

# Workshop

## Combined 1D River and Floodplain with 2D Area behind the Levees

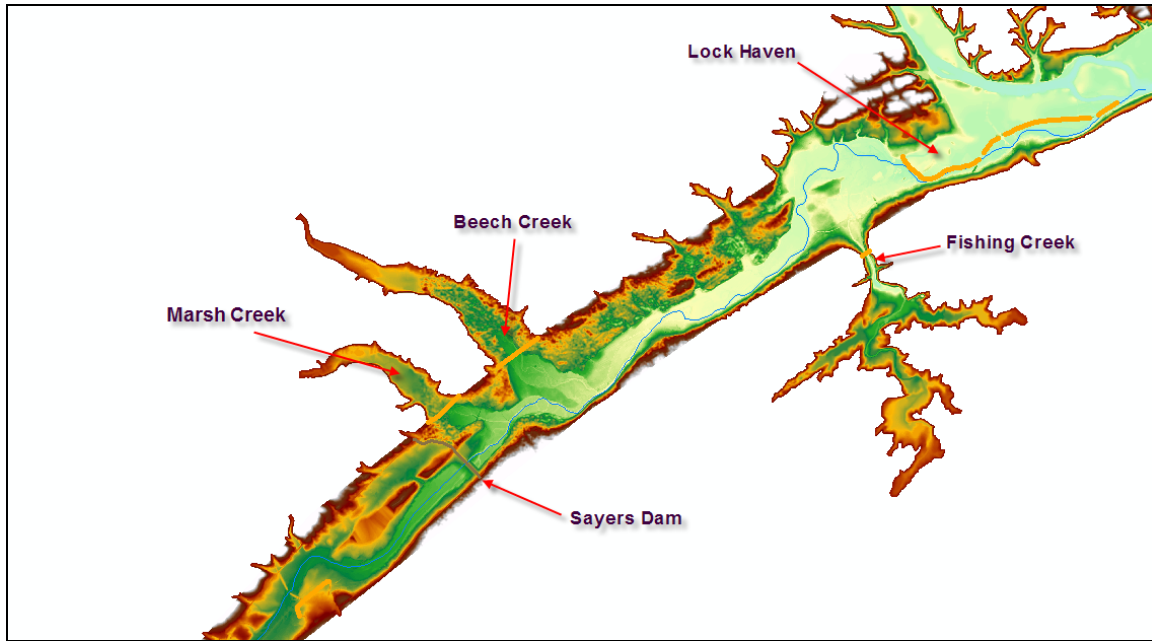
### Introduction

This workshop will help students learn how to use HEC-RAS to: model areas behind levees with 2D Flow Areas; Attach 2D Flow Areas to 1D rivers using a Lateral Structure; and review and understand pertinent 2D Flow Area output. A comparison between modeling a leveed area as 1D vs. 2D will also be made.

**NOTE: While this data is from an actual river system, the model and results of this workshop do not represent current or future conditions of the river. The United States Army Corps of Engineers has granted access to the information in this model for instructional purposes only. Do not copy, forward, or release the information without United States Army Corps of Engineers approval.**

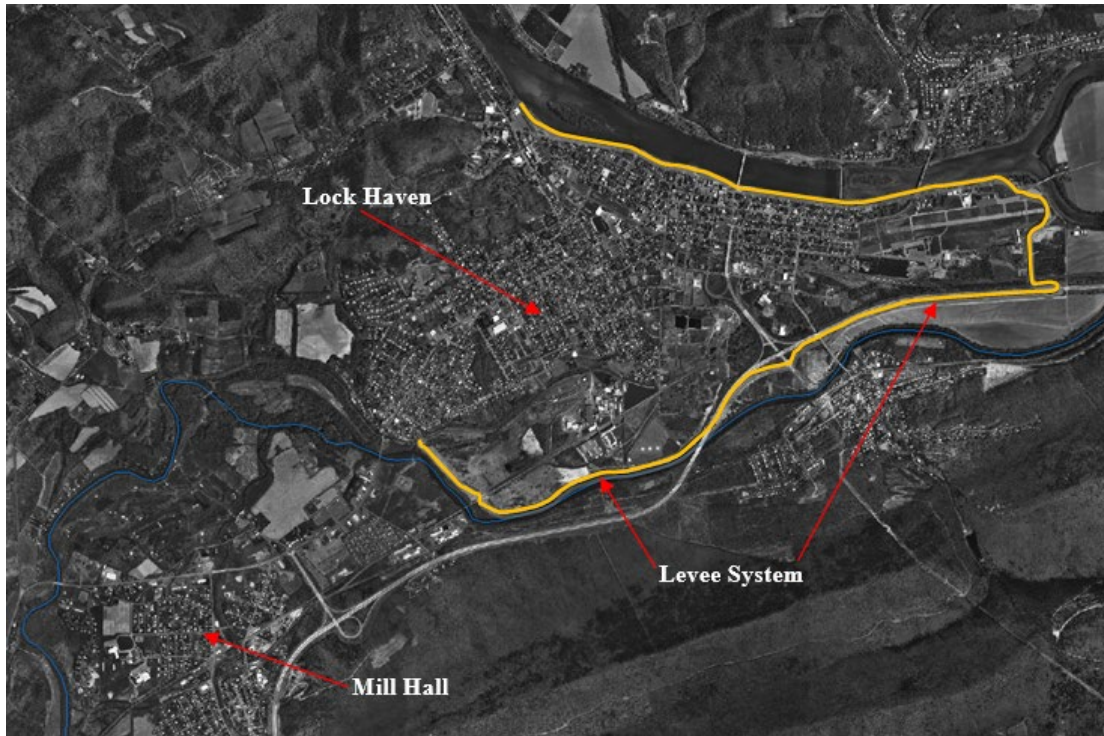
### Background

Figure 1 shows the extent of the terrain data that was used in developing the HEC-RAS model for this Levee analysis. As shown in Figure 1, the reservoir pool and downstream floodplain runs through a narrow corridor within the Appalachian Mountain range. Bald eagle creek flows from Southwest to Northeast and terminates into the West Branch of the Susquehanna River just downstream of the town of Lock Haven, PA. The model represents about 26 miles of the river, with the dam located about 15.4 miles (river station 81454 ft) upstream from the confluence with the West Branch of the Susquehanna. The area downstream of the dam is heavily populated, with the largest population at the town of Lock Haven, which is located at the very downstream end on the north side of the stream. The town of lock Haven is protected with a system of levees that was designed for the 500 year (0.2% Chance) event. Figure 2 is an aerial photo showing some of the populated areas, as well as the levee system that protects Lock Haven.



**Figure 1. Terrain Model for Bald Eagle Creek Study.**

In this workshop we will be analyzing an event that is larger than the levee design event (approximately a 1000yr or 0.1% chance event). The purpose of looking at this event is to determine the consequences of an event larger than the design event. Generally, an analysis of this type would look at the full range of events, up to and above the design event in order to determine risk and uncertainty of the levee. However, given the limits on time for a class workshop, we are only going to look at an event that is little higher than the design event.



**Figure 2. Aerial Photo of Downstream Populated Areas.**

## **Problem Summary**

A project file (**BaldEagleCreek.prj**) with the title “**Bald Eagle Creek 2D Levee Area Example**” has been loaded on your workshop computers. This file contains all of the data for this workshop. The following is a summary of the required tasks for each group:

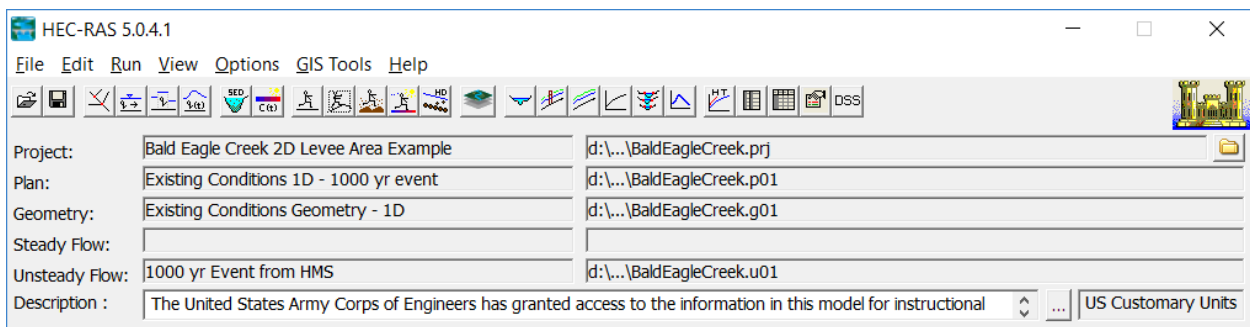
1. Open the project and run the Plan labeled “Existing Conditions 1D – 1000 yr Event”.
2. Briefly review the model results.
3. Make a copy of the geometry file/data by using the “Save As” option and label the geometry something like this “Existing Conditions – 2D Levee Area”.
4. Remove Storage Areas 191 and 192, as well as the hydraulic connection between them. Replace these two storage areas with a single 2D Flow Area. Complete all the necessary information for the 2D Flow Area.
5. Make a new Plan for the 1000 yr event, but using the new Geometry file with the 2D Flow Area. Label the Plan something like “Existing Conditions 2D Levee – 1000yr Event”.

6. Run the new 2D Plan and review the output.
7. Answer several questions.
8. Make a copy of the Plan and add in a Breach Option to the levee. Run the model and answer some additional questions

## Tasks

### 1. Open the Project and Run the 1D Plan

Open the Project and run the only plan, which is called “**Existing Conditions 1D – 1000 yr Event**”.



### 2. Review the Model Results

Review the results specifically looking at the water surface profiles and hydrographs. Evaluate what happens to the Lock Haven levees and the town of Lock Haven (the area behind the levees) during the event.

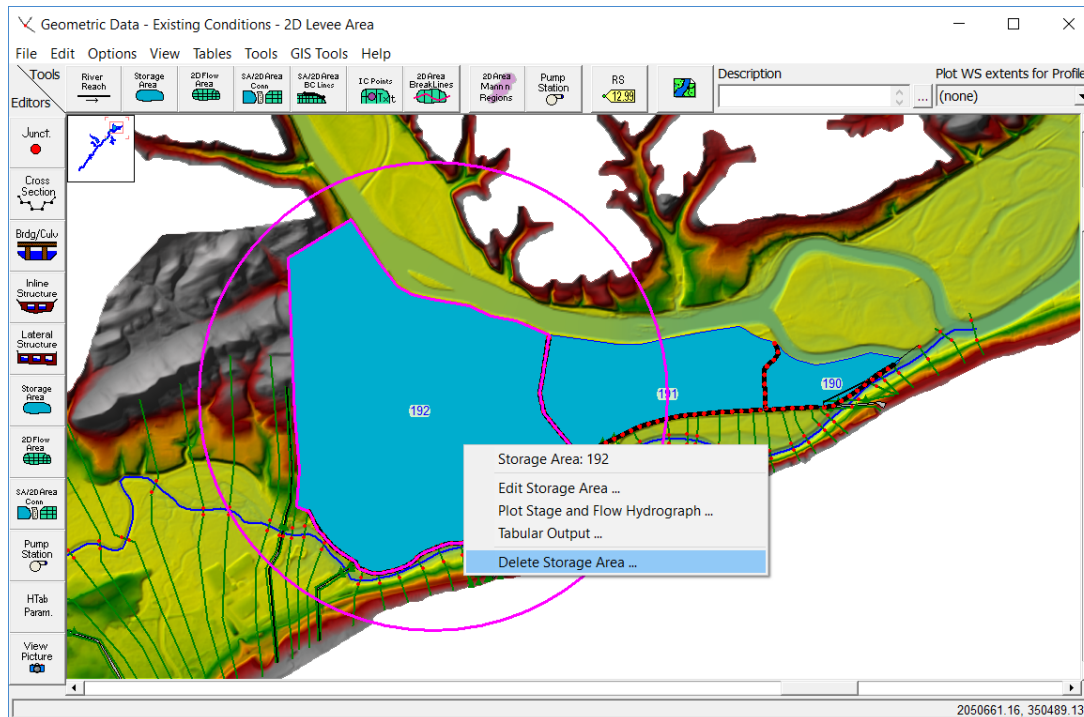
### 3. Make a Copy of the Geometry File

Go to the Geometric Data editor and make a copy of the current Geometry data using the “**Save As**” option. Label the new geometry file something like: “**Existing Conditions – 2D Levee Area**”.

### 4. Replace Storage Areas 191 and 192 with a 2D Flow Area.

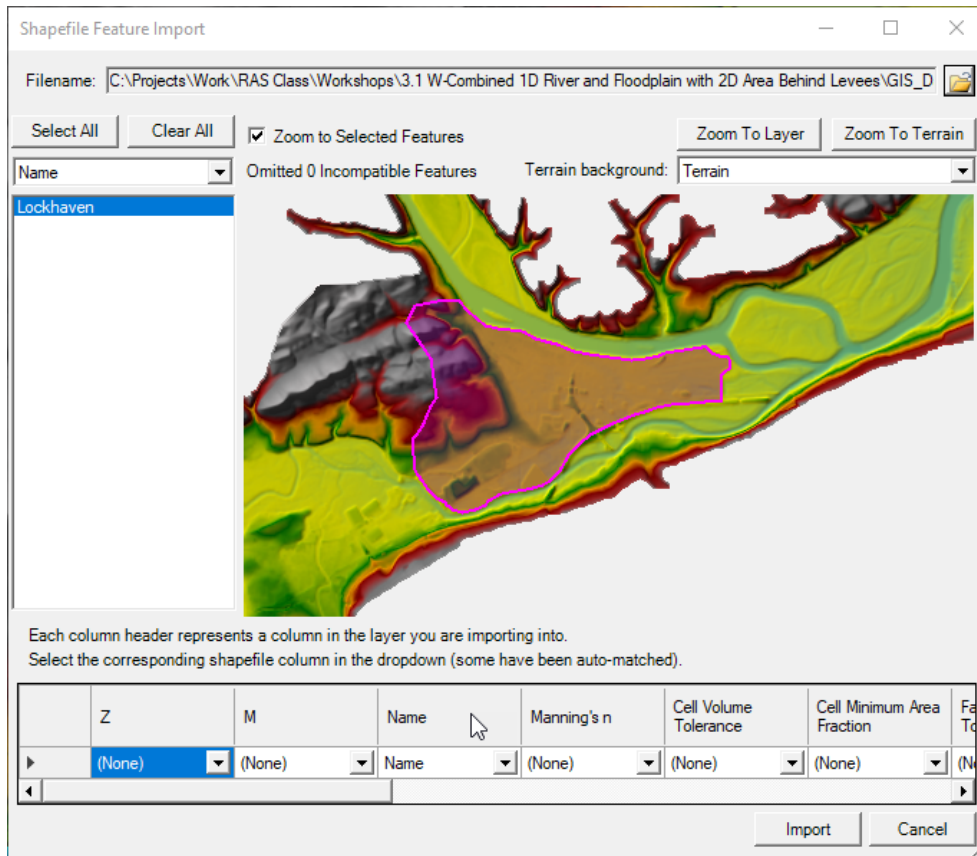
Delete the Storage Areas labeled 191 and 192. Also delete the hydraulic connection that was between storage areas 191 and 192. It is labeled “SA192to191”. Replace the two storage areas with a single 2D Flow Area. To do this, perform the following steps:

- a. Delete Storage Area 191 and 192, as well as the hydraulic connection between them, “SA192to191”. Then SAVE the Geometry.



**Figure 3. Deleting the Storage Areas and Hydraulic Connection in the Geometry Editor.**

- b. Go into RAS Mapper and expand the geometry layer that represents the new geometry file you just saved. Expand the “2D Flow Areas” layer, then right click on the “Perimeters” layer and select **Edit Geometry** (see Figure 4 below). Use the **Add New Feature** drawing tool, then draw the boundary of the 2D Flow Area and give it a name of “LockHaven.” Alternatively, you can import the perimeter from the GIS\_Data folder. To import a Perimeter as a shapefile, right click **Perimeters** while editing, and select **Import Features from Shapefile**. After clicking the browse icon, navigate into the GIS\_Data folder and select “LockHaven2DPerimeter.shp”. You should see your perimeter now in the Import menu. Click Import, and your 2D perimeter will load into the map.

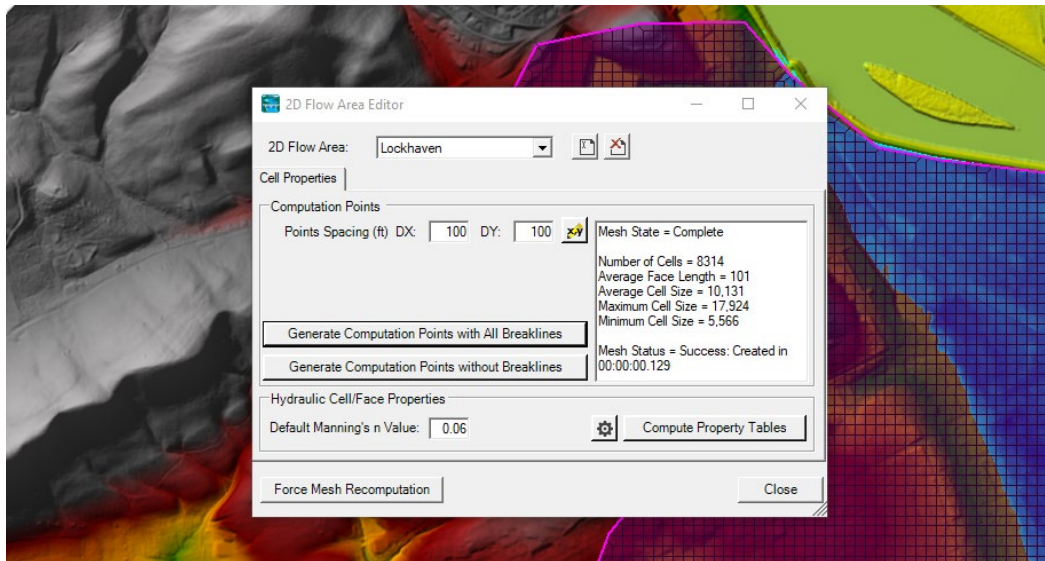


**Figure 4. Shapefile Feature Import**

c. Next, right click on the 2D Flow Area in the map window and select **Edit 2D Area Properties**, this will bring up the editor. Use the 2D Flow Area Editor to create the 2D Mesh with the following properties:

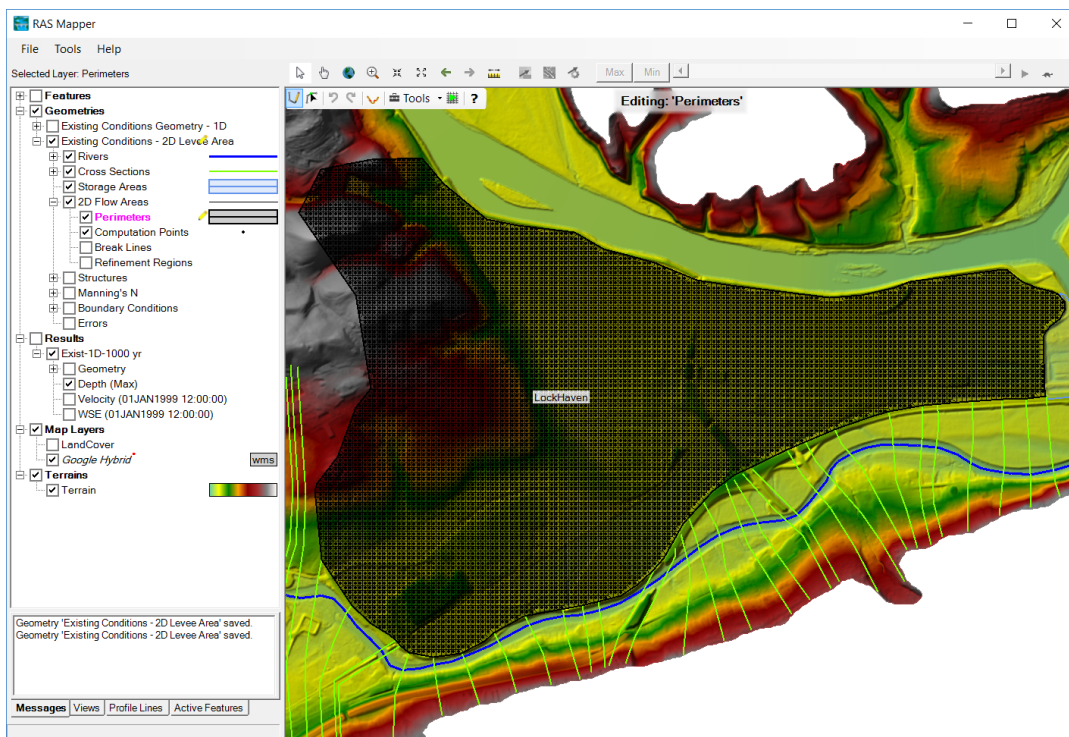
- Cell size :100 X 100 ft
- Manning's n value: 0.06

After you have entered the DX and DY Point Spacing for the cells, and the default Manning's n value, press the button labeled **Generate Computation Points**, in order to make the base mesh. Then close the editor. Check to make sure the cells around the outside of the mesh are all formed correctly and there are no mesh generation mistakes.



**Figure 5. 2D Flow Area Editor.**

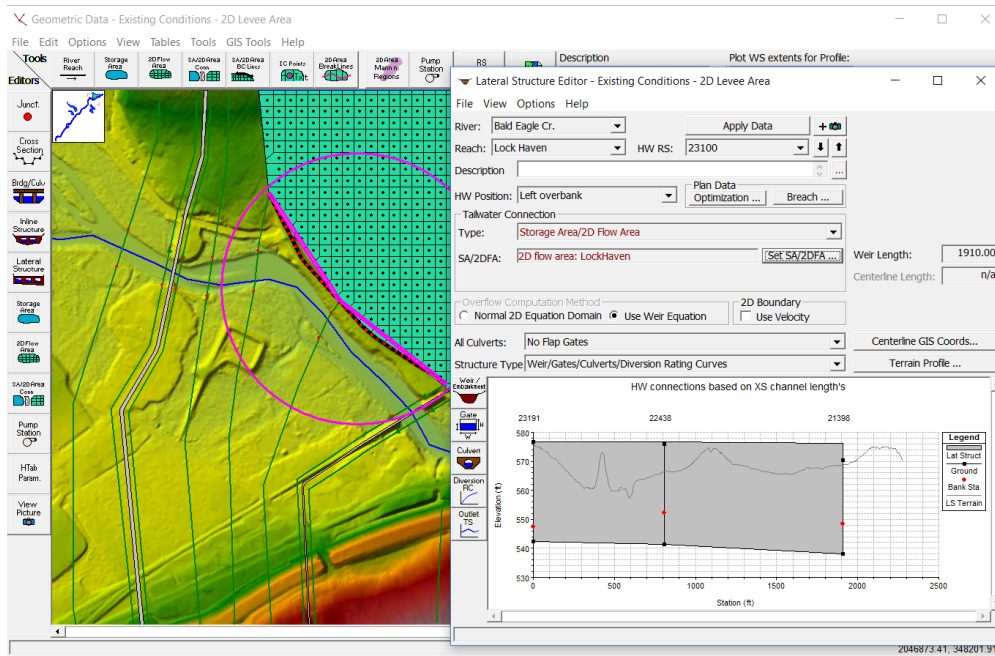
- d. Right click on the 2D Flow Areas/Perimeters layer and select **Stop Editing**. Select **Yes** when asked if you want to save the edits. The new 2D Mesh should look like what is shown in Figure 7 below:



**Figure 6. Final 2D Flow Area with 100 X 100 ft cell size.**

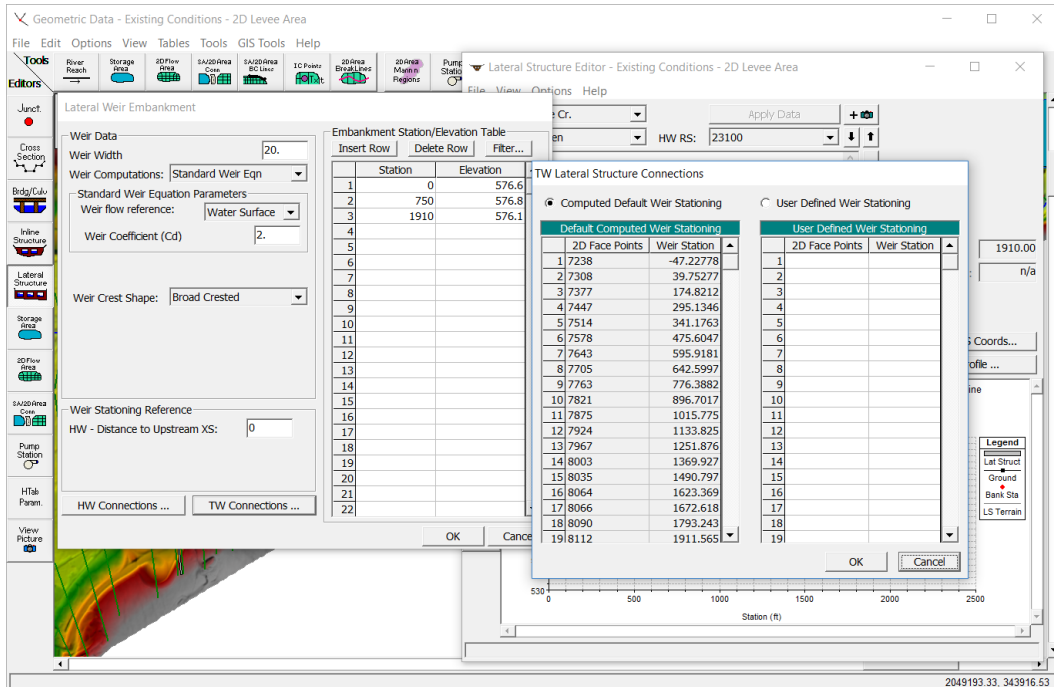
- e. Close RAS Mapper, and open the Geometry editor. Using the **Lateral Structure Editor**, hook up all of the Lateral Structures to the new **LockHaven 2D Flow Area**. This includes the following lateral structures: 23100, 21200, 14800, and 11950 (see Figure 7).

Shown in Figure 8 is the Embankment Station/elevation editor and the Tailwater connection table, showing how the lateral structure is connected to the 2D Flow Area cells.



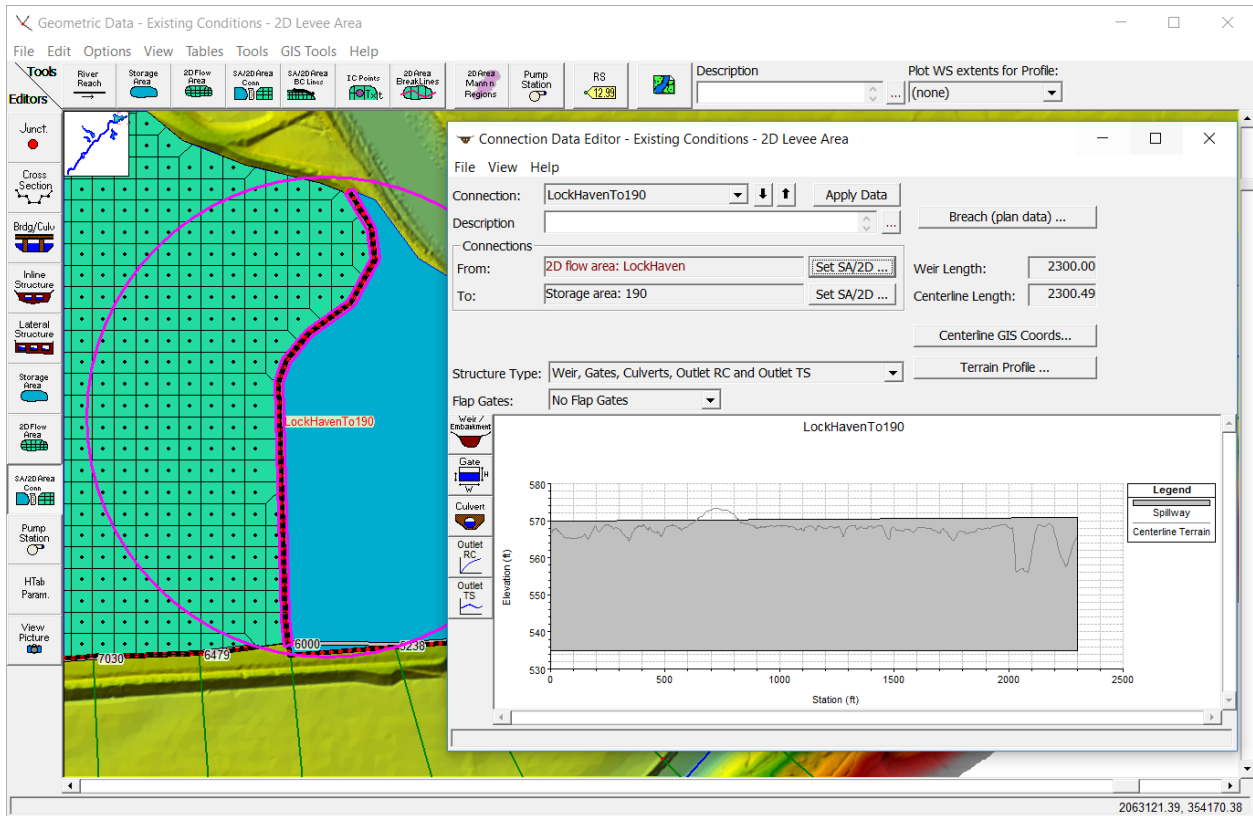
**Figure 7. Using the Lateral Structure Editor to hook the 1D River to the 2D Flow Area**





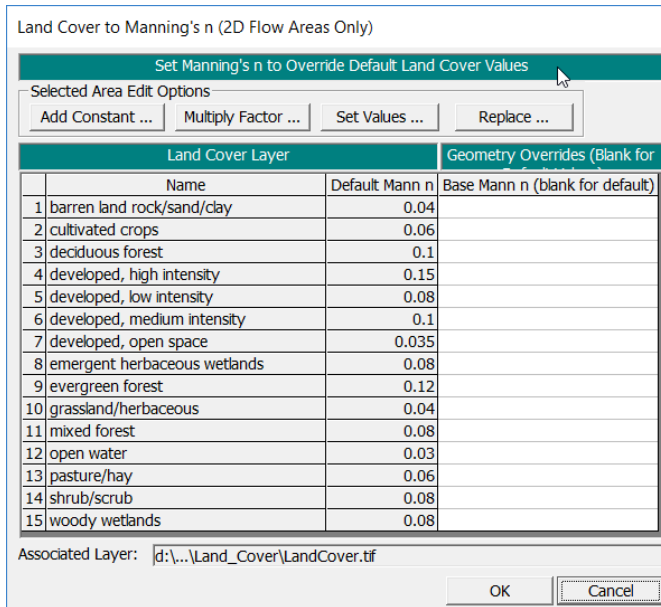
**Figure 8. Lateral Weir Embankment Editor showing Tailwater connection to 2D Flow Area Face Points.**

- f. Rename the SA/2D Area Conn labeled “SA191to190” to “LockhavenTo190” using the **Edit|Change Name** option in the Geometric Data Editor. Using the **SA/2D Area Conn.** editor, open the hydraulic connection called “LockhaveTo190” and connect the 2D Flow Area to the Storage Area called “190” (See Figure 9 below). **SAVE the Geometry Data!** Then close the geometry editor.



**Figure 9. Using the SA/2D Area Conn editor to connect the 2D Flow Area to SA 190.**

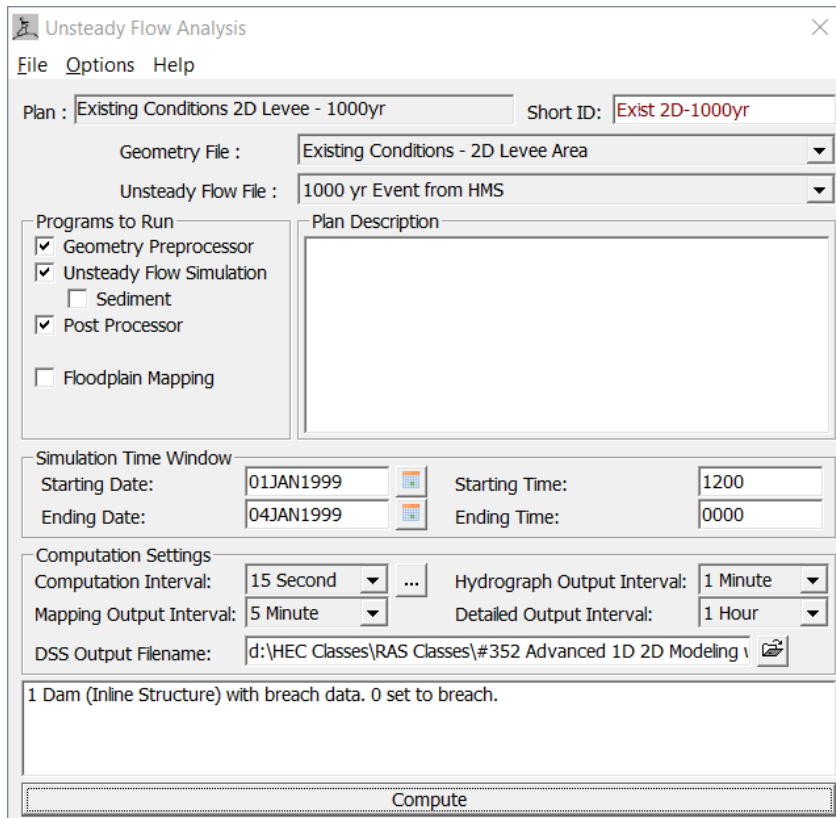
- g. Go to RAS Mapper and right click on the **Geometries** layer on the top left of the data tree, and select **Manage Geometry Associations**. This workshop already has a Land Cover layer that we will use to define Manning's n values in the 2D flow area. Make sure you set both the **Terrain** association and the **Manning's n**. Close RAS Mapper.
- h. Go to the Geometry editor and then the **Tables** menu, and select the **Manning's n by Land Cover** table. Make sure there are Manning's n values assigned to all the land cover types. See below:



h. SAVE the Geometry data.

### 5. Make a new Plan using the 2D Flow Area Geometry.

Go to the **Unsteady Flow Analysis** window (**Run: Unsteady Flow Analysis**). Make a new Plan file using the **Save Plan As** option from the **File** menu under the **Unsteady Flow Analysis** editor. Label the Plan something like: “**Existing Conditions 2D Levee – 1000yr**”. Give the Plan a relevant short ID, like “**Exist-2D-1000yr**”. No special computational options will be needed for this run. See the Unsteady Flow Analysis window below:



## 6. Perform the Computations and Review the Model Output.

Run the new 2D model Plan. When the model has finished running, review the output for the new run by looking at the profile plot, hydrographs, and RAS-Mapper. Compare the 1D model to the 2D Model with the Profile Plot, Hydrograph plots, and RAS-Mapper.

**7. Questions**

**A. How do the results from the plan with Lock Haven modeled as a 2D Flow Area compare to the plan with it modeled as two connected storage Areas? What are some of the differences you see in the model output and why are they different?**

**B. What are the differences in the results in downtown Lock haven, at the following three intersections:**

- a. Intersection of Main St, Mill St, and Bellefonte Avenue**
- b. Intersection of E. Church St. and N. Washington St.**
- c. Intersection of E. Park St. and Prospect St.**

There is a Point Shape file loaded under the **Features** Layer called **PointsOfInterest**, which has all three locations shown as red dots. **Describe the differences in terms of time at which the streets got wet, peak stage, and time to peak. Are these differences significant? Which answer do you think is more correct?**

**Table 1. Intersection of Main St, Mill St, and Bellefonte Avenue**

<b>Model Type</b>	<b>Arrival Time</b>	<b>Peak Stage</b>	<b>Time of Peak</b>
1D Storage Areas			
2D Flow Area			

**Table 2. Intersection of E. Church St. and N. Washington St.**

<b>Model Type</b>	<b>Arrival Time</b>	<b>Peak Stage</b>	<b>Time of Peak</b>
1D Storage Areas			
2D Flow Area			

**Table 3. Intersection of E. Park St. and Prospect St.**

<b>Model Type</b>	<b>Arrival Time</b>	<b>Peak Stage</b>	<b>Time of Peak</b>
1D Storage Areas			
2D Flow Area			

**C. Do you think that the cell size of 100 X 100 ft is adequate for this problem? If not why?**

D. What computational time Step did you use for the 2D Model run? Is this time step appropriate?

E. Is the Terrain data adequate for this area? If not why?

F. By Default the Diffusion Wave equation set was used in the model. Do you think this is adequate for this model, or should the Full Saint Venant Equations be used? How can you test this out?

## 8. Levee Breaching

If you have time add a levee breach into the Lateral Structure at River Station 23100. Save the Plan File as a new Plan, using the **SAVE AS** option. Add in the breach with the following information, using the “**Levee (Lateral Structure) Breach**” option under the Unsteady Flow Analysis **Options** menu:

Levee (Lateral Structure) Breach Data

Lateral: Bald Eagle Cr. Lock Haven 23100 [Dropdown] [Up/Down] Delete this Breach ... Delete all Breaches ...

**Breach This Structure**

Breach Method: Simplified Physical [Dropdown]

Center Station: 1000

Max Possible Bottom Width: 1000

Min Possible Bottom Elev: 566

Left Side Slope: 0.1

Right Side Slope: 0.1

Breach Weir Coef: 2.6

Breach Formation Time (hrs):

Failure Mode: Overtopping [Dropdown]

Piping Coefficient: 0.5

Initial Piping Elev:

Mass Wasting Feature:

Trigger Failure at: WS Elev+Duration [Dropdown]

Threshold WS: 577.6

Duration Above Threshold: 1

Immediate Initiation WS: 580.6

Accumulate Duration

Overtopping Downcutting			Widening Relationship		
	Velocity (ft/s)	Downcutting Rate (ft/hr)		Velocity (ft/s)	Widening Rate (ft/hr)
1	0	0	1	0	0
2	1	0	2	1	0
3	2	0	3	2	0
4	3	5	4	3	10
5	5	10	5	5	50
6	10	25	6	10	100
7	20	100	7	20	200
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		
17			17		
18			18		
19			19		
20			20		
21			21		
22			22		
23			23		

OK Cancel

## Questions

- A. How much more water went into the Lock Haven area due to the levee breach vs. the just overtopping Plan? Compare the hydrographs for that Levee.**
  
  
  
  
  
  
  
  
  
  
- B. What difference did it make to the inundated area and the resulting water surface elevations in down town Lock Haven?**
  
  
  
  
  
  
  
  
  
  
- C. What were the final Breach dimensions through the levee?**