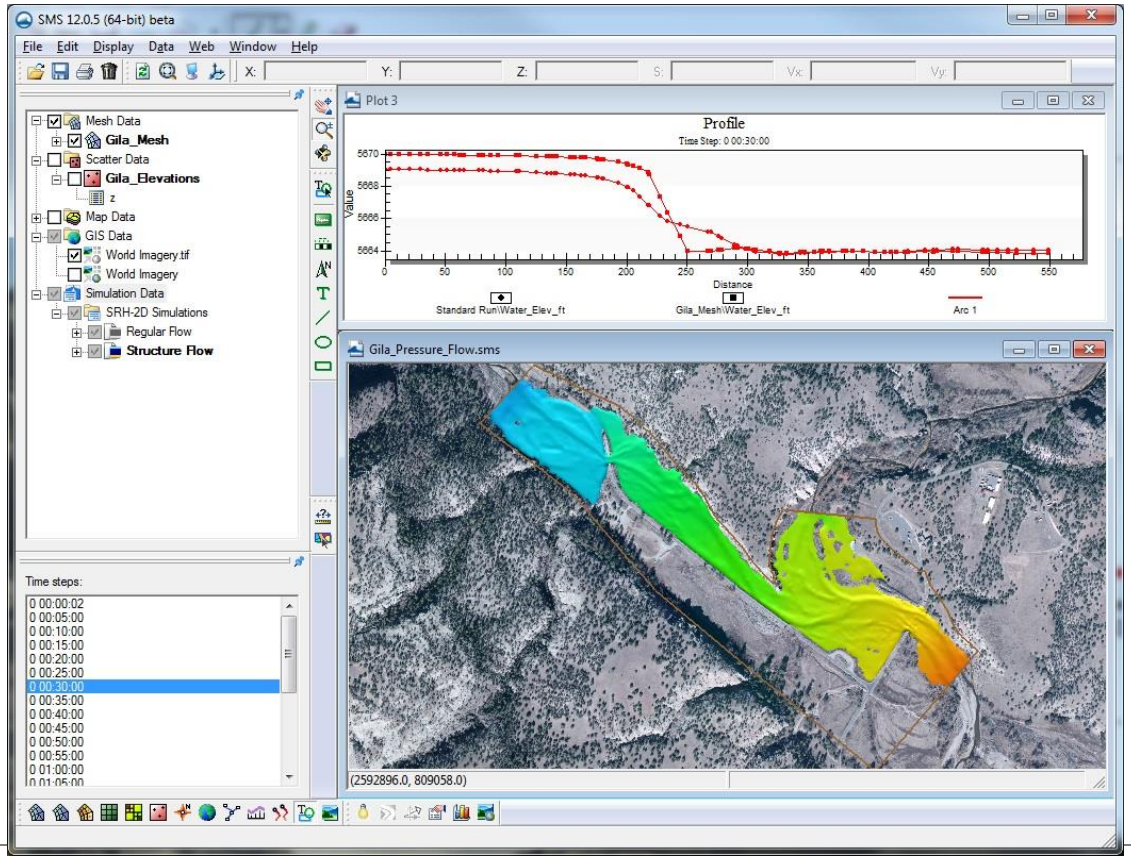
U.S. Department of Transportation
Federal Highway Administration

SMS v. 12.2

SRH-2D Tutorial

Bridge Pressure Flow



Objectives

This tutorial demonstrates the process of creating a pressure flow boundary condition within SRH-2D to model pressurized flow beneath a bridge. The SRH-2D "Simulations" tutorial should have been completed before attempting this tutorial. All files referenced in the instructions are found in the "Input" folder within the "SRH-2D Pressure" folder.

Prerequisites

- SRH-2D – Simulations

Requirements

- SRH-2D
- Mesh Module
- Scatter Module
- Map Module

Time

- 15–20 minutes

1 Model Overview

An existing SRH-2D model will be used to facilitate the setup for this tutorial. The area being modeled is located at the confluence of the West and Middle forks of the Gila River, located in New Mexico.

In this tutorial, an existing bridge just upstream of the confluence will be analyzed. One concern with the design is that the elevation of the low chord will impede the flow of the river during high flows and cause excess scour or adverse backwater effects. The bridge will be represented as a pressure flow boundary condition in SMS. After creating the pressure flow boundary condition and running the model, the solution will be compared with an existing condition solution provided to evaluate the effects.

SRH-2D pressure flow boundary conditions do not currently allow "overtopping" of bridge structures or obstructions to be placed within the pressure flow zone. Pressure flow bridge structures cannot be located along the edge of a mesh.

2 Getting Started

To begin, do the following:

1. Open a new instance of SMS.
2. Select *File* | **Open**.
3. Navigate to the "Gila_Structure.sms" project found in the "Data Files" folder for this tutorial and click **Open**.

The project should appear as displayed in Figure 1.

In the Project Explorer, duplicates of the "Regular Flow" simulation and the "BC" coverage have been made to facilitate the model setup. The duplicates have been renamed as "Structure Flow" and "Structure BC" respectively.

The process of duplicating and linking these items to a simulation was demonstrated in the "Simulations" tutorial. Creating duplicates of simulations or coverages allows modifications to a model while still preserving the original simulation or coverages. This also enables creating several modeling scenarios in the same project and comparing the solutions.

If desired, review the “Simulations” tutorial before continuing.

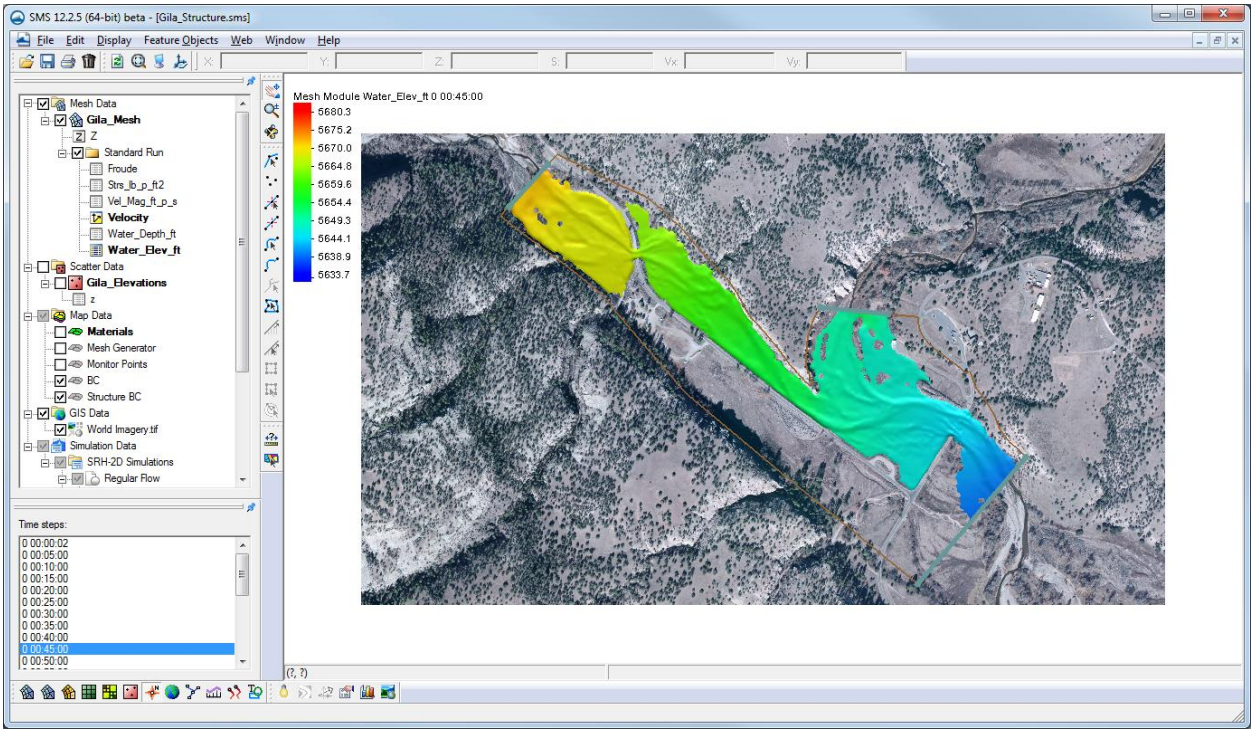


Figure 1 Gila_Structure.sms project

The mesh datasets located under the “ Standard Run” folder in the Project Explorer are from an SRH-2D solution of the existing flow conditions, without the pressure flow BC. They will be used to make comparisons and visualize the effects that the pressure flow boundary condition will have on the model.

3 Creating the Pressure Flow BC

The pressure flow boundary condition will be created at the bridge location just upstream of the confluence (location displayed in Figure 2). Pressure flow boundary conditions are defined by creating an upstream and downstream arc on either side of the bridge, defining the BC type as pressure, and assigning attributes such as low chord elevations and a Manning’s *n* value to the arcs.

3.1 Creating the BC Arcs

To create a boundary condition, first create arcs representing the bridge. Once the arcs have been created in the map coverage and the coverage has been linked to a simulation, they will be applied to the mesh.

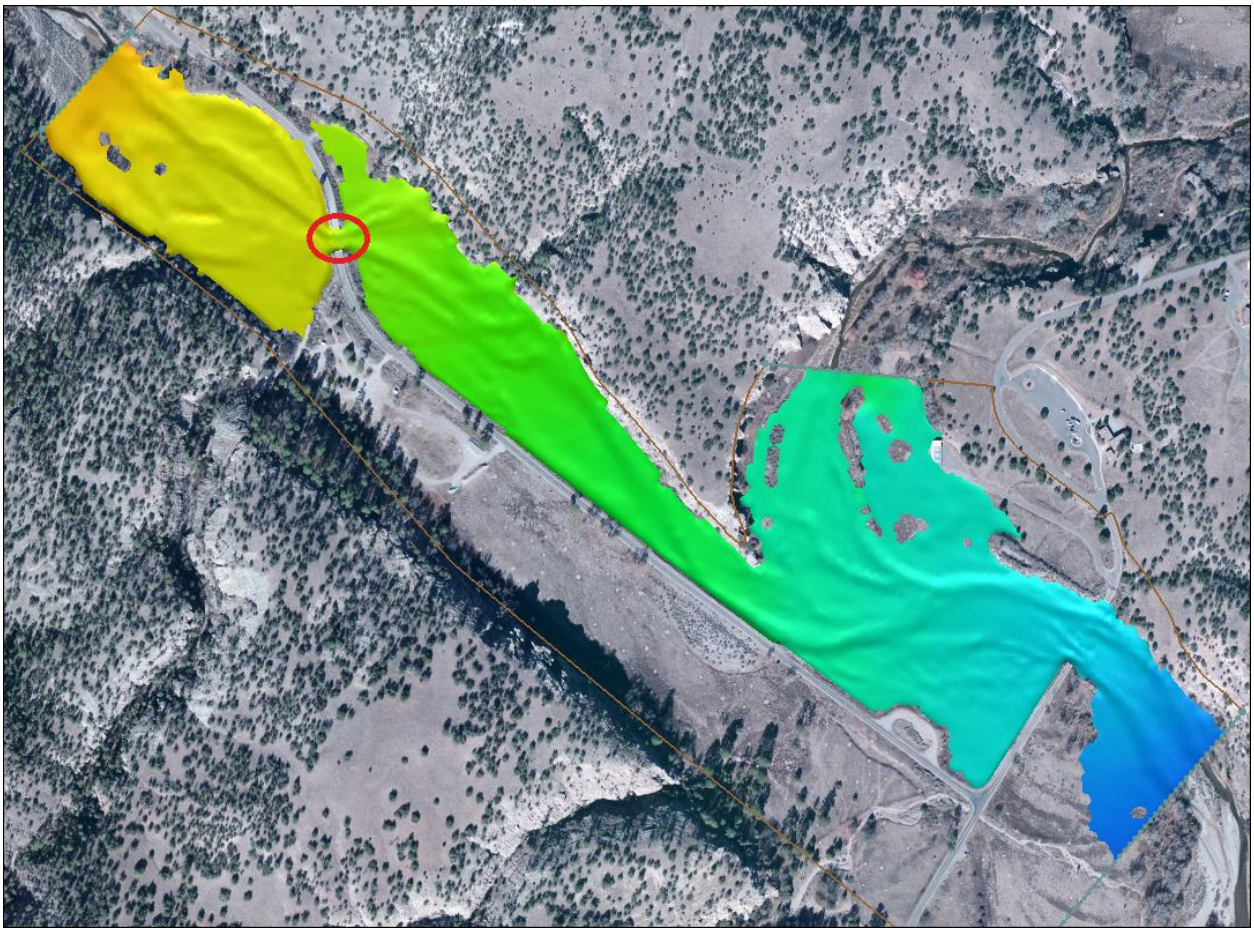


Figure 2 Bridge pressure flow location

1. Use the **Zoom** tool to zoom into the bridge location.

2. Select the "Z" dataset under "Gila_Mesh" in the Project Explorer to display the mesh elevations.

3. Select *Display* | **Display Options…** to open the *Display Options* dialog.

4. In the *2D Mesh* section, turn on *Elements* to turn on the display of mesh elements. Select **OK** to exit the *Display Options* dialog.

5. In the Project Explorer select the "Structure BC" coverage to make it the active coverage.

6. Use the **Create Feature Arc** tool to create one arc on each side of the bridge. These arcs will define the upstream and downstream faces of the bridge pressure flow boundary condition. The created arcs should look similar to Figure 3.

Note: When drawing these arcs, they should be drawn in the same direction. After the first arc has been drawn, ensure that the second arc is drawn in the same direction (north

to south or south to north). Drawing them in opposing directions will cause problems when attempting to run SRH-2D.

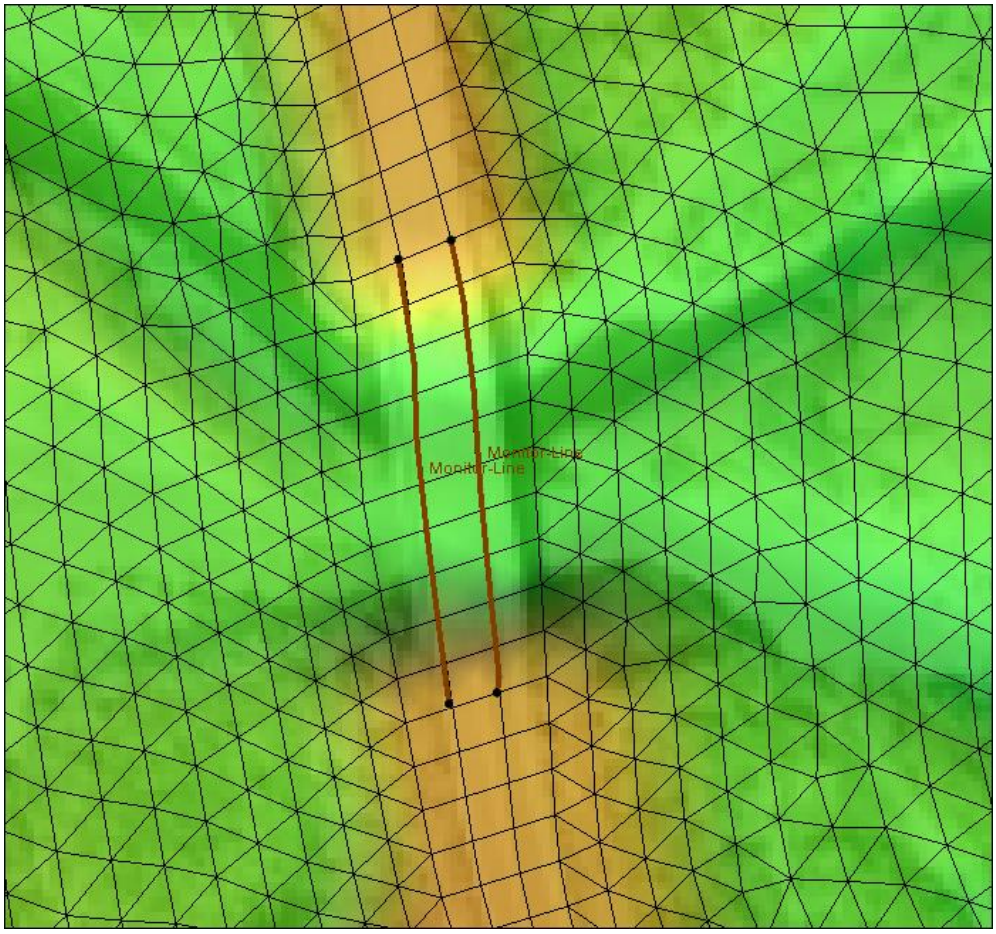


Figure 3 Pressure flow arc locations

3.2 Assigning the BC Attributes

The next step in creating a boundary condition is to specify the BC type and define it by assigning attributes to the arcs.

1. Using the **Select Feature Arc** tool, select the upstream (leftmost) arc and take note of the ID for this arc which is displayed at the bottom of the SMS application.
2. Hold the *Shift* key and select the downstream arc so that both of the arcs are selected.
3. Right-click on either arc and select **Assign Linear BC...** to bring up the *SRH-2D Linear BC* dialog.
4. In the *Type* combo box, select “Pressure”.

5. Note the assignment of “Pressure Upstream” and “Pressure Downstream” to the two arcs, associated with their ID values. If the ID displayed for pressure upstream is not the same as noted above in step 1, switch the associations using the drop-down for *Role*.
6. The *Units* can be left as “ft”.
7. Enter “5664” for both the *Ceiling elevation along upstream* and *Ceiling elevation along downstream*. These ceiling elevations are equivalent to the elevation of the low chord on a bridge.

As a general note, it is not required that the two ceiling elevations be the same. They are allowed to differ one from another as may be the case with some bridges.

8. Enter “0.09” for the *Manning roughness coefficient between water and ceiling*. This roughness value was chosen based on an estimate of what the roughness might actually be. Where data exists, this parameter could be modified by performing a model calibration which would allow the roughness value to be modified based on comparing the computed results to observed field measurements.
9. Select **OK** to exit the *SHE-2D Linear BC* dialog.

4 Saving and Running the Simulation

Now that the bridge pressure flow structure has been created, the model is ready to run.

1. Right-click on the “ Structure Flow” simulation and choose **Model Control**. The *SRH-2D Model Control* dialog will appear.
2. In the dialog, change the *Case Name* to “Pressure_Flow” and select **OK** to close the *SRH-2D Model Control* window.
3. Now would be a good time to save the project. Select *File* | **Save as…**
4. Save the project as “Gila_Pressure_Flow.sms”.
5. Right-click on the “Structure Flow” simulation and choose **Save, Export, and Launch SRH-2D**.
6. Select **OK** if a warning is displayed stating that the “Structure BC” coverage will be renumbered before exporting.

When saving, exporting and launching SRH-2D, SMS will initialize and run pre-SRH, the SRH-2D preprocessor. When pre-SRH has finished running, SRH-2D will begin to run. The progress of the run can be viewed in the SRH-2D window.

7. Once it has finished running, a message should appear stating: “Program terminated with exit code 0”. Select **Yes**.
8. Make sure *Load Solution* is checked, as shown in Figure 4, in the SMS model wrapper and click **Exit**. The solution datasets will now be listed in the Project Explorer under “Gila_Mesh”.

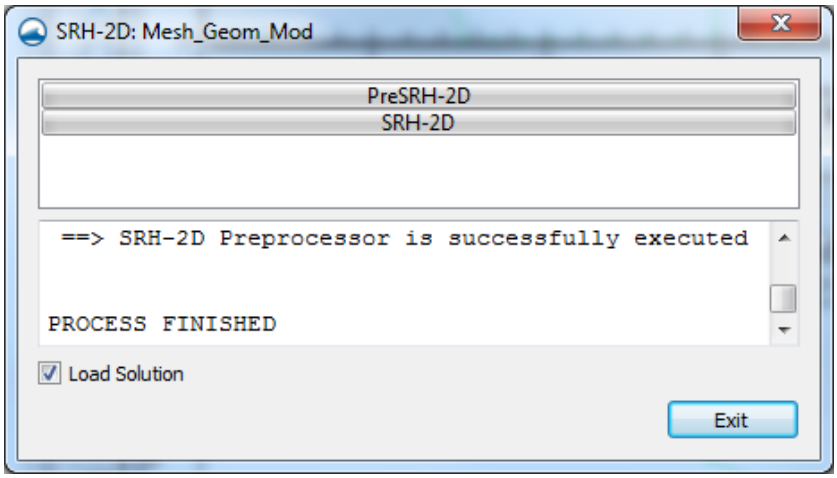


Figure 4 SMS Model Wrapper

9. Select the **Frame** tool to frame the model domain extents.
10. Select *Display* | **Display Options…** to open the *Display Options* dialog.
11. In the *2D Mesh* section of the dialog, turn off *Elements* to turn off the display of mesh elements.
12. Click **OK** to close the *Display Options* dialog.
13. Cycle through the datasets and time steps to see the results. Notice that more water is flowing over the roadway upstream of the bridge.

4.1 Organizing the Solution Datasets

For better dataset organization, a folder will be created in which the pressure flow solution datasets may be stored.

1. Right-click on "Gila_Mesh" under "Mesh Data" and select **New Folder**.
2. Right-click on the new folder and select **Rename**.
3. Enter "Bridge Pressure Flow" as the new name.
4. Select the 6 mesh datasets that correspond to the pressure flow solution by holding down the *Shift* key and selecting the datasets.
5. Drag the selected datasets below the " Bridge Pressure Flow" folder that was created in step 2. The datasets should be organized as shown in Figure 5.

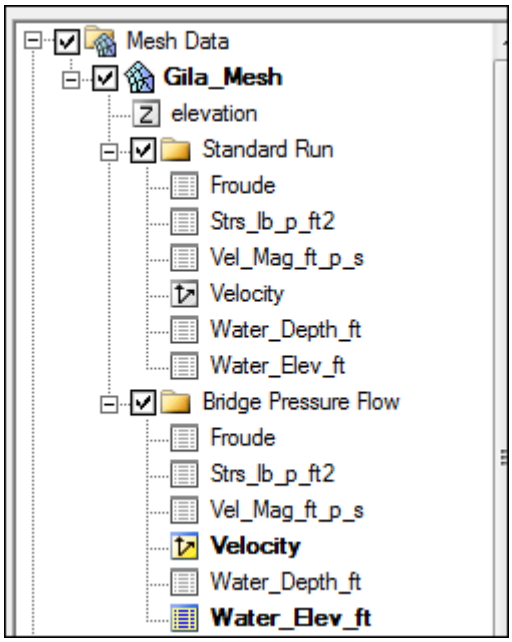


Figure 5 Mesh dataset organization

5 Visualizing Results

With the solution datasets read into the SMS project, create a 2D plot of the water surface elevations to compare the pressure flow solution with the original solution without pressure flow.

5.1 Creating an Observation Arc

To create the 2D plot, first create an observation coverage with an observation arc.

1. Use the **Zoom** tool to zoom into the bridge location.
2. In the Project Explorer select the "Water_Elev_ft" mesh dataset within the "Bridge Pressure Flow" folder to make it the active dataset.
3. In the Project Explorer, right-click on "Map Data" and choose **New Coverage** to bring up the *New Coverage* dialog.
4. In the dialog, under *Coverage Type* choose *Observation* and enter "Observation" as the *Coverage Name*.
5. Select **OK** to close the *New Coverage* dialog and create a coverage called "Observation" in the Project Explorer.
6. Select the "Observation" coverage to make it active.
7. Using the **Create Feature Arc** tool, draw an arc starting on the upstream side of the bridge, running through the channel and under the bridge, and ending on the

downstream side of the bridge. This will be used to create the water surface elevation profile on the 2D plot. The arc should look similar to the one in Figure 6.

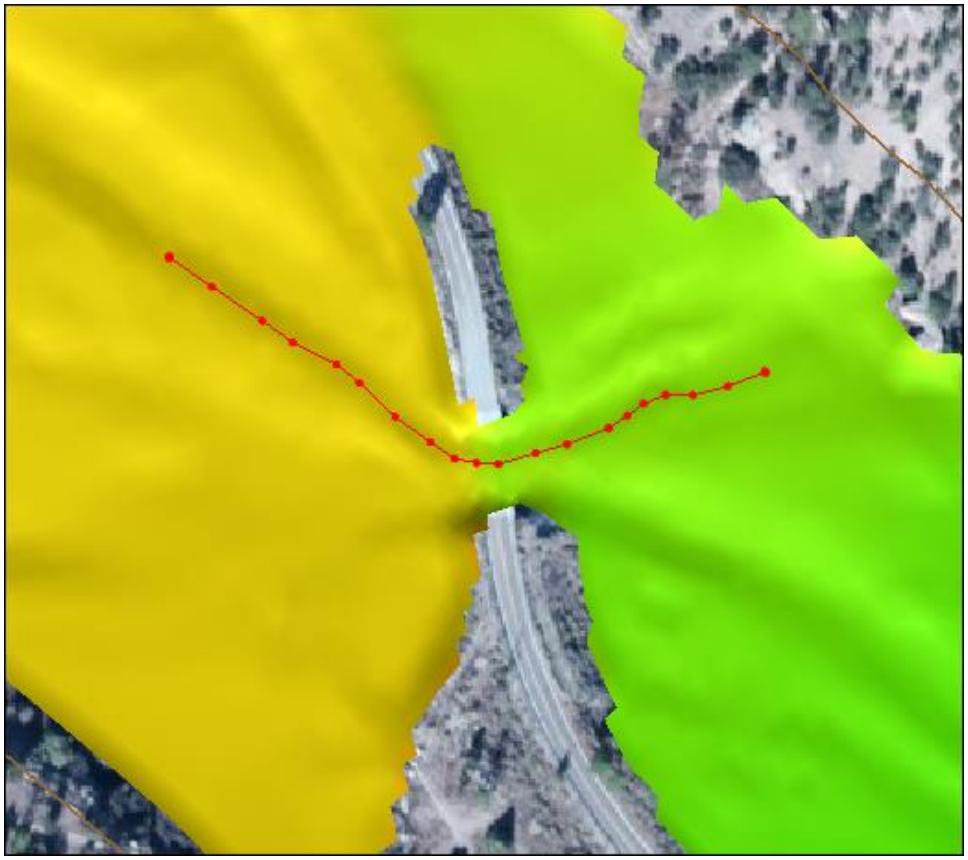


Figure 6 Observation Arc

5.2 Setting Up the Plot Wizard

With the observation arc created, the 2D plot of the water surface elevation profiles can be created.

1. Select *Display* | **Plot Wizard…** to bring up the *Plot Wizard* dialog.
2. In step 1 of 2 of the wizard, select *Observation Profile* then select **Next.**
3. In step 2 of 2of the wizard, choose *Specified* under *Dataset(s)*.
4. Check the boxes next to the "Water_Elev_ft" dataset under both the "Standard Run" folder and under the "Bridge Pressure Flow" folder as shown in Figure 7.

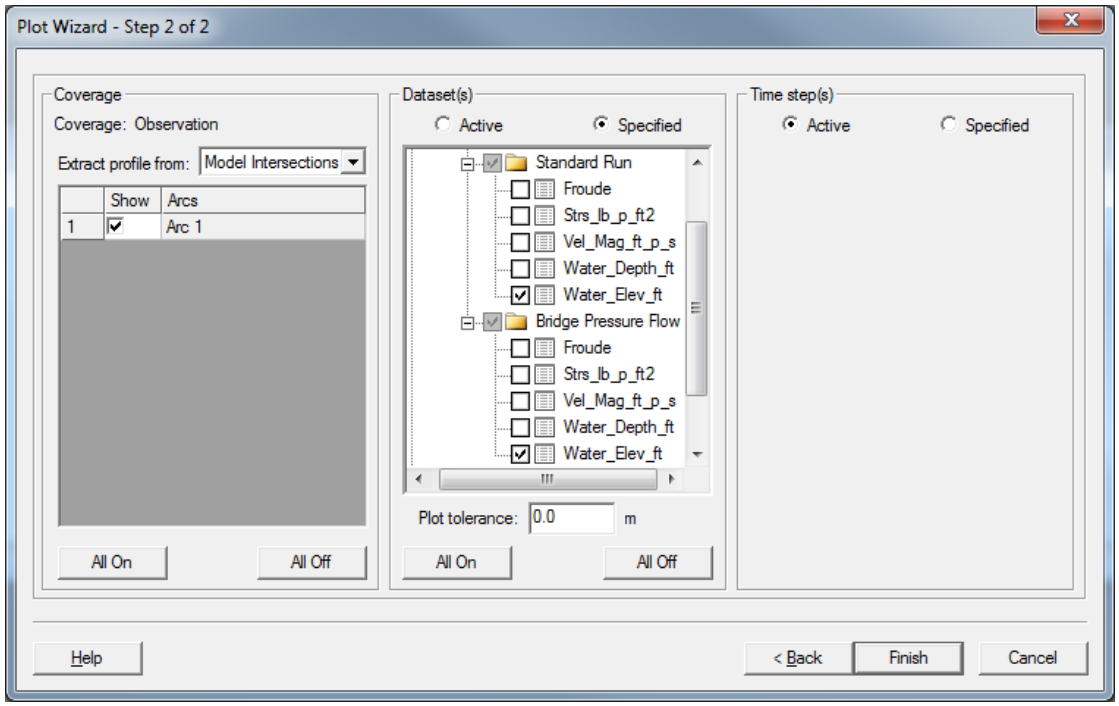


Figure 7 Plot Wizard Step 2 of 2

5. Select **Finish** to close the *Plot Wizard* dialog. The profile plot should appear.

6. Cycle through the time steps to view how the WSE changes with time. During time steps with higher flows the effects of the bridge are apparent as the water is backed up and forced below the bridge deck.

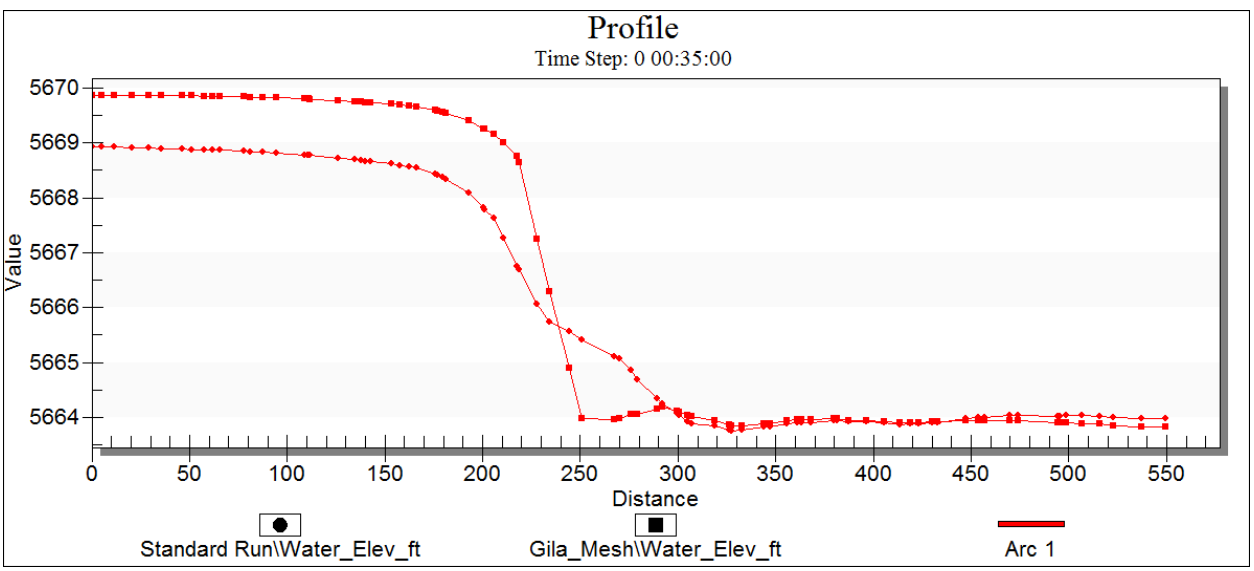


Figure 8 Water Surface Elevation Profile Plot

6 Conclusion

This concludes the "SRH-2D Bridge Pressure Flow"[1] tutorial. Further analysis could be performed on this solution to evaluate other effects of the bridge on the channel. The topics demonstrated in this tutorial include:

- Opening an existing SRH-2D project.
- Creating a pressure flow boundary condition at a bridge location.
- Saving and running SRH-2D
- Creating an observation arc.
- Using an observation arc to create a water surface elevation profile plot to visualize results.

If desired, continue experimenting with the SMS interface or quit the program.

[1] This tutorial was developed by Aquaveo, LLC under contract with the Federal Highway Administration.