

2D Connections in HEC-RAS

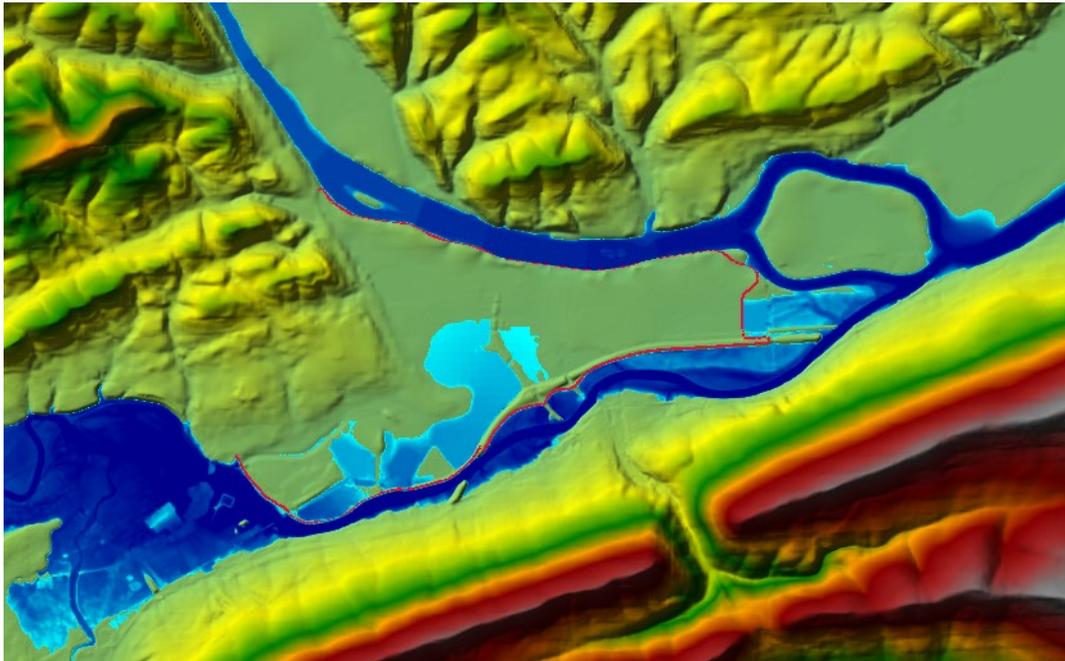
Workshop

1 Objective

This workshop will help students learn how to use the 2D Connections feature of HEC-RAS to model a levee and a levee breach that is inside of a 2D Area.

2 Background

The terrain data (and a depth map) that was used in the HEC-RAS model for Bald Eagle Creek is show below. The town of Lock Haven is protected by three levees. Two of the levees have already been added to the RAS Model. The last levee (which will be referred to as "Upper Levee") is missing. Note: the red line is a centerline background image from the National Levee Data Base—it is not the actual levee.



In this workshop, a 2D Connection will be added to the model and then a levee breach will be added.

2.1 Summary of Tasks

1. **Open** the HEC-RAS project "**2DConnections.prj**".
2. Animate the current plan and note where the water is spilling across the breakline. You will be adding a 2D Connections in this general location.

3. Create a new geometry file and add the hydraulic structure.
4. Run the model.
5. Add the levee breach and run the model.
6. Answer some questions

3 Evaluate the existing plan

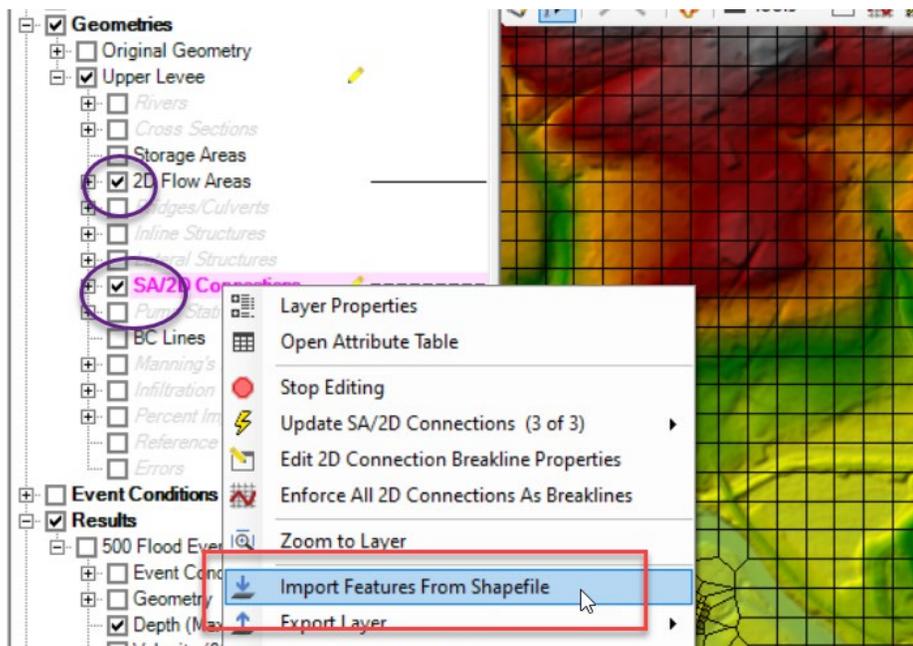
7. **Animate the current plan ("500 Flood Event")**
8. Note where water is spilling into the town.

4 Add the Upper Levee

This task will take you through the steps of adding a levee as a 2D Connection. For this example, the levee was in the National Levee Database and the centerline exists as a shapefile that will be imported. After the centerline has been imported, the connection breakline must be enforced in order to make the faces line up on top of the levee.

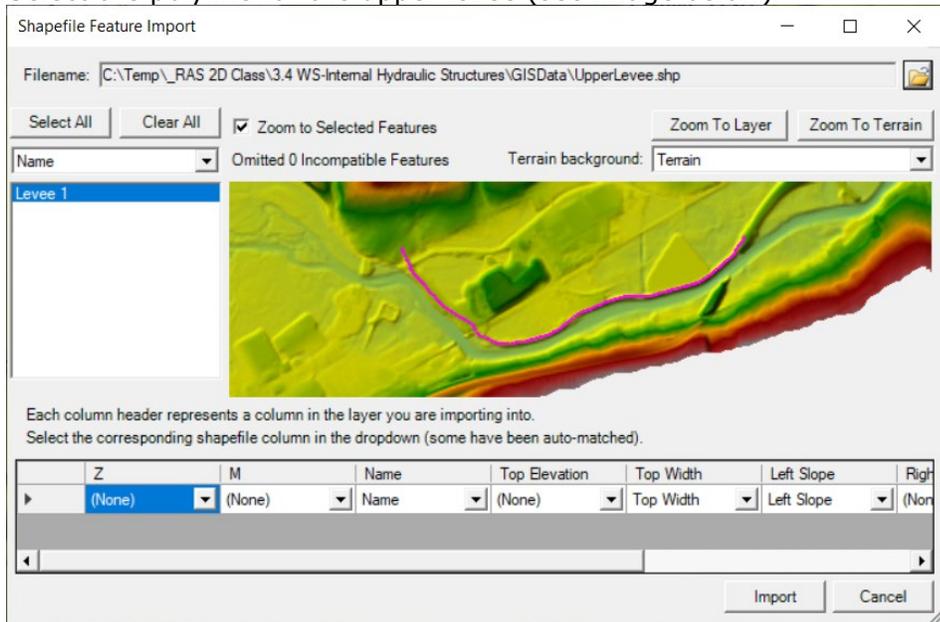
9. **Open RAS Mapper.**

10. Save the geometry by choosing **Save Geometry As ...** ("Upper Levee").
11. Click on the 2D Flow Areas and the SA/2D Connections.
12. **Start Editing** the new Geometry.
13. Right-click on the **SA/2D Connections** layer and choose **Import Features from Shapefile**.



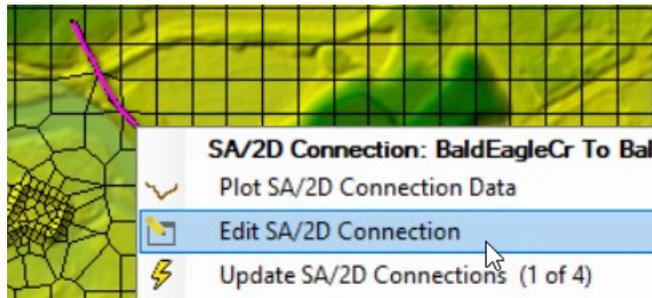
14. Select the "**UpperLevee.shp**" shapefile (in the "GISData" folder).

15. Select the polyline for the upper levee (see image below).

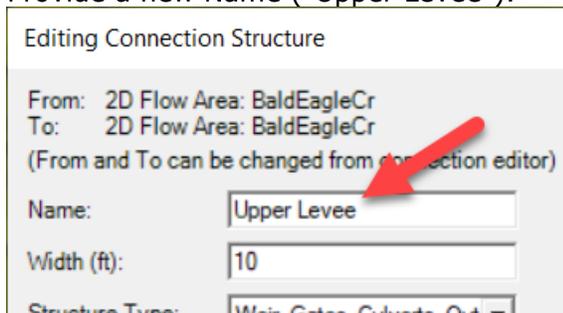


16. Press the **Import** button.

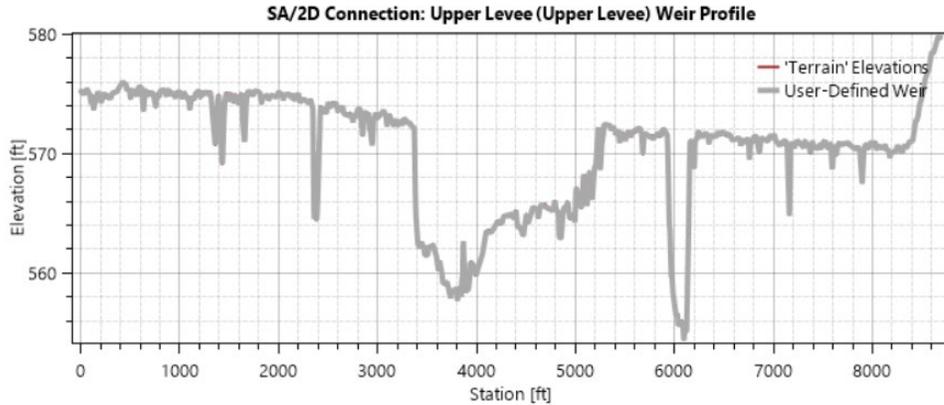
17. Right-click on the levee and choose **Edit SA/2D Connection**.



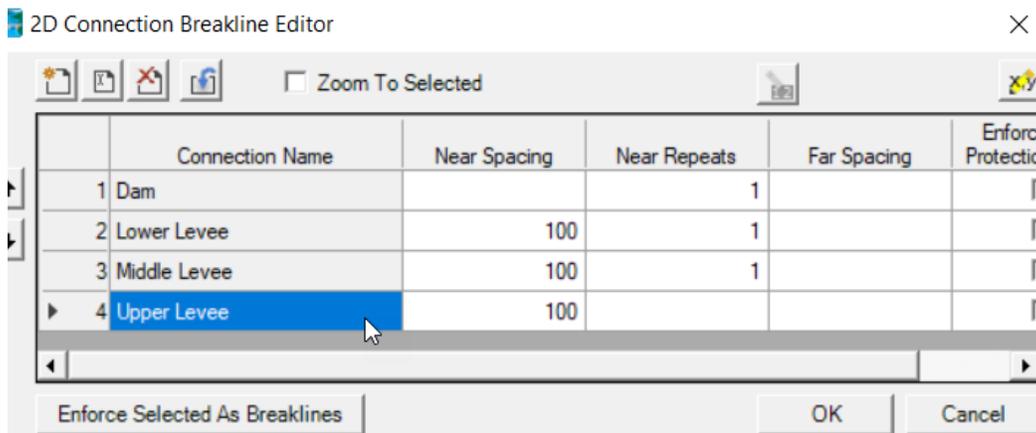
18. Provide a new Name ("Upper Levee").



19. Right-click on the **2D Connection** and choose **Plot 2D Connection Data**.
(Note that the profile follows the Terrain.)



20. Right-click on the **SA/2D Connections** layer and choose **Edit 2D Connection Breakline Properties**. Enter a near spacing of 100, select the row by clicking on the name, and then adjust the mesh by clicking on the Enforce Selected Breaklines button.

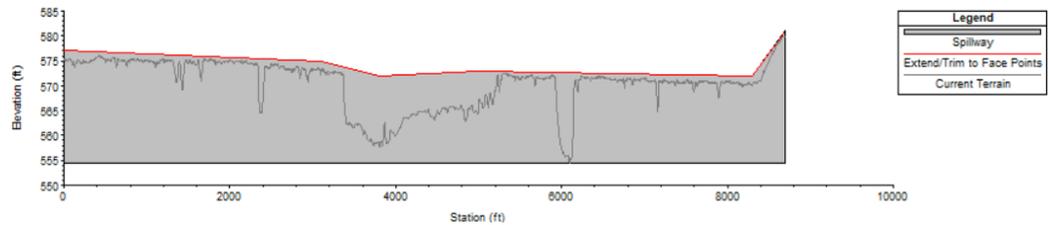


21. **Stop Editing**, saving edits.
22. **Close RAS Mapper**.
23. Open the **Geometric Editor**.
24. **Open** the new **Upper Levee** Geometry.

Open the **SA/2D Connection editor** and select the upper levee. Delete the existing Station/Elevation data. (By default, it brings in the current terrain.) Enter the Station/Elevation data shown below:

	Station	Elevation
1	0	577
2	3100	575
3	3800	572
4	5000	573
5	8300	572
6	8700	581
7		
8		

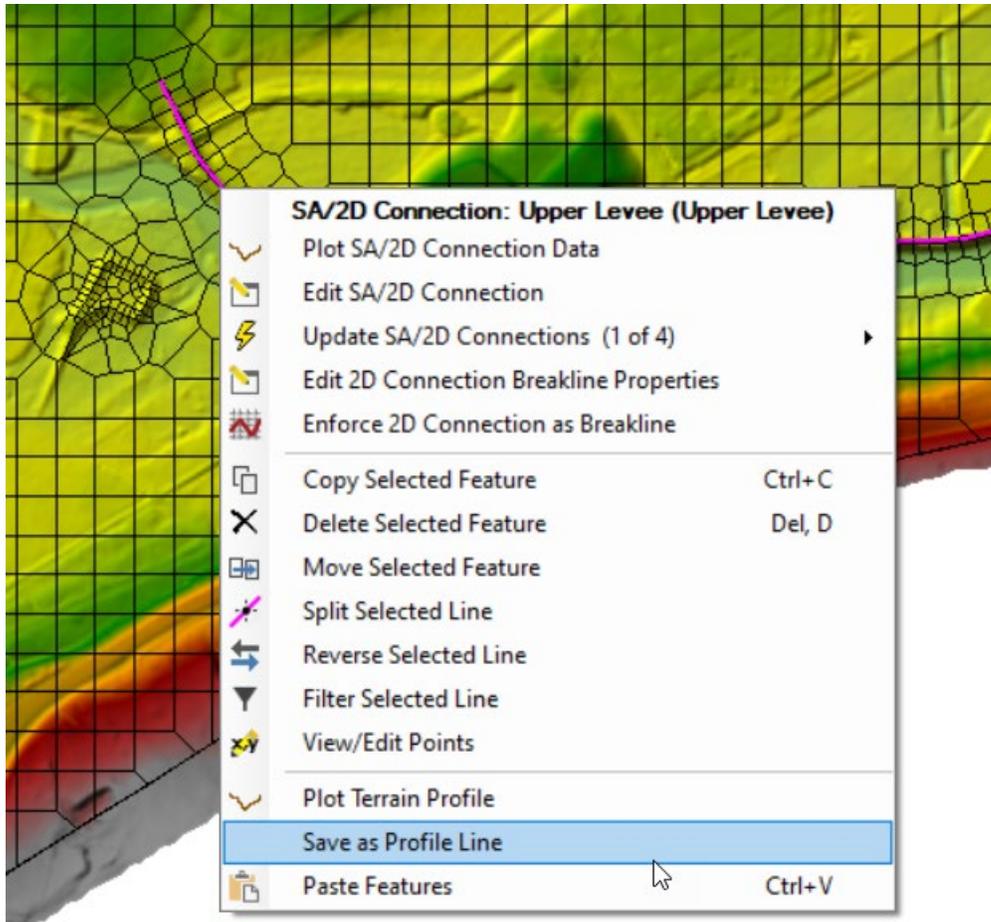
25. Provide a **weir coefficient** of **2.0**.
26. Verify the weir data looks good!



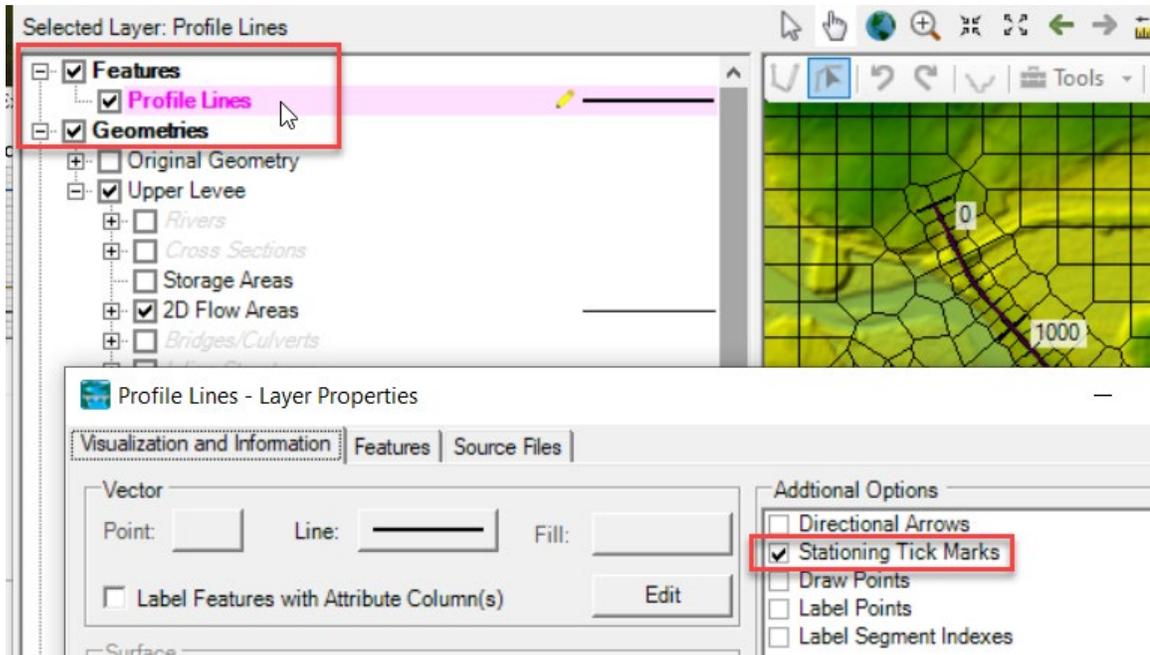
27. Set the **Overflow Computation Method** to **Use Weir Equation**.
28. **Save** the Geometry.
29. Create a **new Plan** and **run** the simulation.
30. Inspect the length of the levee to see if the mesh looks appropriate.

The next step is to add **Stationing Tick Marks** to the levee. This requires creating a profile line which will be done by saving the levee line.

31. **Close** the **Geometry Editor**. Open up **RASMapper**, **Start Editing** and select the **Upper Levee**. Right click on the Upper Levee and **Save as Profile Line** with an appropriate name.
32. **Stop Editing**, saving edits.



33. Turn the Stationing Tick Marks on. Right click on **Profile Lines** and select **Layer Properties**.



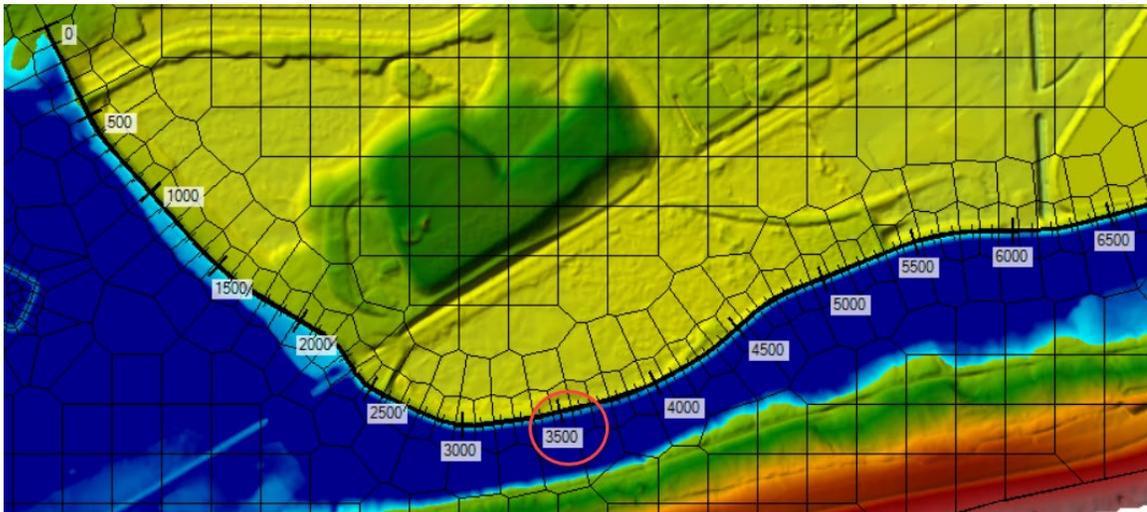
34. Answer some questions.

Question: What is the situation at the downstream end of the structure? Does the Upper Levee connect to the Middle Levee?

Question: What is the cause of this situation? (Hint: turn on **Google Hybrid** under **Map Layers**.) For this model, the downstream end of the structure is not a problem and no changes are necessary. However, how would the user establish that? If it was a problem, what would be the solution?

Question: Is the levee overtopped?

Question: What is the maximum water surface elevation at station 3500 (circled below)?



Question: What is the approximate levee height at this location? How much freeboard is there on the levee for the maximum water surface?

Question: What are the maximum velocities along the toe of the levee in this location?

Question: What changes could be made to the model to improve the accuracy of the velocities along the toe of the levee?

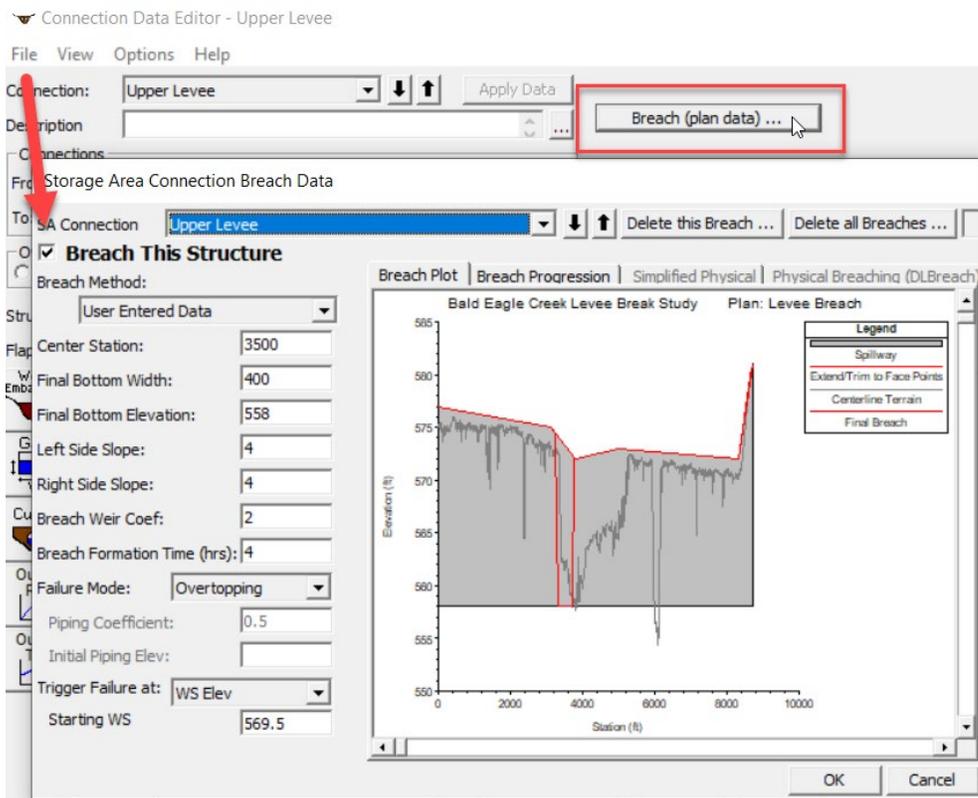
5 Add the Levee Breach

This task will take you through the process of adding the levee breach.

35. Create a new Plan ("Levee Breach")

36. Add a levee Breach to the Upper Levee.

- a. Center Station = 3500 ft
- b. Width = 400 ft
- c. Final Bottom Elevation = 558 ft
- d. Side slopes = 4:1
- e. Formation Time = 4hrs
- f. Failure Mode = Overtopping
- g. Breach Weir Coefficient = 2.0
- h. Trigger Water Surface Elevation = 569.5 ft



37. Save the data and run the model.

Question: When does the breach occur?

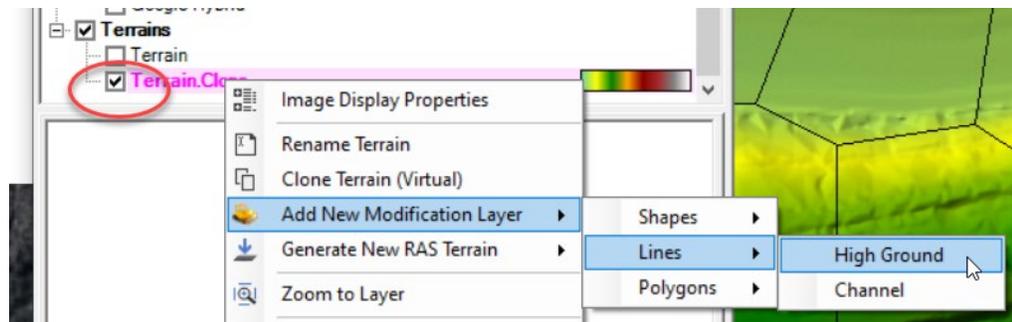
Question: What is the maximum velocity on the toe of the Lock Haven side of the levee?

6 Add the Levee using the Terrain Modification Tools

This task will take you through the process of adding a levee directly into a Terrain Model. This allows you include the levee elevations in the inundation mapping. It is expected that a future version of RAS will more fully automate this process. For this workshop, the existing editing tools will be used.

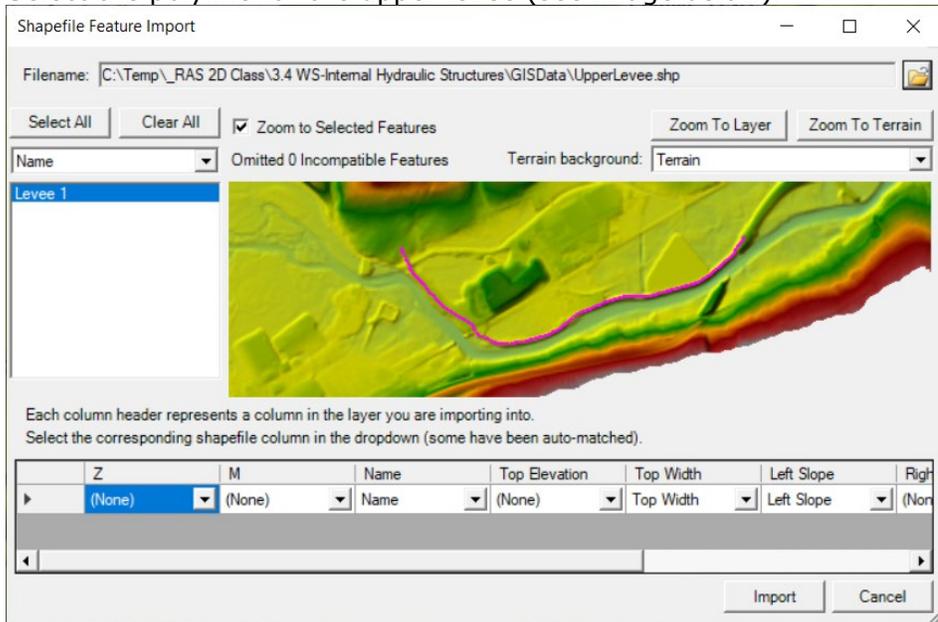
6.2 Modify the Terrain

38. Right-click on the Terrain layer and choose **Clone Terrain**.
39. Press **OK** to keep the suggested name and select the new Clone Terrain.
40. Right-click on the Clone and choose **Add New Modification Layer | Lines | High Ground**.



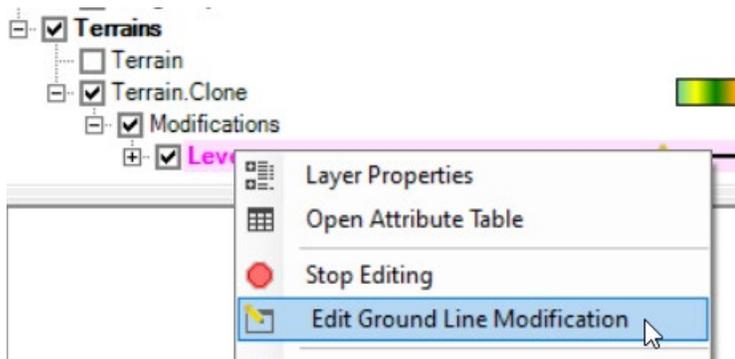
41. Name the modification **Levee**.
42. Right-click on the Levee layer and choose **Import Features from Shapefile**.
43. Select the "**UpperLevee.shp**" shapefile (in the "GISData" folder).

44. Select the polyline for the upper levee (see image below).

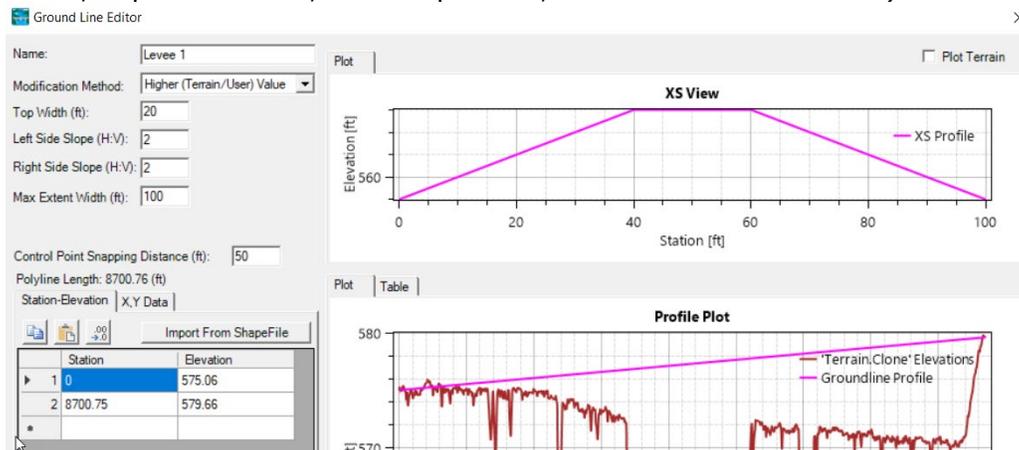


45. Press the **Import** button.

46. Right-click on the Levee Layer and choose **Edit Ground Line Modification**.



47. Keep the information shown in the red rectangle below: (Higher Terrain Value, Top Width = 20, Side Slopes = 2, Max Extent Width = 100)



Normally, it would be easy to just copy and paste the Station/Elevation from the Upper Levee. However, this Editor is still a little "buggy" (*this is still a Beta version*). So for this workshop, the work around is to just enter the SE data by hand again. The first elevation at station 0 (on the first row can be copied over). For the remaining SE data, the station/elevation point can be added at the last row, and then the Editor will automatically sort the SE point into the correct position:

	Station	Elevation
1	0	577
2	8700.75	579.66

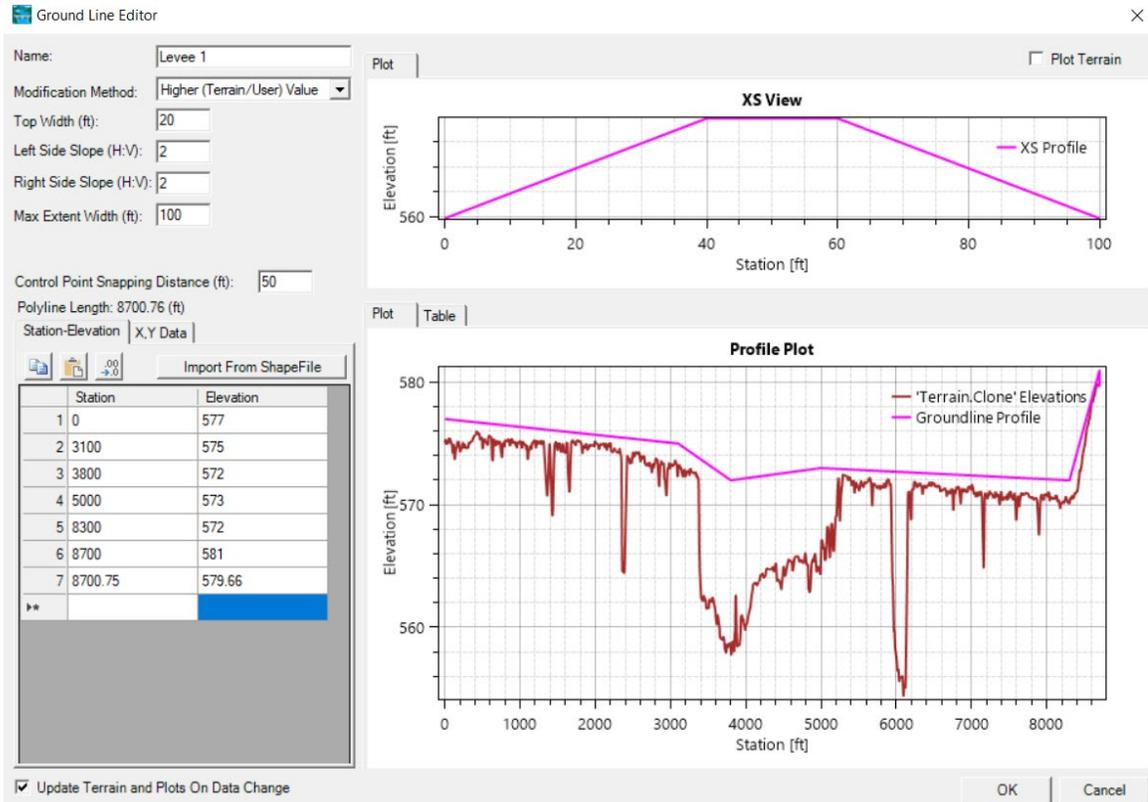
	Station	Elevation
1	0	577
2	8700.75	579.66
	3100	575

	Station	Elevation
1	0	577
2	3100	575
3	8700.75	579.66
	3800	572

48. For convenience, here is the weir data again:

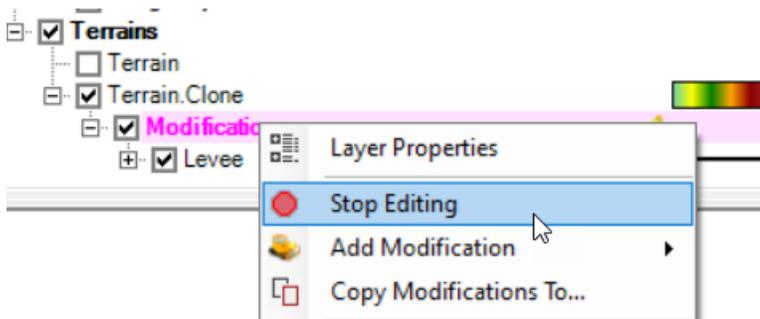
	Station	Elevation
1	0	577
2	3100	575
3	3800	572
4	5000	573
5	8300	572
6	8700	581
7		

49. After the data has been entered, it should look like this:

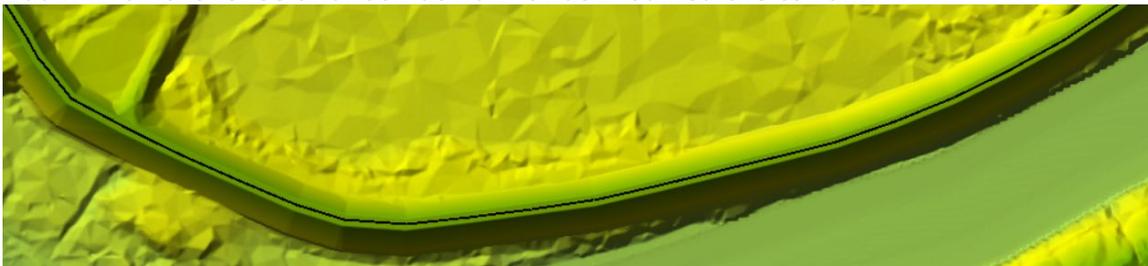


50. Press **OK**

51. **Stop Editing** the Modifications group.

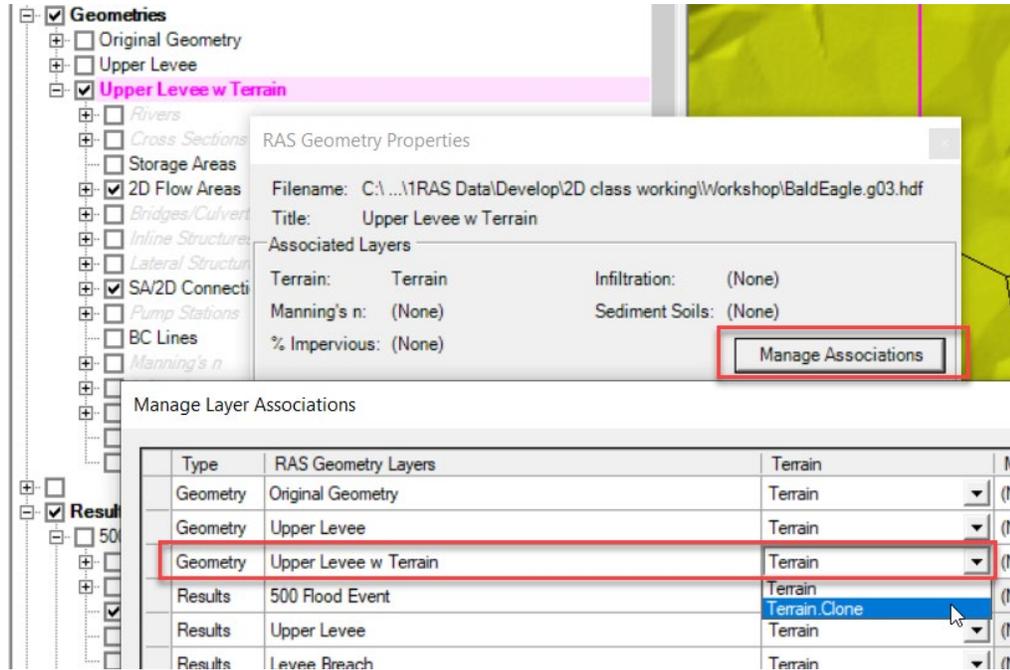


52. Zoom in on the levee and look at how it has modified the terrain.



6.3 Create a new Geometry and rerun the Levee Breach

53. Right-click on the “**Upper Levee**” and **Save Geometry As ...**
54. Provide a **name** for the new Geometry such as **Upper Levee w Terrain**.
55. Right-click on the new Geometry and choose **RAS Geometry Properties**.
56. Click the **Manage Associations** button.
57. Choose the **Terrain Clone**.



58. **Close RASpapper**.
59. Make sure the LeveeBreach Layers plan is selected, and then open the new geometry in the geometry editor. **Save** the new plan with an appropriate name.
60. **Run** the plan.

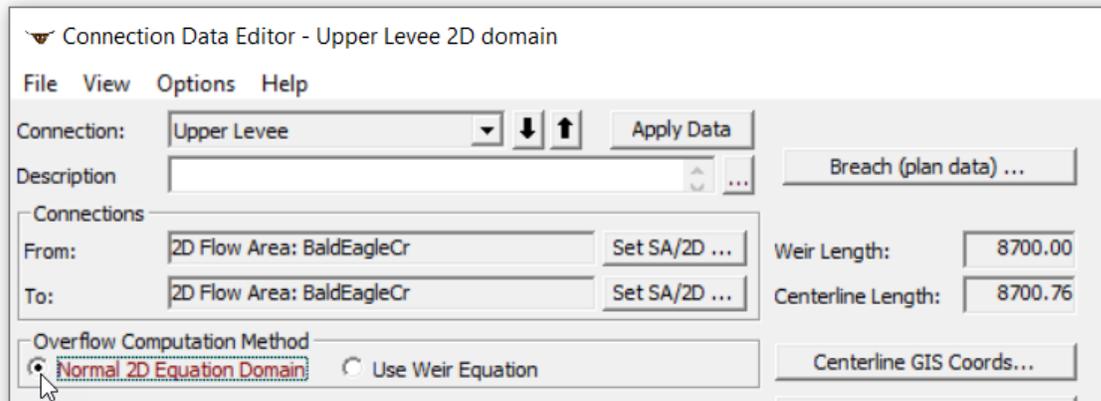
Question: What are the benefits of incorporating the elevation data directly into the terrain?

Question: How does the run with the terrain modification compare with the run without the modification? What is the most likely cause of the difference and which would be more hydraulically accurate?

7 Run the Model with Alternatives

If you have time, you can model the levee breach using the 2D domain equation (which is selected from the 2D area Connection Editor). Additionally, try modeling the levee breach using a 5 second time step [using the weir equation]. For both runs, use the terrain that includes the levee modification.

Since the 2D domain equation is on the 2D area Connection Editor, which is part of the geometry editor, **Save the Geometry** with a new name before switching the equation type.



Question: How does the maximum velocity from the 2D domain equation compare to the weir equation? Which is likely more accurate? Turn Google Hybrid on and compare the arrival time to the residential neighborhood of Lock Haven between the two runs.

Question: How does the 5 second run compare to the 20 second run? Turn Google Hybrid on and compare the arrival time to the residential neighborhood of Lock Haven between the two runs.