Bentley OpenRoads Workshop

2017 FLUG Spring Training Event

442 - Designing with a Pond

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Bentley Institute

Practice Workbook

This workbook is designed for use in Live instructor-led training and for OnDemand self-study. The explanations and demonstrations are provided by the instructor in the classroom, or in the OnDemand videos for this course available on the Bentley LEARN Server (*learn.bentley.com*).

This practice workbook is formatted for on-screen viewing using a PDF reader.

It is also available as a PDF document in the dataset for this course.

Ponds – a Physical and Hydraulic Introduction

SELECTseries 4 (08.11.09.845) or newer

About this Practice Workbook...

- This PDF file includes bookmarks providing an overview of the document. Click on the bookmark to quickly jump to any section in the file. You may have to turn on the bookmark function in your PDF viewer.
- Both Imperial and Metric files are included in the dataset. Throughout this practice workbook Imperial values are specified first and the metric values second with the metric values enclosed in square brackets. For example: *12'* [3.4m]
- Having an appropriate workspace is very important when using the OpenRoads technology. The workspace contains the standards and other design specifications needed to complete your work.

This training uses the *Bentley-Civil* workshop delivered with the software. It is very important that you select the *Bentley-Civil* workspace when working the exercises in this course.

TRNC02561-1/0001

Description and Objectives

Post-development runoff can be a lot higher than the runoff which occurred before the scheme was built (the pre-development situation). There will be more impervious area, with a smoother surface and a quicker response time, than the grass and vegetation that it replaces. This places an extra burden on the receiving watercourse, which can cause problems such as erosion and flooding.

For these reasons, it is common that the runoff from a proposed scheme needs to be controlled. This can either be to a maximum flow for a stated storm event (e.g. so many ft^3/s *[L/s]* for a 100 year, or 1% probability storm), or restricted to the pre-development levels. One commonly used method for achieving this is some form of attenuation, such as a retention pond. This is used to store post-development runoff and release it at a controlled rate. This ensures that the effect of the new development on the receiving watercourse is minimized.

Our class development is the construction of a road through a field. Assuming that a pond will be required:

- We will first prepare out drainage model for the new pond inlet and outlet structures and their pipes – the physical layout
- then we will analyze the pre- and post-development runoff to guide our pond design
- we will then define the hydraulic characteristics of the pond and the outlet control structures
- next we will make sure the pond and its network are hydraulically connected.
- Finally, we will analyze our design and adjust it as necessary to meet discharge targets.

Skills Taught

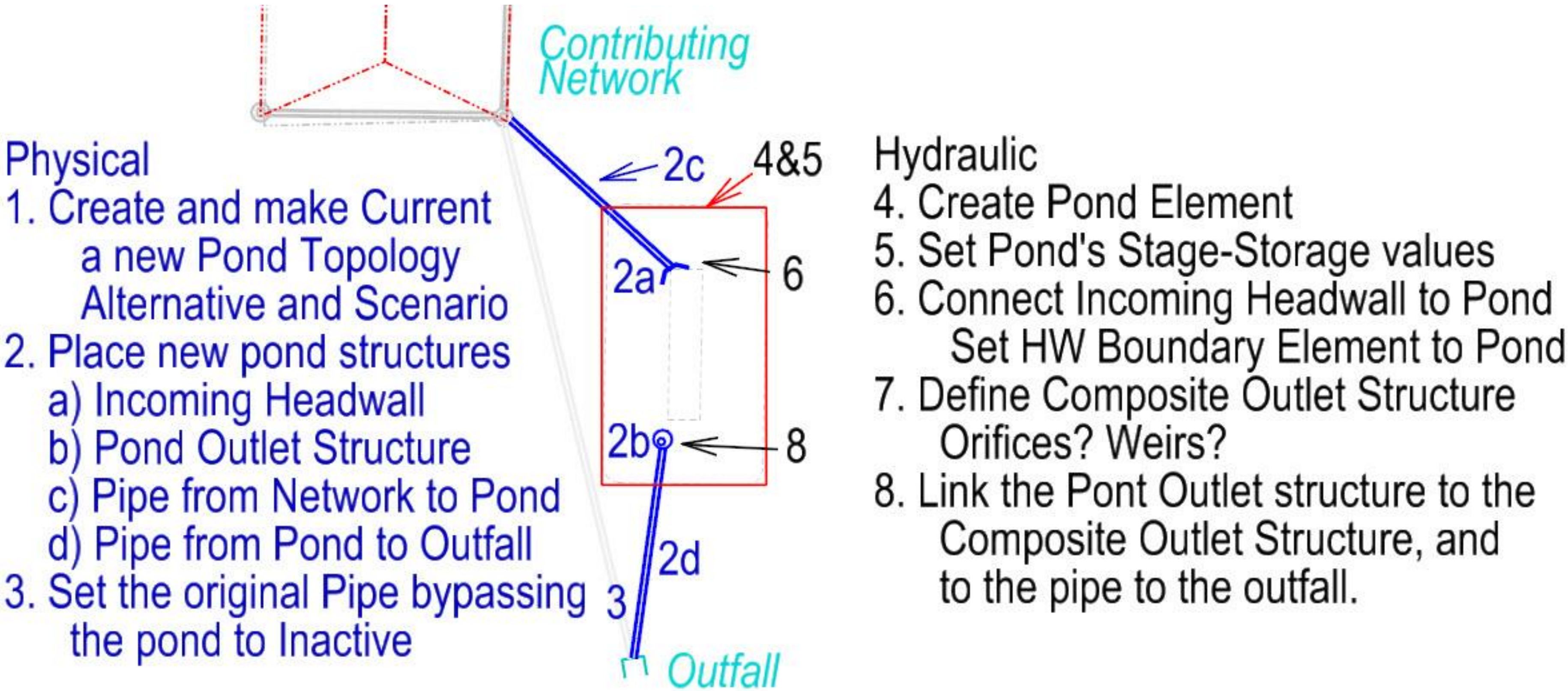
This workbook shows you how to:

- Review the pre-development situation
- Physically place a pond alternative, including pond inlet and outlet structures
- Compare pre and post-development runoff
- Define the pond storage characteristics and outlet controls structures’ hydraulic properties
- Integrate the Hydraulic Properties with the physical structures
- Analyze the results

Skills Assumed

This training assumes that you are familiar with hydraulics, OpenRoads technology, and the OpenRoads technology utilities and drainage capabilities. This is an advance class; it is assumed that you understand the concepts and techniques covered in the Subsurface Utilities Learning Path.

Workflow In a Picture



Getting Started

1. Start the software.
2. Select the workspace...

InRoads, GEOPAK, and PowerCivil Users

A. Select the User, Project, and Interface settings.

- User: *Examples*
- Project: *Bentley-Civil-Imperial* or *[Bentley-Civil-Metric]*
- Interface: *Bentley-Civil*

Continue with step 3

Help with the Workspace

If the *Bentley-Civil-Imperial* or *[Bentley-Civil-Metric]* projects are not listed, review the troubleshooting information in the Bentley Communities by clicking here or visiting communities.bentley.com and searching for “Civil Workspace”.

MX ROAD Users

A. On the MX Project Start Up window, click **New Project**.

B. Click **Browse** and select the folder where the training dataset is located.

C. Key in **Training** in the *Project Name* field.

D. Set the Default MX Project Settings to *UK_imperial [UK_metric]*.

E. Select the User, Project, and Interface settings.

- User: *Examples*
- Project: *Bentley-Civil-Imperial* or *[Bentley-Civil-Metric]*
- Interface: *Bentley-Civil*

F. Click **OK**. The MX project files are created and the software opens into a blank file named draw.dgn.

G. Select **File > Open** from the CAD menu.

Continue with step 3

3. Browse to the folder where you unzipped the dataset files and select the file **_Pond Design.dgn** *[_Pond Design-METRIC.dgn].*

Reviewing the File's Scenarios and Alternatives

Description

In this exercise, you will review the pre-development situation, looking at the scenario that has already been set up, and the data that it contains.

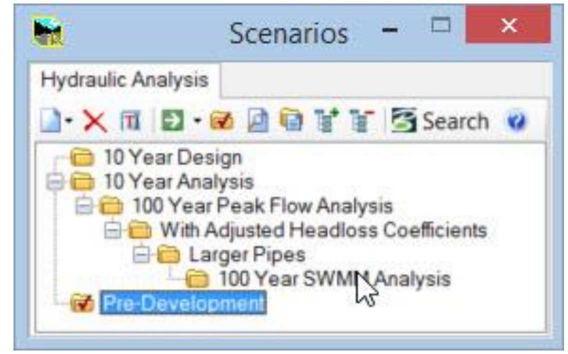
Skills Taught

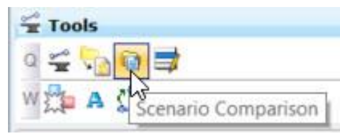
- Using Scenario Comparison tool
- Reviewing Scenarios and Alternatives

Using the Scenario Comparison tool to Compare Two Scenarios

1. In *Compute*, click **Scenarios**.

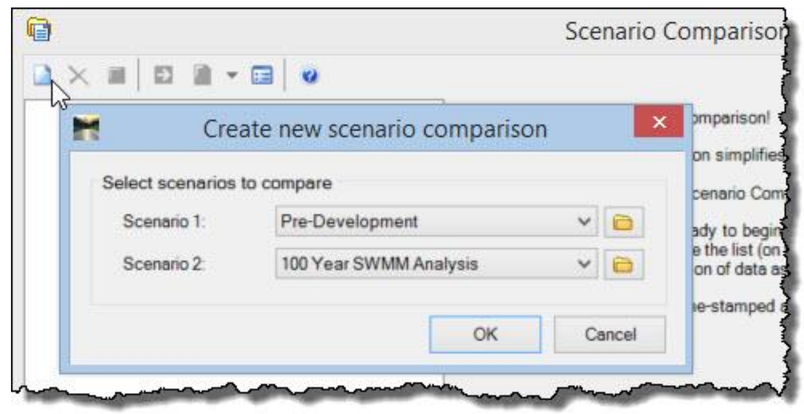
   This file contains a number of Scenarios. We are concerned with two: a pre- and post-development scenario. The difference in maximum discharge rates will determine our pond control design. The pre-development scenario is named *Pre-Development*. The scenario from which we will determine our post-development discharge rate is *100 Year SWMM Analysis*.





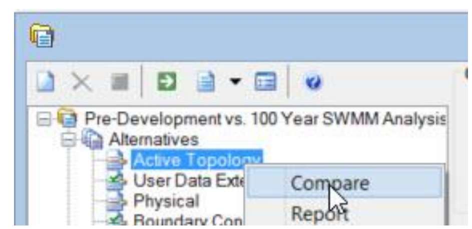
2. In *Tools*, click **Scenario Comparison**.
3. Click on the **New** icon

   This opens the *Create new scenario comparison* tool.
4. Compare **Pre-Development** and **100 Year SWMM Analysis.**

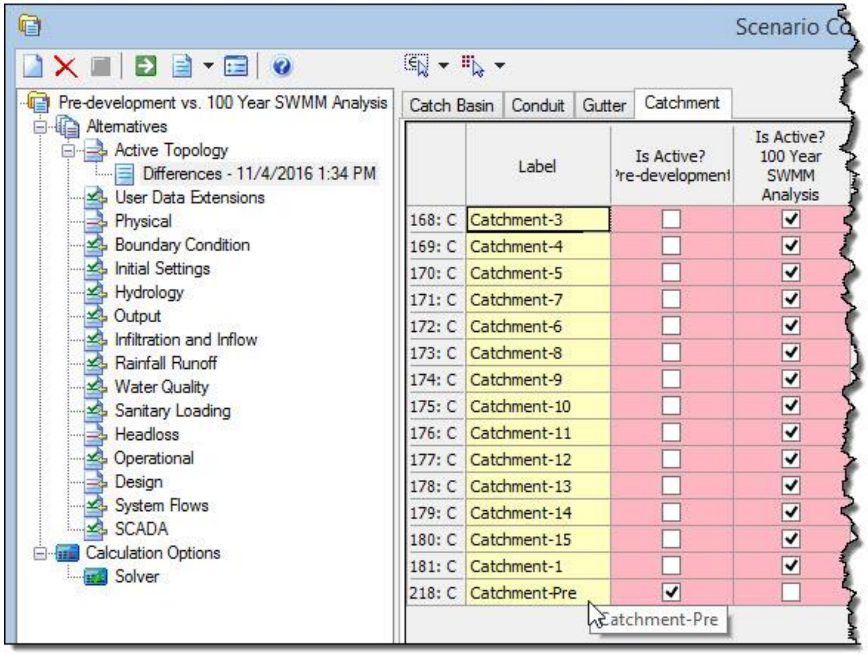


There are a few Alternatives that are different. The only relevant difference – we will explain shortly – is the Active Topology Alternative.

If you right-click on the Active Topology header and click Compare, you will get a detailed comparison of the two topologies.



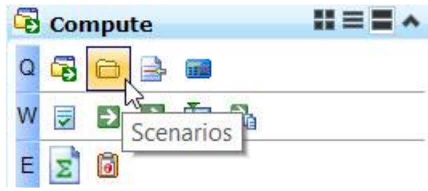
The essence is that the Pre-Development Topology contains a single grass project-wide catchment and the network outfall. The 100 Year SWMM Analysis contains the new pavement catchments but not the pre-development grass catchment.



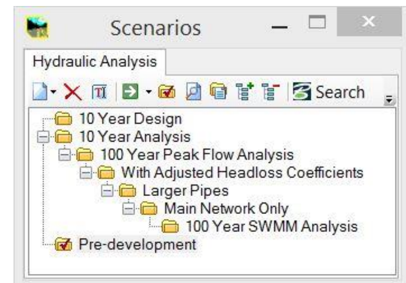
We'll review the details of these Scenarios below.

Reviewing the File's Scenarios and Alternatives

1. In *Compute*, click **Scenarios**.



The *Scenarios* dialog lists the scenarios that are in the design. At the bottom of the list, there is a Scenario called **Pre-Development**, and this is the one which models the situation before the scheme is built.



2. Confirm that the **Pre-Development** Scenario has a red tick against it, showing us that it is the current Scenario.

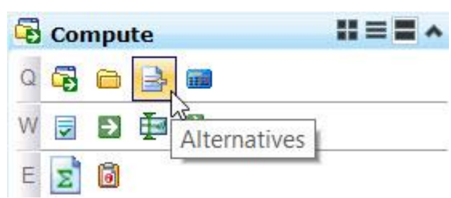
3. *Double-click* the **Pre-Development** Scenario to show the settings for it in the *Hydraulic Analysis* tab of *Utility Properties*.

This dialog shows us the **Alternatives** and **Calculation Options** that the Scenario uses. We can see that some of the **Alternatives** use the **Base** settings, and others have been changed. We will review the ones that have been changed – starting with the **Rainfall Runoff** Alternative.

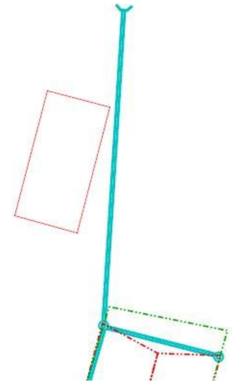
Before we do that, note that the **Calculation Options** are set to **SWMM**. These options are covered in the *Analysis and Design - Dynamic Modeling* class.

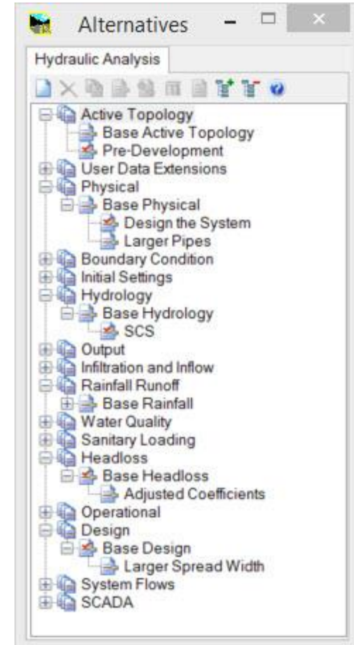
Alternatives	
Active Topology	Pre-development
User Data Extensions	Base User Data Extensions
Physical	Design the System
Boundary Condition	Base Boundary Condition
Initial Settings	Base Initial Settings
Hydrology	SCS
Output	Base Output
Infiltration and Inflow	Base Infiltration and Inflow
Rainfall Runoff	100 Year SCS Type III
Water Quality	Base Water Quality
Sanitary Loading	Base Sanitary Loading
Headloss	Base Headloss
Operational	Base Operational
Design	Base Design
System Flows	Base System Flows
SCADA	Base SCADA
Calculation Options	
Solver Calculation Options	SWMM

4. In Compute, click **Alternatives**.

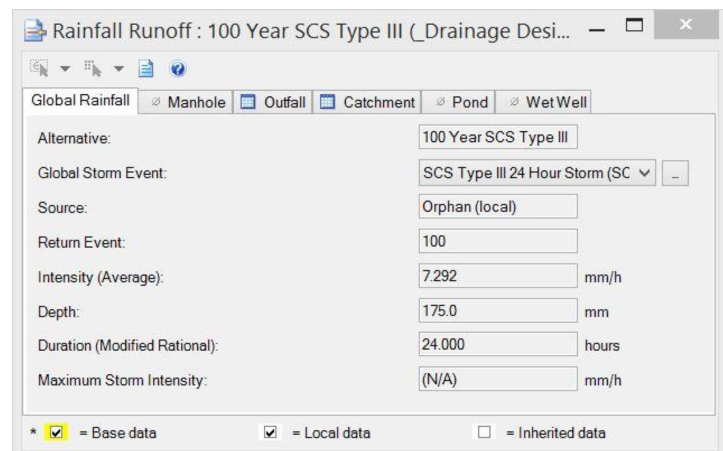


The *Alternatives* dialog shows all of the Alternatives. The ones that are used by the current Scenario have a red tick against them.





5. Expand *Rainfall Runoff*, then double-click **100 Year SCS Type III**.



The *Rainfall Runoff* Alternative dialog shows us that the Global Storm Event has been set to **SCS Type III 24 Hour Storm**. That tells CivilStorm how the rain is falling during this event. The next thing to consider is what happens when it hits the ground.

6. Close the *Rainfall Runoff* Alternative dialog.

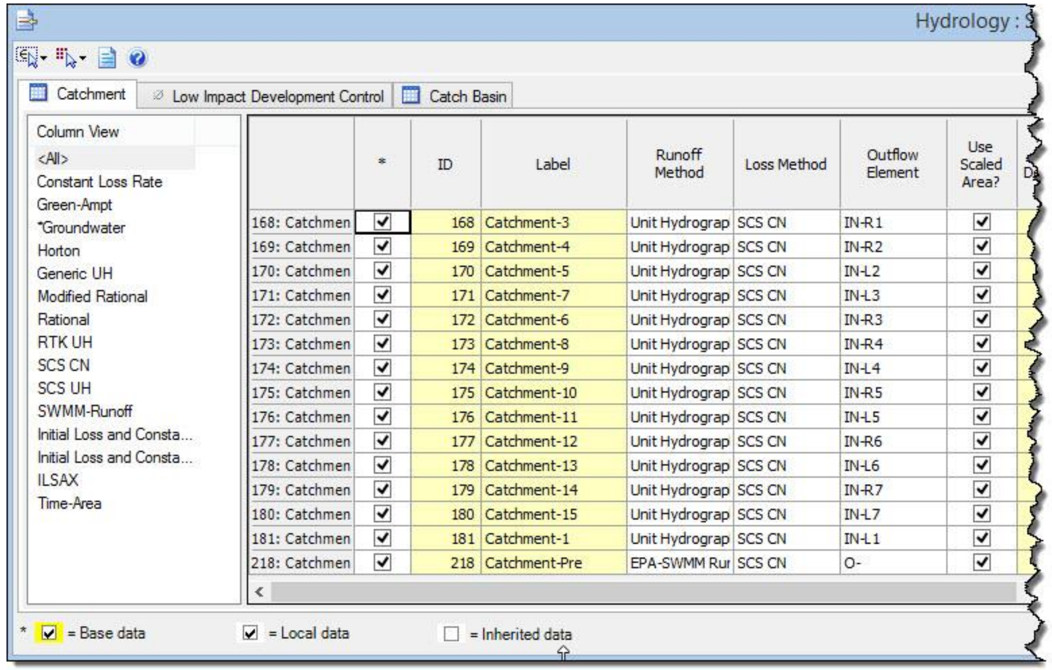
7. In View 1, zoom in to the graphics at the top of the view.

8. Locate the catchment boundary which is drawn in a green dot-dash line style.

9. Hover over it, and a tooltip tells you that it is **Polygon: Catchment-Pre**. This is the catchment which models the pre-developed area of land.

10. In the *Alternatives* dialog, double-click the **SCS** *Hydrology Alternative*.

    The *Hydrology* Alternative dialog opens. **Catchment-Pre** is listed at the bottom. We can see that it is using the *EPA-SWMM* **Runoff Method**, and the *Loss Method* column tells us that it is using the **SCS CN** (Soil Conservation Society Curve Number). We can also see other information, such as the *Outflow Element* that this catchment discharges to, which is the outfall at the top of the graphics.



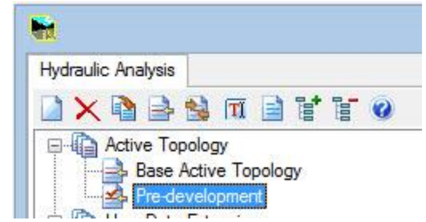
The *Hydrology* Alternative dialog also lists other catchments, so why aren't they all contributing runoff in the **Pre-Development** Scenario?

The answer is because they are not active in this scenario – they have been excluded from it. This is done using a *Topology* Alternative.

Pre-Development Topology

1. In the *Alternatives* dialog, expand *Active Topology*, so you can see that the **Pre-Development** Alternative is current.

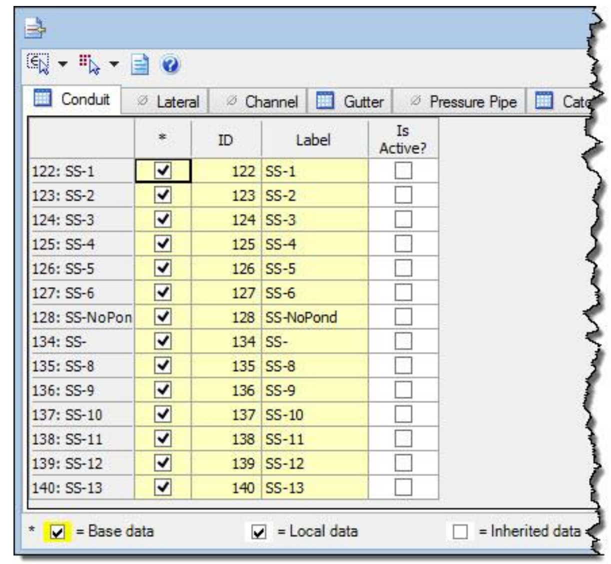
   Note that this is a Base Alternative, not a Child Alternative. The reason for this is that a Base Alternative cannot inherit from its parent. In the case of a *Topology* Alternative, by default nothing in it is active, because it assumes that it has been created to contain new elements.



2. Double-click **Pre-Development.**

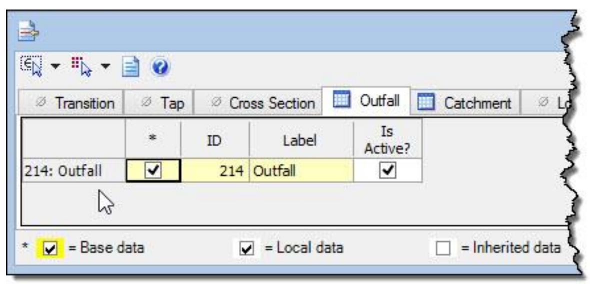
   The *Conduit* tab is shown, and from this we can see that no conduits are active in this Scenario – none of the boxes in the *Is Active?* column are checked.

3. Inspect the *Gutter* and the *Catch Basin* tabs. They show the same thing – that no elements of those two types are active in this Scenario.



	*	ID	Label	Is Active?
122: SS-1	☑	122	SS-1	☐
123: SS-2	☑	123	SS-2	☐
124: SS-3	☑	124	SS-3	☐
125: SS-4	☑	125	SS-4	☐
126: SS-5	☑	126	SS-5	☐
127: SS-6	☑	127	SS-6	☐
128: SS-NoPon	☑	128	SS-NoPond	☐
134: SS-	☑	134	SS-	☐
135: SS-8	☑	135	SS-8	☐
136: SS-9	☑	136	SS-9	☐
137: SS-10	☑	137	SS-10	☐
138: SS-11	☑	138	SS-11	☐
139: SS-12	☑	139	SS-12	☐
140: SS-13	☑	140	SS-13	☐

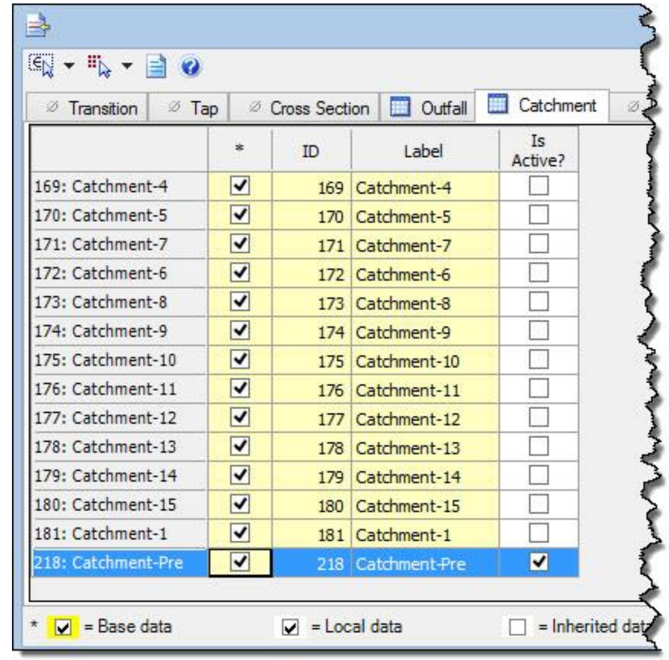
4. Scroll to the right, and inspect the *Outfall* tab. This time we see that the outfall **Outfall** is active, so we know that this Scenario does have an active outfall.



	*	ID	Label	Is Active?
214: Outfall	☑	214	Outfall	☑

Finally, inspect the *Catchment* tab.

Here we can see that only **Catchment-Pre** is active in this Scenario – in other words it is the only one that contributes runoff in it.



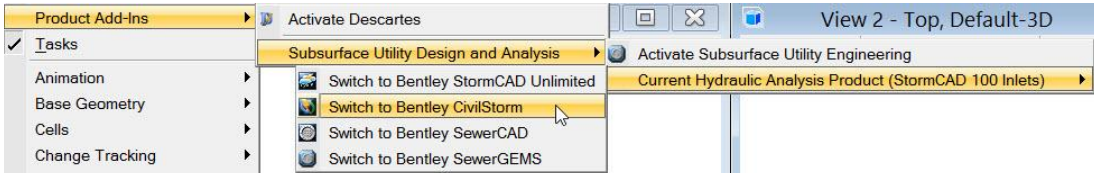
5. Close the *Topology Alternative* dialog.

Ensuring Good and Post-Development Numbers

Before moving forward with a new Pond Design, it is a good idea to make sure that the calculations for the Pre-Development and the current Post-Development Scenarios are good. We really do not know when those calculations were actually performed, so let's do it now.

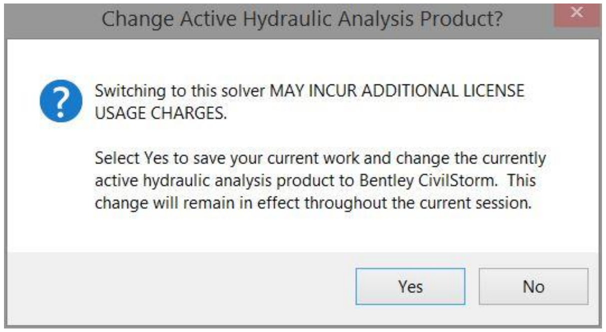
Activating CivilStorm

1. On the menu, click **Tools**, then click as shown in the picture below to switch to CivilStorm.



Note: CivilStorm is not included by default in an OpenRoads license. Activating CivilStorm will log usage against the License Server.

You will see a warning message about licensing and the potential to incur charges if you do not own the appropriate license.



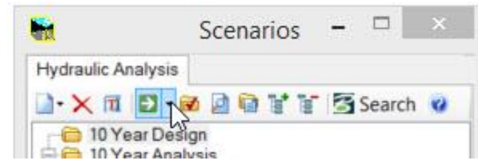
2. Click Yes.

   CivilStorm is activated, and the extra functionality that it contains is now available.

Batch Computing Pre and Post-Development Scenarios

Our engineering goal is to cap the post-development peak discharge rate to the pre-development peak. We need the rates for both. We will Compute the Pre-Development Scenario and the last still-valid post-development Scenario: 100 Year SWMM Analysis (the pond scenario is not ready for calculations yet).

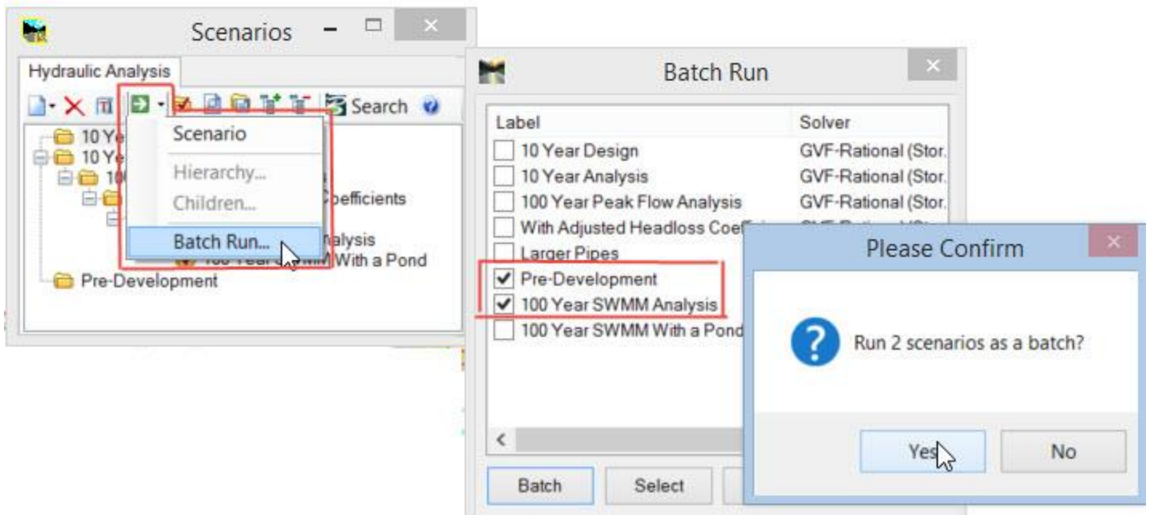
We could compute these Scenarios on their own. However, we compute multiple Scenarios at once using the Batch Run mode.



1. In the *Scenarios* dialog, click the pull-down arrow to the right of the green **Compute** arrow icon.
2. Click **Batch Run** from the pull-down.

   The Batch Run dialog lists the available Scenarios.

3. Check the **Pre-Development** and **100 Year SWMM Analysis** *Scenarios* and click the **Batch** button.



4. In the *Please Confirm* dialog, click **Yes**.

   Both Scenarios are computed, and – because they are using the SWMM solver - this includes calculating the runoff hydrographs and routing them through the system.

In the case of the Pre-Development Scenario, the system only comprises the catchment and an outfall, as we have seen from reviewing the Topology Alternative.

The 100 Year SWMM Analysis Scenario, however, includes all of the other catchments, the inlets, and the conduits that we can see. It also ends at the outfall at the top of the graphics – this outfall is active in both Scenarios.

Note: you do not get the same level of feedback about the calculations. If you want to be sure about calculation completion of particular Scenario, you would have to calculate them individually.

5. Click **OK** on the *Information* dialog if one appears.

Preparing for the Pond

Now that we know how our file is set up and that our calculations are current, let's set it up for a Pond.

We will create a new Pond Scenario pointing to a new Pond Topology.

Scenarios have been covered in other classes, and the *Managing Multiple Scenarios* class goes into some depth on this subject.

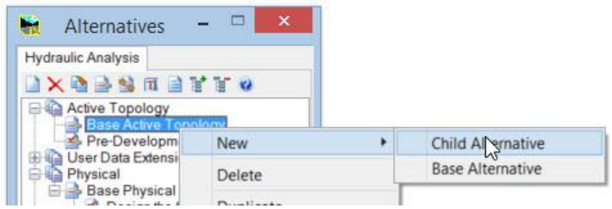
Creating a new Active Topology Alternative for the Pond

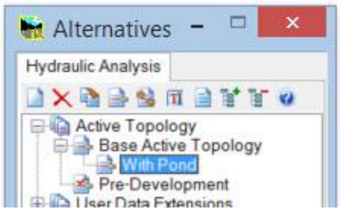
We will need a new Topology Alternative, to store the new pond elements. Why?

- We don't want pond elements to be included in the pre-development scenario.
- We don't want them in the proposed system that we have designed so far, either. It makes sense to leave the unmitigated design intact.
  - There may be multiple mitigation alternatives for evaluation, such as underground storage, different sized ponds or combinations thereof.
  - Multiple Scenarios are easily managed by creating children of the "base" design scenario. Changes to the base design will be inherited by all the children.
  - Maintaining a "pre-pond" state provides a clear and cleanly "archived" starting point should new mitigation alternatives need evaluation.

1. In the Alternatives dialog, expand **Active Topology**
2. *Click* the **Base Active Topology** Alternative
3. *Right-click*, then click **New > Child Alternative**
4. Click the new Alternative, change the name to **With Pond**

   The Alternatives dialog should look like this now.





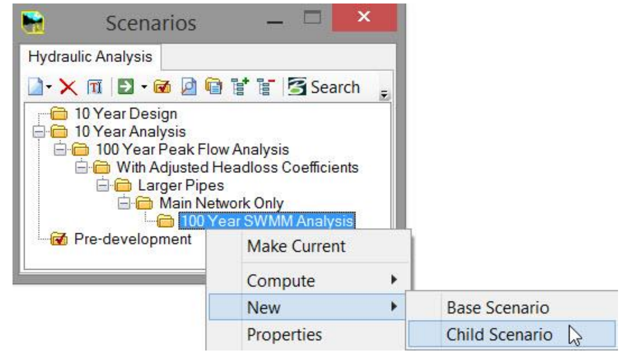
We have created a Child Alternative of the **Base Active Topology** Topology Alternative because we want to inherit the settings from the parent. We want the conduits, catch basins, and catchments to be active, because they will discharge into the pond.

The *Utility Properties* dialog should look like this now.

Alternatives	
Active Topology	With a Pond
User Data Extensions	<I> Base User Data Extensions
Physical	<I> Larger Pipes
Boundary Condition	<I> Base Boundary Condition
Initial Settings	<I> Base Initial Settings
Hydrology	<I> SCS

Creating the Pond Scenario

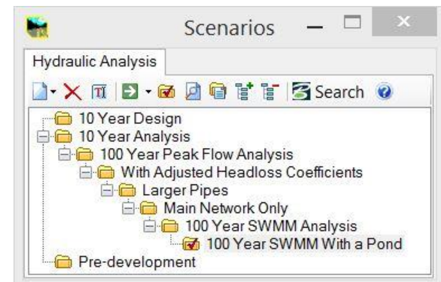
1. In the *Scenarios* dialog, click on the **100 Year SWMM Analysis** Scenario.
2. Right-click, and select **New > Child Scenario**.
3. Name the new Scenario **100 Year SWMM With a Pond**.
4. Select it, right-click > **Make Current**



The *Scenarios* dialog should look like this now.

Note the red tick showing that the *100 Year SWMM With a Pond* Scenario is current.

Ensure that this is how your dialog looks.

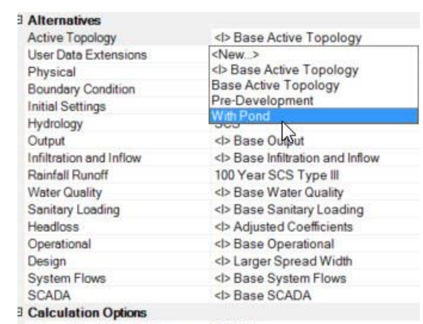


Note: We need to make this new Scenario current because the next step is to create some new Alternatives for the new pond elements. The work that we are about to do will be stored in the Alternatives that are active, so it is important to set this up correctly. All is not lost if you make a mistake here, because you can change things like the Topology Alternative after an element has been created. It's easier to get the setup right before you start.

5. *Double-click* the **100 Year SWMM With a Pond** Scenario, to show the settings for it in the *Hydraulic Analysis* tab of *Utility Properties*.

   This dialog shows us the **Alternatives** and **Calculation Options** that the Scenario uses. At the moment, everything is inherited from the parent Scenario. In many cases, this is what we need – for example the inherited **Physical**, **Hydrology**, and **Rainfall Runoff** Alternatives contain the correct data.

6. Click the *Active Topology* Alternative and select **With Pond**.



Placing a Structure to Discharge into the Pond

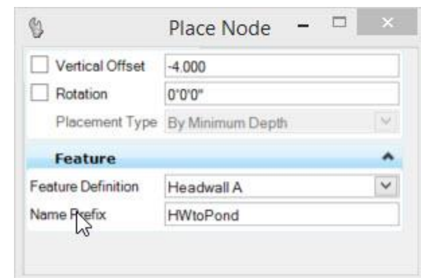
The pond is next to the northernmost pipe in the network.

1. Zoom into this area.

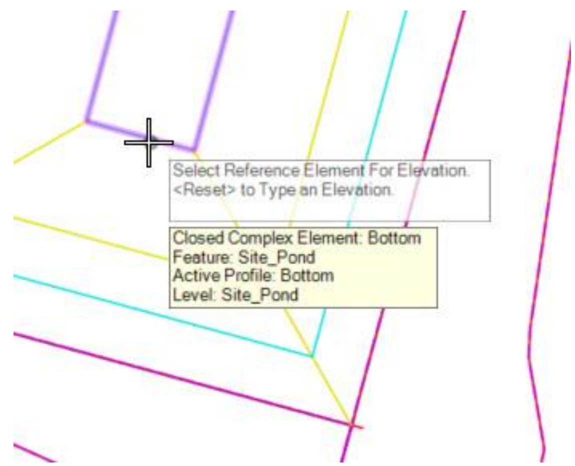
The next step is to define the inlet structure for the pond. We will use a headwall for this.

2. In *Components*, click **Place Node.**

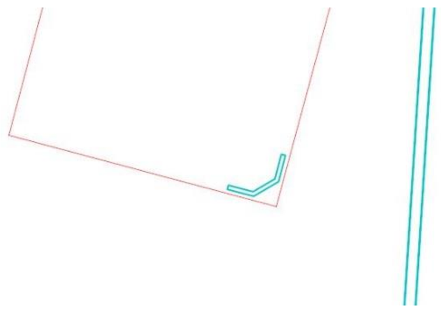
3. In the *Place Node* dialog, select the **Headwall A** *Feature Definition*.
4. Type a *Prefix Name* of **HWtoPond** so that the new label clearly identifies which structure this is.



5. At the *Select Reference Element for Elevation. Reset to Type Elevation* prompt, click the pond bottom.
6. **Click** to accept the default *Placement Type* **(By Minimum Depth).**
7. Locate the headwall in the bottom right corner of the pond (the exact position is not critical).

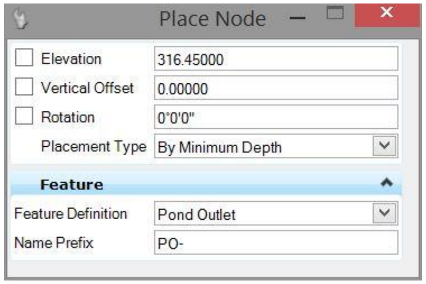


8. Rotate the node as you wish.
9. Click to accept the rotation.



Creating a Pond Outlet Structure

10. In *Components*, click **Place Node.**



11. In the *Place Node* dialog, select the **Drainage Nodes > Pond Outlet** *Feature Definition*.

12. At the *Select Reference Element for Elevation. Reset to Type Elevation* prompt, click the pond water top graphic.

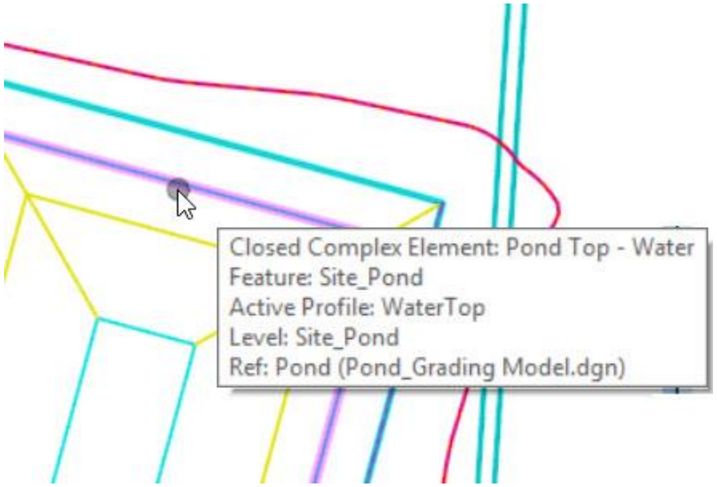
    Note that this is for the top of the structure. There is also a pond "Freeboard" graphic. Hydraulically, it does not matter which you pick. The hydraulic information – the control structures, weirs, orifices, etc. – is input later.

13. Select the default *Placement Type* **(By Minimum Depth)**

14. At the *Define Pond Outlet* prompt, datapoint near the top edge of the pond (the exact position is not critical)

15. Rotate the node as you wish

16. Click to accept the rotation.

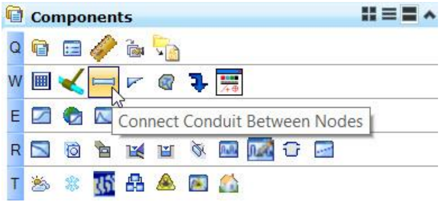


Adding the Pond's Pipes

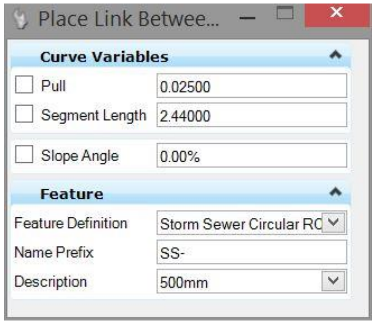
We have now created the pond's inflow and outflow structures. We need to connect them to the contributing network and to the receiving structure.

First let's connect the new headwall **HW-1** into the piped system.

1. In *Components*, click **Connect Conduit Between Nodes**.

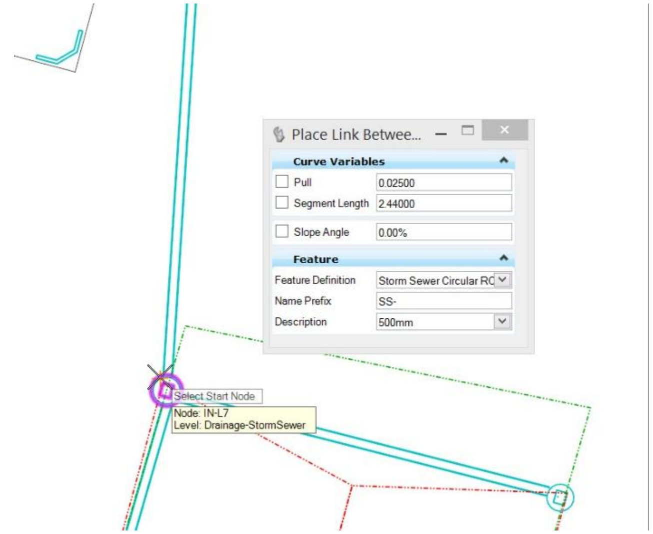


2. For clarity, type **SS To Pond** for *Prefix Name*.
3. Select the **Storm Sewer Circular RCP** Feature Definition.
4. Select the **21"** *[500mm]* **Description**.

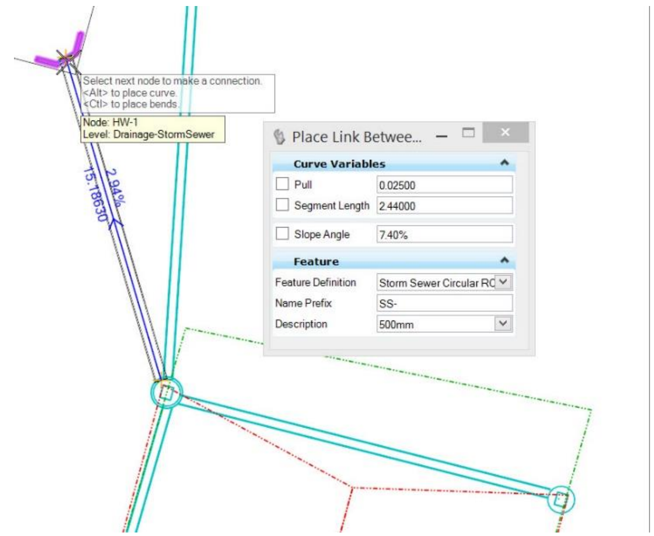


5. At the *Select Start Node* cursor prompt, pick node **IN-L7**.

   The pipe will head to the headwall, so pick a suitable location just to the left of the top of the catch basin.



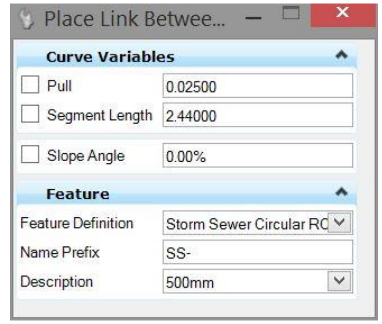
6. At the *Select End Node* cursor prompt, pick headwall **HWtoPond**.



Now we need to connect the pond outlet structure to the outfall. Recall that the orifice in the pond outlet structure has a diameter of 9” *[200mm].*

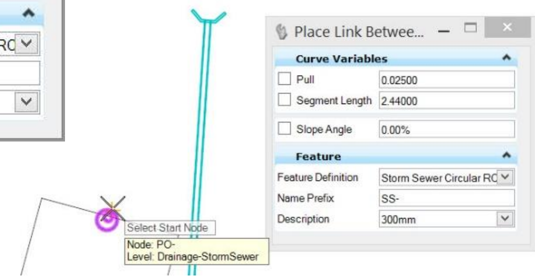
7. In the *Place Link Between Nodes* dialog, change the description to 1 foot *[300mm].*

8. For clarity, type **SS From Pond** for *Prefix Name*.



9. At the *Select Start Node* cursor prompt, pick pond outlet **PO-.**

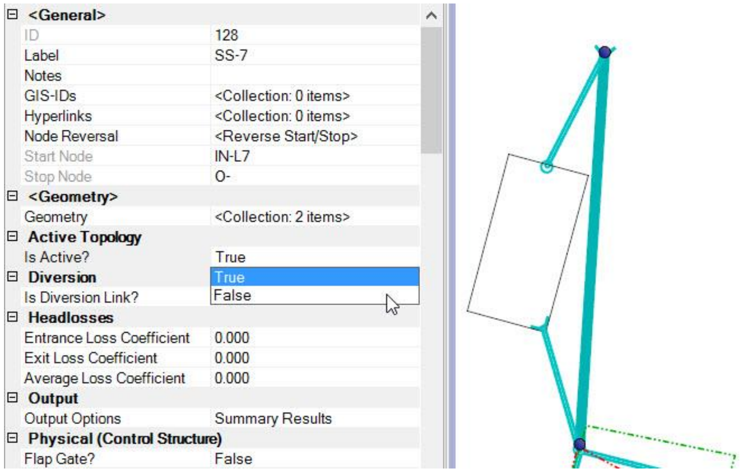
10. The pipe will head to the outfall, so pick a suitable location just to the right of the top of the pond outlet.



Pipe Topology

You will have noticed that we now have two pipes (SS-NoPond and SS To Pond) which exit catch basin IN-L7, and two pipes (SS-NoPond and SS From Pond) which enter the outfall. This does not reflect what we will actually build because – assuming that we do build the pond – pipe SS-NoPond will not exist. If, however, we decide that the pond is not the correct solution, and we adopt a different strategy, then pipe SS-NoPond may exist. What we therefore need to do is to state that pipe SS-NoPond is not active in this pond Scenario.

11. In View 1, select pipe **SS-NoPond.**
12. In the *Hydraulic Analysis* tab of *Utility Properties*, locate the **Active Topology** category.
13. **Click** the value for *Is Active?* From the drop-down list, select **False**.



Hydraulic Pond Design

We have previously placed the physical structures that make up our pond-specific design: pipes, a headwall and a pond outlet control structure. We still must define the hydraulic properties for the pond design and make the network connections for the pond.

We will need to:

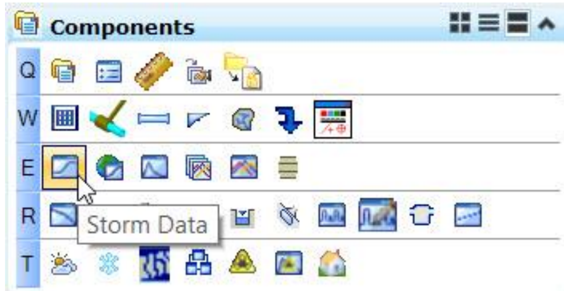
- Confirm the hydrology and hydraulics
- Evaluate the pre- and post-development discharge
- Identify a shape to represent the pond. This shape will store the storage characteristics of the pond, which we will specify
- Hydraulically connect the network headwall to the pond, so that the pond has defined inflow
- Define the pond outlet control structures' elevations, shapes, sizes and other properties
- Connect the Pond Outlet element to
  - The Pond Element, so that inflow staging is available
  - The Outlet Control Structures to regulate the outflow

When the hydraulics are set up and the pond network structures connected, we Compute the pond Scenario. Evaluate and refine.

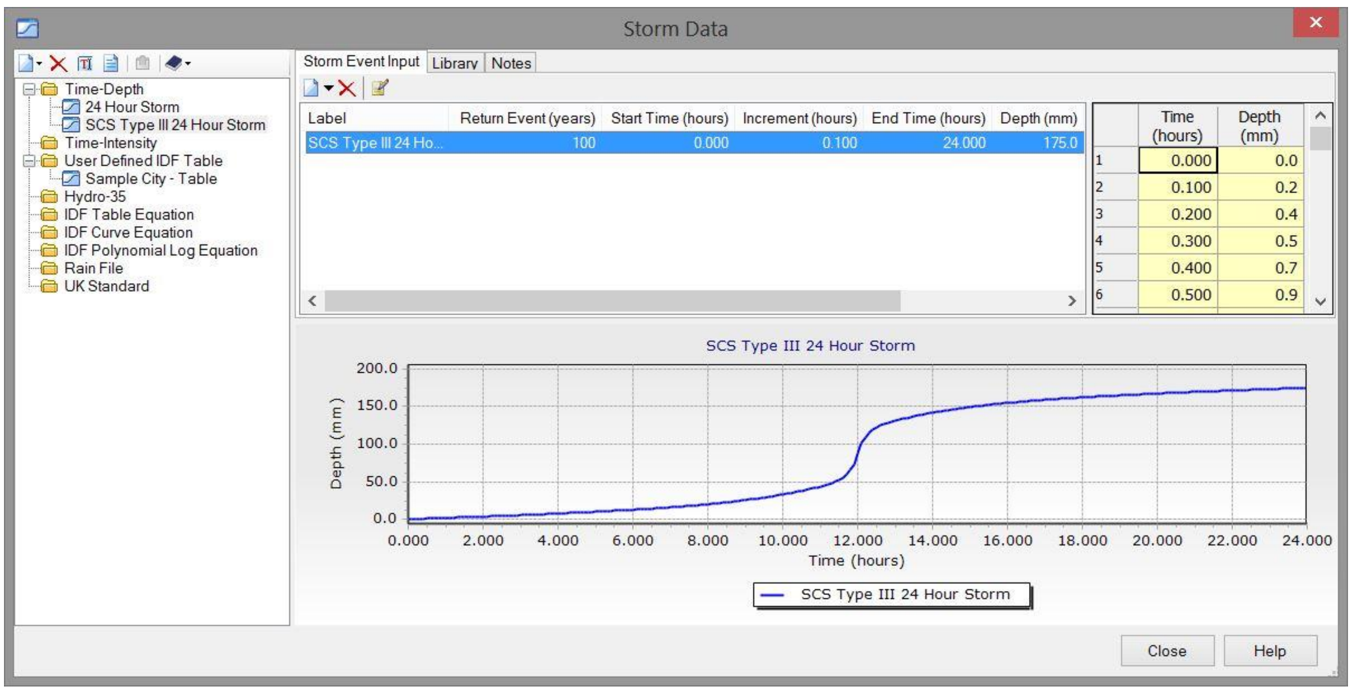
Reviewing Rainfall Data

To create a runoff hydrograph, we need to use a storm event that models how the depth of rainfall varies over the course of the storm event.

1. In *Components*, click **Storm Data**.



2. In the *Storm Data* dialog, on the left hand side, click **SCS Type III 24 Hour Storm**



There are three main areas on this dialog:

- Details of the event, across the top

- A grid of values, on the right
- A graph, across the bottom

This storm event was created using a dimensionless curve, which models the Soil Conservation Society Type III storm profile. From the dialog, we can see that it has a duration of 24 hours, at an increment of 0.1 hours, and the total depth of rainfall is 6” [175mm]. The graph shows us how the depth of rainfall varies over the duration of the storm, and reflects the values in the table.

This is the storm event that we will use.

3. Close the *Storm Data* dialog.

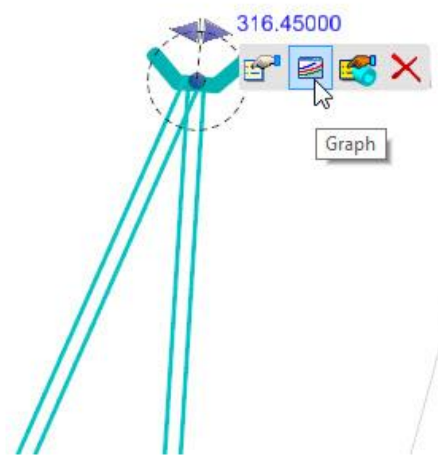
Comparing Pre- and Post-Development Flows

Our engineering goal is to cap the post-development peak discharge rate in this Pond Scenario to the pre-development peak. We need the rates for both.

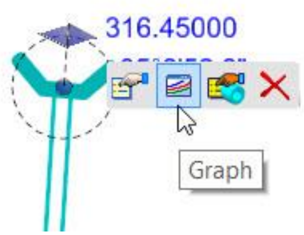
Earlier in this class, we computed the Pre-Development Scenario and the last still-valid post-development Scenario: 100 Year SWMM Analysis (the pond scenario is not ready for calculations yet).

Almost any relevant attribute for a structure can be graphed. The graph can show values across Scenarios. The graphing capability is very powerful. We will use it to evaluate the Pre- and Post-Development at the outfall (it is common to both Scenarios).

1. In View 1, zoom in to the top of the network.
2. Locate and zoom in close to the **outfall**, and select it.



3. Ensure that the cursor is not hovering over a manipulator, so that the context toolbar appears (you may need to zoom in very close to achieve this, because the graphic is small, so the manipulators are close together).
4. Click the **Graph** icon.



The *Graph Series Options* dialog is displayed. We use this to choose the information that we want to see.

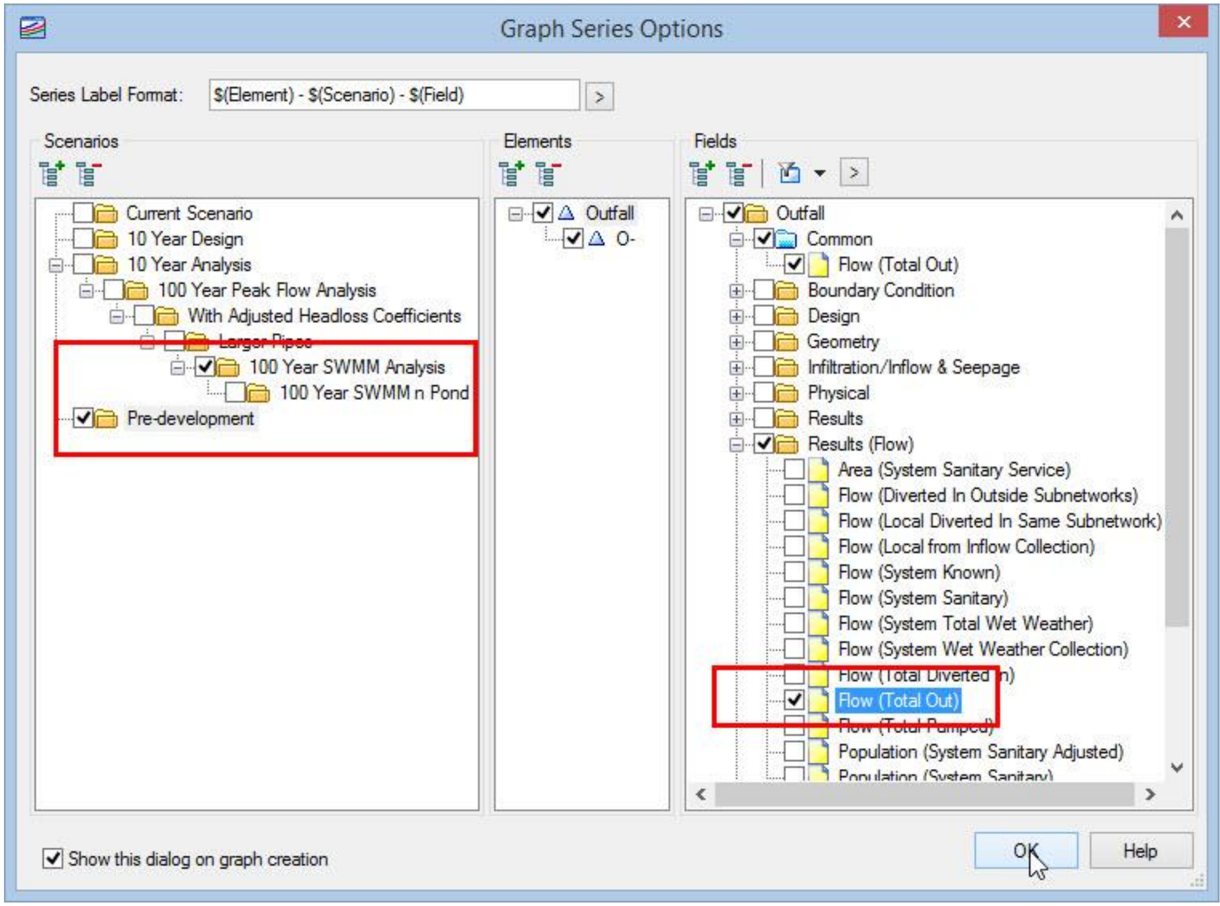
The List on the left is for choosing which Scenarios' data to graph.

Note that the Current Scenario may be checked by default.

5. Select the **100 Year SWMM Analysis** and **Pre-development** Scenarios.

The List on the Right is all the attributes available for graphing.

6. Select the **Flow (Total Out)** property.
7. Click **OK**.

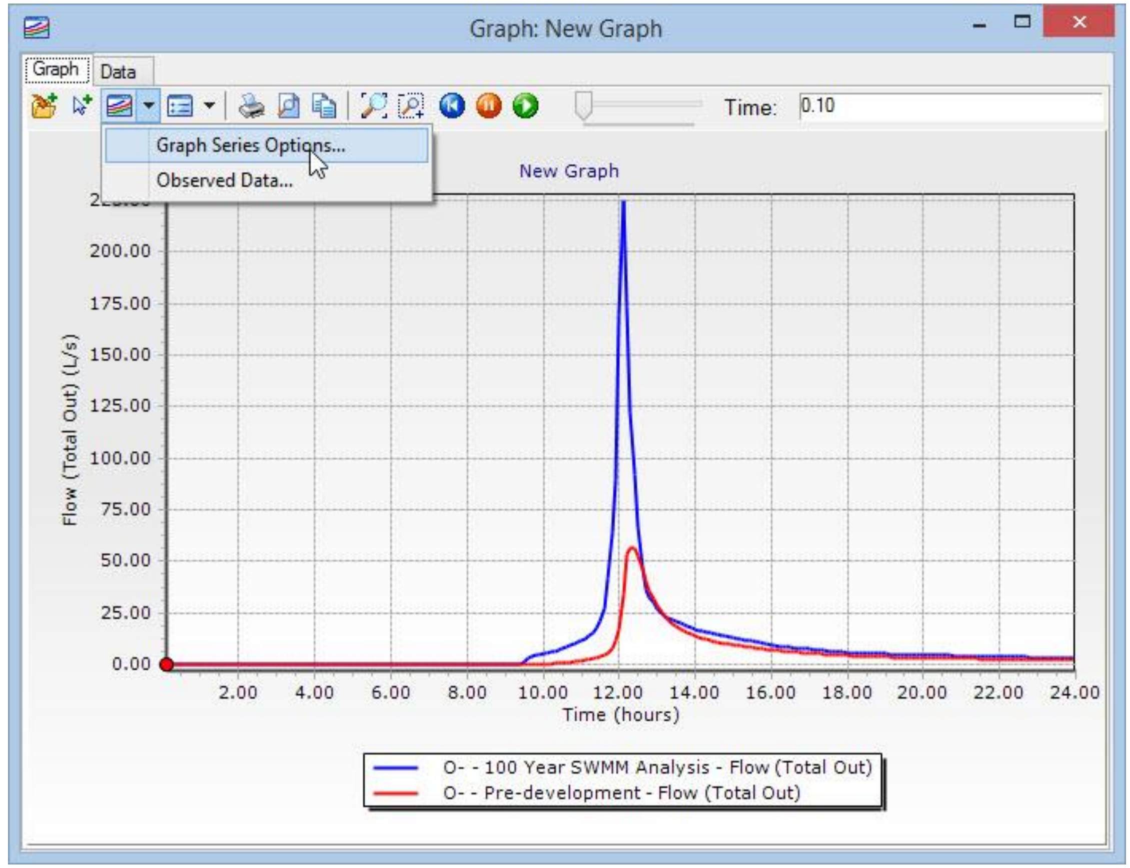


5. Click **OK**.

The *Graph* dialog shows the runoff hydrograph for the **Pre-Development** and post-development Scenarios. This can be used to identify the peak allowable flow for the post development design and can be used to estimate the pond storage requirements for any detention needs.

Note that displayed data can be changed or added via the Graph Series Options.. menu item

The data is live, meaning that an active graph will update if a calculation is run.



The graph shows us that attenuation is required, to reduce the peak flow from the post-development Scenario down to pre-development levels. We can see that the post-development Scenario peaks at a flow of approximately *[225 L/s]* – roughly *[170 L/s]* more than the pre-development peak.

6. Close the *Graph* dialog.

Estimating the Pond Constraints

The size of the pond is dependent on many variables, including available space, maximum allowable depth, and minimum mandated storage requirements to detail additional runoff due to development.

Storage requirements can be calculated from the total runoffs of pre- and post-development calculations. For this exercise, we will provide numbers that represent a reasonable starting point.

Pond Elevation ranges are generally constrained by network hydraulic grades, terrain, and proposed design restrictions.

A 3D pond is referenced into the design file. The bottom of the pond is set near the invert of the adjacent structures. There is an assumed constraint of a maximum depth of three feet *[1 metre].* We will also assume a freeboard of 1 foot *[0.25 m].*

The table below summarizes key elevations derived from the referenced pond model. We will use these values in our design input.

	Elevation	Area	*Elevation*	*Area*
	ft.	sq. ft.	*m*	*sq. m.*
Pond Top	**1041.25**	**2800**	***317.37***	***260.13***
Freeboard	1.00		*0.3*	
Pond Max Water Level	**1040.25**	**1984**	***317.07***	***184.32***
Max Depth	3.00		*0.92*	
Pond Bottom	**1037.25**	**304**	***316.15***	***28.24***

The size of the pond is a rough estimate at this point derived from the discharge curves.

Our CivilStorm results will provide us information from which to adjust our initial estimates.

Note: the OpenRoads pond model was built with rules that provide easy adjustment of size, elevation, interior slope and freeboard. There is a video on the learn server showing its adjustment capabilities. New areas can be measured after adjustments.

Defining the Pond Element

Description

In this exercise, you will create the new pond elements.

Skills Taught

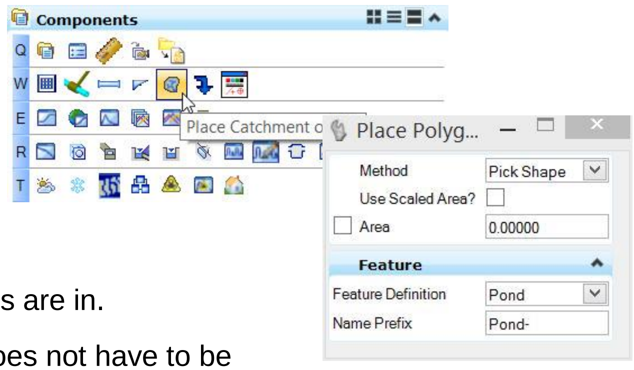
- Creating a pond element
- Defining Stage-Area or Stage-Volume

We have now created the inlet and outlet structures for the new pond, and we have a pond “grading” model. What we do not have at this point is graphic entity to store the pond hydraulic information such as stage-area information.

We will create such a Pond element in this section.

Currently, CivilStorm does not read directly from the “grading model”, though that functionality is expected.

1. In *Components*, click **Place Polygon Feature**
2. Select the **Pond** Feature Definition.



3. At the *Select Layout Method* prompt, select the **Pick Points** method.
4. Place points at each of the four corners of the pond. **Reset** when all the vertices are in.

   Note: we will not be using the area of the shape for calculations, so the pond does not have to be exact or even representative of the shape (you could even a an extra vertex or two to make it easier to see and select).

   Note also: CivilStorm does not recognize the OpenRoads pond in this release. Otherwise the Pick Shape method would be more logical.
5. At the *Select Outflow* prompt, click **Reset** (right mouse button).

6. At the *Select Reference Surface* prompt, any of the options will do. Clicking on the Pond Surface, if visible, would drape it to the pond. Reset to drape to the active surface would be 3D, but the active terrain may or may not have the proposed pond merged into it. The <**Alt**> key will keep it at zero elevation.

7. The Pond is now added to the utility database.

8. Click **Element Selection**.

9. Select the new pond element and review its Utility Properties

   The *Hydraulic Analysis* tab of *Utility Properties* shows the properties for the pond element.

   Note the Active Topology category, which confirms that the pond element is active in the Topology Alternative for the current Scenario.

10. Locate the **Physical** category.

11. Change the *Volume Type* property to **Elevation-Area**.

12. Click on the text **<Collection: 0 items>.** This is where we define the elevations and volumes data for our pond.

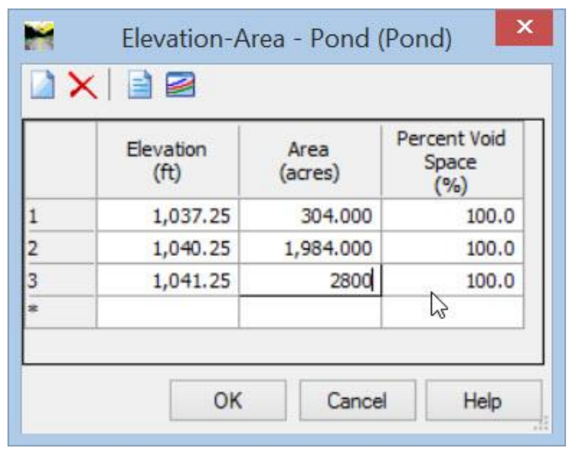
13. In the *Elevation-Area* dialog, type in the values shown below.

    Note: that the Elevation entries must be entered from low elevation to high.

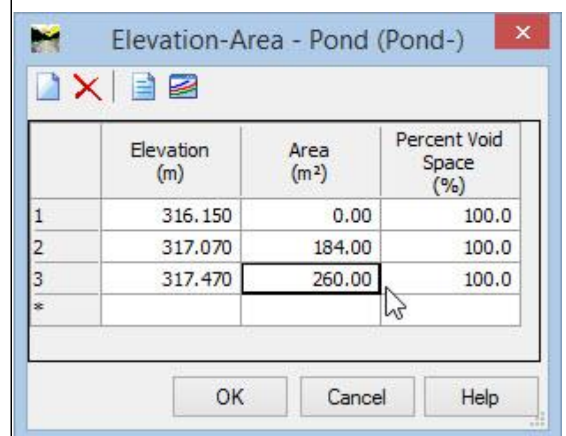
    Note: make sure that the Area Units are appropriate (sq. ft. or sq. m.). Right-click on the Area header and Click Units and Formatting to change.

   Volume calculations are interpreted between entries. There should be an Elevation entry whenever there is change in the pond storage geometry. Technically the middle value (the desired water maximum) was not necessary.

Imperial

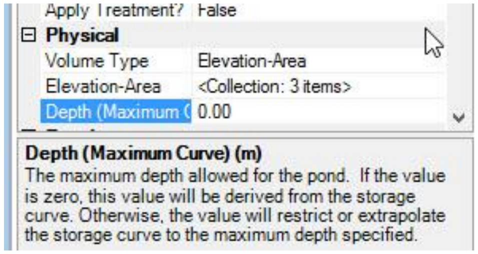


Metric



7. Click **OK** to close the *Elevation-Area* dialog.

8. The **Physical** category should look like this.



Linking Inflow to the Pond Element

Description

In this exercise, you will link the network flow to the pond.

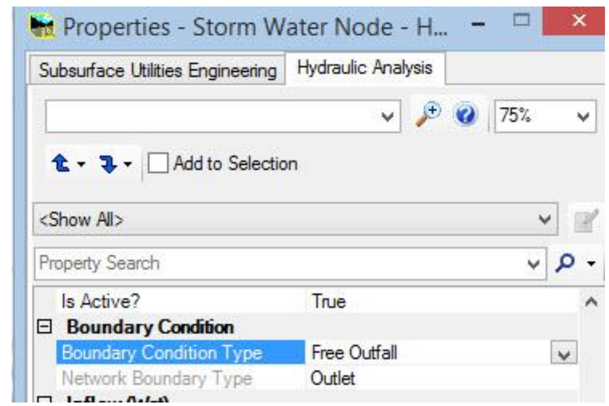
Skills Taught

- Setting the Pond's incoming Headwall's Boundary Element

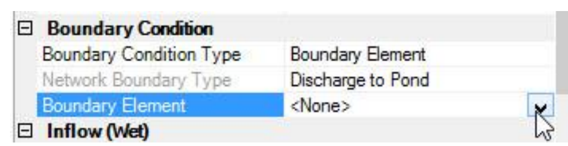
The pond element has been created with stage-storage values, and we have a headwall in the pond with a hydrograph of flow. They are not hydraulically connected yet. To connect them, we will set the Headwall's Boundary Type and Element to point to the pond.

1. Open the Utility Properties of the Headwall discharging into the pond.

   The Headwall prototype had set the Boundary Condition Type to Free Outfall. We want to set the Boundary Condition Type to Boundary Element and then select the pond as that element.



2. Click on the field to the right of the *Boundary Condition Type*. Select **Boundary Element** from the pull-down.



3. Now designate the Pond as the Boundary Element by clicking on the field to the right of *Boundary Element*. **Click** the pull-down and select **<Select Boundary Element>**.

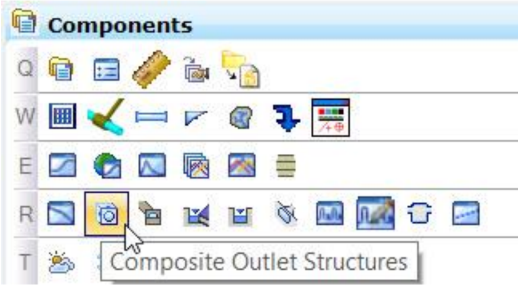
4. Click on the **Pond Element** in the drawing. The field should now list the pond's name (in this case, "Pond").

   The network flow is now discharging into the pond.

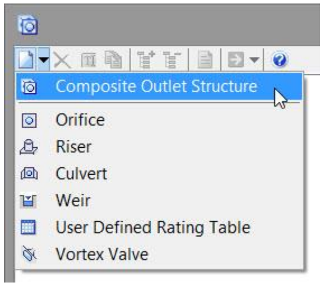
Defining the Pond Outlet Hydraulic Properties

We have located the pond outlet structure. The next thing to do is to define how it works, as this is an important factor in how well the pond will attenuate the post-development runoff.

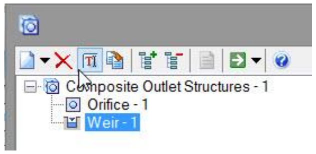
1. In *Components*, click the **Composite Outlet Structures** icon.



2. In the *Composite Outlet Structures* dialog, click **New > Composite Outlet Structure.**
3. Click **New > Orifice.**
4. Click **New > Weir.**

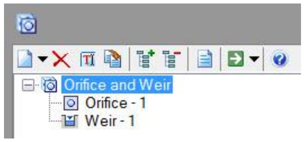


This creates two elements in the composite outlet structure. The dialog should look like this.



5. Right-click on **Composite Outlet Structures – 1**, and click **Rename**

6. Change the name to **Orifice and Weir.** The dialog should look like this.



We have selected two types of flow control device. The weir will function if the pond fills up, and the orifice will attenuate the flow that leaves the pond. The next step is to specify the properties of these two devices, to control how they both operate.

As noted earlier, at this stage the values of these properties are only guesses, since we cannot know the right values until the pond design has been completed, is working, and can be tested.

7. Click the **Orifice and Weir** element.

8. Fill in the properties as shown.

Imperial

<General>	
ID	259
Label	Orifice and Weir
Notes	
Headwater	
Headwater Type	Use Pond for Headwater Range
Pond	Pond
Minimum (Headwater) (ft)	1,037.25
Maximum (Headwater) (ft)	1,041.25
Increment (Headwater) (ft)	0.50
Spot Elevations (Headwater)	<Collection: 0 items>
Tailwater	
Tailwater Type	Free Outfall
Outlet Structure (Convergence Tolerances)	
Maximum Iterations	30
Headwater Tolerance (Minimum) (ft)	0.00
Headwater Tolerance (Maximum) (ft)	0.50
Tailwater Tolerance (Minimum) (ft)	0.00
Tailwater Tolerance (Maximum) (ft)	0.50
Flow Tolerance (Minimum) (ft^3/s)	0.000
Flow Tolerance (Maximum) (ft^3/s)	0.250

Metric

<General>	
ID	225
Label	Orifice and Weir
Notes	
Headwater	
Headwater Type	Use Pond for Headwater Range
Pond	<Automatic>
Minimum (Headwater) (m)	0.000
Maximum (Headwater) (m)	0.000
Increment (Headwater) (m)	0.000
Spot Elevations (Headwater)	<Collection: 0 items>
Tailwater	
Tailwater Type	Free Outfall
Outlet Structure (Convergence Tolerances)	
Maximum Iterations	30
Headwater Tolerance (Minimum) (m)	0.000
Headwater Tolerance (Maximum) (m)	0.150
Tailwater Tolerance (Minimum) (m)	0.000
Tailwater Tolerance (Maximum) (m)	0.150
Flow Tolerance (Minimum) (m^3/s)	0.000
Flow Tolerance (Maximum) (m^3/s)	0.250

We have stated that the headwater range will be defined by the pond itself and have provided some convergence tolerances for the calculations.

9. Click the **Orifice – 1** element.

10. Fill in the properties as shown.

Imperial

Outlet Structure	
Outlet Structure Type	Orifice
Flow Direction	Forward Flow Only
Number of Openings	1
Orifice Coefficient	0.500
Elevation (ft)	1,038.00
Outlet Structure (IDs and Direction)	
Outlet ID	Orifice - 1
Downstream ID	Tailwater
Notes	
Outlet Structure (Advanced)	
Elevation (On) (ft)	0.00
Elevation (Off) (ft)	0.00
Outlet Structure (Orifice)	
Orifice Type	Circular Orifice
Orifice Diameter (in)	8.0

Metric

Outlet Structure	
Outlet Structure Type	Orifice
Flow Direction	Forward Flow Only
Number of Openings	1
Orifice Coefficient	0.500
Elevation (m)	316.500
Outlet Structure (IDs and Direction)	
Outlet ID	Orifice - 1
Downstream ID	Tailwater
Notes	
Outlet Structure (Advanced)	
Elevation (On) (m)	0.000
Elevation (Off) (m)	0.000
Outlet Structure (Orifice)	
Orifice Type	Circular Orifice
Orifice Diameter (mm)	200.0

The orifice invert is near the same level as the bottom of the pond. There will be one opening, of **8** in. *[200 mm]* diameter.

11. Click the **Weir – 1** element.

12. Fill in the properties as shown.

Imperial

Outlet Structure	
Outlet Structure Type	Weir
Flow Direction	Forward Flow Only
Weir Type	Rectangular Weir
Elevation (ft)	1,040.00
Weir Coefficient (ft^(1/2)/s)	0.50
Rectangular Weir	Suppressed
Weir Length (ft)	3.000
Outlet Structure (IDs and Direction)	
Outlet ID	Weir - 1
Downstream ID	Tailwater
Notes	
Outlet Structure (Weir)	
Vary Coefficient with Depth	False
Outlet Structure (Advanced)	
Elevation (On) (ft)	0.00
Elevation (Off) (ft)	0.00
Outlet Structure (Weir, Advanced)	
User Defined Table	False

Metric

Outlet Structure	
Outlet Structure Type	Weir
Flow Direction	Forward Flow Only
Weir Type	Rectangular Weir
Elevation (m)	317.650
Weir Coefficient (m^(1/2)/s)	0.50
Rectangular Weir	Suppressed
Weir Length (m)	1.000
Outlet Structure (IDs and Direction)	
Outlet ID	Weir - 1
Downstream ID	Tailwater
Notes	
Outlet Structure (Weir)	
Vary Coefficient with Depth	False
Outlet Structure (Advanced)	
Elevation (On) (m)	0.000
Elevation (Off) (m)	0.000
Outlet Structure (Weir, Advanced)	
User Defined Table	False

The rectangular weir is slightly below the top water level of the pond, so it will start to transfer flow out of the pond just before the top water level is reached.

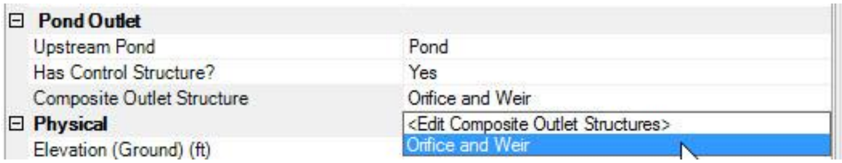
13. Close the *Composite Outlet Structures* dialog.

Linking the Pond Outlet Structure to the Pond and to the Outlet Hydraulics

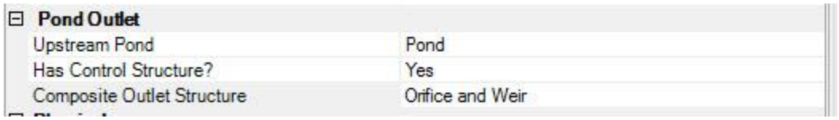
To complete this structure, we need to connect the Pond Outlet node to the Pond shape and assign the tabular composite outlet structure to the Pond Outlet node.

1. In View 1, select the pond outlet node **PO-** that we have just placed.
2. In the *Hydraulic Analysis* tab of *Utility Properties*, locate the **Pond Outlet** category.
3. Click on the **<None>** to the right of *Upstream Pond*.
4. Select **Pond** from the list (all Pond shapes are listed here).

5. Change the **Has Control Structure?** property to **Yes**
6. Click the field to the right of the **Composite Outlet Structure** property, and select **Orifice and Weir** from the drop-down list.



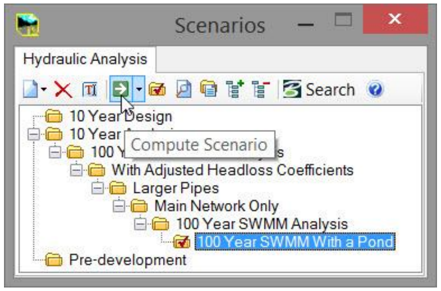
The properties should now look like this.



Computing the Pond Scenario

Now that the design of the pond is complete. Let's compute it, and see what happens.

1. In the *Scenarios* dialog, click **Compute**.

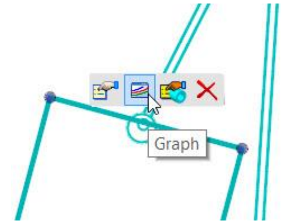


Recall that this Scenario uses the SWMM solver, so the runoff hydrographs are calculated, and routed through the piped system and the pond. After a few moments, the SWMM Summary is displayed. Take a moment to review this.

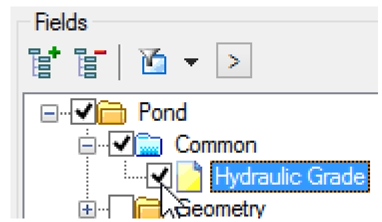
Designing Attenuation

Now that the pond has been created and computed, we need to investigate how well it operates.

1. In View 1, select the pond element **Pond-.** From the context toolbar, click **Graph**.

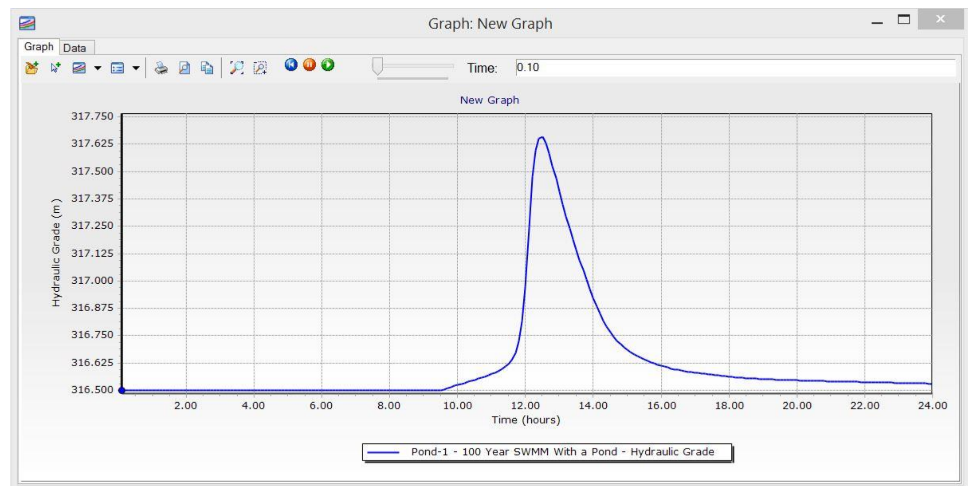


2. Make sure *Hydraulic Grade* is selected.



3. Click **OK** on the *Graph Series Options* dialog.

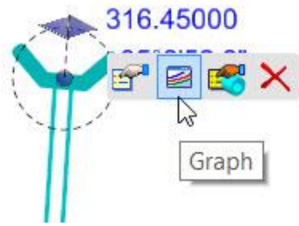
The graph is displayed.



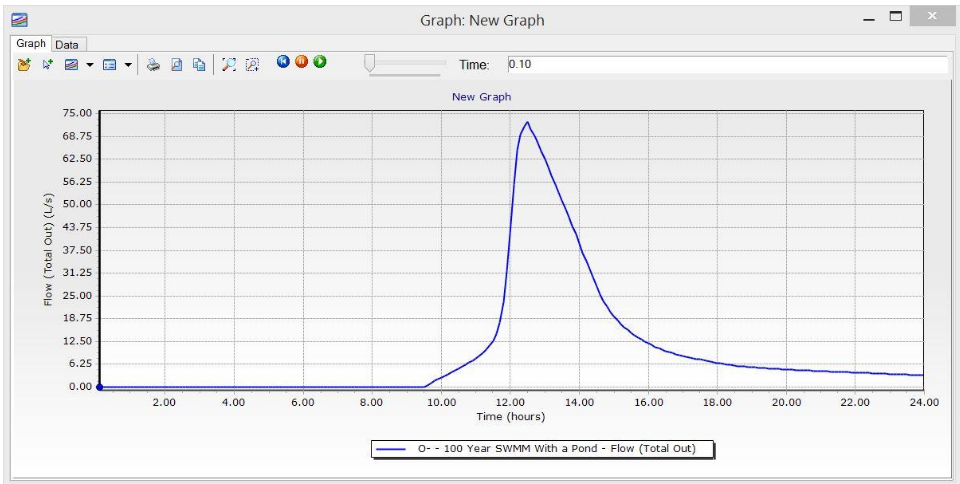
Recall that we capped our maximum water level at 141.25 ft *[317.75m],* and the weir starts to operate at 1039.0 ft. *[317.65m].* The graph shows that the Hydraulic Grade Line (HGL), which is the water level in the pond, reaches this level, so we don't have enough storage.

4. Close the *Graph* dialog.

5. In View 1, select the outfall.
6. Click the **Graph** icon.

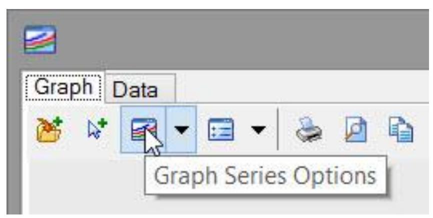


7. The *Graph Series Options* dialog is displayed.
8. Click **OK**.



The flow at the outfall peaks above the peak flow from the **Pre-Development** Scenario. To check, let's add it to the graph.

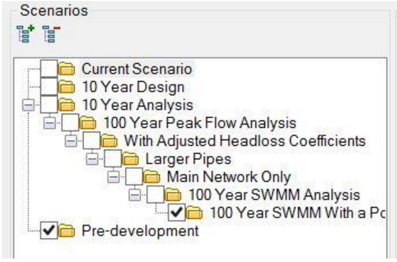
9. Click the **Chart Series Options** icon.



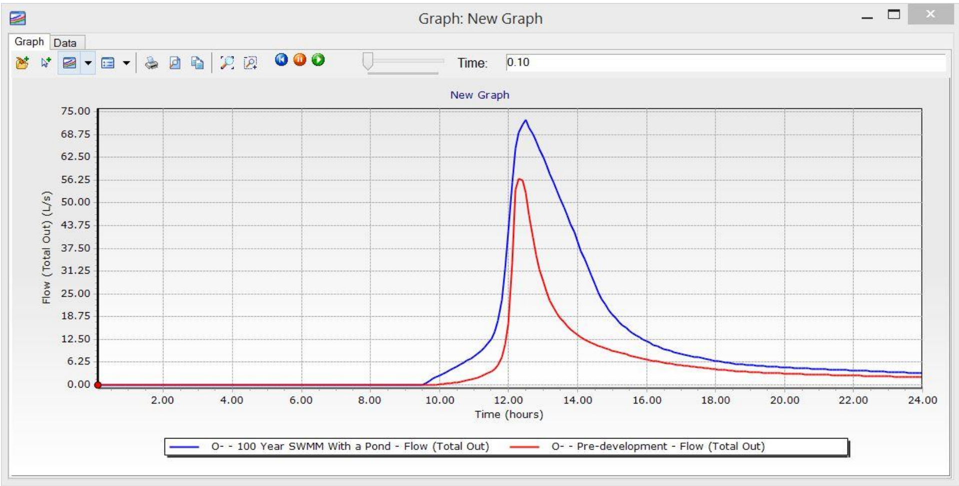
The *Graph Series Options* dialog is displayed.

10. Check the box for the **Pre-Development** Scenario in the left column.

11. Click **OK**.



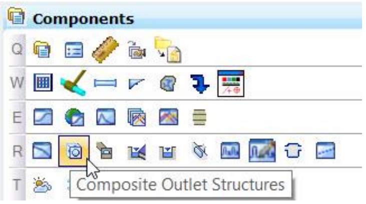
The graph is updated, and now shows us the results that were computed for this Scenario as well.



We can see that the pond outlet structure has not reduced the flow to the pre-development level, so we need to adjust it.

12. Close the *Graph* dialog.

13. In *Components*, click **Composite Outlet Structures**.



The dialog opens, and shows the structure that we created earlier. Now that the outlet structure knows about the pond that it is connected to, the properties for the minimum and maximum headwater are filled in. The dialog also shows a graph of the rating table for our outlet structure.

14. Click the text **Orifice and Weir**.

    The graph shows how the combination of the orifice and the weir operate.

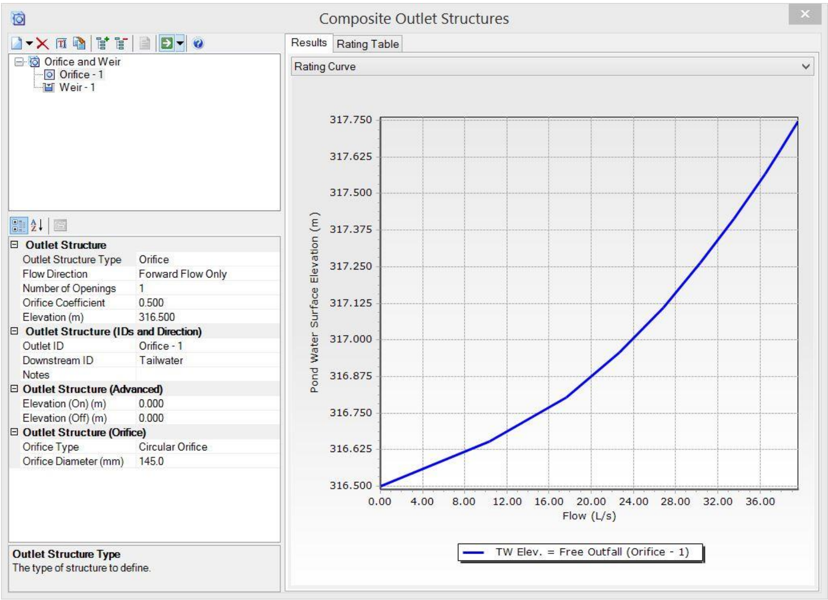
15. Click the text **Orifice-1**.

    The graph shows how the orifice operates. The horizontal scale goes to more than **2.5** cfs *[70 L/s],* and we need to reduce this.

16. Change the value of the Orifice Opening Diameter to **6** in. *[145mm].*

17. Click the *Compute Rating Curve* icon, to update the graph.

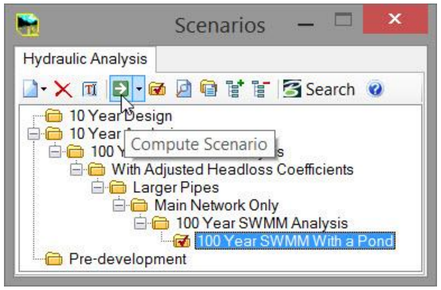
    The graph now looks like this, and shows that the flow has reduced.



18. Close the *Composite Outlet Structures* dialog.

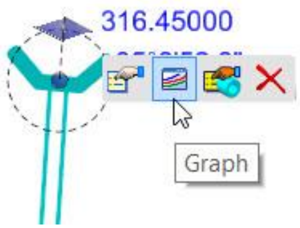
We now need to compute the Scenario again, to update the results for the whole system.

19. In the *Scenarios* dialog, click **Compute**.



20. In View 1, select the outfall.

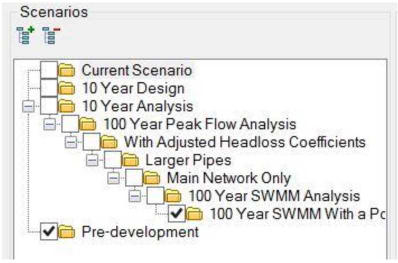
21. Click the **Graph** icon.



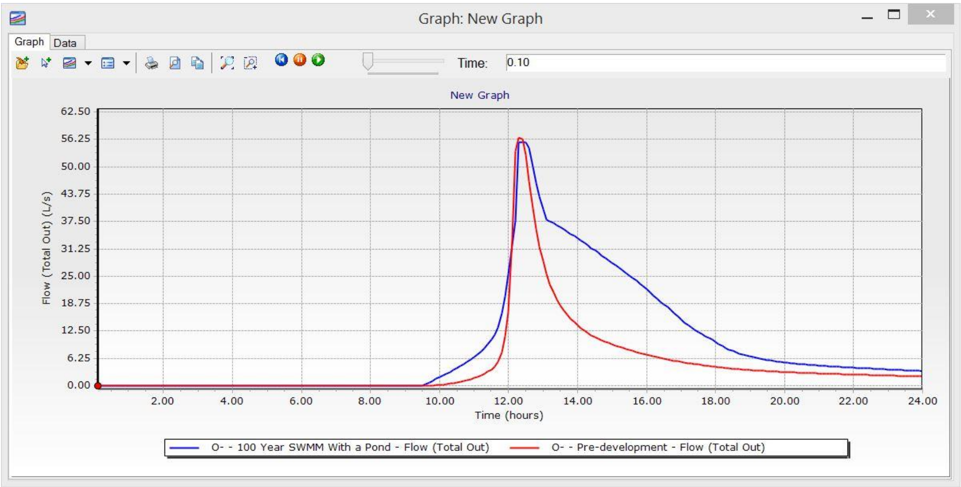
22. The *Graph Series Options* dialog is displayed.

23. Check the box for the **Pre-Development** scenario.

24. Click **OK**.



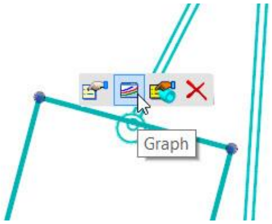
The graph shows that we have now reduced the post-development flow to the pre-development level.



We now need to check the water level in the pond.

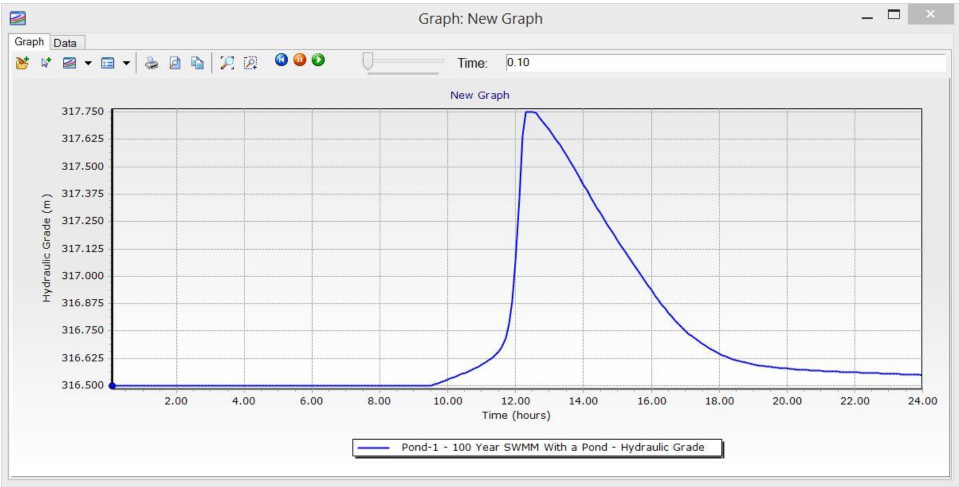
25. In View 1, select the pond element **Pond-.**

26. From the in-context toolbar, click **Graph**.



The *Graph Series Options* dialog is displayed.

27. Click **OK**.



The graph shows that the top water level has been reached, so we now know that the pond is not big enough. We need to increase the size of the pond, until the HGL stays below the top water level.

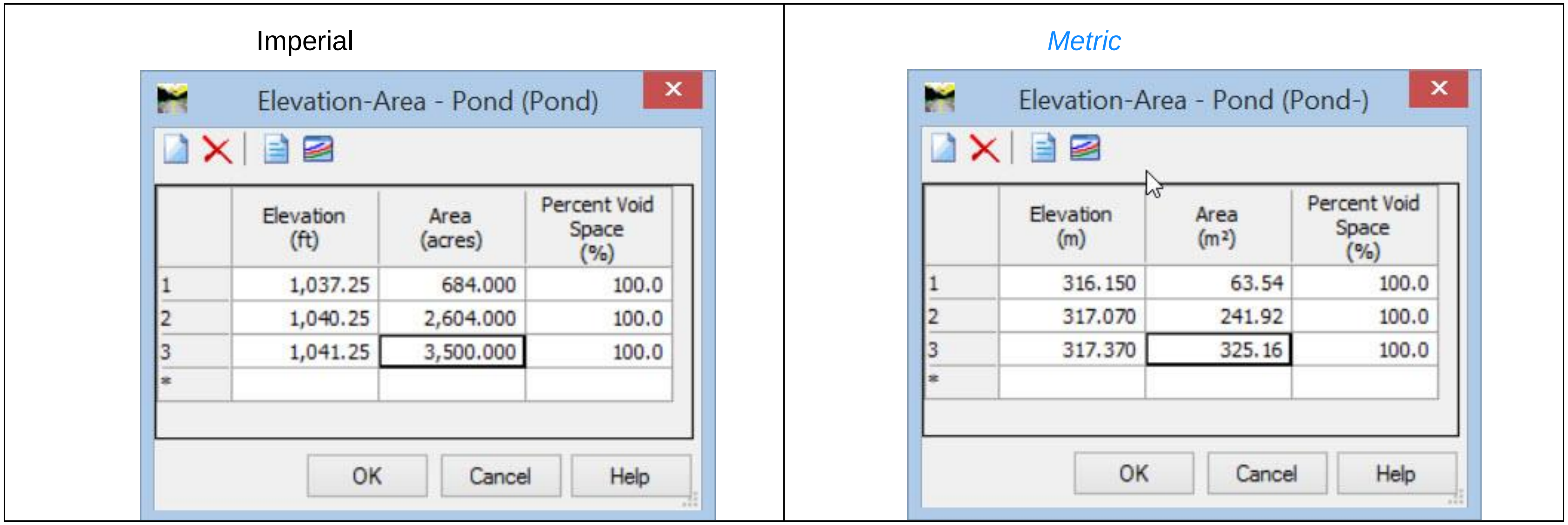
28. Close the *Graph* dialog.

The pond is still selected. In the Hydraulic Analysis tab of Utility Properties, locate the Elevation-Volume property.

29. Click the **<Collection: 3 items>** text

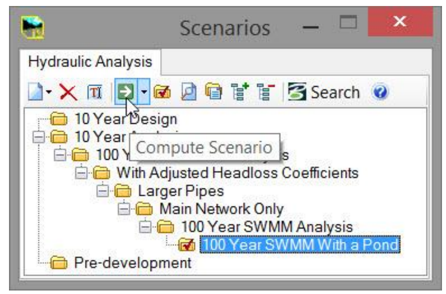
30. Click the **ellipsis** icon to open the *Elevation-Area* table.

31. Adjust the table to the values shown below.



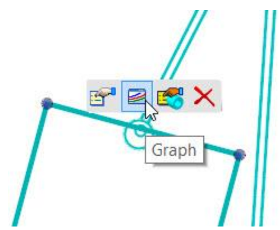
32. Click **OK**.

33. In the *Scenarios* dialog, click **Compute**.



34. In View 1, select the pond element **Pond-.**

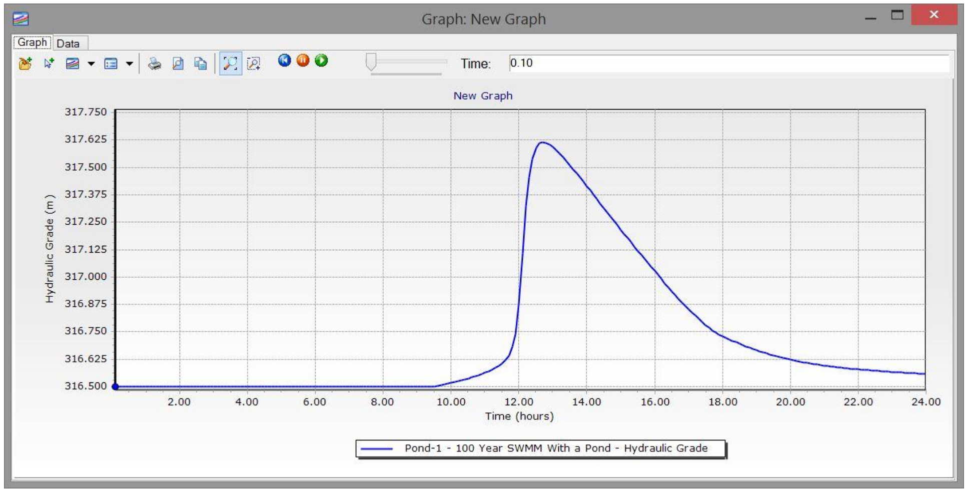
35. From the in-context toolbar, click **Graph**.



The *Graph Series Options* dialog is displayed.

36. Click **OK**.

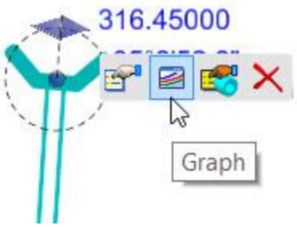
The graph dialog shows that the pond is no longer flooding.



As a final check, let's look at the hydrographs at the outfall again.

37. In View 1, select the outfall.

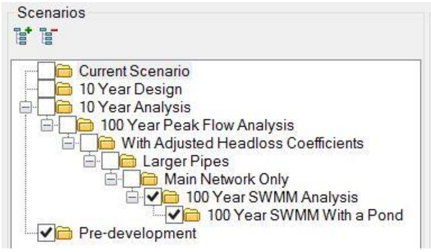
38. Click the **Graph** icon.



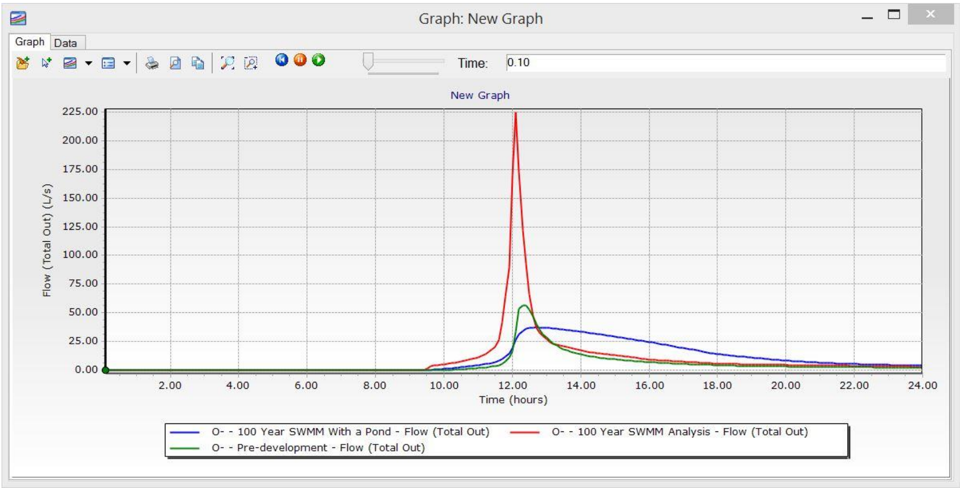
The *Graph Series Options* dialog is displayed.

39. Check the boxes for the **Pre-Development** and the **100 Year SWMM Analysis** scenarios.

40. Click **OK**.



The graph is displayed.



We can see that the post-development flow has reduced further, because increasing the storage available has reduced the head that operates the orifice, so less flow goes through it. We can now iterate further to optimize the pond.