

# Dam Breach Analysis with 2D Areas Workshop

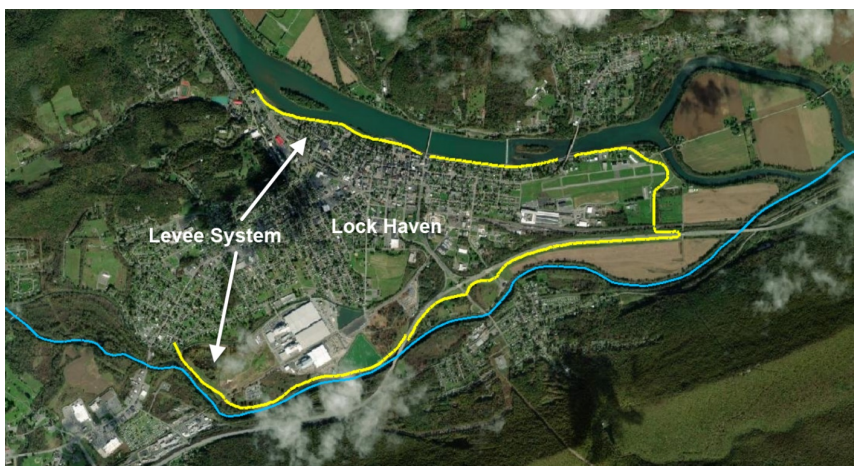
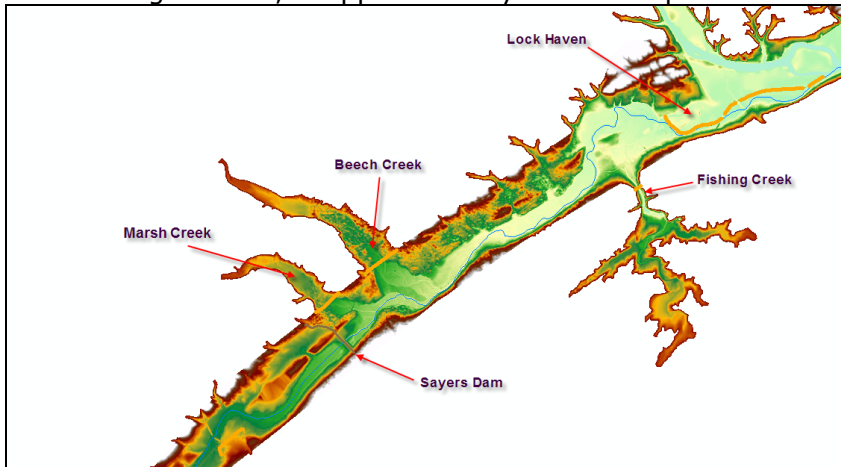
## Objective

This workshop will guide students on using HEC-RAS to (1) simulate a RAS Model to breach, (2) interpret the results of a dam breach simulation, and (3) review results and perform model refinement.

**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

The town of Lock Haven is situated on the north bank of Bald Eagle Creek in central Pennsylvania. Lock Haven sits behind a levee system that was designed to provide protection for a 500-year (0.2% Chance) event. Sayers Dam, a flood control project on Bald Eagle Creek, is approximately 15 miles upstream of Lock Haven.



In this workshop we will be performing a dam breach analysis to determine the consequences of a failure of Sayers Dam by inputting design inflows for the reservoir and setting the Sayers Dam to breach.

**\*\*\* This workshop continues from the previous Geometry workshop. \*\*\***


## 1 Open the HEC-RAS Project

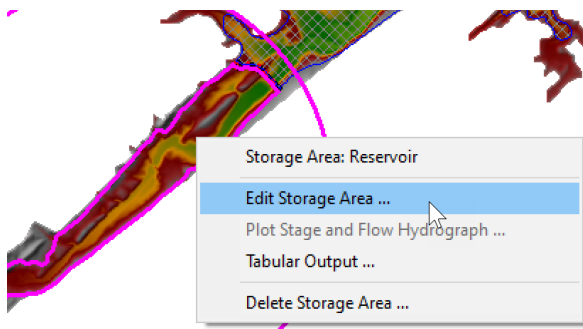
1. **Open RAS**
2. **Open** the "DamBreachWorkshop.prj" RAS project file.

## 2 Complete the Geometric Data

3. **Open RAS Mapper** and make sure you have the
  - a. **Base Geometry** and
  - b. **Terrain**
4. Right-click on the **Geometry** and choose **Save As**
5. Provide a new **name** "2D500ft"
6. **Close RAS Mapper**

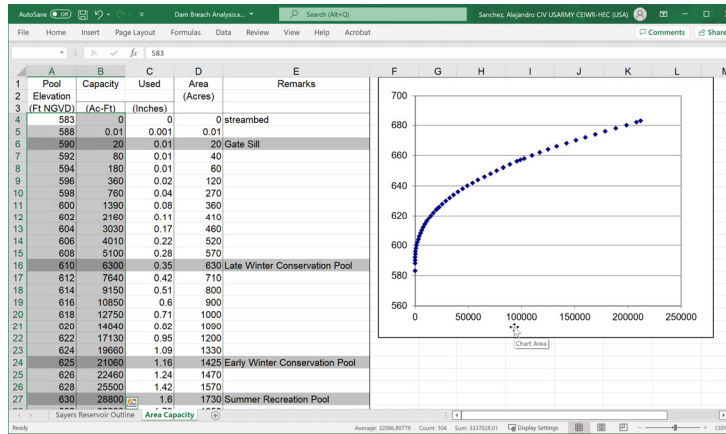
### 2.1 Edit the Reservoir Volume-Elevation Curve

7. **Open** the **Geometric Data** editor by clicking on the  in the main HEC-RAS window.
8. **Open** the **Geometry** "Base Geometry"
9. **Edit** the **Storage Area**

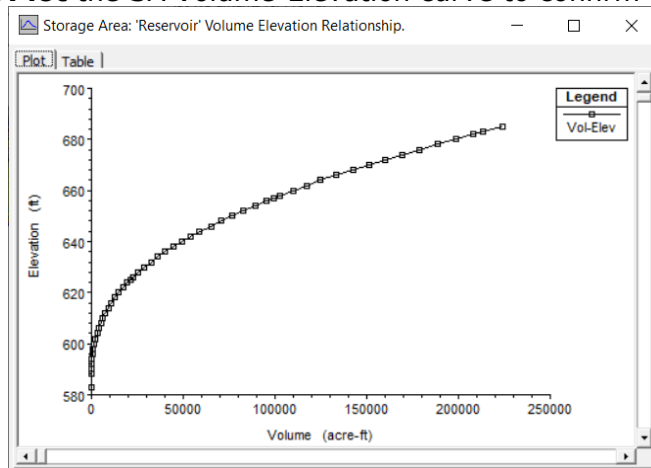


Note that there are already Volume-Elevation data provided. These data were extracted from the terrain model, but we need to replace with more accurate data.

10. **Enter the Elevation-Volume Relationship** – this data is in the Excel spreadsheet provided.



11. **Plot** the SA Volume-Elevation curve to confirm it has been entered correctly.



### 3 Create a Plan with Breach and Simulate

12. **Open** the **Unsteady Flow Analysis** editor .

13. **Save** the plan with a title "Breach 500ft" and Short ID "Breach500ft".

14. **Check** the boxes for the **Geometry Preprocessor** and **Unsteady Flow Simulation**.

15. Set the **time window** for a longer simulation

Simulation Time Window

Starting Date: 01JAN2222 Starting Time: 0000

Ending Date: 04JAN2222 Ending Time: 1200

16. Set up an appropriate **Computation Interval**

Computation Settings

Computation Interval: 1 Minute Hydrograph Output Interval: 1 Minute

Mapping Output Interval: 10 Minute Detailed Output Interval: 1 Hour

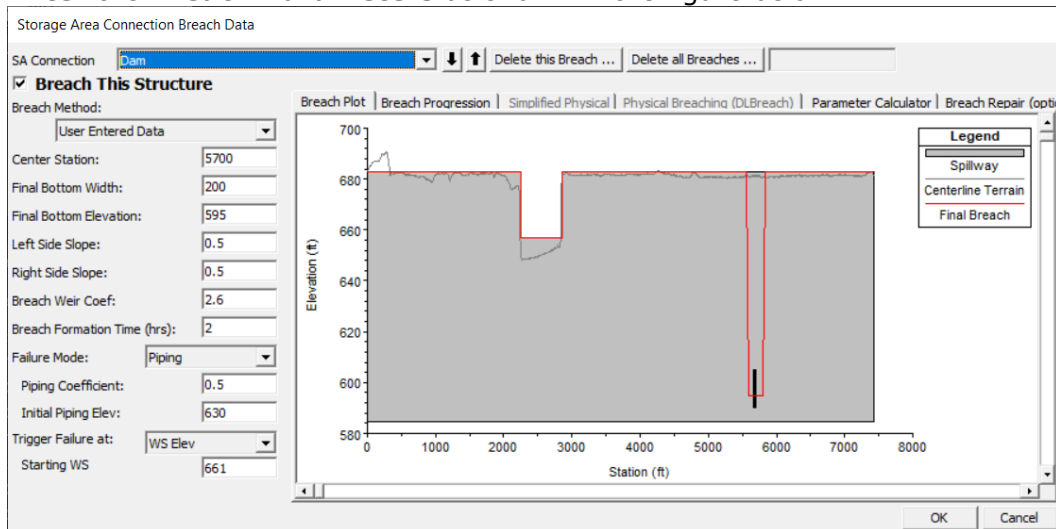
17. **Set** the **Mapping Output Interval, Hydrograph Output Interval**.

18. Click on the menu **Options | Computation Options and Tolerances**, select the **2D Flow Options** tab, and set the **Initial Conditions Time** for the 2D area to **2 hrs**.

	Parameter	(Default)	Downstream Area
1	Theta (0.5-1.0)	1	1
2	Theta Warmup (0.5-1.0)	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		2
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1

19. Click on the menu **Options | SA Connection Breach**.

20. Enter the **Breach Parameters** as shown in the figure below



21. Check the box for **Breach This Structure**.
22. In the **Breach Progression** tab **Select Sine Wave**.
23. **Save** the Plan Data.
24. **Compute** the results. The simulation should take about 30 seconds.

## 4 Review Results

After running the model, review the output and answer some questions.

*Question: What is the Peak Outflow coming out of the Dam from the flow event and the breach?*

*Question: What is the peak flow coming out of the 2D Flow Area for the downstream Normal Depth boundary condition outlet? Does this flow make sense given the upstream inflow from the Dam breach, the terrain data, and the computational mesh used?*

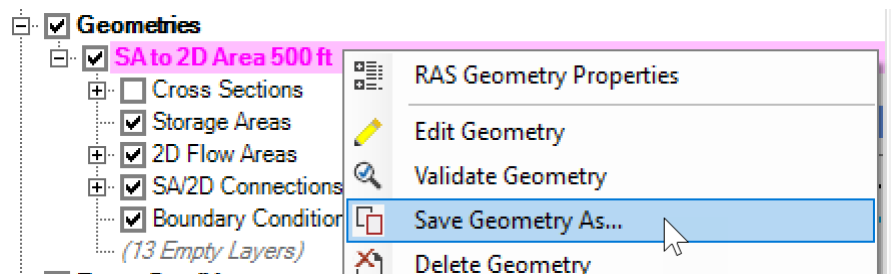
Question: Is the Computational Time Step appropriate for the selected 2D Flow Area cell size and the floodwave being routed through it?

Question: Is the Computational cell size in the 2D Flow Area adequate for modeling the terrain, levees, and roads in this area? If not, briefly describe why not?

Question: What is the floodwave arrival time to the town of Lock Haven?

## 5 Change 2D Cell Size and Re-Run

25. In **RAS Mapper**, **Save Geometry As** and provide a new name ("2D Area 250ft")

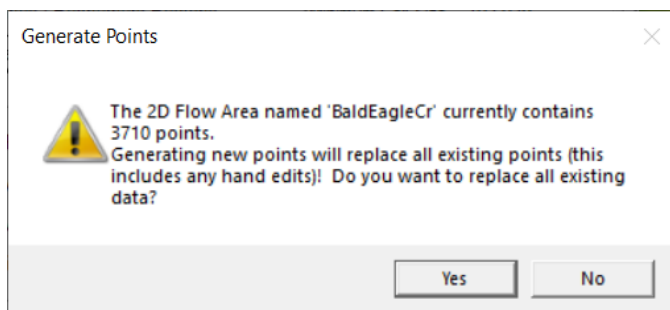
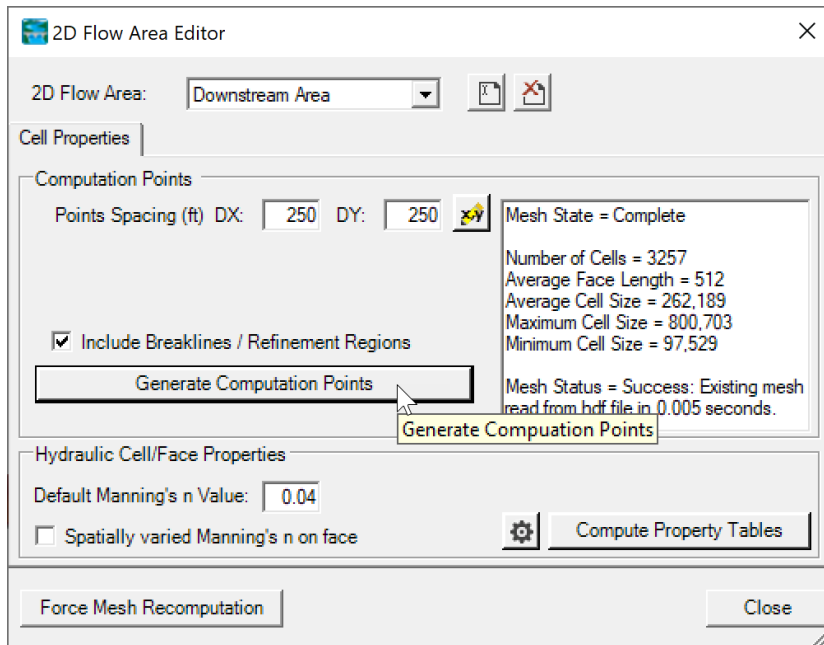


26. **Start Editing** the mesh by clicking on the .

27. **Click** on the **Edit Mesh Properties** button in the toolbar



28. Change the **cell size** to **250 ft** and **Generate Computation Points** with **Include Breaklines** checked. A menu will appear. Select **Yes** to generate the new points.



29. **Close** the **2D Flow Editor**.
30. **Inspect** the mesh and **edit** any areas with poor mesh quality manually.
31. **Stop** editing the **Geometry**.
32. **Save** the base **Plan** to a new plan with the title "2D Area 250 ft" and Short ID "2D250ft"
33. **Select** the **new Geometry** for the Plan.
34. **Select** an appropriate **time step**
35. **Compute**
36. Review the following questions

*Question: Is the peak outflow from the dam any different than the previous run done with 500ft mesh?*

*Question: Has the Peak outflow coming out of the 2D Flow Area changed? If so, why?*

*Question: Are there any differences in the inundation mapping between the two runs? Look at the Max Depth inundation, as well as different time steps during the event in order to answer this question. It will also be helpful to change the color of one of the plans to something other than Blue. (Changed my 500ft Plan to Red, and moved below the 250ft plan, to make it easier to see differences between the two plans.)*

*Question: Does the smaller cell size better represent the downstream terrain and the levee system protecting Lock Haven? Is it detailed enough with this cell size? If not, what are the options you could use to model the Lock Haven levee system more accurately than it is currently represented in this model?*

*Question: Do you think it is appropriate to use the Diffusion Wave equations or the Full Shallow Water equations for this Dam Breach analysis in the Bald Eagle system? Why or why not?*

## **6 Change Governing Equations and Re-Run**

37. **Create** a new plan with the 250ft resolution mesh and **Save** it with the Title "Breach250ft SWE" and Short ID "2D250ftSWE"
38. In the **Unsteady Flow Analysis** editor, select on the menu **Options | Computation Options and Tolerances** and select the **2D Flow Options** tab.
39. Set the **Equation Set** on line 6 to **SWE-ELM (original/faster)**. This is the Eulerian-Lagrangian Solver of the Shallow Water Equations.
40. **Select** an appropriate **time step** for the SWE-ELM solver.
41. **Save** the Plan Data.
42. **Compute** the results.

*Question: Generally, are the results from the SWE solver different from the Diffusion Wave (DWE) solver?*

*Question: Where are the largest differences expected between the SWE and DWE solvers and why?*

*Question: How can you tell if you used an appropriate time step? What variables or model output would you look at to determine if the time step is appropriate?*

## 7 Use the Breach Parameter Calculator and Change the Breach Width

43. **Create** a new with plan the 250ft resolution mesh, SWE-ELM solver, and Save it with the Title "2D 250ft SWE Mod" and Short ID "2D250ftSWEMod".
44. In the **Unsteady Flow Data** editor, select the menu **Options | SA Connection Breach**.
45. **Select** the tab **Parameter Calculator**, and enter the parameters as shown below

Storage Area Connection Breach Data

SA Connection: Sayers Dam

**Breach This Structure**

Breach Method: User Entered Data

Center Station: 5200

Final Bottom Width: 400

Final Bottom Elevation: 590

Left Side Slope: 0.5

Right Side Slope: 0.5

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 630

Trigger Failure at: WS Elev

Starting WS: 676

Input Data

Top of Dam Elevation (ft): 683

Breach Bottom Elevation (ft): 590

Pool Elevation at Failure (ft): 676

Pool Volume at Failure (acre-ft): 178780

Failure mode: Piping

MacDonald

Dam Crest Width (ft): 100

Slope of US Dam Face Z1 (H:V): 0.3

Earth Fill Type: Non-homogeneous or Rockfill

Slope of DS Dam Face Z2 (H:V): 0.3

Xu Zhang (and Von Thun)

Dam Type: Dam with corewall

Dam Erodibility: Medium

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	2102	0.5	2.43	Select
Froehlich (1995)	439	0.9	3.31	Select
Froehlich (2008)	408	0.7	2.94	Select
Von Thun & Gillete	349	0.5	0.77	Select
Xu & Zhang	291	0.61	5.00 *	Select

OK Cancel

46. Use parameters based on the Parameter Calculator - Set the Breach Final **Bottom Width to 400 ft.**
47. **Save** the Plan Data.
48. **Compute** the results.

*Question: Plot time series of water levels near the dam and near the city of Loch Haven. How different are the water levels at these two locations?*

*Question: Did changing the Final Breach Width affect the model stability? If so why would it do that?*