when the cistern volume is full, create an overflow outlet in the model

that will allow unrestricted overflow when the cistern volume is full, such as a weir that will convey a large flow at a low head (e.g., a 96-inch riser or a 25-foot weir). The purpose of this is to cause the model to send excess flow to the next downstream element without storage.

- Use the “Analyze” option on the element that represents the cistern (right-click the element and select “Analyze,” so an “A” appears in the element). This will make the element stage and outflow data available in the Analysis Window so the user and/or reviewer may verify the maximum stage occurring in the cistern, and (if applicable) verify that the overflow outlet conveyed excess flow to the next downstream element without storage.

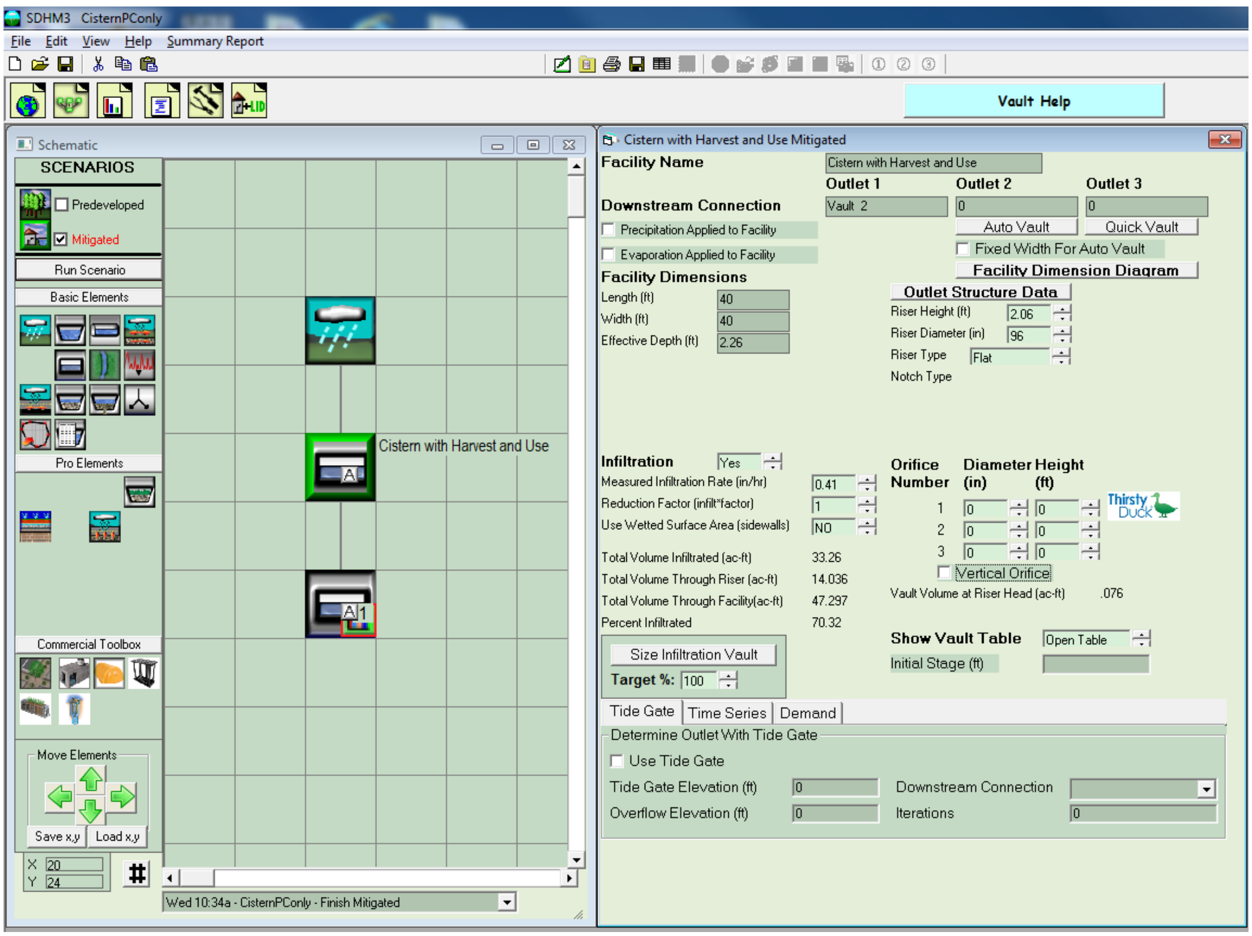

Figure A-6
Example of Cistern Used as Pollutant Control BMP Located Upstream of Flow Control BMP Setup in SDHM 3.1

Additional Considerations for Cistern Used as Combined Pollutant Control and Flow Control BMP

When the cistern is designed to provide combined pollutant control and flow control for the project within a single BMP, the low flow control outlet and overflow outlet will be within the cistern. See Figure A-7 for an example element setup for a cistern as a combined pollutant control and flow control BMP.

- Create a low flow outlet (e.g., an orifice) above the water level associated with the cistern harvest and use volume to provide flow control for runoff discharged downstream, consistent with the proposed low flow outlet.
- Create an overflow outlet in the model consistent with the proposed overflow outlet.

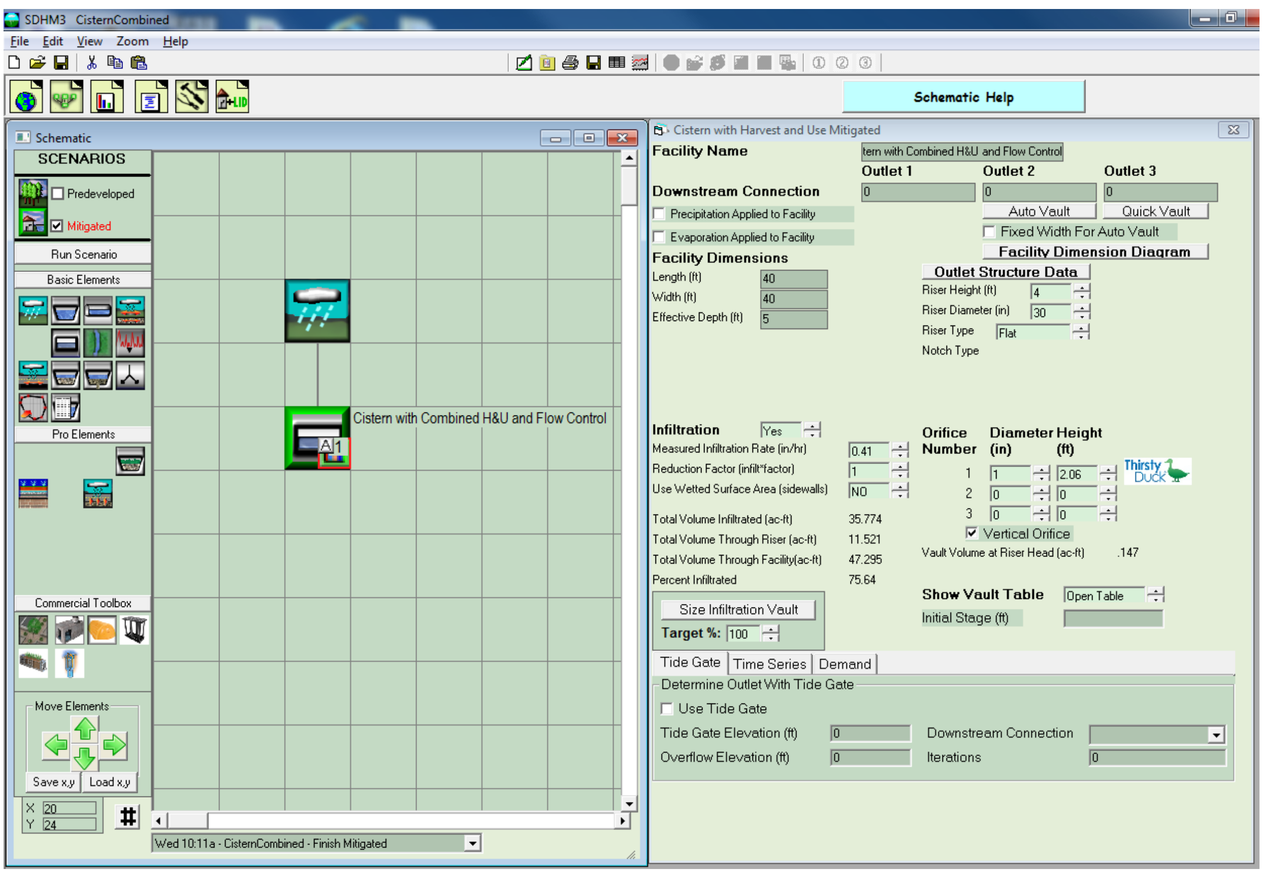

Figure A-7
Example of Cistern as Combined Pollutant Control and Flow Control BMP Setup in SDHM 3.1

A.6 MODELING INFILTRATION BASINS (INF-1)

An infiltration basin (INF-1) typically consists of an earthen basin with a flat bottom constructed in uncompacted native soils. An infiltration basin retains storm water and allows it to evaporate and/or percolate into the underlying soils. Infiltration basins can also be constructed as linear trenches or as underground infiltration galleries. Typical infiltration basin components include freeboard and surface ponding, and may include an aggregate storage layer. While an infiltration basin may be vegetated, the INF-1 category does not include engineered soil media. For infiltration BMPs that include engineered soil media and planting, see bioretention (INF-2).

There are several elements applicable to various infiltration basin configurations. Infiltration basins that do not include an aggregate storage layer may be modeled using the Basic Elements "Trapezoidal Pond," "Storage Tank," "Storage Vault," or "Irregular Shaped Pond," or an applicable Commercial Element. Infiltration basins that do include an aggregate storage layer may be modeled using the Basic Element "Gravel Trench Bed," or an applicable Commercial Element.

Prior to performing hydromodification management calculations, determine the minimum surface area and cross section for the BMP to meet pollutant control performance standards. From this starting point, the surface area and volume may be increased to meet hydromodification management performance standards. Note that any forebay surface area and volume should not be included as part of the infiltration basin model as the purpose of the forebay is to trap materials that clog BMPs and prevent infiltration.

- Select the element that best represents the configuration of the infiltration basin.
- For open-air, surface-level infiltration basins, select "Precipitation Applied to Facility" and "Evaporation Applied to Facility." For closed, underground infiltration basins, de-select "Precipitation Applied to Facility" and "Evaporation Applied to Facility."
- Select "Yes" for "Native Infiltration". Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, "Reduction Factor" will be 1. For elements with sidewalls, consideration of infiltration from sidewalls, "Use Wetted Surface Area (sidewalls)", is project-specific, depending on the BMP design.

See Figure A-8 for an example of element setup for a surface-level infiltration basin with no aggregate storage layer. See Figure A-9 for an example of element setup for a surface-level infiltration basin with an aggregate storage layer.

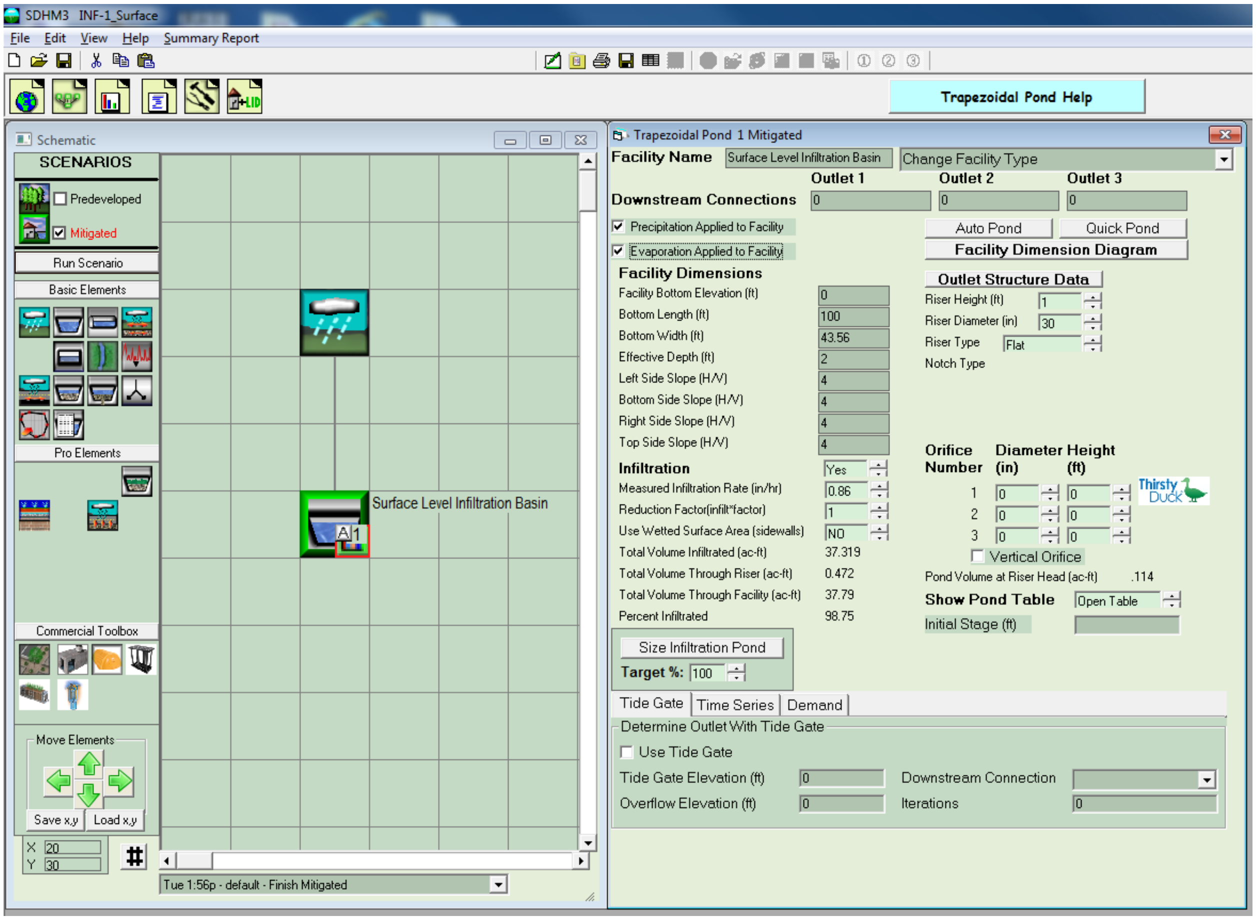

Figure A-8

Example of Surface-Level Infiltration Basin (INF-1) with No Aggregate Storage Setup in SDHM 3.1

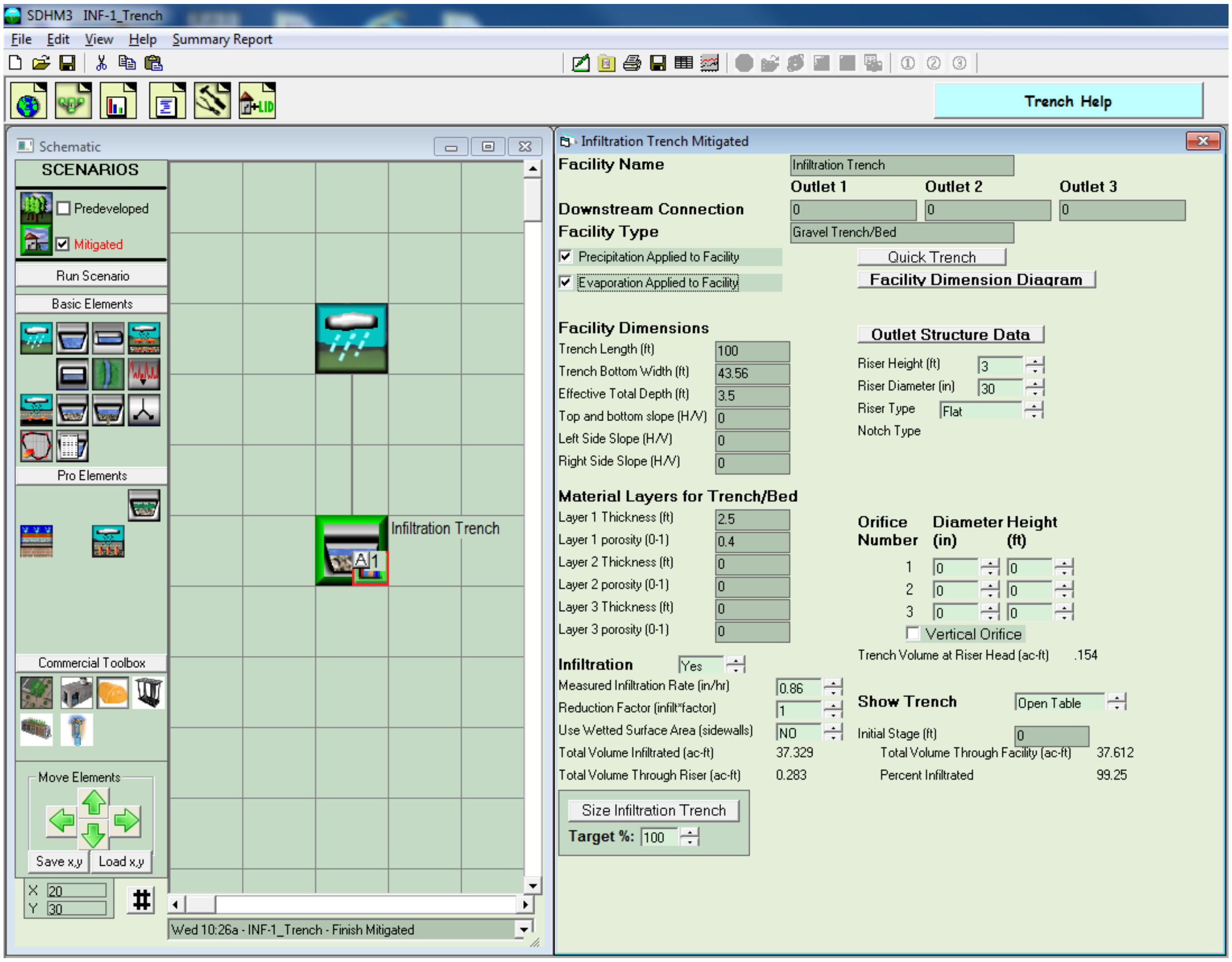

Figure A-9

Example of Surface-Level Infiltration Basin (INF-1) with Aggregate Storage Setup in SDHM 3.1

A.7 MODELING BIORETENTION (INF-2), BIOFILTRATION WITH PARTIAL RETENTION (PR-1), and BIOFILTRATION (BF-1) BMPs

Bioretention (INF-2), biofiltration with partial retention (PR-1), and biofiltration (BF-1) BMPs are similar in that they each include the following layers from top to bottom: freeboard, shallow surface ponding, non-floating mulch, engineered soil media, filter course layer, and aggregate storage layer. However, each has certain defining characteristics that make it a unique category corresponding to a specific BMP Fact Sheet.

- Bioretention (INF-2) has no underdrain. It has no liner, and has uncompacted native soils at the bottom of the facility. Bioretention provides for infiltration of the DCV into the native soils at the bottom of the facility.
- Biofiltration with partial retention (PR-1) has an underdrain, which is elevated ≥3 inches above the bottom elevation of the aggregate storage layer. It has no liner, and has uncompacted native soils at the bottom of the facility. Biofiltration with partial retention provides for infiltration of a portion of the DCV into the native soils at the bottom of the facility, and the remaining portion of the DCV may flow through the underdrain.
- Biofiltration (BF-1) has an underdrain, which is not elevated other than the minimum 3 inches above the bottom elevation of the aggregate storage layer. It may include a liner or compacted native soils at the bottom of the facility. Biofiltration design provides for all of the DCV to flow through the underdrain.

All of the above BMPs may be modeled using the SDHM Pro Element "Biofiltration".

Each layer of the BMP is discussed below from top to bottom of the facility. Note that minimum and/or maximum depths for any of the layers discussed below may vary by jurisdiction. Refer to the local BMP Design Manual for the jurisdiction in which the project is located for requirements. Prior to performing hydromodification management calculations, determine the minimum surface area and cross section for the BMP to meet pollutant control performance standards. From this starting point, the surface area and volume may be increased to meet hydromodification management performance standards.

- **Freeboard,** defined in SDHM as "total height above top of outlet to top of biofilter," provides room for head over overflow structures in the model. Based on applicable BMP Fact Sheets in Appendix E, the minimum freeboard is 12 inches (1 foot). For the purpose of the model, the amount of "freeboard" needs to be enough to contain the highest water surface elevation above the outlet structure that occurs in the model during the simulation. Note that the need for conveyance of the 100-year storm for flood control and other drainage design requirements may require additional depth or increased freeboard, which must be evaluated separately in the project's drainage study.
- **Shallow surface ponding** in the model will be defined by the "Riser Outlet Structure" or "Vertical Orifice + Overflow". Create a structure that will provide surface ponding

consistent with the applicable BMP Fact Sheet in Appendix E (e.g., ≥ 6 inches and ≤ 12 inches). The outlet structure may include an orifice. Note that when an orifice is included, only ponding below the outlet structure orifice may be included as storage for pollutant control sizing.

- “Material Layers for Biofilter” in the model will be used to represent the **mulch, engineered soil media, and aggregate storage layer**. Available materials in SDHM 3.1 are “GRAVEL”, “ESM”, and “Mulch”. Mulch is optional or mandatory depending on the jurisdiction. Where mulch is required, select “Mulch” for Soil Layer 1 and enter a depth consistent with the applicable BMP Fact Sheet in Appendix E. Select “ESM” for the next layer (Layer 2 if mulch is used, or Layer 1 if mulch is not used) and enter a depth consistent with the applicable BMP Fact Sheet in Appendix E. Select “GRAVEL” for the next layer (Layer 3 if mulch is used, or Layer 2 if mulch is not used) and enter a depth representing the combined depth of the filter course layer and aggregate storage layer consistent with the applicable BMP Fact Sheet in Appendix E. When an underdrain will be used, the thickness of the “GRAVEL” layer should include the aggregate storage both above and below the underdrain. Do not edit the soil types without prior approval from the local jurisdiction.

Additional Considerations for Bioretention (INF-2)

Bioretention (INF-2) has no underdrain. It has no liner, and has uncompacted native soils at the bottom of the facility. See Figure A-10 for an example of bioretention element setup.

- Do not select “Underdrain Used.”
- Select “Yes” for “Native Infiltration”. Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, “Reduction Factor” will be 1. Consideration of infiltration from sidewalls, “Use Wetted Surface Area (sidewalls)”, is project-specific, depending on whether the BMP design includes all material layers under the sidewalls (see the “Facility Dimension Diagram”).

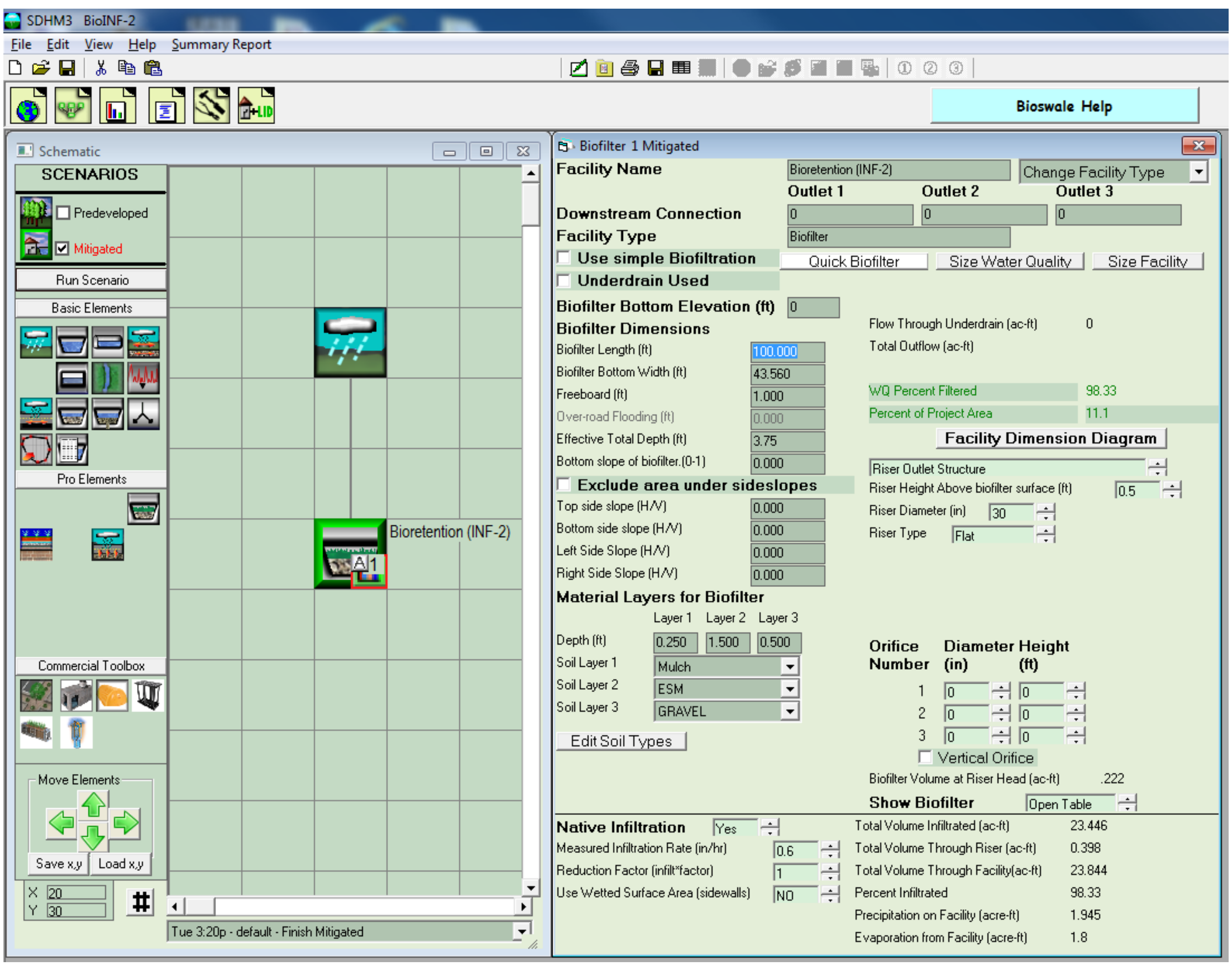

Figure A-10
Example of Bioretention (INF-2) Setup in SDHM 3.1

Additional Considerations for Biofiltration with Partial Retention (PR-1)

Biofiltration with partial retention (PR-1) has an underdrain, which is elevated ≥3 inches above the bottom elevation of the aggregate storage layer. It has no liner, and has uncompacted native soils at the bottom of the facility. See Figure A-11 for an example of biofiltration with partial retention element setup.

- Select "Underdrain Used". Enter the underdrain diameter, consistent with the applicable BMP Fact Sheet in Appendix E. The "Offset" is the "elevation of underdrain and orifice above biofilter bottom". Enter the underdrain offset, consistent with the applicable BMP Fact Sheet in Appendix E.

- Select "Yes" for "Native Infiltration". Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, "Reduction Factor" will be 1. Consideration of infiltration from sidewalls, "Use Wetted Surface Area (sidewalls)", is project-specific, depending on whether the BMP design includes all material layers under the sidewalls (see the "Facility Dimension Diagram").

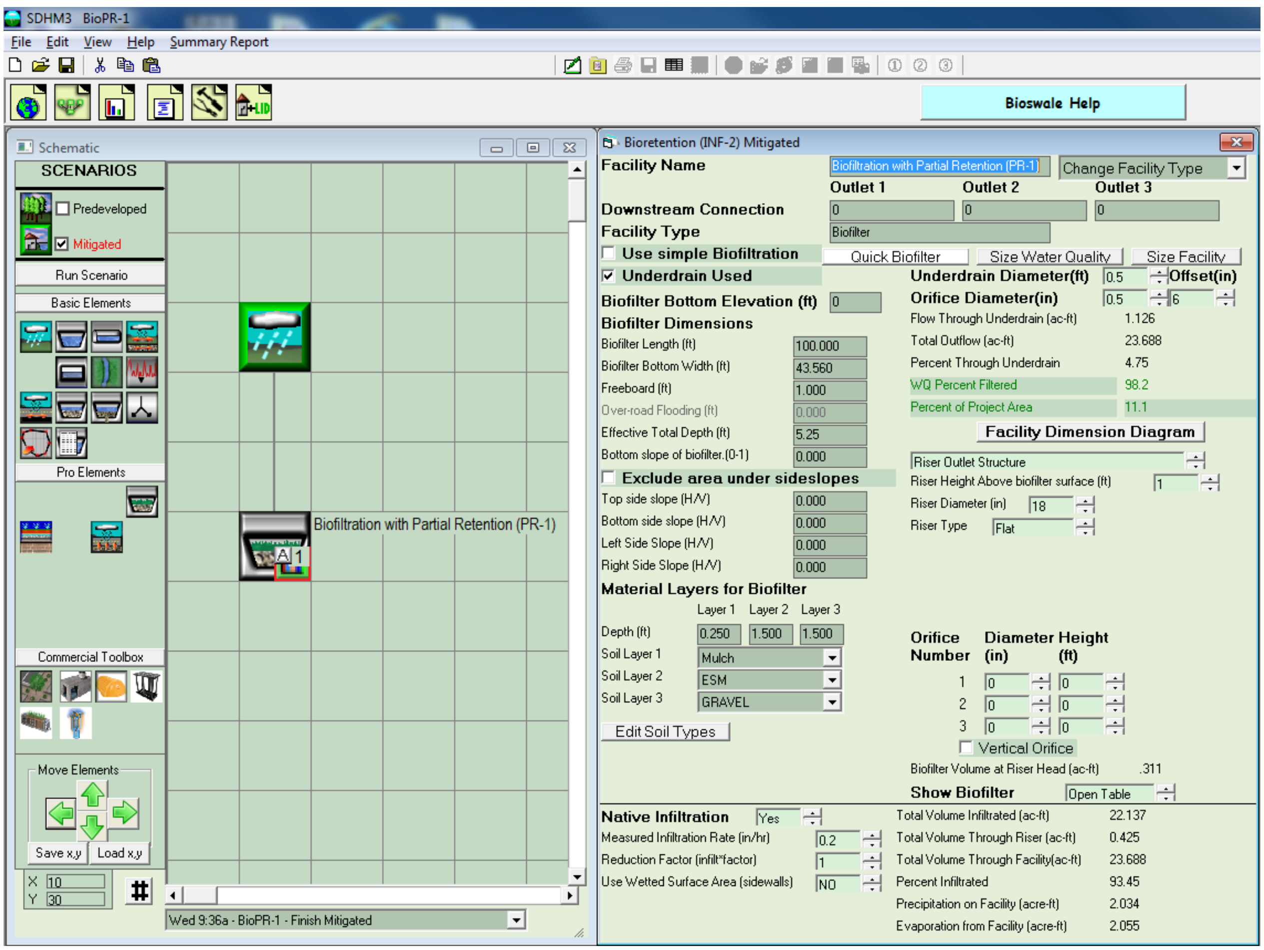

Figure A-11
Example of Biofiltration with Partial Retention (PR-1) Setup in SDHM 3.1

Additional Considerations for Biofiltration (BF-1)

Biofiltration (BF-1) has an underdrain, which is not elevated other than the minimum 3 inches above the bottom elevation of the aggregate storage layer. It may include a liner or compacted native soils at the bottom of the facility. See Figure A-12 for an example of biofiltration element setup.

- Select “Underdrain Used”. Enter the underdrain diameter, consistent with the applicable BMP Fact Sheet in Appendix E. The “Offset” is the “elevation of underdrain and orifice above biofilter bottom”. Enter the underdrain offset, consistent with the applicable BMP Fact Sheet in Appendix E.

- Select “No” for “Native Infiltration”.

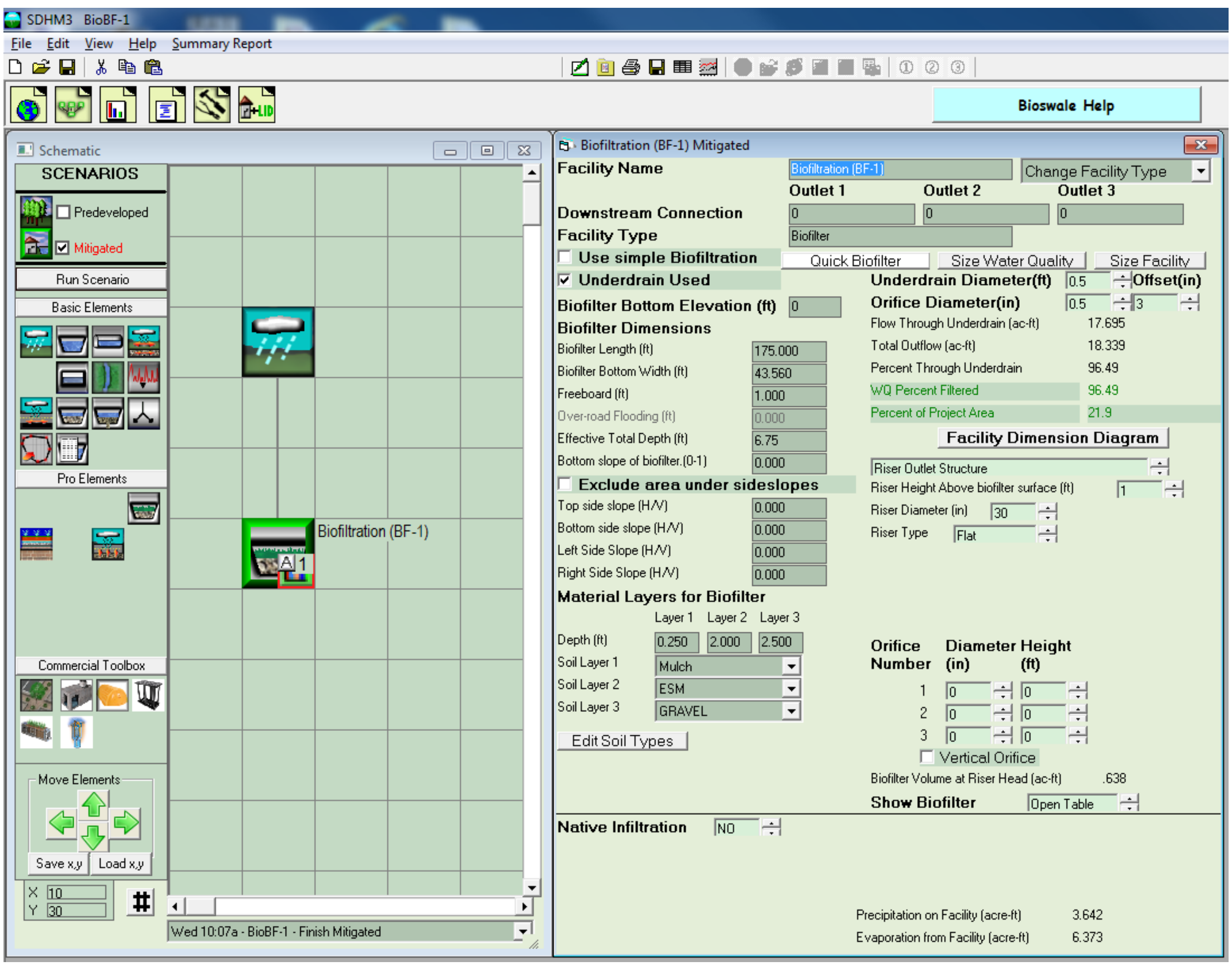

Figure A-12
Example of Biofiltration (BF-1) Setup in SDHM 3.1

Modeling Dry Extended Detention Basins (FT-4)

Dry extended detention basins are basins that have been designed to detain storm water for an extended period to allow sedimentation and typically drain completely between storm events. Refer to the BMP Design Manual for the local jurisdiction for siting and design requirements for dry extended detention basins. Dry extended detention basins may be modeled using the SDHM Basic Elements “Trapezoidal Pond,” “Storage Tank,” “Storage Vault,” “SSD Table,” or an applicable commercial element. See Figure A-13 for an example of element setup for dry extended detention basins.

- Select the element that best represents the configuration of the dry extended detention basin.
- For open-air, surface-level dry extended detention basins, select “Precipitation Applied to Facility” and “Evaporation Applied to Facility.” For closed, underground dry extended detention basins, de-select “Precipitation Applied to Facility” and “Evaporation Applied to Facility.”
- If infiltration is applicable, select “Yes” for “Infiltration”. Enter the design infiltration rate based on the results of Worksheet D.5-1. The design infiltration rate based on the results of Worksheet D.5-1 includes a safety factor. Therefore, “Reduction Factor” will be 1. For elements with sidewalls, consideration of infiltration from sidewalls, “Use Wetted Surface Area (sidewalls)”, is project-specific, depending on the BMP design.
- Create a low flow outlet for flow control and overflow outlet consistent with the applicable BMP Fact Sheet and local jurisdiction requirements.

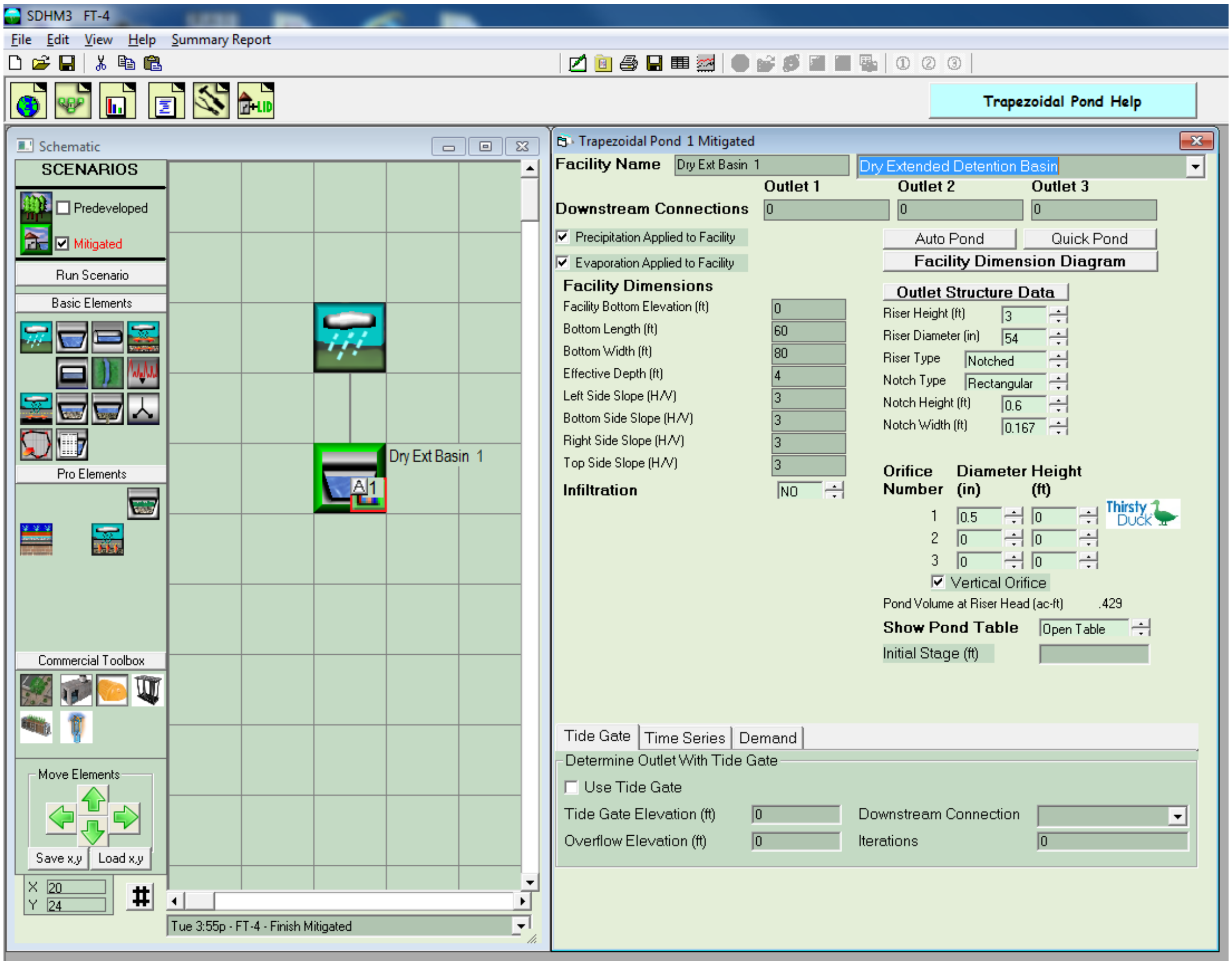

Figure A-13
Example of Dry Extended Detention Basin (FT-4) Setup in SDHM 3.1

APPENDIX B: DEFAULT SDHM 3.1 HSPF PERVIOUS PARAMETER VALUES

The default SDHM 3.1 HSPF pervious parameter values are found in SDHM 3.1 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. SDHM Pervious Land Types

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

41	B	Urban	Moderate (5-15%)
42	B	Urban	Steep (>15%)
43	C	Urban	Flat (0-5%)
44	C	Urban	Moderate (5-15%)
45	C	Urban	Steep (>15%)
46	D	Urban	Flat (0-5%)
47	D	Urban	Moderate (5-15%)
48	D	Urban	Steep (>15%)
49	A	Urban, No Irrigation	Flat (0-5%)
50	A	Urban, No Irrigation	Moderate (5-15%)
51	A	Urban, No Irrigation	Steep (>15%)
52	B	Urban, No Irrigation	Flat (0-5%)
53	B	Urban, No Irrigation	Moderate (5-15%)
54	B	Urban, No Irrigation	Steep (>15%)
55	C	Urban, No Irrigation	Flat (0-5%)
56	C	Urban, No Irrigation	Moderate (5-15%)
57	C	Urban, No Irrigation	Steep (>15%)
58	D	Urban, No Irrigation	Flat (0-5%)
59	D	Urban, No Irrigation	Moderate (5-15%)
60	D	Urban, No Irrigation	Steep (>15%)

Table 2. SDHM HSPF Pervious Parameter Values – Part I

PLS	NAME	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1	A,NatVeg,Flat	4.20	0.090	100	0.050	2.50	0.915
2	A,NatVeg,Mod	3.80	0.070	80	0.100	2.50	0.915
3	A,NatVeg,Steep	3.50	0.045	75	0.150	2.50	0.915
4	A,Dirt,Flat	4.20	0.090	100	0.050	2.50	0.915
5	A,Dirt,Mod	3.80	0.070	80	0.100	2.50	0.915
6	A,Dirt,Steep	3.50	0.045	75	0.150	2.50	0.915
7	A,Rock,Flat	2.60	0.045	100	0.050	2.50	0.915
8	A,Rock,Mod	2.40	0.035	80	0.100	2.50	0.915
9	A,Rock,Steep	2.20	0.022	75	0.150	2.50	0.915
10	B,NatVeg,Flat	4.00	0.070	100	0.050	2.50	0.915
11	B,NatVeg,Mod	3.70	0.055	80	0.100	2.50	0.915
12	B,NatVeg,Steep	3.40	0.040	75	0.150	2.50	0.915
13	B,Dirt,Flat	4.00	0.070	100	0.050	2.50	0.915
14	B,Dirt,Mod	3.70	0.055	80	0.100	2.50	0.915
15	B,Dirt,Steep	3.40	0.040	75	0.150	2.50	0.915
16	B,Rock,Flat	2.50	0.035	100	0.050	2.50	0.915
17	B,Rock,Mod	2.30	0.028	80	0.100	2.50	0.915
18	B,Rock,Steep	2.20	0.020	75	0.150	2.50	0.915
19	C,NatVeg,Flat	3.80	0.035	100	0.050	2.50	0.915
20	C,NatVeg,Mod	3.50	0.033	80	0.100	2.50	0.915
21	C,NatVeg,Steep	3.20	0.030	75	0.150	2.50	0.915
22	C,Dirt,Flat	3.80	0.035	100	0.050	2.50	0.915
23	C,Dirt,Mod	3.50	0.033	80	0.100	2.50	0.915
24	C,Dirt,Steep	3.20	0.030	75	0.150	2.50	0.915
25	C,Rock,Flat	2.40	0.022	100	0.050	2.50	0.915
26	C,Rock,Mod	2.20	0.020	80	0.100	2.50	0.915
27	C,Rock,Steep	2.10	0.015	75	0.150	2.50	0.915
28	D,NatVeg,Flat	3.30	0.030	100	0.050	2.50	0.915
29	D,NatVeg,Mod	3.00	0.025	80	0.100	2.50	0.915
30	D,NatVeg,Steep	2.70	0.020	75	0.150	2.50	0.915
31	D,Dirt,Flat	2.80	0.025	100	0.050	2.50	0.915
32	D,Dirt,Mod	2.50	0.022	80	0.100	2.50	0.915
33	D,Dirt,Steep	2.20	0.020	75	0.150	2.50	0.915
34	D,Rock,Flat	2.40	0.022	100	0.050	2.50	0.915
35	D,Rock,Mod	2.20	0.020	80	0.100	2.50	0.915
36	D,Rock,Steep	2.10	0.015	75	0.150	2.50	0.915
37	A,Urban,Flat	4.20	0.090	50	0.050	2.50	0.915
38	A,Urban,Mod	3.80	0.070	50	0.100	2.50	0.915
39	A,Urban,Steep	3.50	0.045	50	0.150	2.50	0.915
40	B,Urban,Flat	4.00	0.070	50	0.050	2.50	0.915
41	B,Urban,Mod	3.70	0.055	50	0.100	2.50	0.915

42	B,Urban,Steep	3.40	0.040	50	0.150	2.50	0.915
43	C,Urban,Flat	3.80	0.040	50	0.050	2.50	0.915
44	C,Urban,Mod	3.50	0.035	50	0.100	2.50	0.915
45	C,Urban,Steep	3.20	0.030	50	0.150	2.50	0.915
46	D,Urban,Flat	3.80	0.030	50	0.050	2.50	0.915
47	D,Urban,Mod	3.50	0.025	50	0.100	2.50	0.915
48	D,Urban,Steep	3.20	0.020	50	0.150	2.50	0.915
49	A,UrbNoIrr,Flat	4.20	0.090	50	0.050	2.50	0.915
50	A,UrbNoIrr,Mod	3.80	0.070	50	0.100	2.50	0.915
51	A,UrbNoIrr,Steep	3.50	0.045	50	0.150	2.50	0.915
52	B,UrbNoIrr,Flat	4.00	0.070	50	0.050	2.50	0.915
53	B,UrbNoIrr,Mod	3.70	0.055	50	0.100	2.50	0.915
54	B,UrbNoIrr,Steep	3.40	0.040	50	0.150	2.50	0.915
55	C,UrbNoIrr,Flat	3.80	0.040	50	0.050	2.50	0.915
56	C,UrbNoIrr,Mod	3.50	0.035	50	0.100	2.50	0.915
57	C,UrbNoIrr,Steep	3.20	0.030	50	0.150	2.50	0.915
58	D,UrbNoIrr,Flat	3.80	0.030	50	0.050	2.50	0.915
59	D,UrbNoIrr,Mod	3.50	0.025	50	0.100	2.50	0.915
60	D,UrbNoIrr,Steep	3.20	0.020	50	0.150	2.50	0.915
61	Green Roof	1.00	0.050	50	0.001	0.50	0.100

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. SDHM HSPF Pervious Parameter Values – Part II

PLS	NAME	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
1	A,NatVeg,Flat	2.00	2.00	0.00	0.050	0.050
2	A,NatVeg,Mod	2.00	2.00	0.00	0.050	0.050
3	A,NatVeg,Steep	2.00	2.00	0.00	0.050	0.050
4	A,Dirt,Flat	2.00	2.00	0.00	0.050	0.050
5	A,Dirt,Mod	2.00	2.00	0.00	0.050	0.050
6	A,Dirt,Steep	2.00	2.00	0.00	0.050	0.050
7	A,Rock,Flat	2.00	2.00	0.00	0.050	0.050
8	A,Rock,Mod	2.00	2.00	0.00	0.050	0.050
9	A,Rock,Steep	2.00	2.00	0.00	0.050	0.050
10	B,NatVeg,Flat	2.00	2.00	0.00	0.050	0.050
11	B,NatVeg,Mod	2.00	2.00	0.00	0.050	0.050
12	B,NatVeg,Steep	2.00	2.00	0.00	0.050	0.050
13	B,Dirt,Flat	2.00	2.00	0.00	0.050	0.050
14	B,Dirt,Mod	2.00	2.00	0.00	0.050	0.050
15	B,Dirt,Steep	2.00	2.00	0.00	0.050	0.050
16	B,Rock,Flat	2.00	2.00	0.00	0.050	0.050
17	B,Rock,Mod	2.00	2.00	0.00	0.050	0.050
18	B,Rock,Steep	2.00	2.00	0.00	0.050	0.050
19	C,NatVeg,Flat	2.00	2.00	0.00	0.050	0.050
20	C,NatVeg,Mod	2.00	2.00	0.00	0.050	0.050
21	C,NatVeg,Steep	2.00	2.00	0.00	0.050	0.050
22	C,Dirt,Flat	2.00	2.00	0.00	0.050	0.050
23	C,Dirt,Mod	2.00	2.00	0.00	0.050	0.050
24	C,Dirt,Steep	2.00	2.00	0.00	0.050	0.050
25	C,Rock,Flat	2.00	2.00	0.00	0.050	0.050
26	C,Rock,Mod	2.00	2.00	0.00	0.050	0.050
27	C,Rock,Steep	2.00	2.00	0.00	0.050	0.050
28	D,NatVeg,Flat	2.00	2.00	0.00	0.050	0.050
29	D,NatVeg,Mod	2.00	2.00	0.00	0.050	0.050
30	D,NatVeg,Steep	2.00	2.00	0.00	0.050	0.050
31	D,Dirt,Flat	2.00	2.00	0.00	0.050	0.050
32	D,Dirt,Mod	2.00	2.00	0.00	0.050	0.050
33	D,Dirt,Steep	2.00	2.00	0.00	0.050	0.050
34	D,Rock,Flat	2.00	2.00	0.00	0.050	0.050
35	D,Rock,Mod	2.00	2.00	0.00	0.050	0.050
36	D,Rock,Steep	2.00	2.00	0.00	0.050	0.050
37	A,Urban,Flat	2.00	2.00	0.00	0.050	0.050
38	A,Urban,Mod	2.00	2.00	0.00	0.050	0.050
39	A,Urban,Steep	2.00	2.00	0.00	0.050	0.050
40	B,Urban,Flat	2.00	2.00	0.00	0.050	0.050
41	B,Urban,Mod	2.00	2.00	0.00	0.050	0.050

42	B,Urban,Steep	2.00	2.00	0.00	0.050	0.050
43	C,Urban,Flat	2.00	2.00	0.00	0.050	0.050
44	C,Urban,Mod	2.00	2.00	0.00	0.050	0.050
45	C,Urban,Steep	2.00	2.00	0.00	0.050	0.050
46	D,Urban,Flat	2.00	2.00	0.00	0.050	0.050
47	D,Urban,Mod	2.00	2.00	0.00	0.050	0.050
48	D,Urban,Steep	2.00	2.00	0.00	0.050	0.050
49	A,UrbNoIrr,Flat	2.00	2.00	0.00	0.050	0.050
50	A,UrbNoIrr,Mod	2.00	2.00	0.00	0.050	0.050
51	A,UrbNoIrr,Steep	2.00	2.00	0.00	0.050	0.050
52	B,UrbNoIrr,Flat	2.00	2.00	0.00	0.050	0.050
53	B,UrbNoIrr,Mod	2.00	2.00	0.00	0.050	0.050
54	B,UrbNoIrr,Steep	2.00	2.00	0.00	0.050	0.050
55	C,UrbNoIrr,Flat	2.00	2.00	0.00	0.050	0.050
56	C,UrbNoIrr,Mod	2.00	2.00	0.00	0.050	0.050
57	C,UrbNoIrr,Steep	2.00	2.00	0.00	0.050	0.050
58	D,UrbNoIrr,Flat	2.00	2.00	0.00	0.050	0.050
59	D,UrbNoIrr,Mod	2.00	2.00	0.00	0.050	0.050
60	D,UrbNoIrr,Steep	2.00	2.00	0.00	0.050	0.050
61	Green Roof	2.00	2.00	0.00	0.150	0.800

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. SDHM HSPF Pervious Parameter Values – Part III

PLS	NAME	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	A,NatVeg,Flat	See Table 5	0.600	0.040	1.00	0.300	see Table 6
2	A,NatVeg,Mod	See Table 5	0.600	0.040	1.00	0.300	see Table 6
3	A,NatVeg,Steep	See Table 5	0.600	0.040	1.00	0.300	see Table 6
4	A,Dirt,Flat	See Table 5	0.600	0.017	1.00	0.300	see Table 6
5	A,Dirt,Mod	See Table 5	0.600	0.017	1.00	0.300	see Table 6
6	A,Dirt,Steep	See Table 5	0.600	0.017	1.00	0.300	see Table 6
7	A,Rock,Flat	See Table 5	0.600	0.025	1.00	0.300	see Table 6
8	A,Rock,Mod	See Table 5	0.600	0.025	1.00	0.300	see Table 6
9	A,Rock,Steep	See Table 5	0.600	0.025	1.00	0.300	see Table 6
10	B,NatVeg,Flat	See Table 5	0.600	0.040	1.00	0.300	see Table 6
11	B,NatVeg,Mod	See Table 5	0.600	0.040	1.00	0.300	see Table 6
12	B,NatVeg,Steep	See Table 5	0.600	0.040	1.00	0.300	see Table 6
13	B,Dirt,Flat	See Table 5	0.600	0.017	1.00	0.300	see Table 6
14	B,Dirt,Mod	See Table 5	0.600	0.017	1.00	0.300	see Table 6
15	B,Dirt,Steep	See Table 5	0.600	0.017	1.00	0.300	see Table 6
16	B,Rock,Flat	See Table 5	0.600	0.025	1.00	0.300	see Table 6
17	B,Rock,Mod	See Table 5	0.600	0.025	1.00	0.300	see Table 6
18	B,Rock,Steep	See Table 5	0.600	0.025	1.00	0.300	see Table 6
19	C,NatVeg,Flat	See Table 5	0.600	0.040	1.00	0.300	see Table 6
20	C,NatVeg,Mod	See Table 5	0.600	0.040	1.00	0.300	see Table 6
21	C,NatVeg,Steep	See Table 5	0.600	0.040	1.00	0.300	see Table 6
22	C,Dirt,Flat	See Table 5	0.600	0.017	1.00	0.300	see Table 6
23	C,Dirt,Mod	See Table 5	0.600	0.017	1.00	0.300	see Table 6
24	C,Dirt,Steep	See Table 5	0.600	0.017	1.00	0.300	see Table 6
25	C,Rock,Flat	See Table 5	0.600	0.025	1.00	0.300	see Table 6
26	C,Rock,Mod	See Table 5	0.600	0.025	1.00	0.300	see Table 6
27	C,Rock,Steep	See Table 5	0.600	0.025	1.00	0.300	see Table 6
28	D,NatVeg,Flat	See Table 5	0.600	0.040	1.00	0.300	see Table 6
29	D,NatVeg,Mod	See Table 5	0.600	0.040	1.00	0.300	see Table 6
30	D,NatVeg,Steep	See Table 5	0.600	0.040	1.00	0.300	see Table 6
31	D,Dirt,Flat	See Table 5	0.600	0.017	1.00	0.300	see Table 6
32	D,Dirt,Mod	See Table 5	0.600	0.017	1.00	0.300	see Table 6
33	D,Dirt,Steep	See Table 5	0.600	0.017	1.00	0.300	see Table 6
34	D,Rock,Flat	See Table 5	0.600	0.025	1.00	0.300	see Table 6
35	D,Rock,Mod	See Table 5	0.600	0.025	1.00	0.300	see Table 6
36	D,Rock,Steep	See Table 5	0.600	0.025	1.00	0.300	see Table 6
37	A,Urban,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
38	A,Urban,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
39	A,Urban,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
40	B,Urban,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
41	B,Urban,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6

42	B,Urban,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
43	C,Urban,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
44	C,Urban,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
45	C,Urban,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
46	D,Urban,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
47	D,Urban,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
48	D,Urban,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
49	A,UrbNoIrr,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
50	A,UrbNoIrr,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
51	A,UrbNoIrr,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
52	B,UrbNoIrr,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
53	B,UrbNoIrr,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
54	B,UrbNoIrr,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
55	C,UrbNoIrr,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
56	C,UrbNoIrr,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
57	C,UrbNoIrr,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
58	D,UrbNoIrr,Flat	See Table 5	0.600	0.030	1.00	0.300	see Table 6
59	D,UrbNoIrr,Mod	See Table 5	0.600	0.030	1.00	0.300	see Table 6
60	D,UrbNoIrr,Steep	See Table 5	0.600	0.030	1.00	0.300	see Table 6
61	Green Roof	See Table 5	0.100	0.550	1.00	0.100	see Table 6

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. SDHM HSPF Pervious Parameter Values: Monthly Interception Storage (inches)

PLS	NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	A,NatVeg,Flat	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
2	A,NatVeg,Mod	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
3	A,NatVeg,Steep	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
4	A,Dirt,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
5	A,Dirt,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
6	A,Dirt,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
7	A,Rock,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
8	A,Rock,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
9	A,Rock,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
10	B,NatVeg,Flat	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
11	B,NatVeg,Mod	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
12	B,NatVeg,Steep	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
13	B,Dirt,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
14	B,Dirt,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
15	B,Dirt,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
16	B,Rock,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
17	B,Rock,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
18	B,Rock,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
19	C,NatVeg,Flat	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
20	C,NatVeg,Mod	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
21	C,NatVeg,Steep	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
22	C,Dirt,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
23	C,Dirt,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
24	C,Dirt,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
25	C,Rock,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
26	C,Rock,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

27	C,Rock,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
28	D,NatVeg,Flat	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
29	D,NatVeg,Mod	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
30	D,NatVeg,Steep	0.10	0.10	0.10	0.10	0.06	0.06	0.06	0.06	0.06	0.10	0.10	0.10
31	D,Dirt,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
32	D,Dirt,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
33	D,Dirt,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
34	D,Rock,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
35	D,Rock,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
36	D,Rock,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
37	A,Urban,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
38	A,Urban,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
39	A,Urban,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
40	B,Urban,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
41	B,Urban,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
42	B,Urban,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
43	C,Urban,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
44	C,Urban,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
45	C,Urban,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
46	D,Urban,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
47	D,Urban,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
48	D,Urban,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
49	A,UrbNoIrr,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
50	A,UrbNoIrr,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
51	A,UrbNoIrr,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
52	B,UrbNoIrr,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	B,UrbNoIrr,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
54	B,UrbNoIrr,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
55	C,UrbNoIrr,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

56	C,UrbNoIrr,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
57	C,UrbNoIrr,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
58	D,UrbNoIrr,Flat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
59	D,UrbNoIrr,Mod	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
60	D,UrbNoIrr,Steep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
61	Green Roof	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Table 6. SDHM HSPF Pervious Parameter Values: Monthly Lower Zone Evapotranspiration

PLS	NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	A,NatVeg,Flat	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
2	A,NatVeg,Mod	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
3	A,NatVeg,Steep	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
4	A,Dirt,Flat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
5	A,Dirt,Mod	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
6	A,Dirt,Steep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
7	A,Rock,Flat	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
8	A,Rock,Mod	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
9	A,Rock,Steep	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	B,NatVeg,Flat	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
11	B,NatVeg,Mod	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
12	B,NatVeg,Steep	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
13	B,Dirt,Flat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
14	B,Dirt,Mod	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
15	B,Dirt,Steep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
16	B,Rock,Flat	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
17	B,Rock,Mod	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
18	B,Rock,Steep	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
19	C,NatVeg,Flat	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
20	C,NatVeg,Mod	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
21	C,NatVeg,Steep	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
22	C,Dirt,Flat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
23	C,Dirt,Mod	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
24	C,Dirt,Steep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
25	C,Rock,Flat	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
26	C,Rock,Mod	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30

27	C,Rock,Steep	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
28	D,NatVeg,Flat	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
29	D,NatVeg,Mod	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
30	D,NatVeg,Steep	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40
31	D,Dirt,Flat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
32	D,Dirt,Mod	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
33	D,Dirt,Steep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
34	D,Rock,Flat	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	D,Rock,Mod	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	D,Rock,Steep	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	A,Urban,Flat	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
38	A,Urban,Mod	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
39	A,Urban,Steep	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
40	B,Urban,Flat	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
41	B,Urban,Mod	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
42	B,Urban,Steep	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
43	C,Urban,Flat	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
44	C,Urban,Mod	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
45	C,Urban,Steep	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
46	D,Urban,Flat	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
47	D,Urban,Mod	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
48	D,Urban,Steep	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60
49	A,UrbNoIrr,Flat	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
50	A,UrbNoIrr,Mod	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
51	A,UrbNoIrr,Steep	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
52	B,UrbNoIrr,Flat	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
53	B,UrbNoIrr,Mod	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
54	B,UrbNoIrr,Steep	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
55	C,UrbNoIrr,Flat	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40

56	C,UrbNoIrr,Mod	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
57	C,UrbNoIrr,Steep	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
58	D,UrbNoIrr,Flat	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
59	D,UrbNoIrr,Mod	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
60	D,UrbNoIrr,Steep	0.40	0.40	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.40	0.40	0.40
61	Green Roof	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60

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APPENDIX C: DEFAULT SDHM 3.1 HSPF IMPERVIOUS PARAMETER VALUES

The default SDHM 3.1 HSPF impervious parameter values are found in SDHM 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. SDHM Impervious Land Types

IMPLND No.	Surface	Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-15%)
3	Impervious	Steep (>15%)

Table 2. SDHM HSPF Impervious Parameter Values – Part I

IMPLND No.	LSUR	SLSUR	NSUR	RETSC
1	100	0.05	0.011	0.10
2	100	0.10	0.011	0.08
3	100	0.15	0.011	0.05

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. SDHM 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

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

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APPENDIX D: BIOFILTRATION MODELING METHODOLOGY

Water Movement Through The Soil Column

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

Consider a simple two-layered biofiltration 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. While 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.

<u>Water Movement Equations</u>

There are several equations used to determine water movement from the surface of the biofiltration 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

<u>Surface ponding and infiltration into the top subsurface layer</u>

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

$$f = K\left(1 + \frac{(\phi - \theta)(d + \varphi)}{F}\right)$$ (Equation 1; Ref: Rossman, 2009)

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

$$\frac{K(\theta)}{K_{sat}} = \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/2}\left[1 - \left(1 - \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/m}\right)^m\right]^2$$ (Equation 2; Ref: Blum et al, 2001)

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.

Percolation through the subsurface layers

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

$$h = -\frac{1}{\alpha}\left[\frac{1}{SE^{1/m}} - 1\right]^{1/n} + z$$

(Equation 6; Ref: Blum et al, 2001)

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

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

(Equation 7; Ref: Blum et al, 2001)

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 from the Soil Column

Evapotranspiration is an important component of the biofiltration facility's hydrologic processes. Evapotranspiration removes water from biofiltration 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 biofiltration soil layers (top layer first)

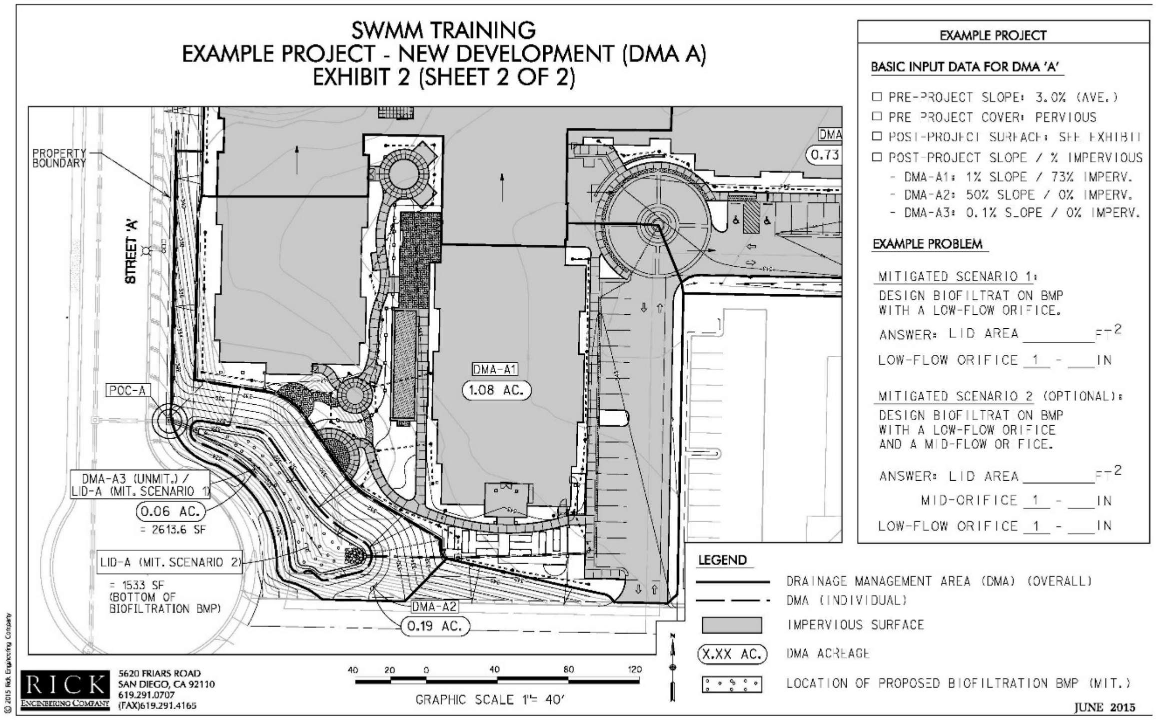
Water will be removed from vegetation interception storage and surface ponding and the biofiltration soil layers (starting at the top layer) down to the rooting depth at the potential rate. Water is taken from the soil layers below the rooting depth based on a percentage factor to be determined. Without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

References

Blum, V.S., S. Israel, and S.P. Larson. 2001. *Adapting MODFLOW to Simulate Water Movement in the Unsaturated Zone.* MODFLOW 2001 and Other Modeling Odysseys, International Groundwater Modeling Center (IGWMC), Colorado School of Mines, Golden, Colorado, September 11-14, 2001. In MODFLOW 2001 and Other Modeling Odysseys, Proceedings. pp.60-65.

Rossman, L.A. 2009. *Modeling Low Impact Development Alternatives with SWMM.* Presented at CHI International Stormwater and Urban Water Systems Conference, Toronto, Ontario, Canada, February 20, 2009.

APPENDIX E: SDHM 3.1 COMPLEX MODEL EXAMPLE



This is an example project that has also been used in a San Diego SWMM training class by Rick Engineering. To set up, run, and save this example project we will use the same 12 steps that we used in the Quick Start example on page 5.

As a reminder, the 12 steps are:

1. Select project location
2. Set up Predevelopment land use scenario
3. Set up Mitigated (developed) land use scenario
4. Calculate lower and upper HMP thresholds based on Predevelopment runoff
5. Calculate lower and upper HMP thresholds based on USGS regional equations (optional)
6. Compare sets of threshold values (optional)
7. Change thresholds (optional)
8. Size Mitigated scenario HMP facility
9. Review analysis
10. Produce report
11. Save project
12. Exit SDHM

Let's get started.

In this particular example the project site is 1.33 acres in total area. The exact project site location is unknown, but the precipitation record used for the modeling was the Poway rain gage.

The soil type was specified to be D soil. The Predeveloped land use was labeled "mass-graded lot". We will assume that this is the same as the "Dirt" land cover category in SDHM. The land slope is 3%. In SDHM this slope falls within the Flat slope category of 0-5%. Therefore, the Predeveloped area will consist of 1.33 acres of D, Dirt, Flat.

The proposed development consists of buildings (roofs), courtyard, and parking, plus landscaped graded slopes and a biofiltration basin. The biofiltration basin will provide hydromod mitigation for the development.

Table 1 shows a breakdown of the proposed development area:

Table 1. Proposed Development

DMA	Description	Total (ac)	% Impervious	Imp (ac)	Perv (ac)
1a	building, courtyard, parking	1.08	73%	0.79	0.29
1b	graded slope (steep)	0.19	0%	0.00	0.19
1c	biofiltration basin	0.06	0%	0.00	0.06
Total		1.33		0.79	0.54

Note that most of the graded slope is the side slope to the biofiltration basin. In SDHM we can include it as the side slopes in the area represented by the biofiltration basin (SDHM Biofiltration element). Therefore, we can adjust the proposed development area breakdown, as shown in Table 2.

Table 2. Proposed Development Adjusted

DMA	Description	Total (ac)	% Impervious	Imp (ac)	Perv (ac)
1a	building, courtyard, parking	1.08	73%	0.79	0.29
1b*	graded slope (steep)	0.05	0%	0.00	0.05
1c	biofiltration basin bottom	0.06	0%	0.00	0.06
1c**	biofiltration basin sides	0.14	0%	0.00	0.14
Total		1.33		0.79	0.54

* Slopes not draining directly to biofiltration basin.
** Slopes draining directly to biofiltration basin.

Based on the information in Table 2, the Mitigated scenario developed area will be input as shown in Table 3.

Table 3. SDHM Land Input

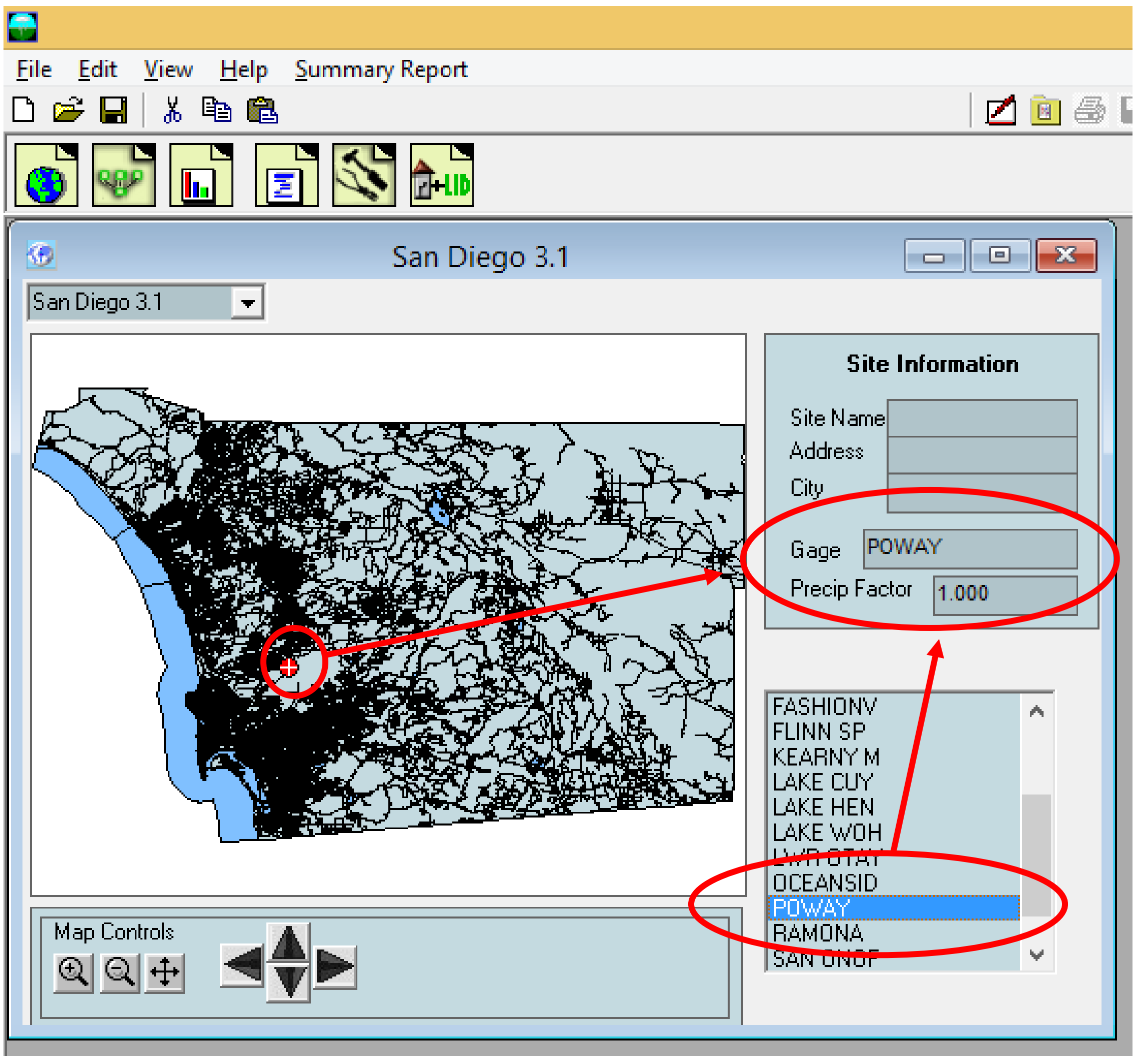
Description	Area (ac)
D, UrbNoIrr, Flat	0.29
D, UrbNoIrr, Steep	0.05
Biofiltration Total Area	0.20
Impervous, Flat	0.79
Total	1.33

Note: the pervious areas are assumed to be urban vegetation with no irrigation (UrbNoIrr).

For this site the hydromod low threshold is 0.1Q2 (10% of the 2-year peak flow).

With the above information we can now set up our project in SDHM 3.1.

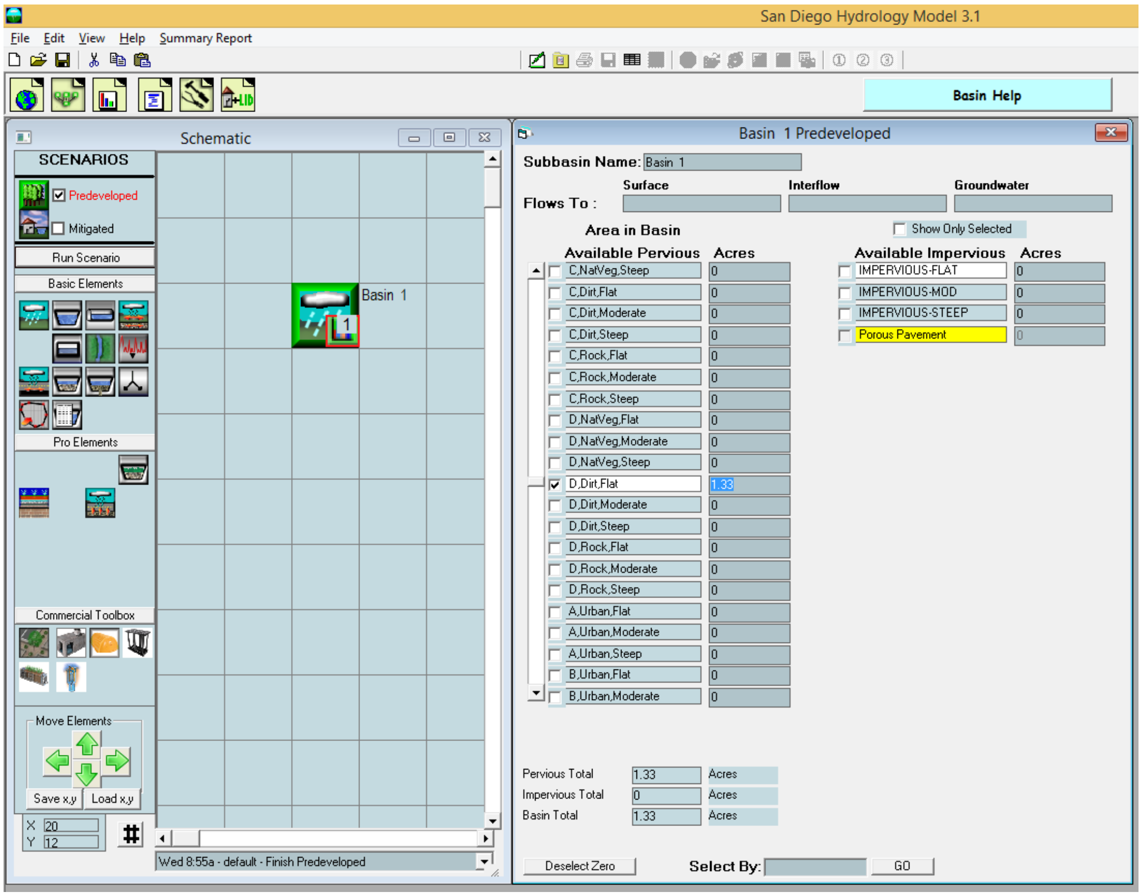
Step 1. Select project location.



We open SDHM 3.1 and using our mouse we select our project site on the San Diego County map by clicking on the project location. We can use the map controls in the lower left corner to enlarge or shrink the map. We select the appropriate nearby rain gage (Poway). The rain gage and precipitation multiplication factor (1.000) are shown in the upper right side of the screen.

Step 2. Set up Predevelopment land use scenario.

We go to the General Project Information screen and for the Predeveloped scenario select the Landuse Basin element (default name: Basin 1).



We input 1.33 acres of D soil, Dirt land cover, Flat slope (0-5%).

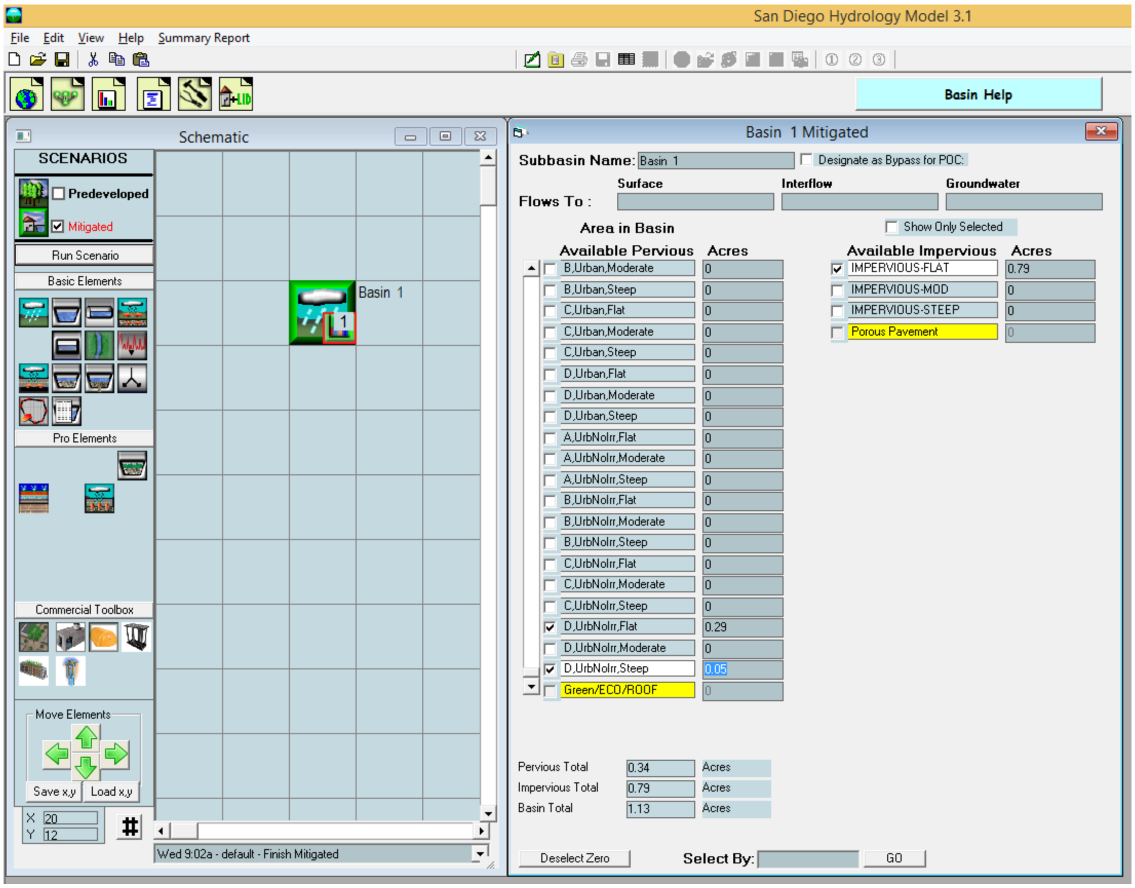
We connect Basin 1 to POC 1.

We click on Run Scenario and compute the Predeveloped runoff.

On to Step 3.

Step 3. Set up Mitigated (developed) land use scenario.

We check the Mitigated scenario box to go to the Mitigated scenario. Once there we select the Landuse Basin element (default name: Basin 1).



For the new development (Mitigated) land use we input:

> 0.29 acres of D soil, Urban landscape with no irrigation, Flat slope (0-5%)
> 0.05 acres of D soil, Urban landscape with no irrigation, Steep slope (>15%)
> 0.79 acres of Impervious, Flat slope (0-5%)

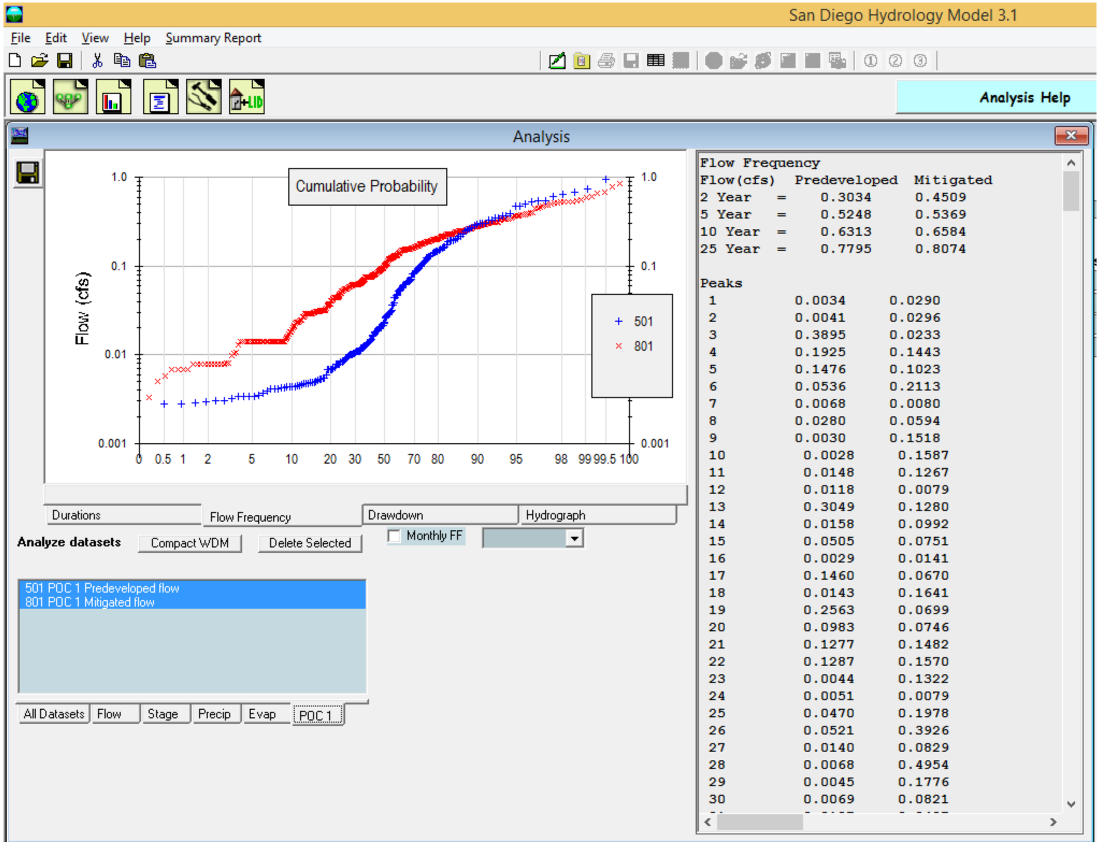
Note that the above Mitigated Basin 1 area total is only 1.13 acres. There is an additional 0.20 acres of land that will be included in the Biofiltration element input. The total of 1.33 acres equals the Predeveloped project area.

We connect Basin 1 to POC 1.

We click on Run Scenario and compute the Mitigated runoff.

Now we can compute Q2 and Q10 from the Predeveloped runoff in Step 4.

Step 4. Calculate lower and upper HMP thresholds based on Predevelopment runoff.



We go to the Analysis screen, select the Flow Frequency tab, and then click on the POC 1 tab.

SDHM-computed Predeveloped Q2 = 0.303 cfs
SDHM-computed Predeveloped Q10 = 0.631 cfs

Step 5. Calculate lower and upper HMP thresholds based on USGS regional equations (optional).

The USGS regional regression equations are:

Q2 = 3.60*(A^0.672)*(P^0.753)
Q10 = 6.56*(A^0.783)*(P^1.07)

Where A = drainage area (sq. miles)
P = mean annual precipitation (inches)

The lower threshold equals 0.10Q2.

The drainage area is 1.33 acres (0.002078125 square miles). The mean annual precipitation for Poway is 12.2 inches.

USGS Q2 = 0.373 cfs
USGS Q10 = 0.757 cfs

Step 6. Compare sets of threshold values (optional).

From Step 4 the SDHM-computed Predeveloped Q2 and Q10 values are:

SDHM-computed Predeveloped Q2 = 0.303 cfs
SDHM-computed Predeveloped Q10 = 0.631 cfs

From Step 5 the USGS regression equation Q2 and Q10 values are:

USGS Q2 = 0.373 cfs
USGS Q10 = 0.757 cfs

To minimize the size of the HMP facility we want to select the set of values that includes the largest Q2 value.

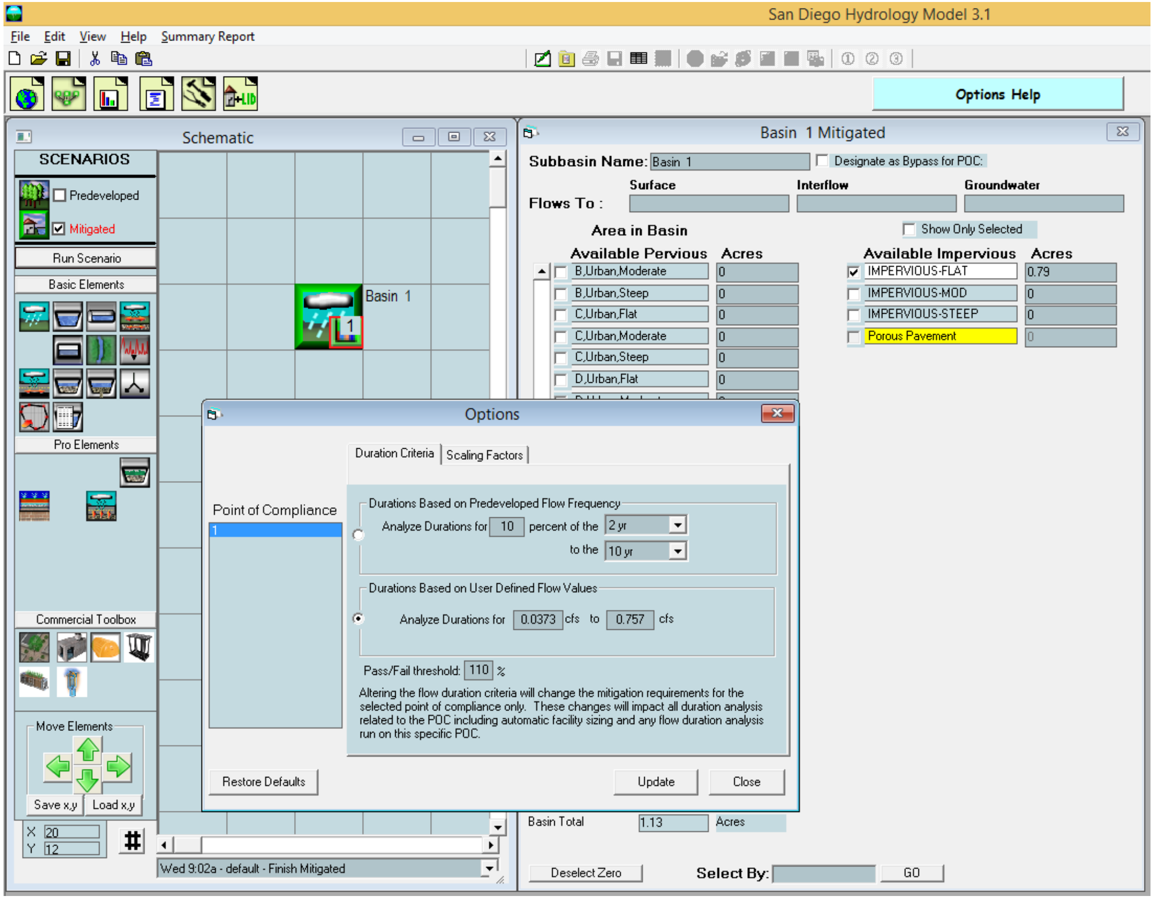
For this example the USGS Q2 value is larger than the SDHM-computed Predeveloped Q2 value. Therefore we will select the USGS values.

The lower threshold for this example is 10% of Q2; the upper threshold is Q10.

Lower threshold = 0.0373 cfs
Upper threshold = 0.757 cfs

Because we are not using the default SDHM-computed Predeveloped 0.10Q2 and Q10 values for the thresholds we need to change the lower and upper thresholds in Step 7 if we want to take advance of these higher USGS-based threshold values.

Step 7. Change thresholds (optional).



We go to View, Option, and select Durations Based on User-Defined Flow Values.

We change Analyze Durations for

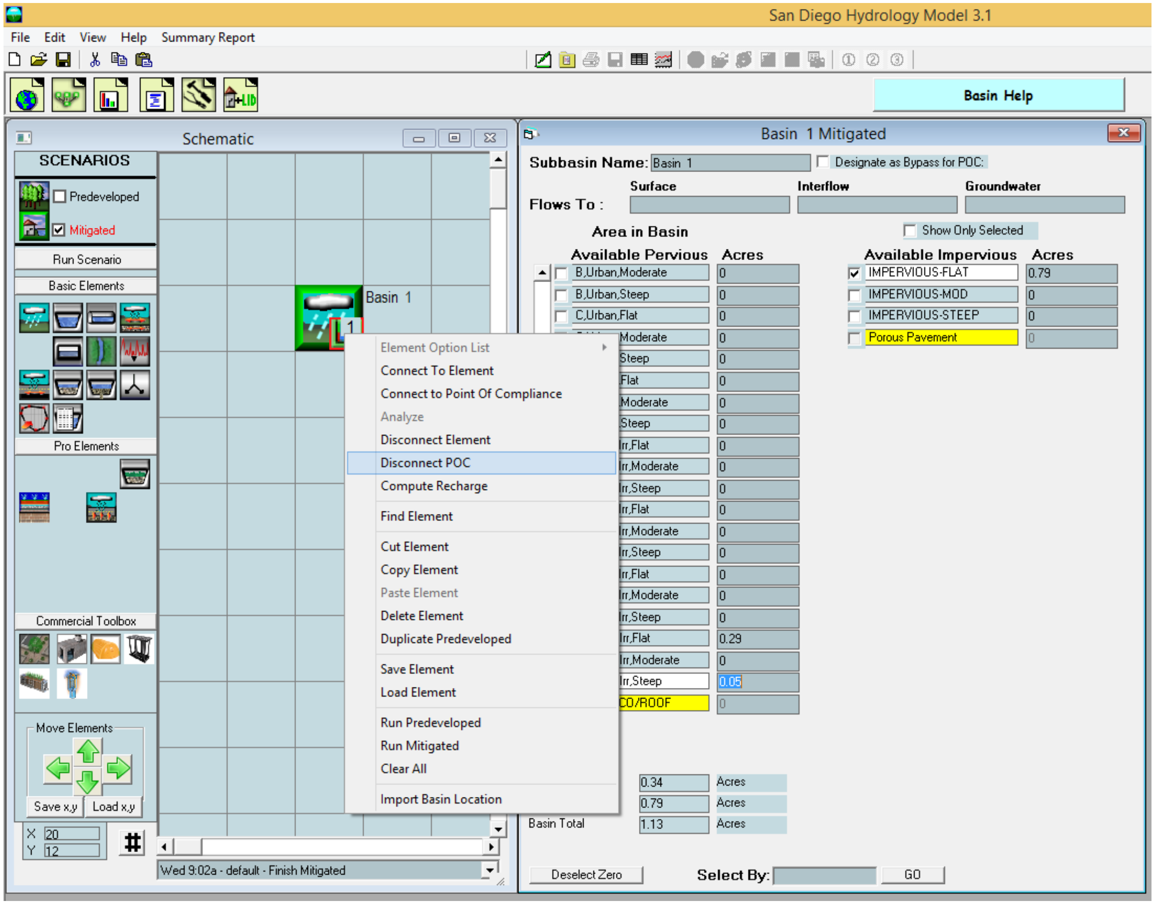
to 0.0373 to 0.757 cfs.

We click Update. That updates the threshold range for POC 1.

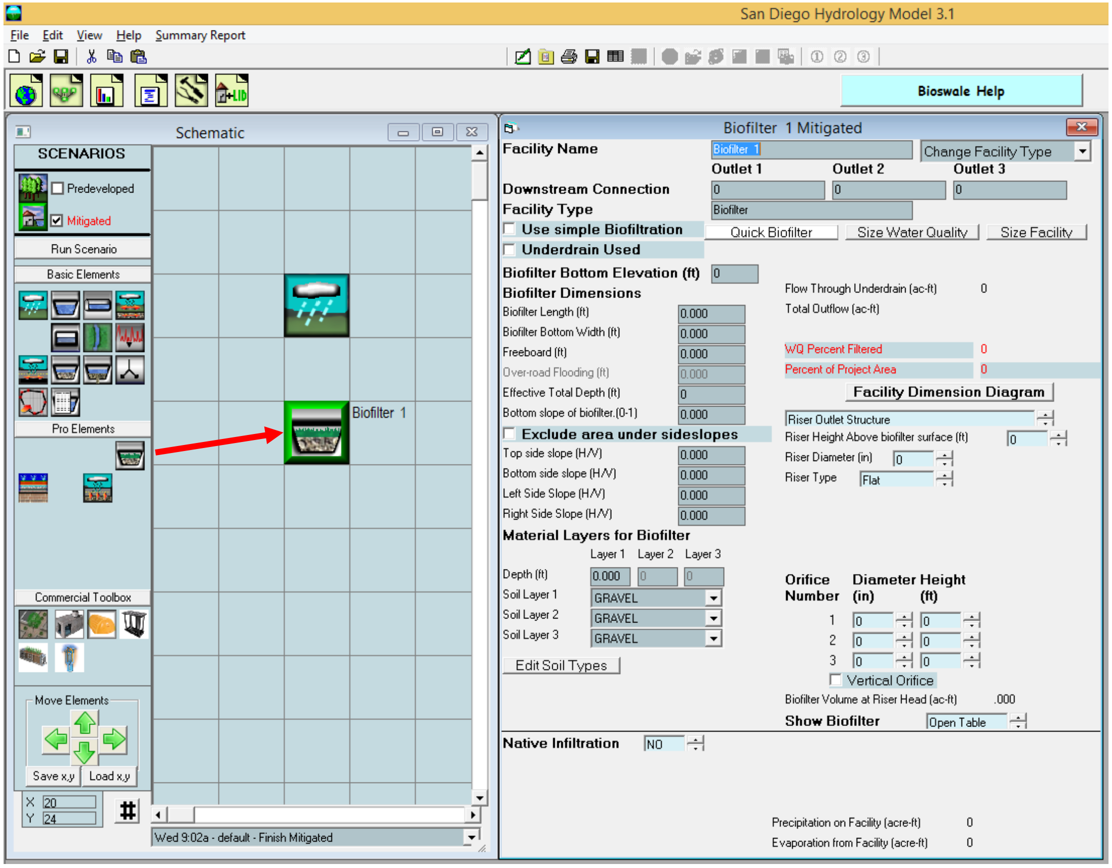
Our new threshold range for the HMP flow duration analysis is 0.0373 cfs to 0.757 cfs.

Now we can finish setting up and sizing our biofiltration facility in Step 8.

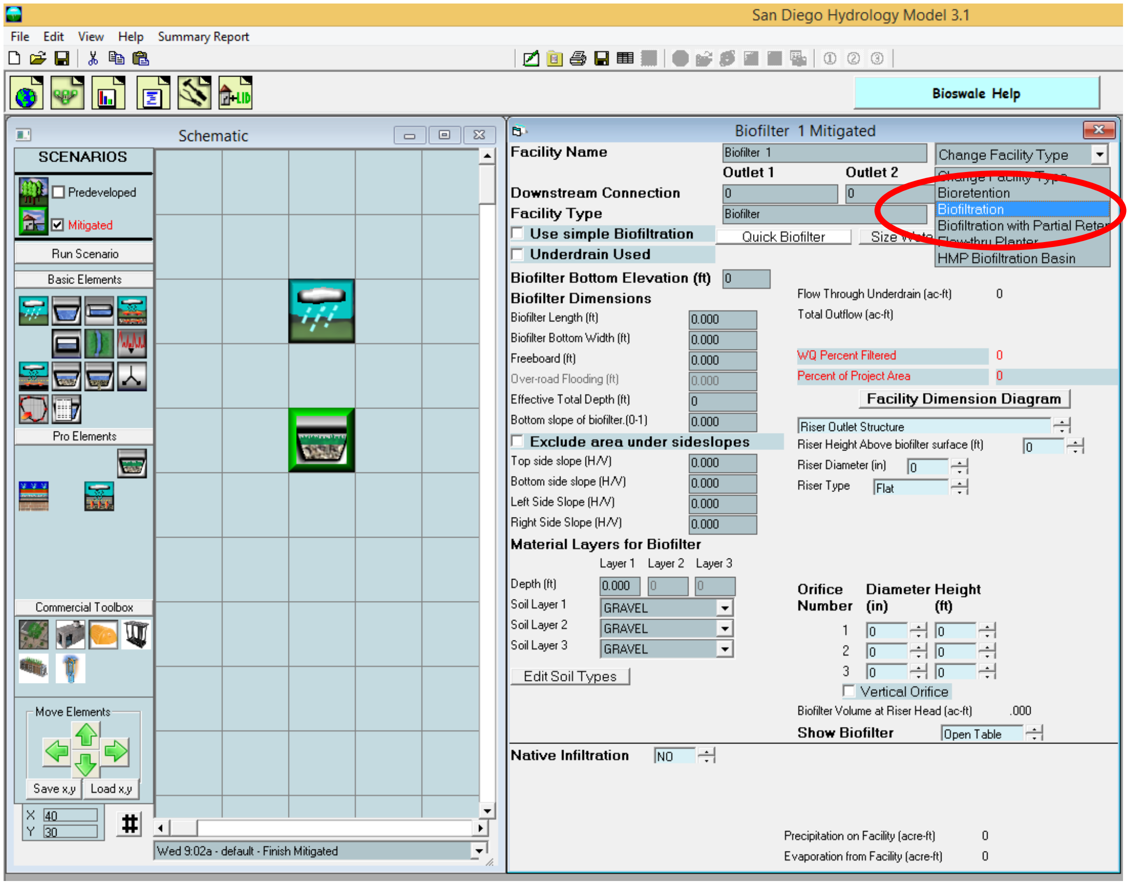
Step 8. Size Mitigated scenario HMP facility.



The first thing that we need to do is to disconnect POC 1 from Basin 1 in the Mitigated scenario. After we add the Biofiltration element we will connect the discharge from that element to POC 1.

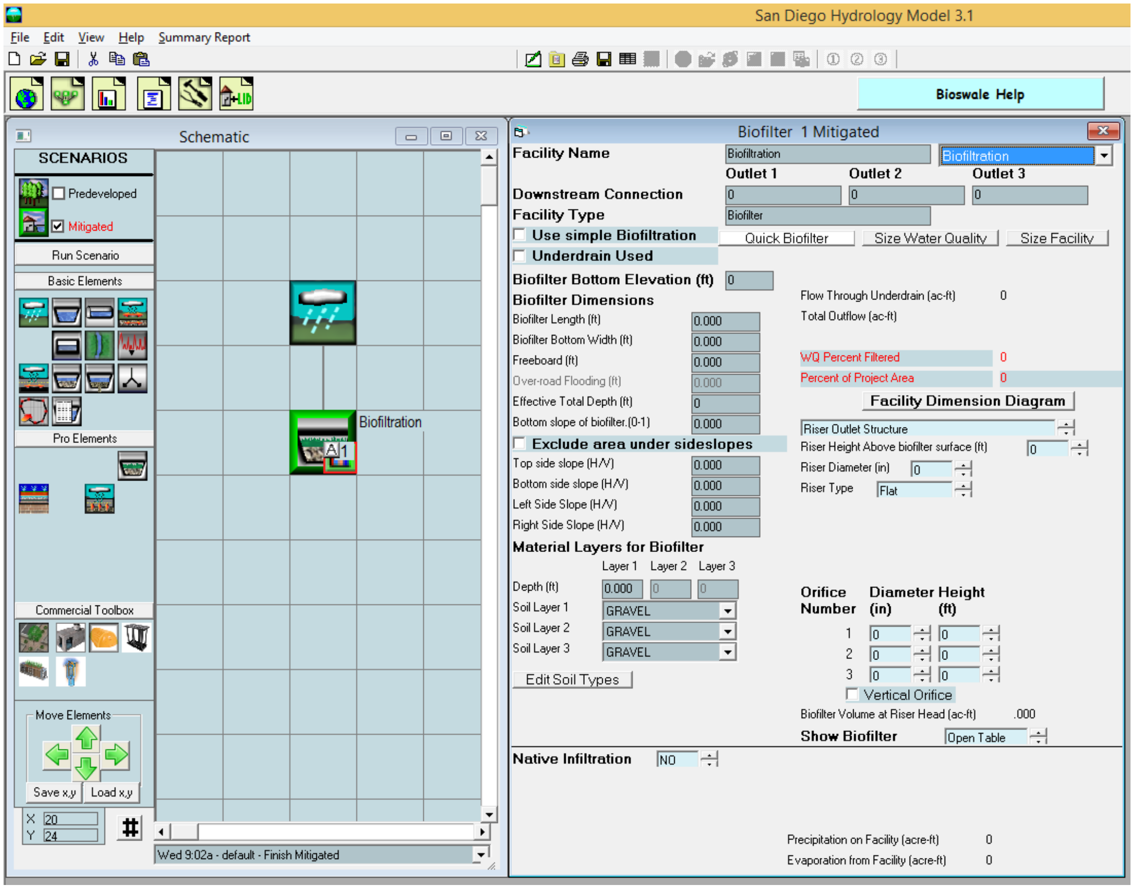


We add a Biofiltration element (default name: Biofilter 1).



We change the Facility Type to Biofiltration and that changes the facility name to the same.

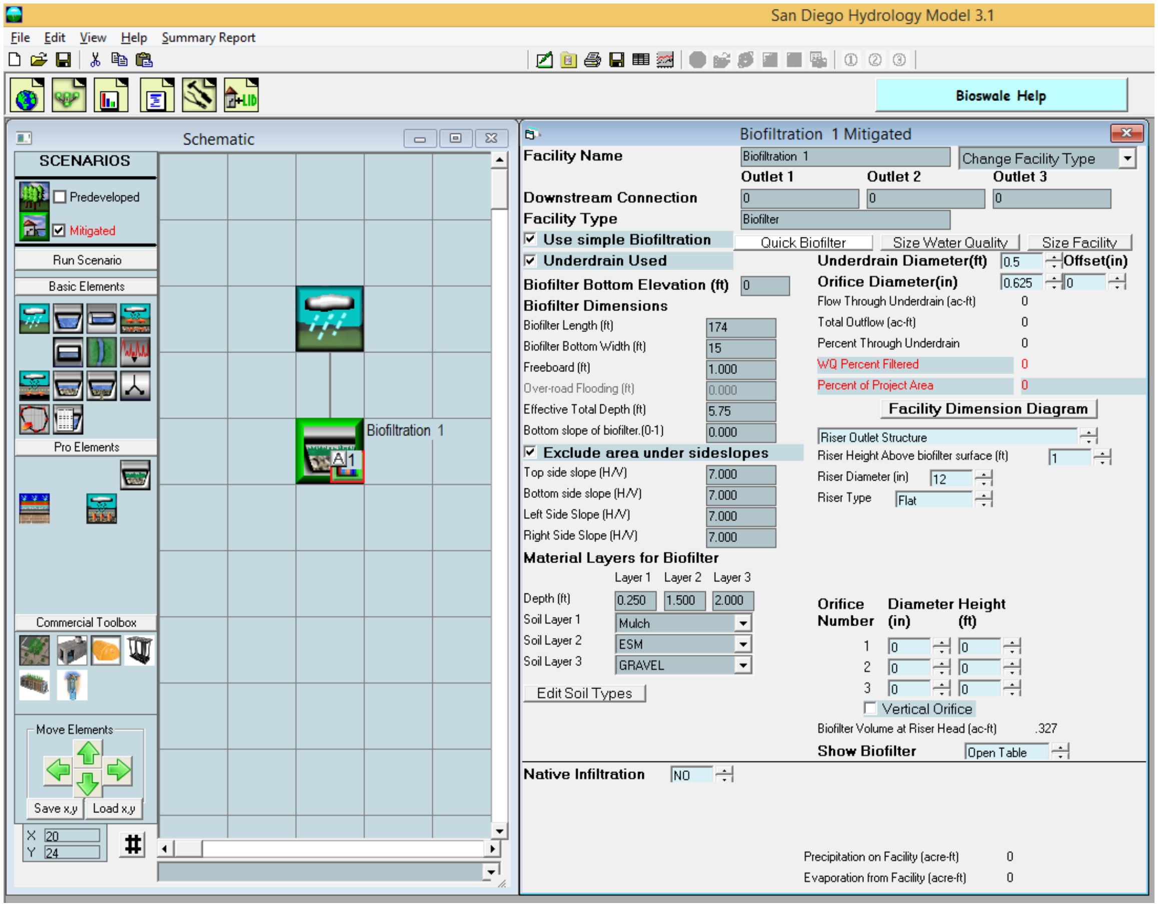
Note that the facility type and facility name do not change any of the input options or computational methods in the element. These changes are only to assist the user in documenting to the reviewer how this SDHM Biofiltration element will be used in this project.



We connect Basin 1 to Biofiltration and Biofiltration Outlet 1 to POC 1.

Outlet 1 includes all of the surface discharge including flow through the underdrain

We are now ready to input information for the biofiltration basin.



First, we check the box for Use Simple Biofiltration. This will speed up the calculations related to flow through the three material layers. This is slightly less accurate than the default complex method and we can switch it back to the complex method later once we have completed our design sizing if so desired.

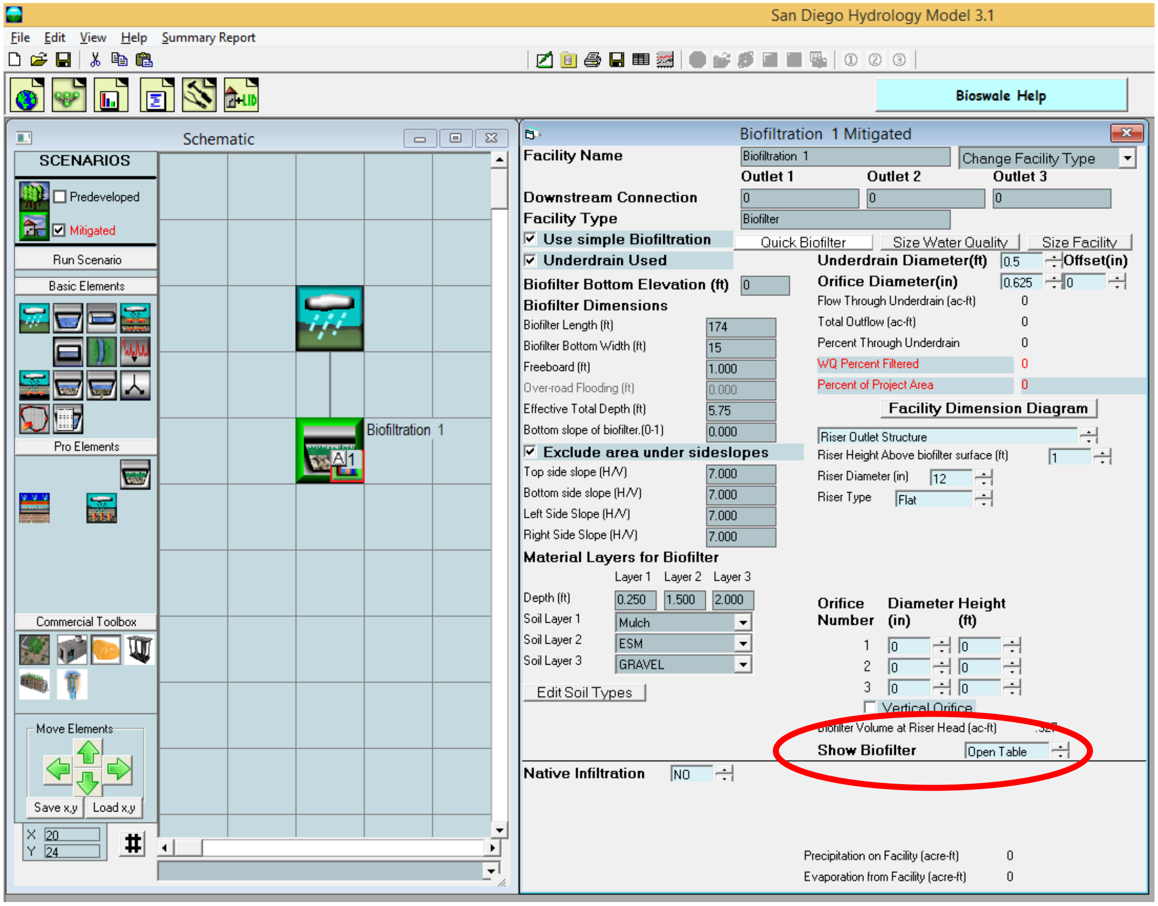
We also check the Underdrain Used box. We will include underdrain input information discussed below.

The biofiltration basin has a bottom footprint of 0.06 acres. That is equal to 2613.6 square feet. We don’t know the actual dimensions of the bottom footprint, but from the drawing it appears to be long and narrow. If we assume an average bottom width of 15 feet then the bottom length is approximately 174 feet. Those are the dimensions that we will use in the model.

On the surface there is one foot of ponding prior to overflowing into a flat riser with a diameter of 12 inches. There is an additional one foot of freeboard above the riser height.

The biofiltration basin has three material layers. The top layer (Layer 1) is mulch and is 3 inches (0.25 feet) thick. The second layer (Layer 2) is the San Diego-specified engineered soil media (ESM). Layer 2 is 18 inches (1.5 feet) thick. The lowest layer (Layer 3) is gravel and is two feet thick.

At the bottom of the gravel layer is an underdrain with a perforated pipe diameter of 6 inches (0.50 feet) with an offset of zero (the offset being the height above the bottom of the lowest material layer). The perforated pipe drains to an outlet control structure that contains a 0.625-inch diameter orifice. This orifice will control all flow from the three soil layers. It will not control the flow through the surface riser.

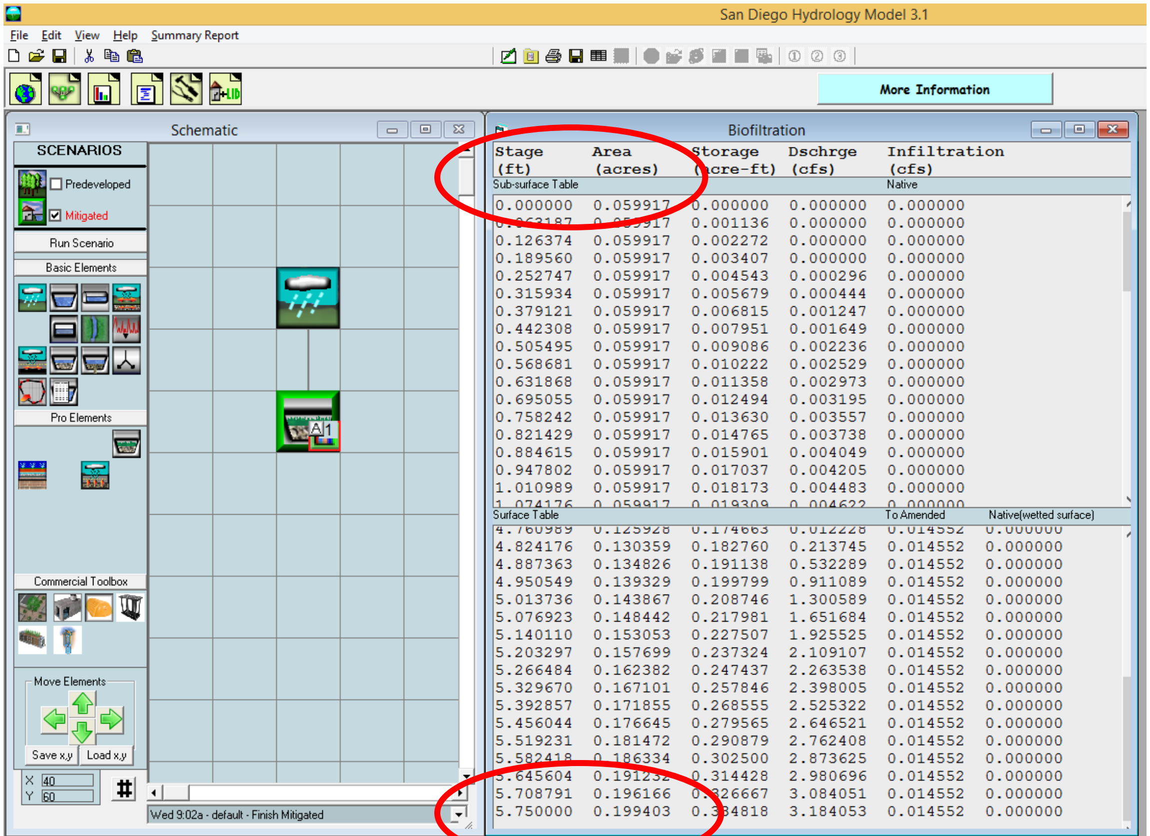


The biofiltration basin bottom slope is zero.

We select side slopes of 7 feet horizontal to 1 foot vertical to produce a total biofiltration basin surface area of 0.20 acres.

We check the "Exclude area under sideslopes" box to designate that the 7:1 side slopes are only for the above-ground slopes. The material layers have vertical side slopes.

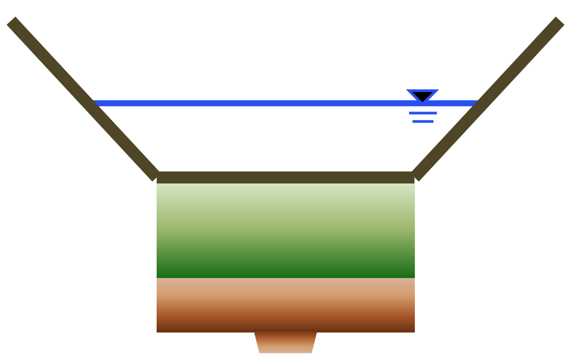
To check the biofiltration basin bottom and top surface areas we click on the down arrow to the right of the "Show Biofilter" Open Table label.



The top row of the Sub-surface Table (Stage 0.00 feet) lists the footprint surface area for the bottom of the biofiltration basin. Based on a width of 15 feet and length of 174 feet the bottom surface area is 0.059917 (or 0.06) acres.

The bottom row of the Surface Table (Stage 5.75 feet) lists the surface area at the top of the freeboard. This stage of 5.75 feet is the sum of Layer 1 depth of 0.25 feet, Layer 2 depth of 1.5 feet, Layer 2 depth of 2.0 feet, riser height of 1 foot, and freeboard height of 1 foot. The surface area for this maximum stage value is 0.199403 (or 0.20) acres.

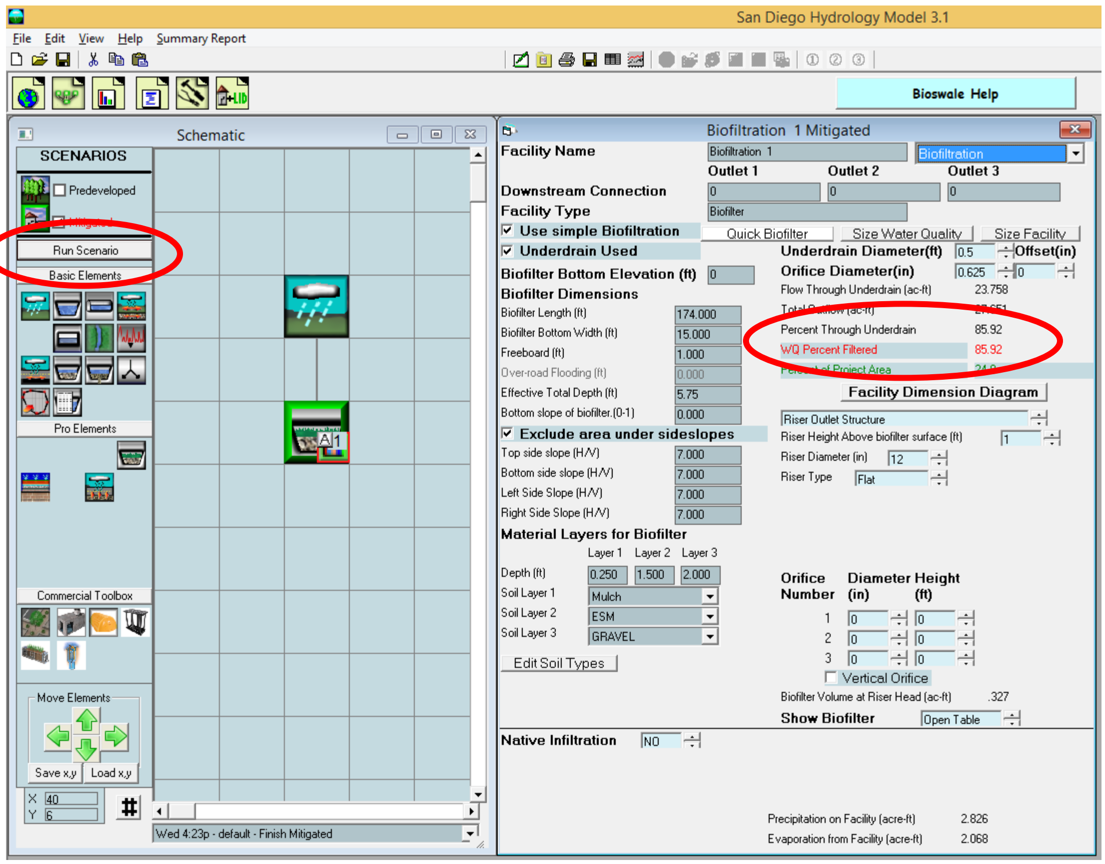
Both the bottom area and top areas are correct. The biofiltration basin looks like:



The side walls are vertical for the three material layers and then sloping for the ponding area.

Finally, we leave the Native Infiltration set to No. There is no infiltration to the native soil beneath the gravel layer (Layer 3). All flow through the material layers must exit via the underdrain.

We can now run the Mitigated scenario.

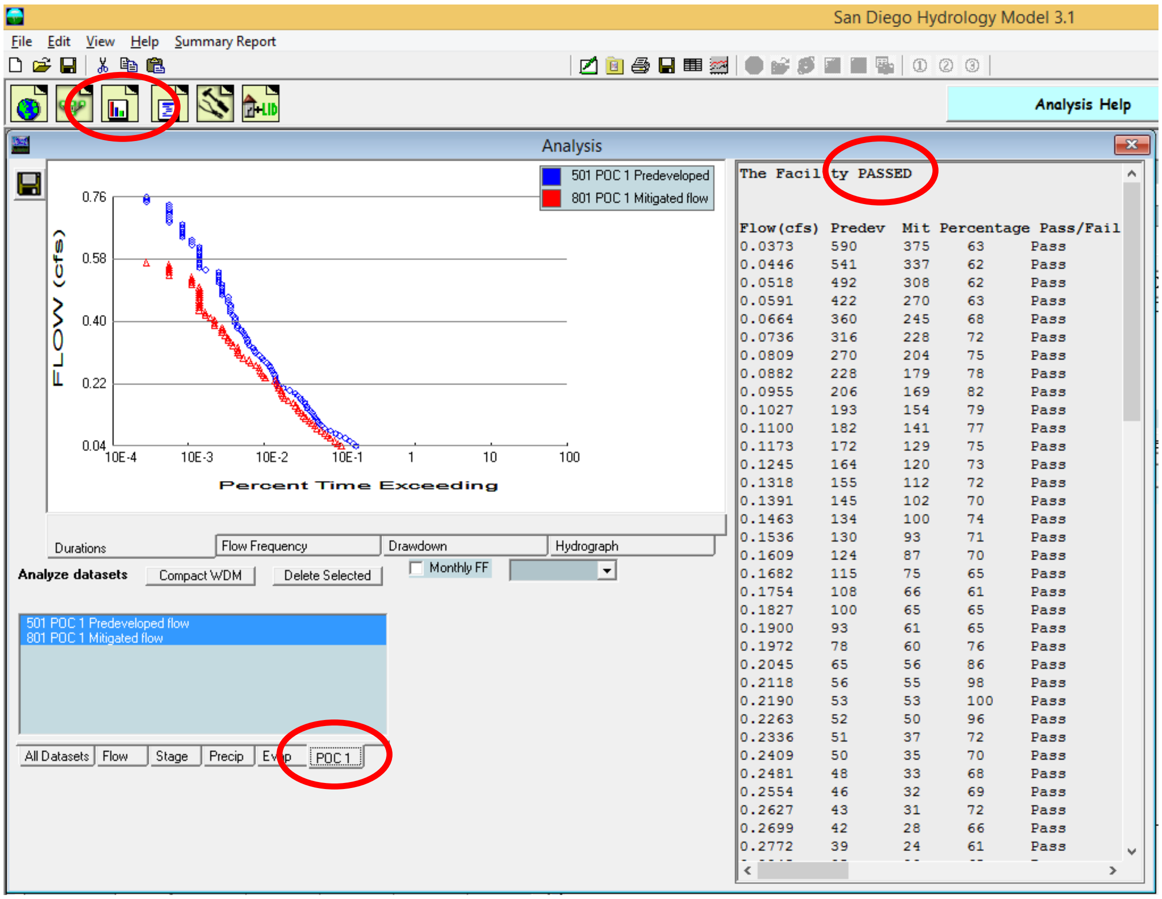


After clicking on Run Scenario the percent of total runoff volume through the underdrain for the entire simulation period (1963-2004) is reported on the Biofiltration element screen. For this biofiltration basin approximately 86 percent of the total runoff volume went through the three material layers and was discharged by the underdrain. The remaining 14 percent overtopped the riser and was discharged without going through the underdrain control orifice.

The percent through the underdrain does not tell us whether or not the project meets the hydromod flow duration requirements, but it gives us an idea of how much of the runoff is controlled.

Step 9. Review analysis.

We go to the Analysis window by clicking on the third icon from the right at the top of the screen to check the hydromod flow duration results.



We click on the POC 1 tab and the flow duration results are plotted and summarized in a table.

The plotted results show the red line (Mitigated flows) to the right of the blue line (Predeveloped flows) for the range of flows from 0.10Q2 (0.0373 cfs) to Q10 (0.757 cfs).

The flow duration table on the right shows that for each flow level the percentage (Mitigated/Predeveloped) does not exceed the maximum allowed 110% and passes for that level. It only takes one failure for the hydromod standard to not be met.

The results demonstrate that the biofiltration basin passes the HMP flow duration criteria and is large enough as modeled.

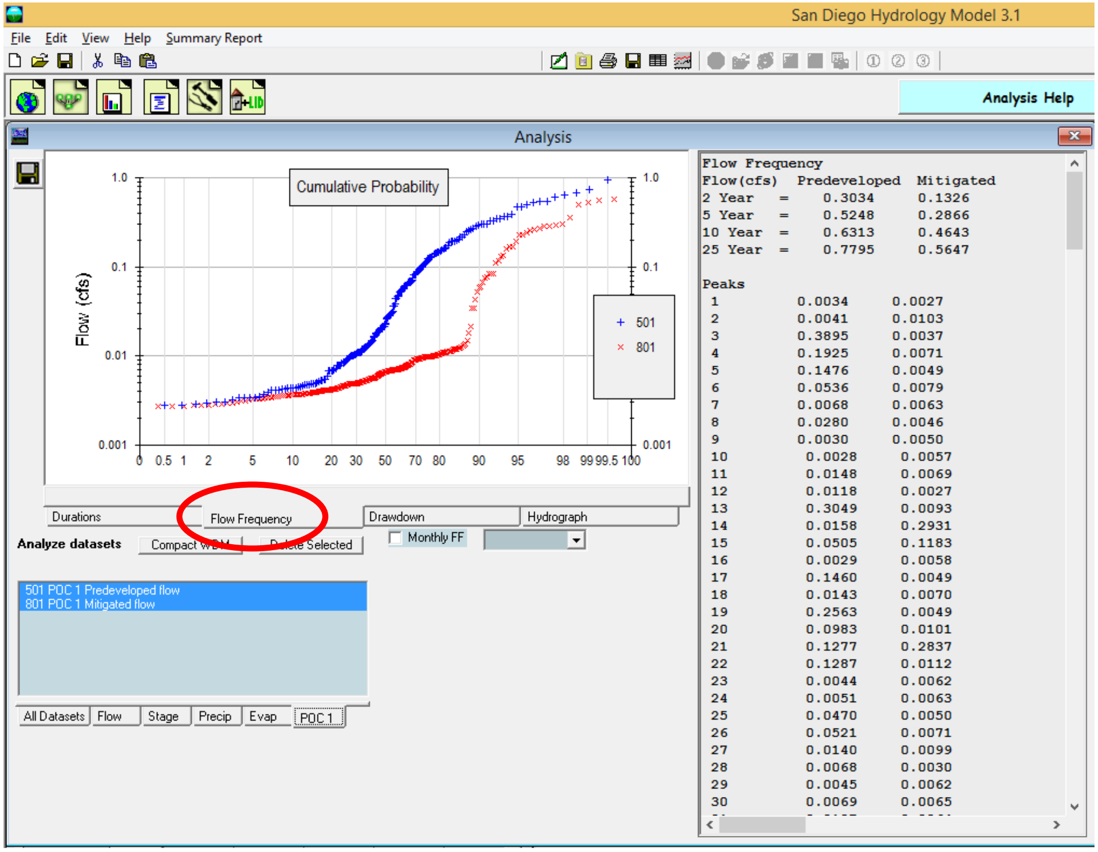
For this example we were able to get the biofiltration basin to pass on the first try. But we may not always be that lucky. Below are some things to try if the facility does not pass:

1. Increase the biofiltration basin bottom footprint while keeping the total biofiltration top area the same. This can be accomplished by increasing the bottom width and making the side slopes steeper. This provides more storage in the material layers and potentially allows for more water to go to the underdrain.

2. If the underdrain orifice diameter is controlling the discharge through the material layers then the orifice diameter can be increased to increase the percent of runoff filtered. This also results in less water ponding on the surface and fewer and smaller discharges through the riser. Conversely, if the flow durations are failing at the lower threshold (0.10Q2) then decreasing the size of the underdrain orifice diameter will reduce the number of times that the lower threshold flows occur.

3. If neither of the two above solutions work then increasing the biofiltration top area may be the only solution. If that area is increased then the contributing drainage area from the upstream Landuse Basin element should be decreased by the same amount.

Finally, we can compute the flow frequency for both the Predeveloped and Mitigated runoff at the POC, although this is not required.

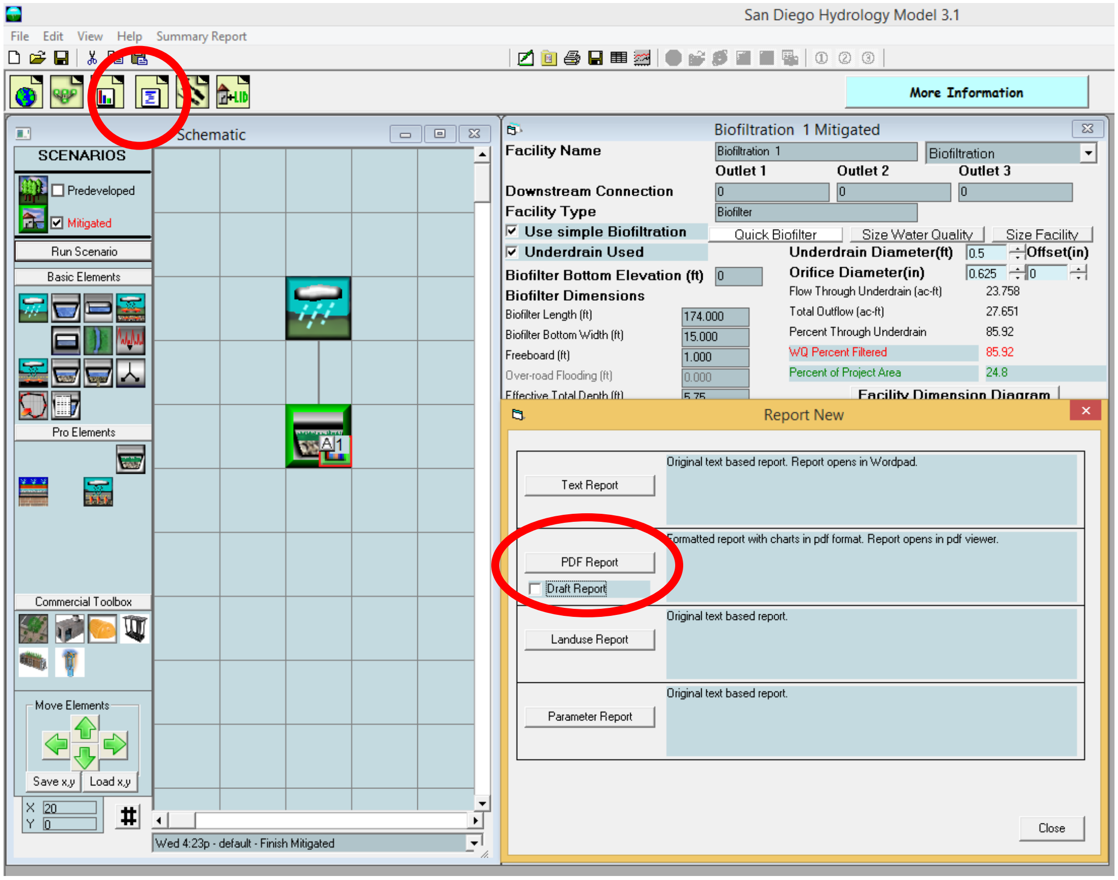


The Weibull-calculated flow frequency results can be observed by going to the Analysis window, selecting Flow Frequency, and then clicking on the POC 1 tab.

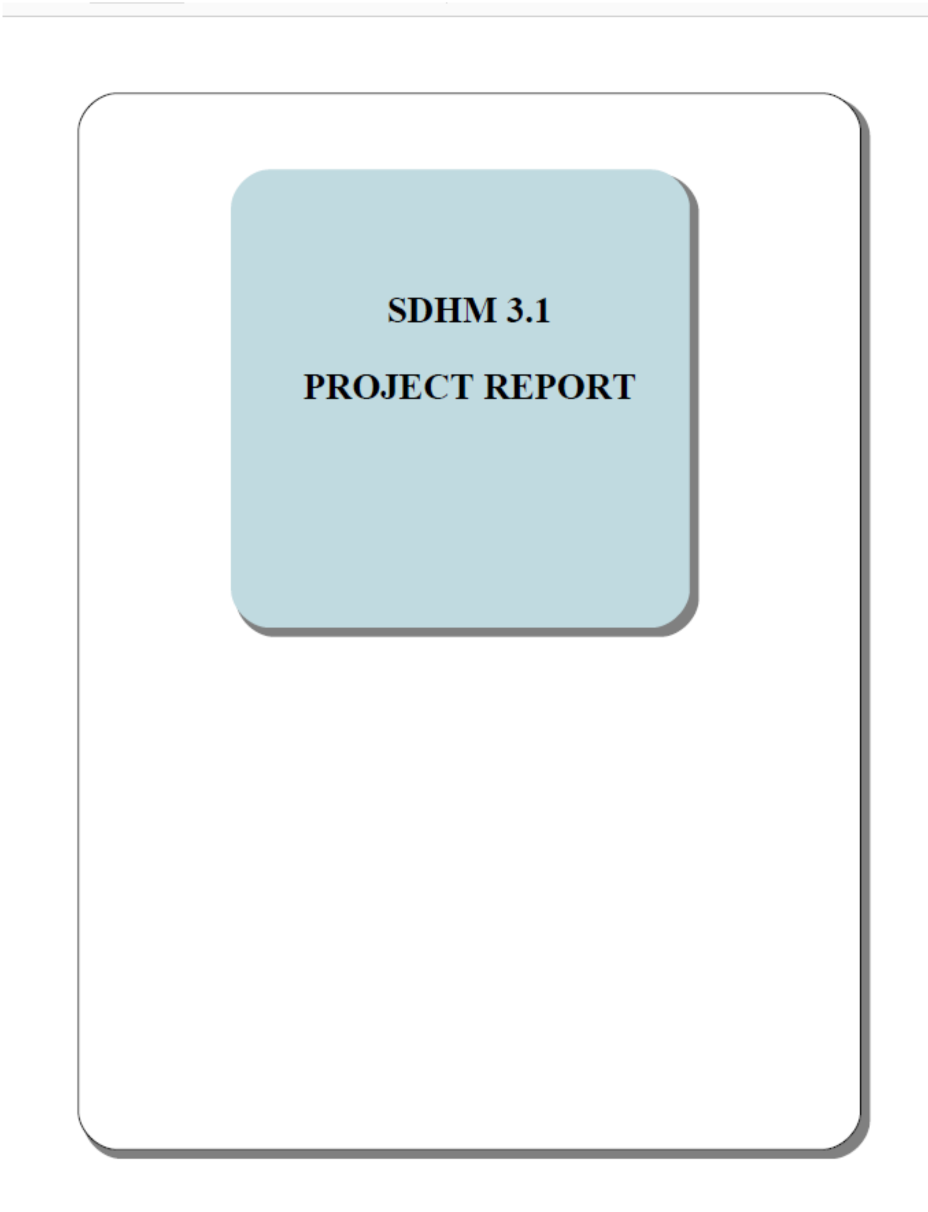
The flow frequency table shows that the Mitigated frequency values are smaller than the corresponding Predevelopment frequency values.

The Report file can now be generated and the project saved and submitted to the local municipal permitting agency.

Step 10. Produce report.

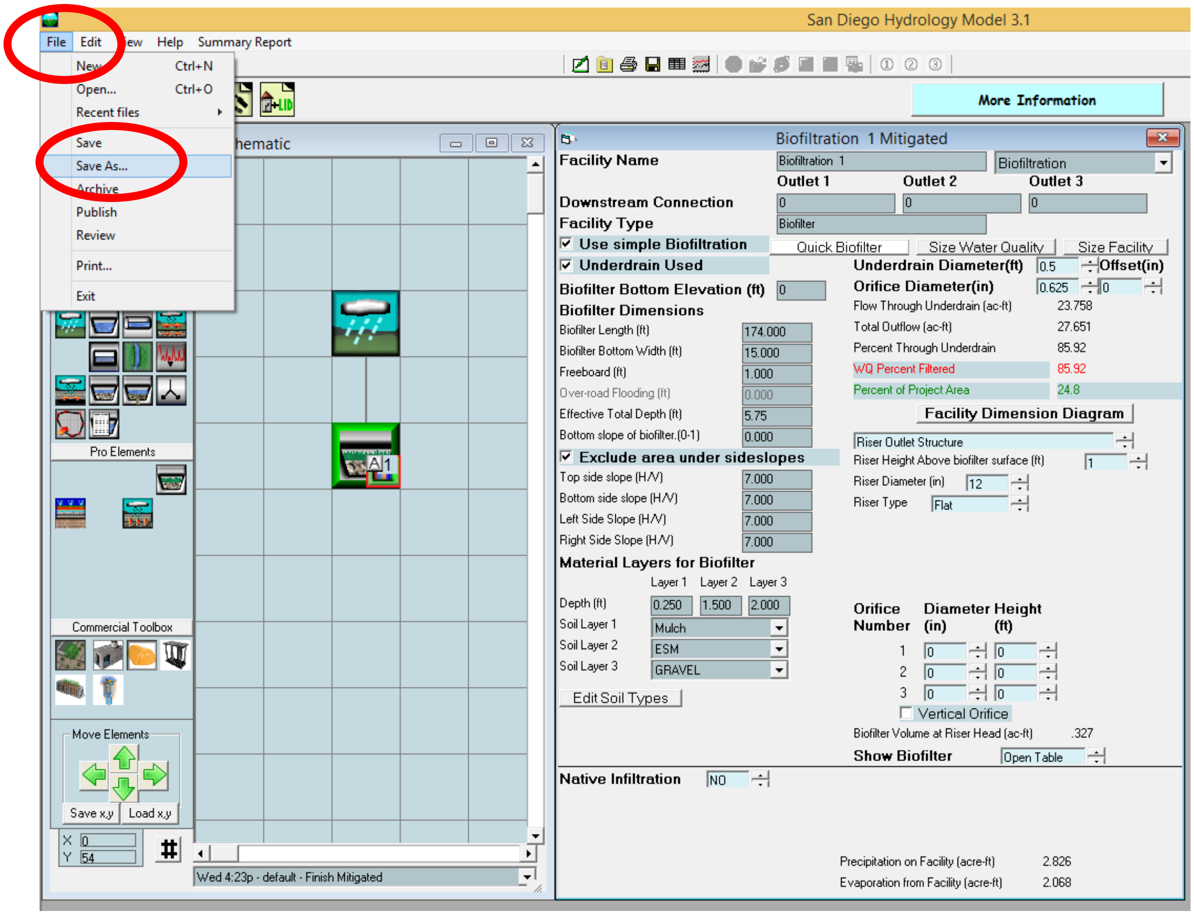


We will generate a project report by clicking on the Reports tool bar button (fourth from the left). We will select the PDF Report option and uncheck the Draft Report box.

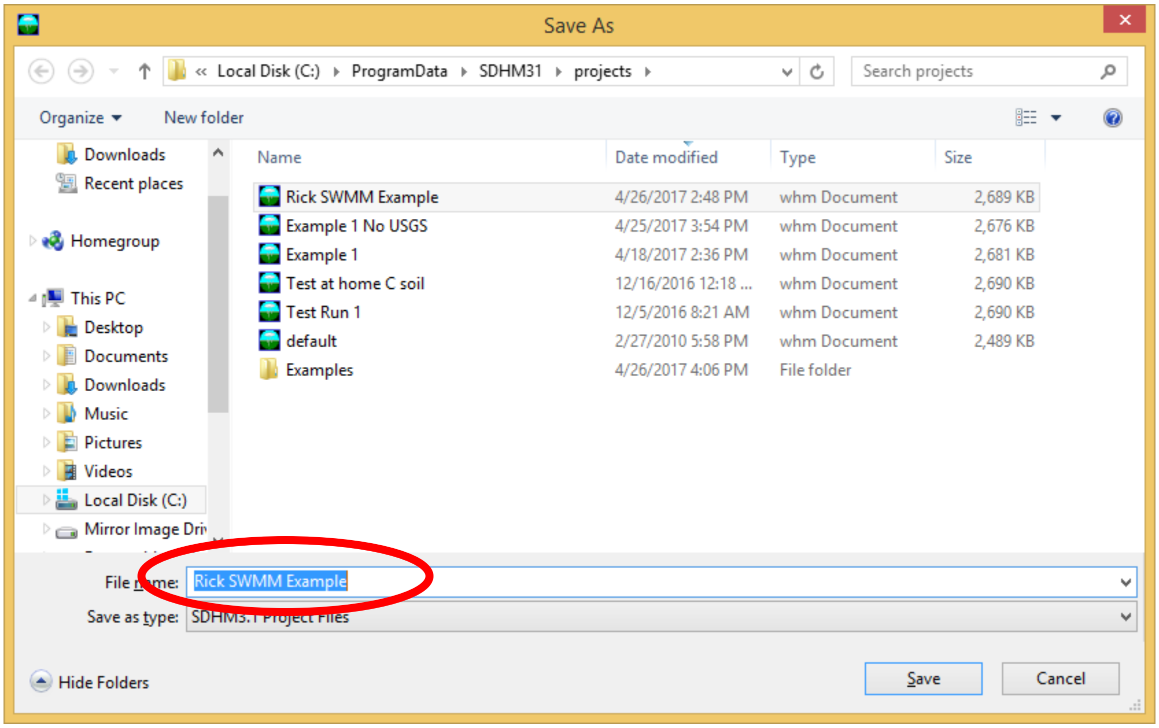


Scroll down the Report screen to see all of the results.

Step 11. Save project.

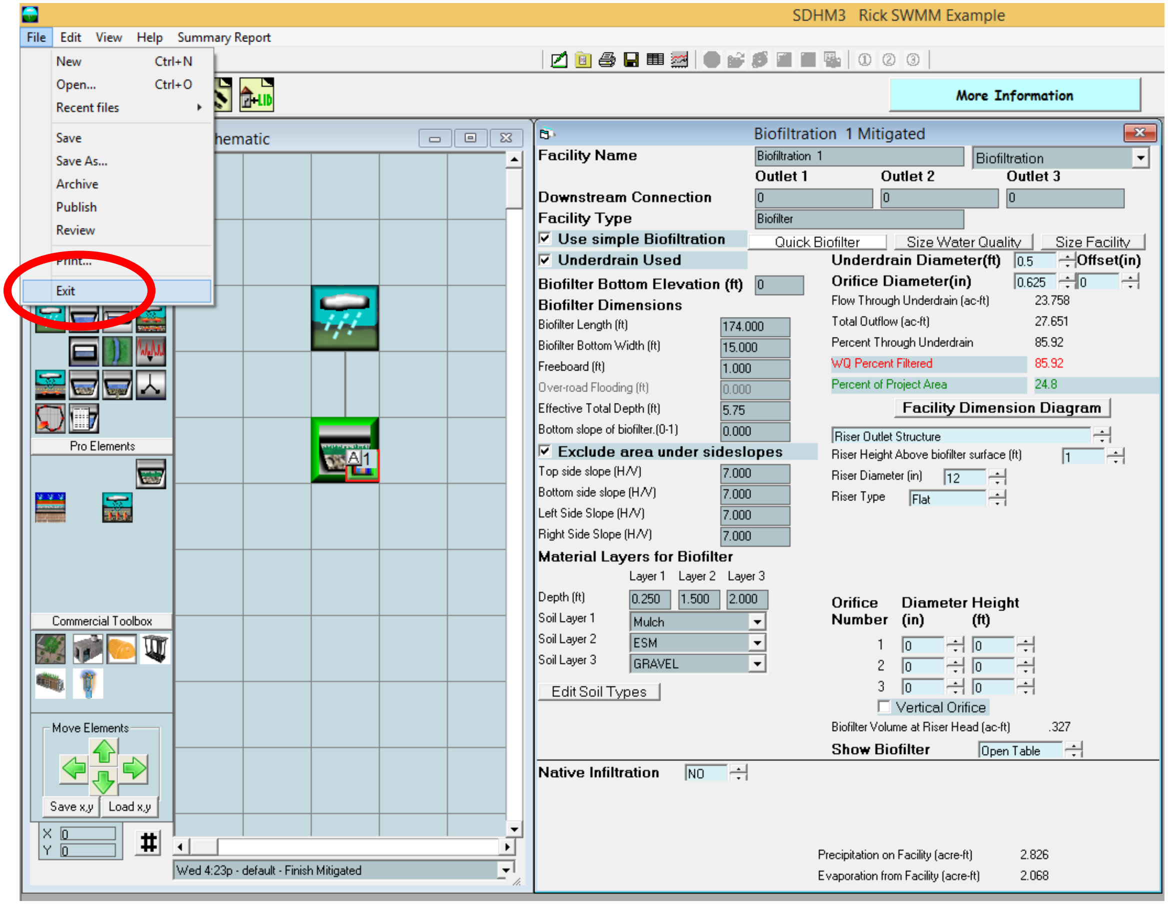


To save the project click on File in the upper left corner and select Save As.



Select a file name and save the SDHM 3.1 project file. The user can exit SDHM 3.1 and later reload the project file with all of its information by going to File, Open.

Step 12. Exit SDHM.



To exit SDHM 3.1 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.

NOTE: A simple SDHM 3.1 example project is discussed in Quick Start on page 5.