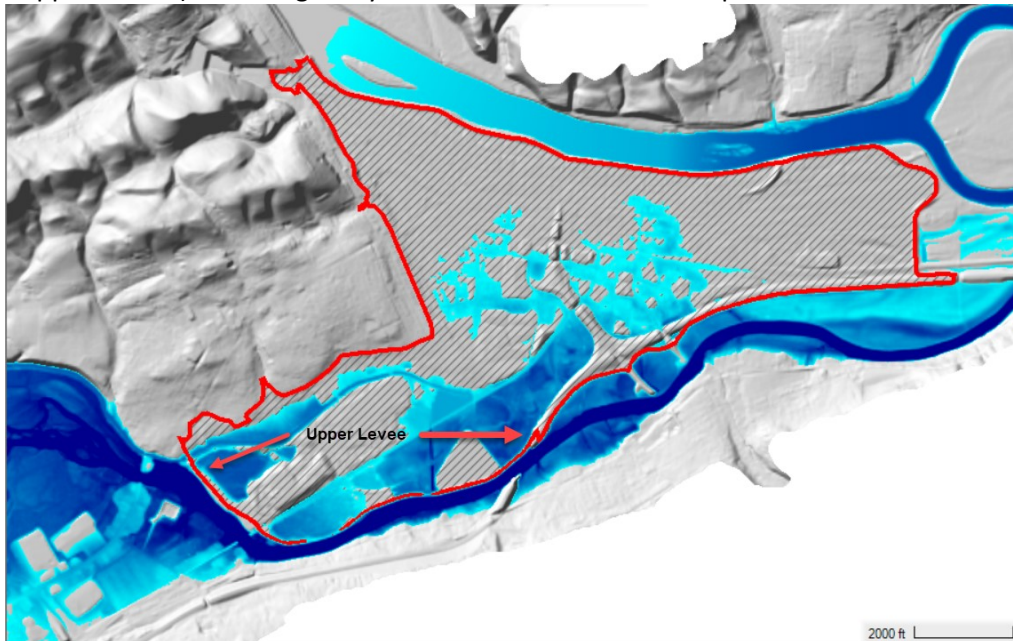# 2D Connections in HEC-RAS
Workshop

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 protected area (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 and you will add it in this workshop.

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

3   Evaluate the existing plan

1. **Open HEC-RAS** and the **"2DConnections.prj"** project

2. **Run** the **"500yr Flood Event"** plan

3. **Animate the results in RAS Mapper**

4. 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.

5. In Mapper, Save the "Original Geometry" by right-click, **Save Geometry As**. Name the geometry "Upper Levee".

6. Turn on the 2D Flow Areas and the SA/2D Connections.
   Note that the lower levees are present in the model.

7. **Start Editing** the new Geometry.

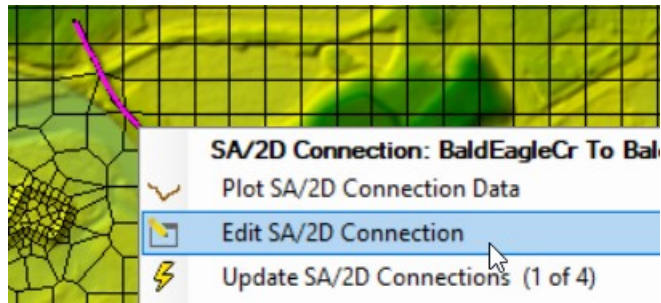8. Right-click on the **SA/2D Connections** layer and choose **Import Features from Shapefile**.
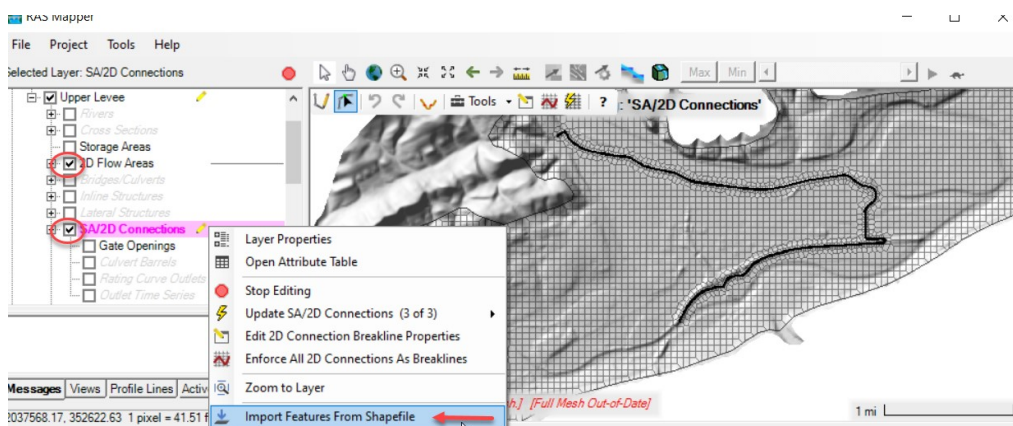
9. Select the "**UpperLevee.shp**" shapefile (in the "GISData" folder).

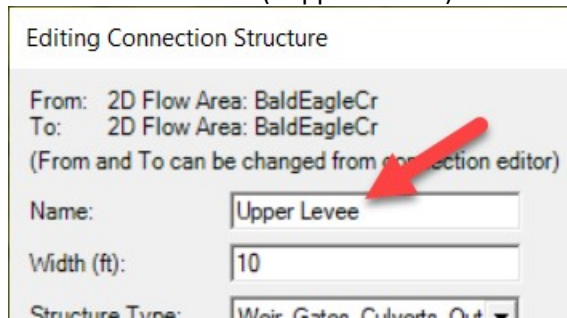10. Select the polyline for the upper levee (see image below).
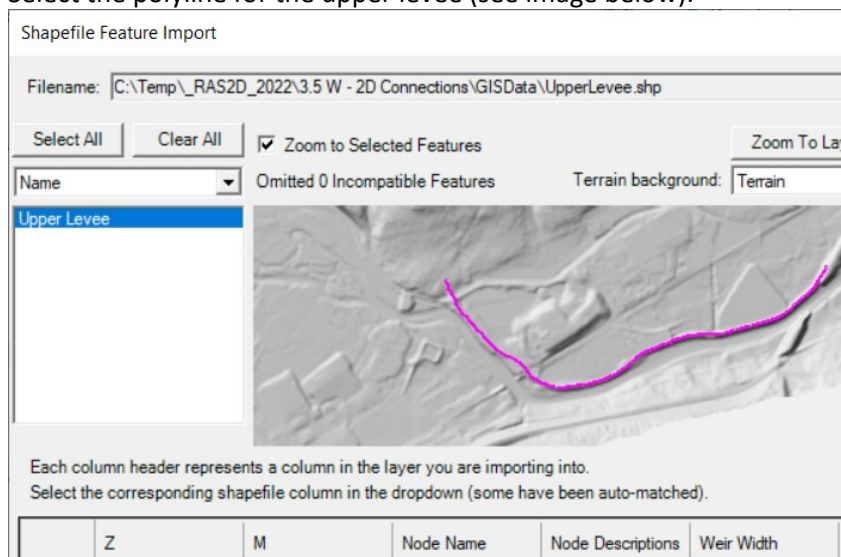
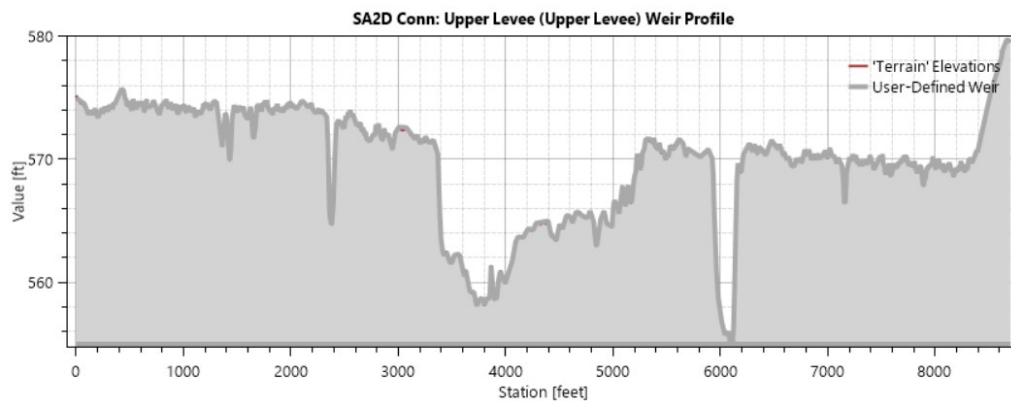Note that Elevation data are not provided on the levee centerline.

11. Press the **Import** button.

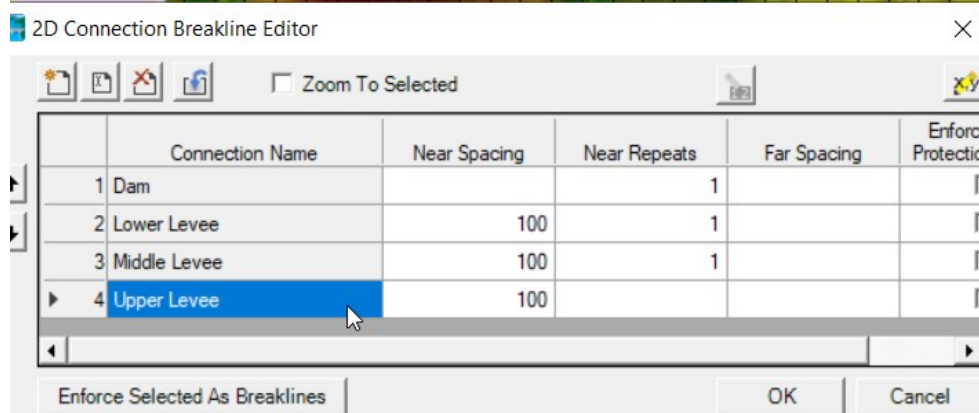12. Right-click on the levee and choose **Edit SA/2D Connection.**

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

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

15. Right-click on the **SA/2D Connections** layer and choose **Edit 2D Connection Breakline Properties.** Enter a near spacing of **100**. Close the editor.

16. Right-click on the levee and choose the **Enforce 2D Connection as Breakline** menu item.
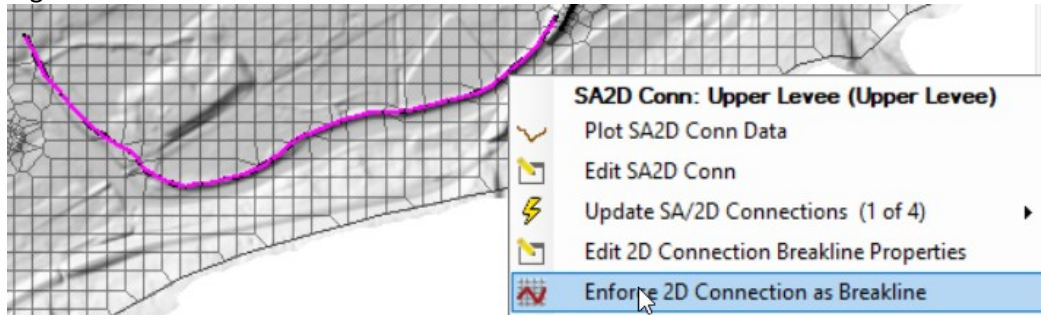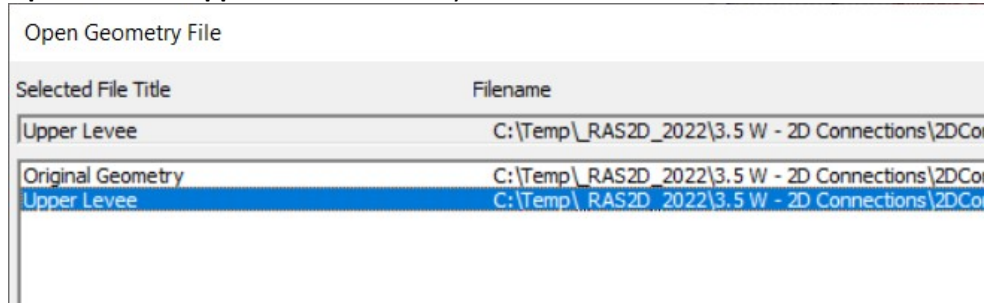

17. **Stop Editing**, saving edits.

18. **Close RAS Mapper**.

Complete the data in the Geometric Data Editor.

19. Open the **Geometric Editor**.

20. **Open** the new **Upper Levee** Geometry.

| Open Geometry File	
Selected File Title	Filename
Upper Levee	C:\Temp_RAS2D_2022\3.5 W - 2D Connections\2DCor
Original Geometry	C:\Temp_RAS2D_2022\3.5 W - 2D Connections\2DCor
Upper Levee	**C:\Temp_RAS2D_2022\3.5 W - 2D Connections\2DCor**

21. Open the **SA/2D Connection editor** and select the upper levee.

    Delete the existing Weir Station/Elevation data. (By default, it brings in the current terrain.) Enter the Station/Elevation data shown below. (It is also included in the Upper Levee.xlsx spreadsheet.)

    Embankment Station/Elevation Table

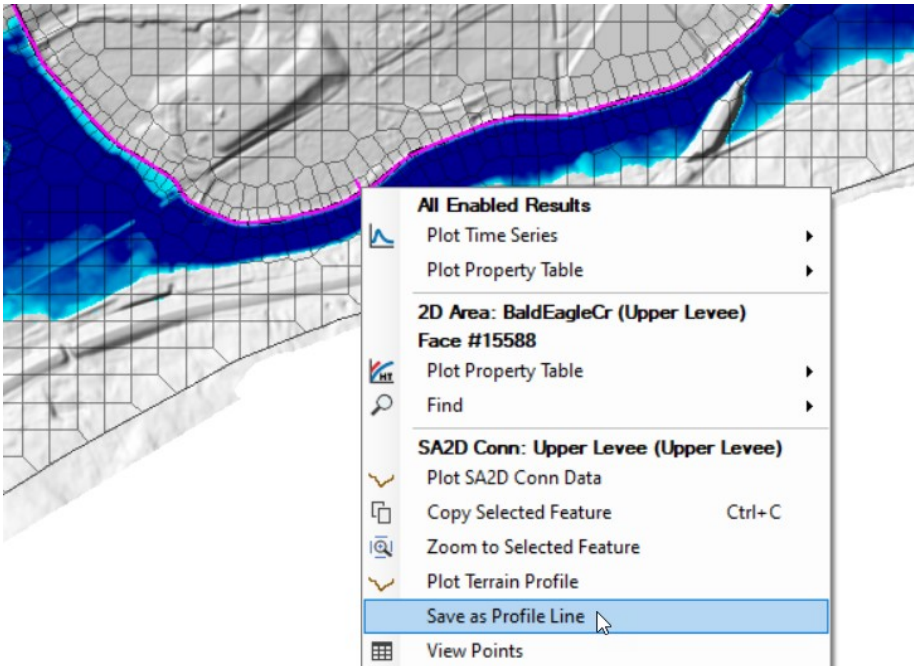 | | Station | Elevation |
    | --- | --- | --- |
    | 1 | 0 | 577 |
    | 2 | 3100 | 575 |
    | 3 | 3800 | 572 |
    | 4 | 5000 | 573 |
    | 5 | 8300 | 572 |
    | 6 | 8700 | 581 |
    | 7 | | |
    | 8 | | |

22. Provide a **weir coefficient** of **2.0**.

23. Verify the weir data looks good!
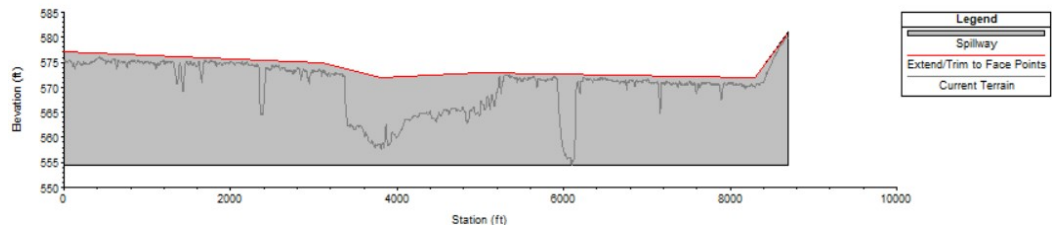
24. Set the **Overflow Computation Method** to **Use Weir Equation**.

25. **Save** the Geometry.

26. Create a **new Plan** ("**Upper Levee – No Breach**") and **run** the simulation.

The next step is to add **Stationing Tick Marks** to the levee. This requires creating a profile line from the levee line.

27. **Close** the **Geometry Editor**. Open up **RASMapper**,

28. Right-click on the Upper Levee and **Save as Profile Line** with an appropriate name. (Make sure you have the SA/2D Connections layer selected.)
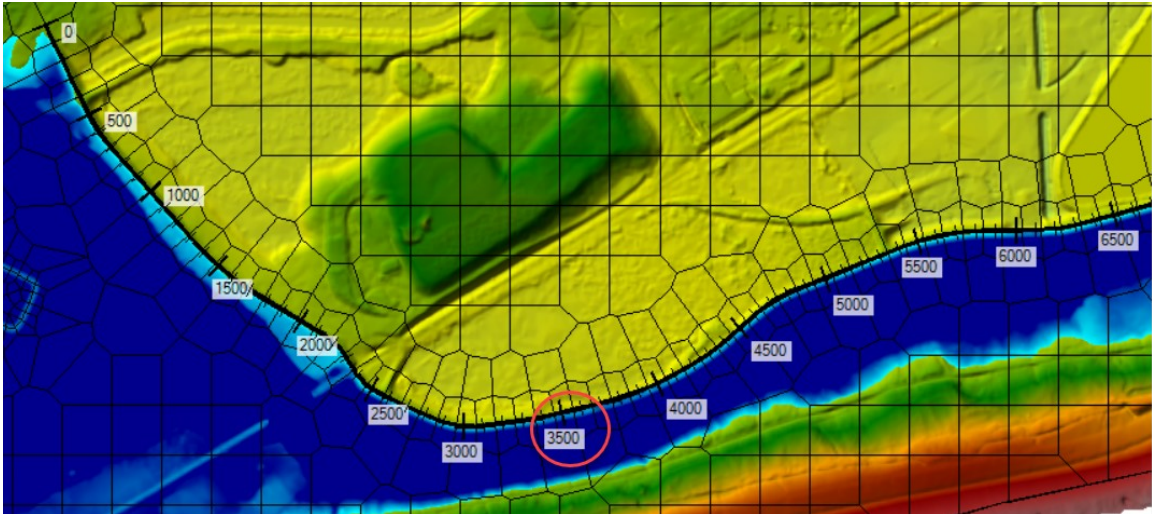

29. Turn the **Plot Tick Marks** option on from the Profile Lines tab.
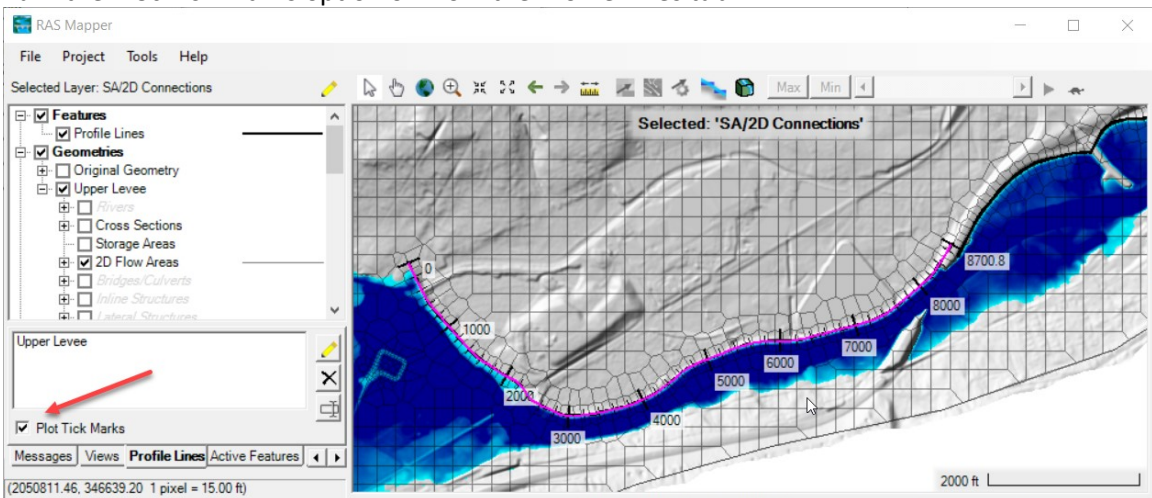
30. Answer some questions.

   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?
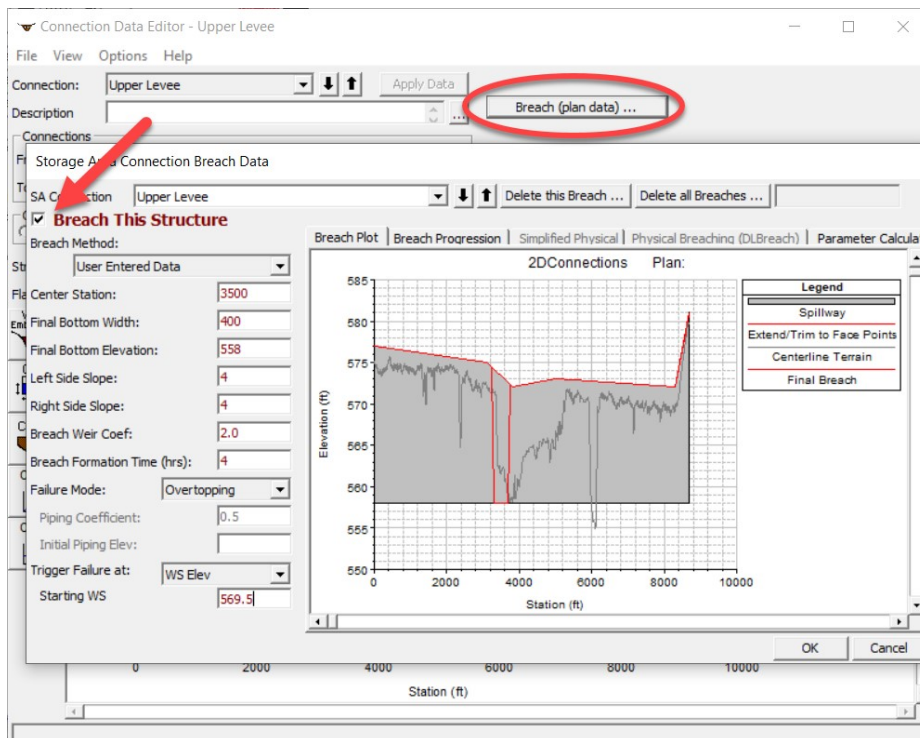
5 Add the Levee Breach

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

31. Create a new Plan ("**Levee Breach**")

32. From the Geometric Schematic, choose the Upper Levee 2D Connection and choose to the **Breach** data button.

33. 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

34. **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.
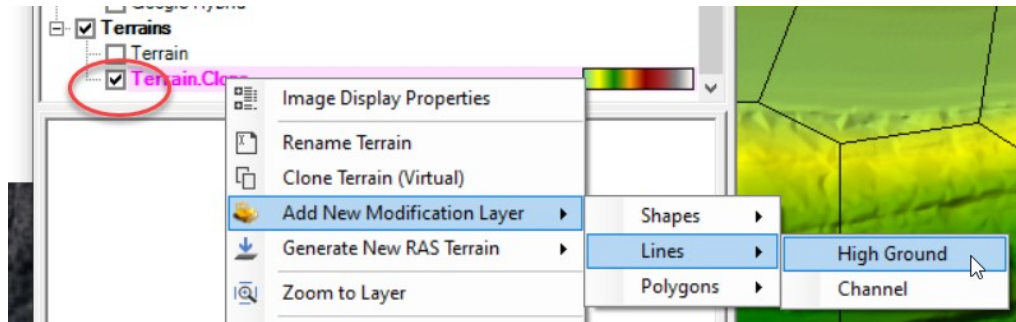
6.1   Modify the Terrain

35. Right-click on the **Terrain** layer and choose **Clone Terrain**.
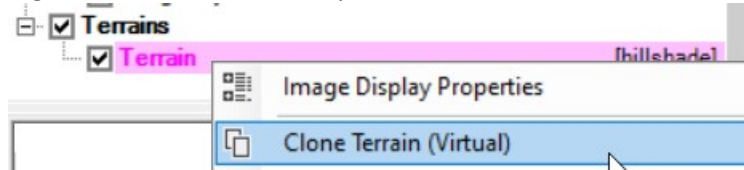
36. Press **OK** to keep the suggested name and select the new Clone Terrain.

37. Right-click on the Clone and choose **Add New Modification Layer | Lines | High Ground**.
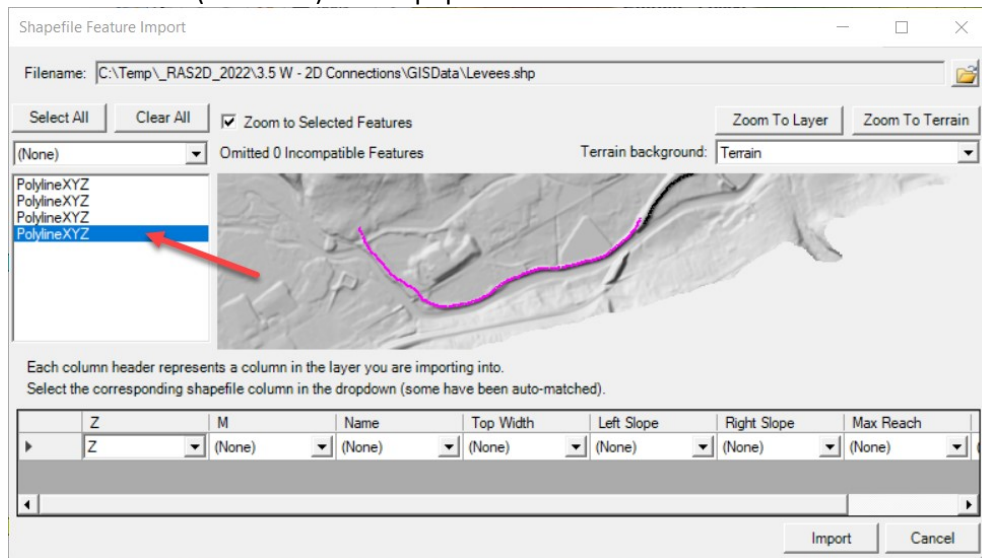

38. Name the modification **Levee**.

39. Right-click on the Levee layer and choose **Import Features from Shapefile**.

40. Select the "**Levees.shp**" shapefile (in the "GISData" folder).
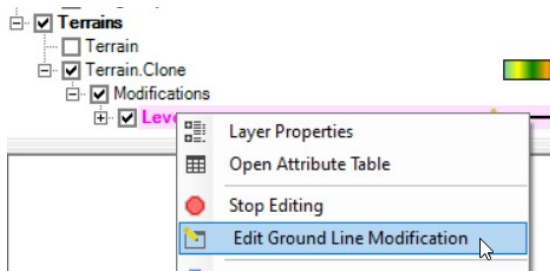
41. **Select** the polyline for the upper levee (see image below).
    Note that the Z (Elevation) field is populated.

42. Press the **Import** button.

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

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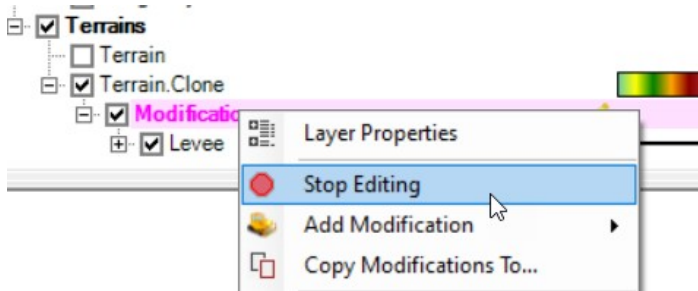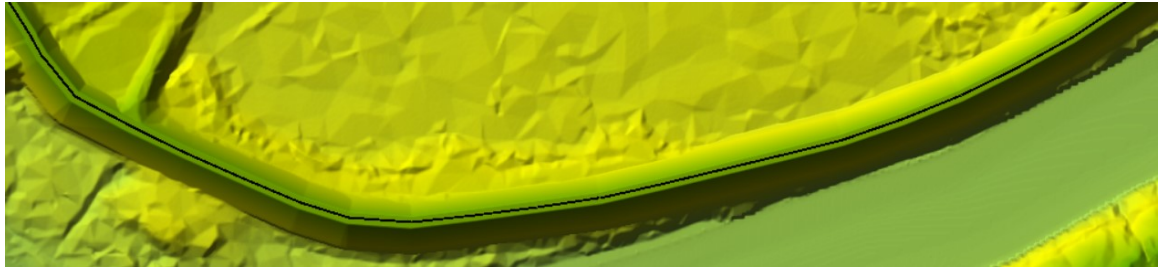

45. Press **OK**

46. **Stop Editing** the Modifications group.

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

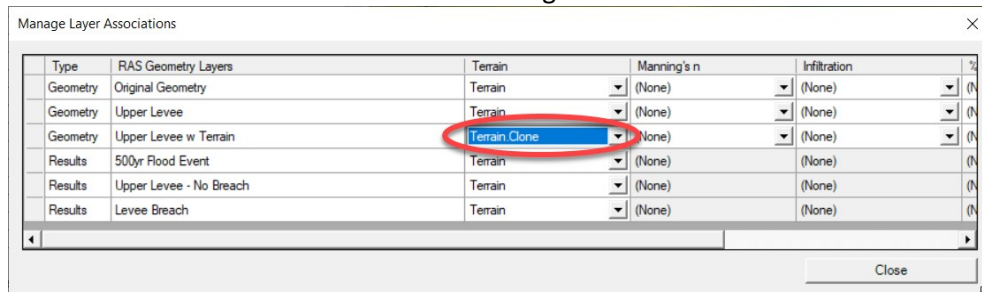## 6.2   Create a new Geometry and rerun the Levee Breach

48. Right-click on the "**Upper Levee**" and **Save Geometry As** …

49. Provide a **name** for the new Geometry such as "**Upper Levee w Terrain**".

50. Right-click on the new Geometry and choose **RAS Geometry Properties**.

51. Click the **Manage Associations** button.

52. Choose the **Terrain Clone** and close the dialog.

53. **Close RAS Mapper**.

54. Make sure the Levee Breach plan is selected, and then **Save Plan As**…. Give the new a plan a Name ("Breach w Terrain Mod").

55. Make sure to pick the new Geometry ("**Upper Levee w Terrain**").

56. **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

As time allows… evaluate a few scenarios. Use the same Terrain for all runs. Be prepared to discuss

57. Try a run using the 2D domain equation (which is selected from the 2D area Connection Editor).

    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.
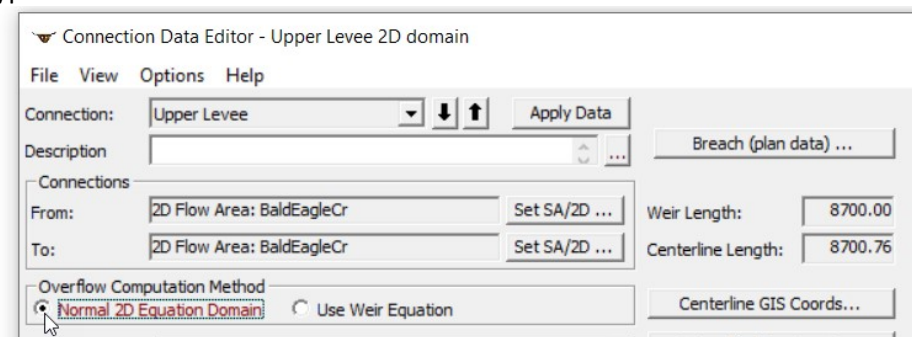
    Question: How does the maximum velocity from the 2D domain equation compare to the weir equation? Which is likely more accurate?

58. Try a run using the **full shallow water equations**.

    Question: Is there a difference?

59. Try a reduced time step, try modeling the levee breach using a 5 second time step using the weir equation.

    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.