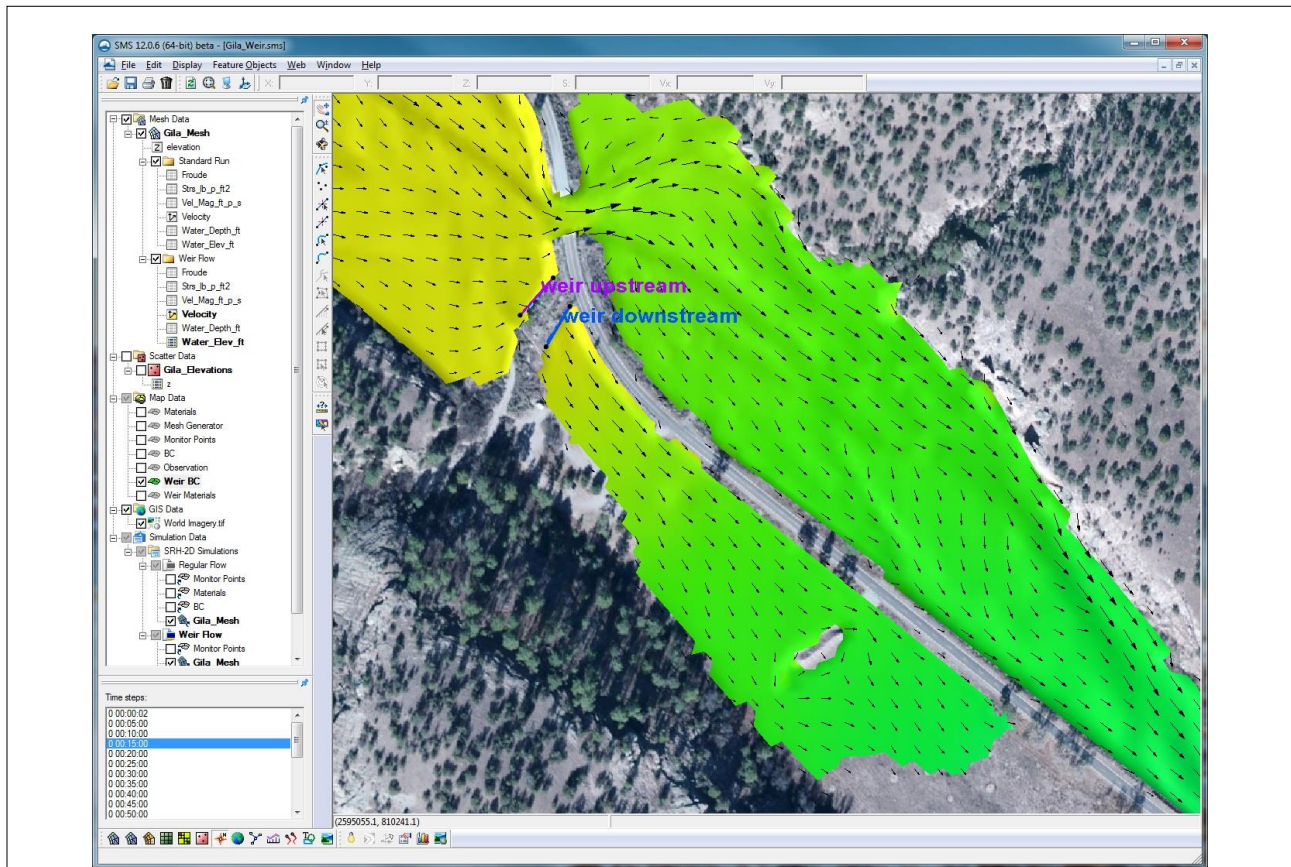




SRH-2D Tutorial Weir Flow



Objectives

This tutorial demonstrates the process of using a weir boundary condition (BC) within SRH-2D to model an overflow weir near a bridge structure. The “Simulations” tutorial should have been completed before attempting this one.

Prerequisites

- SRH-2D-Working with Simulations

Requirements

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

Time

- 20–30 minutes



1	Model Overview	2
2	Getting Started	2
3	Creating the Weir Boundary Condition.....	3
3.1	Creating the BC Arcs	3
3.2	Assigning the BC Attributes.....	6
3.3	Modifying the Material Coverage	7
4	Creating a Monitor Line.....	8
5	Saving and Running the Simulation.....	9
5.1	Organizing the Solution Datasets	11
6	Analyzing the Results.....	12
6.1	Visualizing the Datasets	12
6.2	Viewing the Monitor Line Output File.....	12
7	Conclusion	13

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.







Upstream of the confluence, the water has shown to back up around a bridge opening and flood over the road. To mitigate this flooding, an overflow weir has been proposed to help divert water into an overflow basin. In the model, the weir will be portrayed as two arcs representing the upstream and downstream faces of the weir structure.

Limitations of the SRH-2D weir structure are that it does not allow reverse flow, and that the momentum from the 2D computations on the approach side of the weir do not get carried through the structure. If it is desired to account for momentum and also create a scenario in which reverse flow occurs, a more appropriate approach would be to modify the geometry of the mesh to represent the weir. All files for this tutorial are found in the *SMS_SRH-2D_Weir/Data* folder.

2 Getting Started

To begin, do the following:

1. Open a new instance of SMS, or press *Ctrl-N* within SMS.
2. Select *File | Open...* to bring up the *Open* dialog.
3. Navigate to the *SRH2D_Weir/Data* folder for this project and select "Gila_Structure.sms".
4. Click **Open** to import the project and close the *Open* dialog. The Graphics Window should appear similar to that shown in Figure 1.

In the Project Explorer, duplicates of the “ Regular Flow” simulation and the “ BC” and “ Materials” coverages have already been made to aid in setting up the model. The duplicates have been renamed as “ Weir Flow”, “ Weir Materials”, and “ Weir BC”, respectively.

The process of duplicating these items was demonstrated in the “Simulations” tutorial. Creating duplicates of simulations or coverages allows making 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.

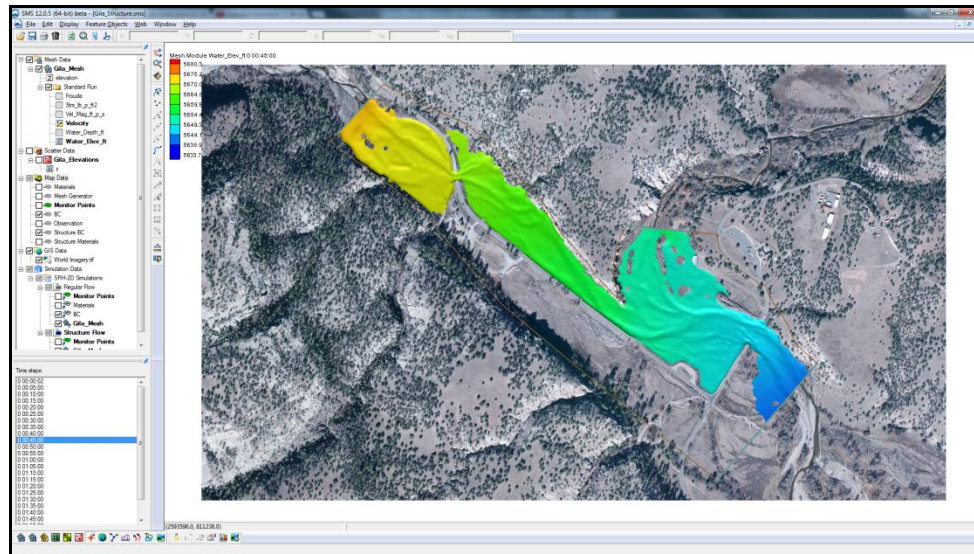


Figure 1 Gila_Structure.SMS project

The mesh datasets located under the “ Standard Run” folder in the Project Explorer are SRH-2D solution datasets of the existing flow conditions, without the weir structure. They have been provided to compare the effect that the overflow weir will have on the flooding.

3 Creating the Weir Boundary Condition

The weir structure will be created along a berm near the bridge that is located just upstream of the confluence (see Figure 2). In SMS, weir boundary conditions are defined by creating two arcs that represent the upstream and downstream faces of the weir. SMS also requires that the materials coverage be edited to properly define the weir BC.

3.1 Creating the BC Arcs

The first step in creating a boundary condition is to create the arcs that will represent the structure. Once the arcs have been created in the map coverage and the coverage has been linked to a simulation, the weir structure will be defined.

1. **Zoom** into the location shown in Figure 2.
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. Select “2D Mesh” from the list on the left.
5. On the *2D Mesh* tab, turn on *Elements*.
6. Select **OK** to exit the *Display Options* dialog.

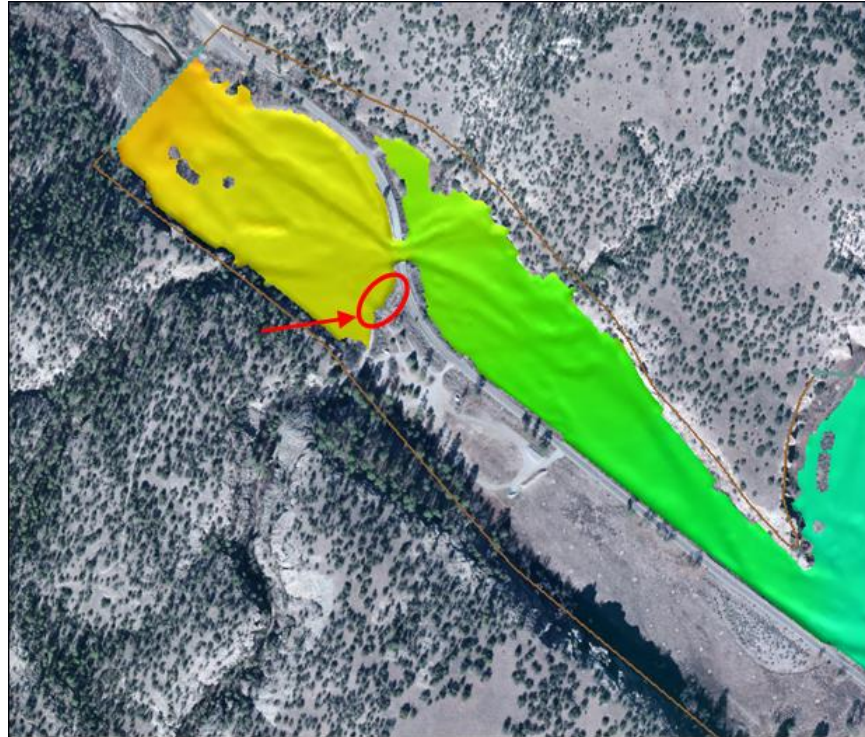






Figure 2 Weir location

7. In the Project Explorer, select the “ Weir BC” coverage to make it active.
8. Use the **Create Feature Arc**  tool to create two arcs, one on the upstream face and one on the downstream face. The created arcs should look similar to Figure 3. Do not be concerned about the exact placement of the arcs since they will be modified in the next step.
9. For consistency, change the coordinate locations of each of the 4 end nodes on the arcs to the coordinates shown in Figure 4. To do this, start by using the **Select Feature Point**  tool to select a point at the end of an arc and manually enter the X and Y values into the fields at the top of the Graphics Window in SMS.
10. If any vertices exist along these arcs, they should be selected and deleted using the **Select Feature Vertex**  tool and pressing the *Delete* key.

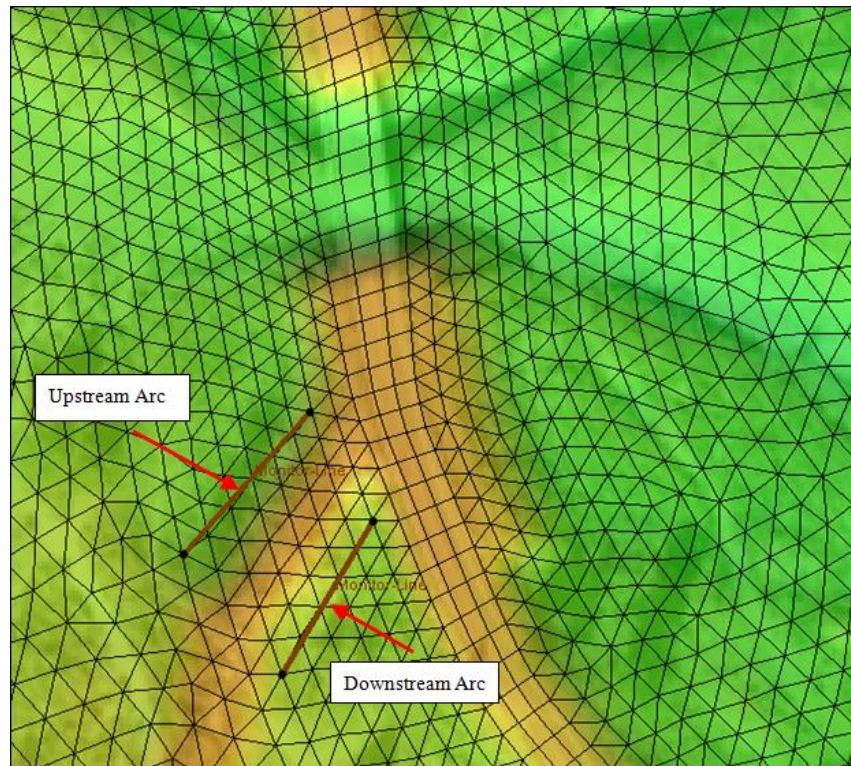


Figure 3 Weir boundary condition arc locations

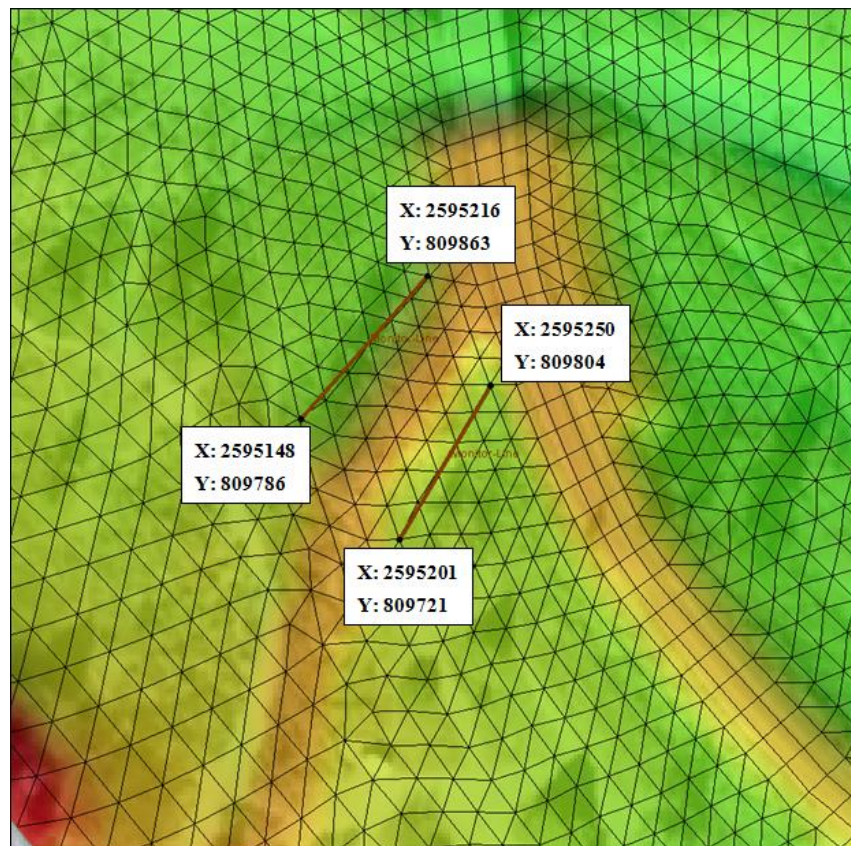



Figure 4 Coordinate location of arc end nodes

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 arc and take note of the ID for this arc (displayed at the bottom of the Graphics Window in SMS).
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 *Linear BC* dialog.
4. Select “Weir” from the *Type* drop-down.
5. Note the assignment in the *Role* column of “weir upstream” and “weir downstream” to the two arcs, associated with their ID values in the *Object Id* column. If the ID displayed for “weir upstream” is not the same as noted above in step 1, switch the associations using the *Role* drop-down.
6. Select “ft” for the *Units*.
7. Enter “5666” for Crest elevation and “100” for Length of Weir.
8. Gravel roadway is the weir type that most closely relates to the berm. Select “Gravel” from the *Type* drop-down.
9. Select **OK** to exit the *Linear BC* dialog.

Several other weir types exist including: “paved”, “single”, “double”, “sharp”, “broad” and “user”. With the “user” weir type, weir coefficients and dimensionless submergence factor coefficients a and b can be specified.

The dimensionless submergence factor coefficients are used to calculate the submergence coefficient as shown in the following equation:

$$C_s = \left[1 - \left(\frac{Z_D - Z_C}{Z_U - Z_C} \right)^a \right]^b$$

Where:

C_s = submergence coefficient

Z_D = average downstream water surface elevation

Z_C = average weir crest elevation

Z_U = average upstream water surface elevation

a = dimensionless submergence factor coefficient

b = dimensionless submergence factor coefficients

The following is the equation used by SRH-2D to calculate flow over a weir:

$$Q_w = C_s C_w \sqrt{g} L_w (Z_U - Z_C)^{3/2}$$

Where:

Q_w = flow rate

C_s = submergence coefficient

C_w = dimensionless discharge coefficient for unsubmerged weir flow

g = gravity






L_w = length of weir segment

Z_U = average water surface elevation along upstream arc

Z_C = average crest elevation

3.3 Modifying the Material Coverage

When creating a weir structure, the materials coverage will need to be modified. SRH-2D requires that all mesh elements between the two weir boundary condition arcs be inactive, no-flow elements. In order to define the elements between the weir arcs as inactive no-flow elements, a polygon must be created in the materials coverage and be defined as an “unassigned” material type.

1. In the Project Explorer, turn on the “ Weir Materials” coverage and select it to make it the active coverage.
2. Turn off “ World Imagery.tif” in the Project Explorer.
3. Select *Display* | **Display Options...** to bring up the *Display Options* dialog.
4. Select “2D Mesh” from the list on the left.
5. On the *2D Mesh* tab, turn off *Elements*.
6. Select **OK** to close the *Display Options* dialog.
7. Use the **Create Feature Arc**  tool to create an arc enclosing the region between the weir arcs. If drawn correctly, the arc should enclose upon itself and appear similar to the arc in Figure 5.
8. Select *Feature Objects* | **Build Polygons**. This will build a new polygon in the enclosed area created in the previous step.
9. Using the **Select Feature Polygon**  tool, double click on the new polygon to bring up the *Assign Material Properties* dialog.
10. Select “Unassigned” from the material list on the left.
11. Click **OK** to close the *Assign Material Properties* dialog. This assigns a material type of “unassigned” to the area between the weir arcs, designating the underlying elements as inactive/no-flow elements.
12. Turn off “ Weir Materials” in the Project Explorer.

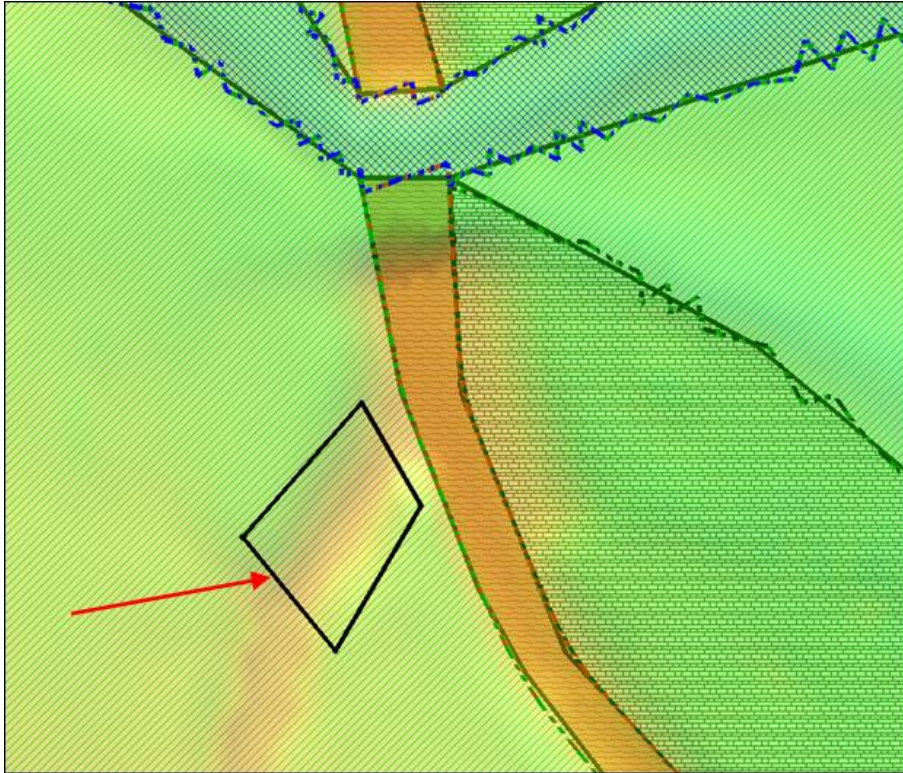




Figure 5 Arc enclosing the area between the weir arcs

4 Creating a Monitor Line

SRH-2D Monitor lines allow extracting flows and water surface elevation data from the model at a specified location. A monitor line will be created near the downstream face of the weir in order to monitor the flow coming out of the weir structure.

1. Select the “ Weir BC” coverage to make it active.
2. Using the **Create Feature Arc**  tool, create a monitor line barely offset from the downstream weir face arc. Be sure to zoom in so that the arc does not snap to the same location as the weir arc (see Figure 6).
3. Right-click on “Map Data” in the Project Explorer and select **Display Options...** to bring up the *Display Options* dialog.
4. Select “Map” from the list on the left.
5. Turn on *Snap Preview* (*Shift + Q*), and click **OK** to close the *Display Options* dialog.

The dotted lines displayed in the Figure 6 and on the computer screen represent the “Snap Preview” for the boundary condition arcs. The snap preview displays where the boundary condition arcs will be applied to the mesh. In the case of the downstream weir arc and monitor line arc, the snap preview lines for both arcs overlap the same element edges.

When the simulation is exported, two identical nodestrings will be written to the SRHGEOM file, one to define the monitor line and the other to define the weir face.

Normally, it is not suggested that nodestrings overlap; however, since a monitor line is not adding complexity to the model, this combination of nodestrings will not cause any problems with the model run.

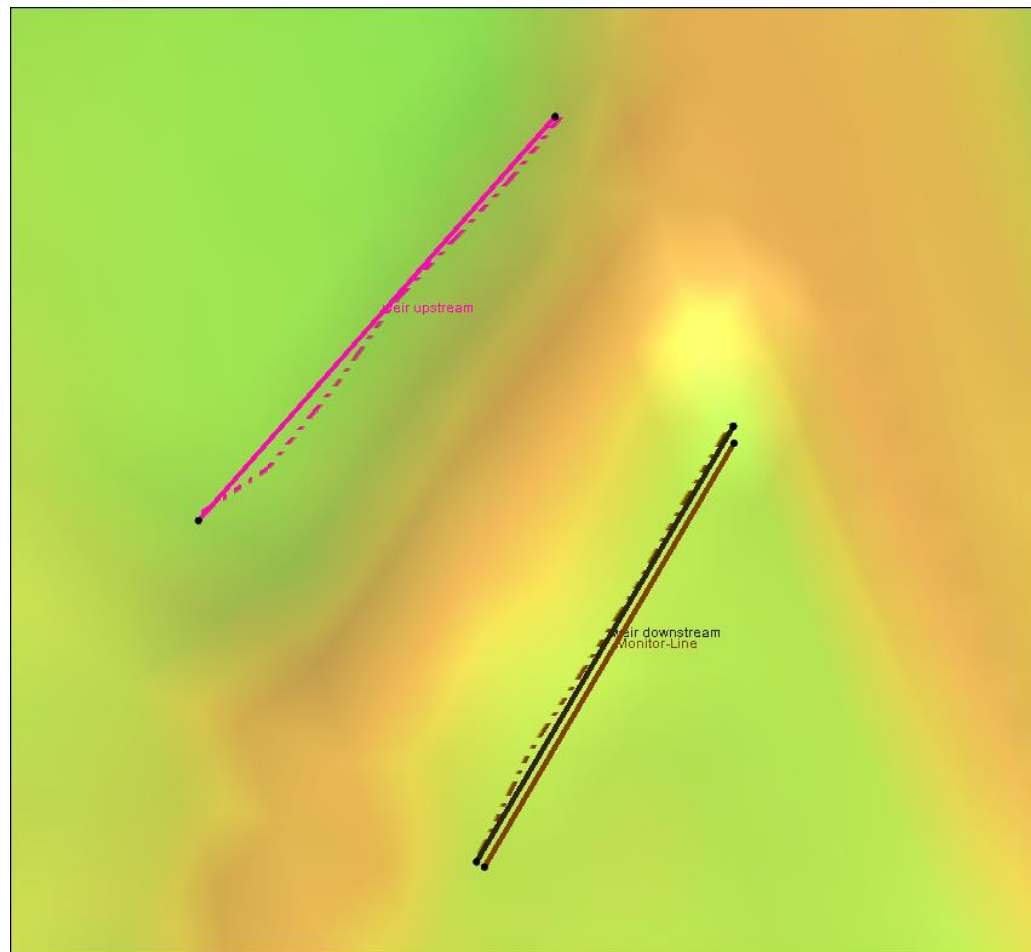


Figure 6 Monitor line offset from the downstream weir arc

5 Saving and Running the Simulation

With the weir structure created, the model is ready to run once the model controls have been set and the project has been saved.

To set the model controls, do the following:

1. Right-click on the “Weir Flow” simulation and select **Model Control...** to bring up the *Model Control* dialog.
2. Enter “Weir_Flow” in the *Case Name* field.
3. Leave all other settings at the default and click **OK** to close the *Model Control* dialog.

To save the project, do the following:

4. Select *File* | **Save as...** to bring up the *Save As* dialog.

5. Enter “Gila_Weir.sms” as the *File name*.
6. Select “Project Files (*.sms)” from the *Save as type* drop-down.
7. Click **Save** to save the project and close the *Save As* dialog.

To launch SRH-2D, do the following:

8. Right click on the “Weir Flow” simulation and choose **Save, Export, and Launch SRH-2D**.
9. Select **OK** if a warning is displayed stating that the Weir Materials or Weir BC coverage will be renumbered before exporting. This brings up the *SRH-2D: Weir Flow* dialog and a wrapper window with three windows. The windows can be resized and arranged so that each can be seen, as shown in Figure 7.

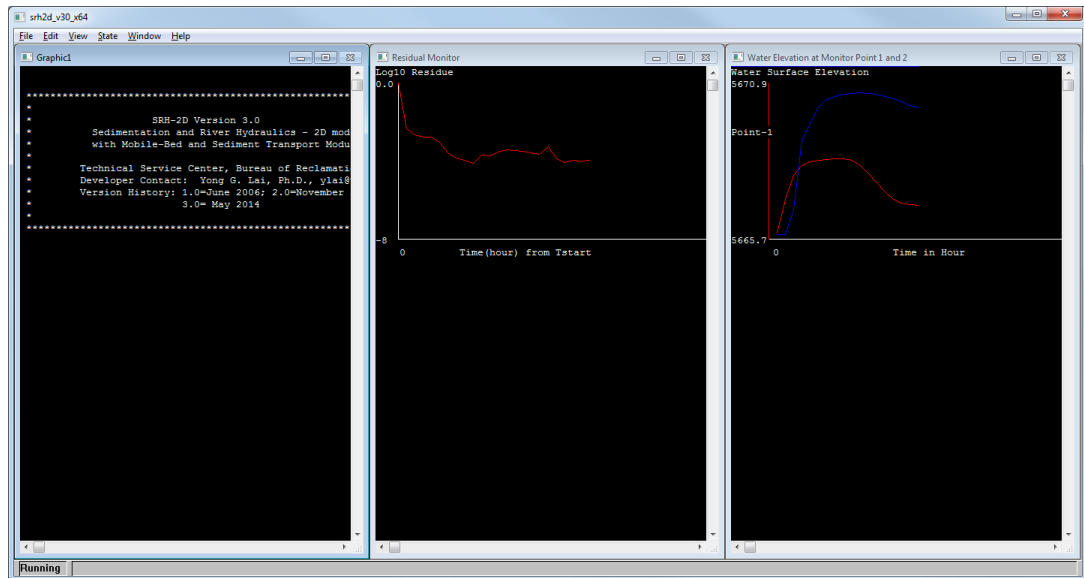



Figure 7 Wrapper window showing SRH-2D running status

SMS will initialize and run the SRH-2D preprocessor, pre-SRH. When pre-SRH has finished running, SRH-2D will begin to run. Once the run is complete, a dialog should appear stating: “Program terminated with exit code 0”.

10. Select **Yes** to close the dialog and bring up the SMS model wrapper.
11. Turn on *Load Solution*, as shown in Figure 8, and click **Exit** to close the SMS model wrapper. The solution datasets will now be listed in the Project Explorer under “ Gila_Mesh”.

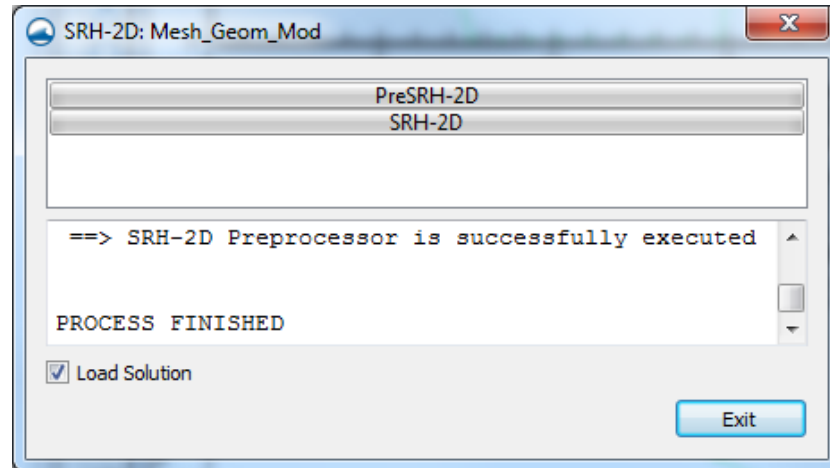









Figure 8 SMS Model Wrapper

12. **Frame**  the project.
13. Turn off “ Weir BC” in the Project Explorer.
14. Turn on “ World Imagery.tif”.

5.1 Organizing the Solution Datasets

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

1. Right-click on “ Gila_Mesh” under “ Mesh Data” and select **New Folder**. A new folder named “ New Folder” will appear in the Project Explorer.
2. Enter “Weir Flow” and press the *Enter* key to set the new name.
3. Select the six new mesh datasets corresponding to the simulation just completed by selecting the first one, holding down the *Shift* key, then selecting the last dataset.
4. Drag the selected datasets below the new “ Weir Flow” folder (see Figure 9).

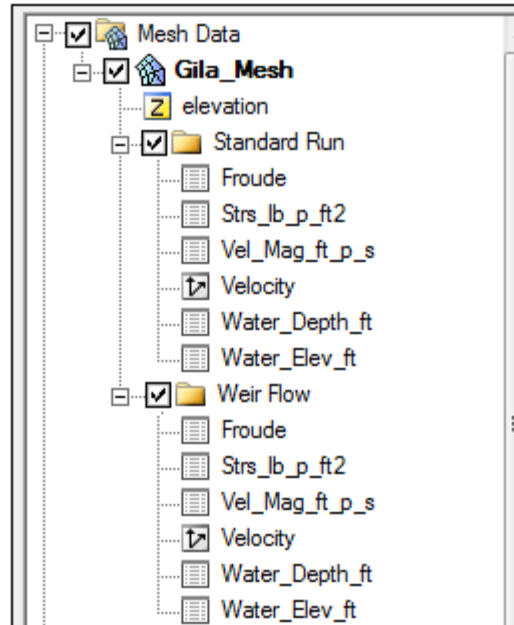




Figure 9 Mesh dataset organization

6 Analyzing the Results

6.1 Visualizing the Datasets

The datasets will now be visualized and the output from the monitor line will be viewed.

1. Select the “ Water_Elev_ft” dataset in the “ Weir Flow” folder to make it active.
2. Cycle through the time steps to view the water flowing through the weir and into the overflow basin. Notice that the water no longer flows across the road just north of the bridge. If desired, cycle through the other datasets to visualize them.

6.2 Viewing the Monitor Line Output File

A file was exported to the in the output files that lists the flows and average water surface elevation along the monitor line arc. This can be viewed in any text editor application.

1. Browse to the SRH2d_Weir/ Gila_Weir/SRH-2D/Weir Flow directory.
2. Using a text editor application, open the file “Weir_Flow_LN1.dat”.
3. Observe the flows and average water surface elevations listed in the monitor line output file. The water stops flowing across the weir sometime between 80 and 83 minutes during the simulation run. Multiplying the flow values by their respective time increments and summing them up would yield a rough volume estimate for the water within the overflow basin of 1.97×10^6 ft³ or 45.2 ac-ft of water.

Monitor line output files will always be named according to the case name and monitor line number. For example, if the case name for a different run was “High_Tailwater” and two monitor lines existed in the model, the monitor line output files would be called “High_Tailwater_LN1.dat” and “High_Tailwater_LN2.dat” respectively.

The discharge flows and WSE for the weir structure are also written out to another output file called “Weir_Flow_Weir1.dat”.

7 Conclusion

This concludes the “SRH-2D - Weir Flow”¹ tutorial. If desired, continue to experiment with the SMS interface or quit the program.

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