Simplified Bridge Hydraulics in HEC-RAS
Workshop

1 Objective

This workshop will help students learn how to use HEC-RAS to use the 1D bridge option inside a 2D flow area.

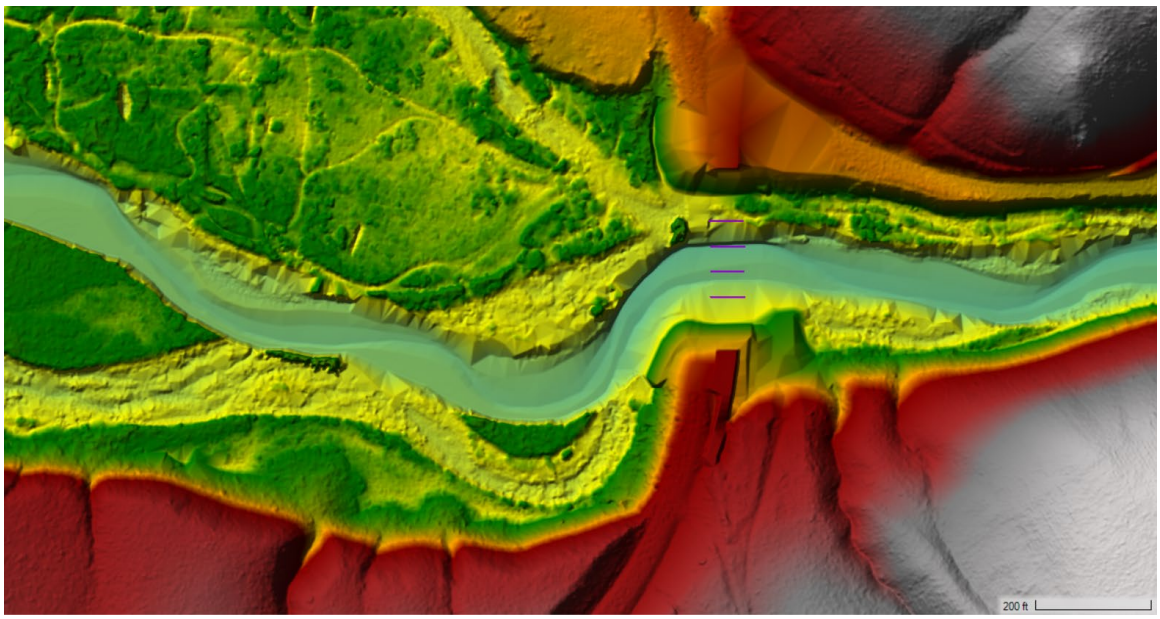
The workshop will begin by developing a base geometry and plan that models a section of river with the shallow water equations (SWE) and then another geometry and plan will be developed with a Connection structure that will operate in bridge mode to simulate a road crossing. These simulations will then be compared.

The

2 Background

The figure below shows the terrain and bridge crossing (flow west to east). The floodplain is highly constricted at the bridge which includes four rows of piers, these piers are marked by purple lines in the view below. The square piers have 4ft sides.

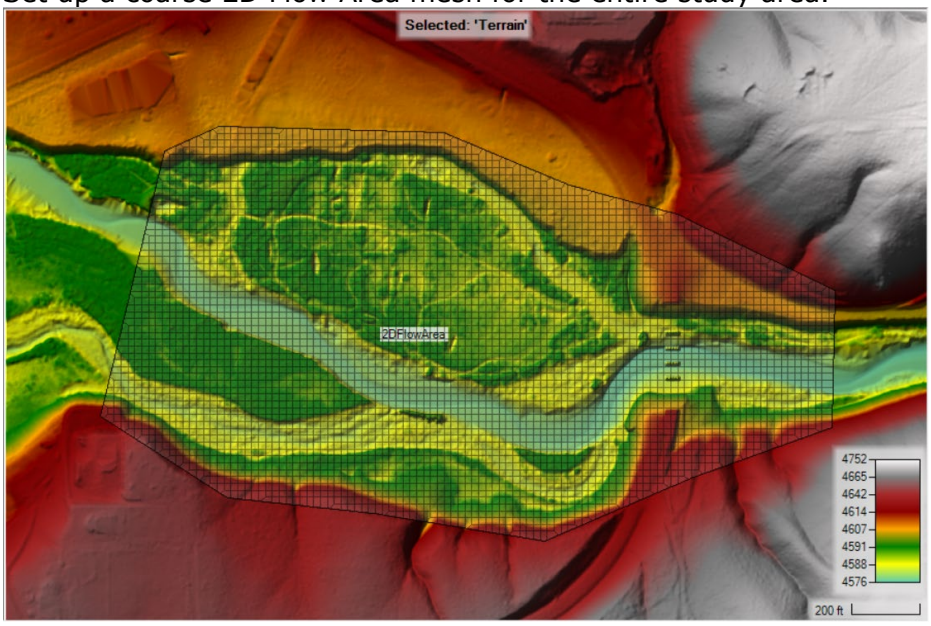
The flow event modeled does not overtop the bridge or hit the low chord.



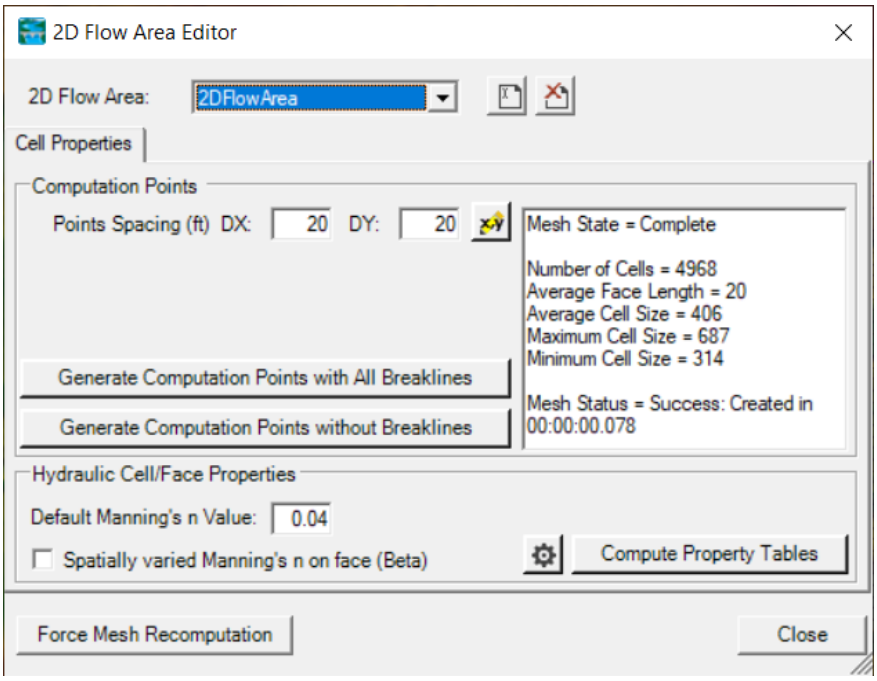
3 Create Initial Model Geometry

1. **Open HEC-RAS** and start a new project
2. **Open RAS Mapper**
    a. Set the **projection** ("GIS_Data" folder)
    b. Create a **New Terrain** ("Terrain" folder)
    c. **Add** a **New Geometry**.

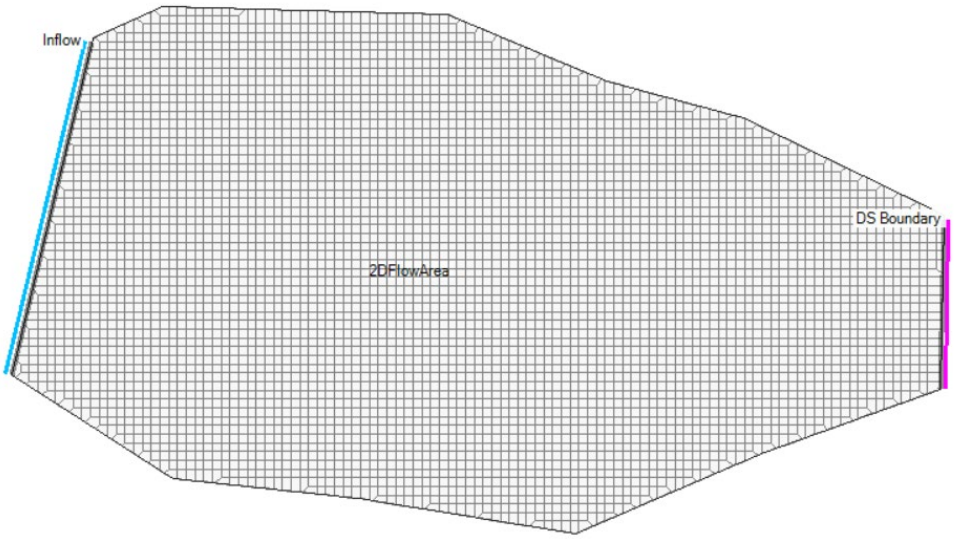
3. Set up a coarse 2D Flow Area mesh for the entire study area.



4. Try **20ft** cells with a n value of **0.04**.



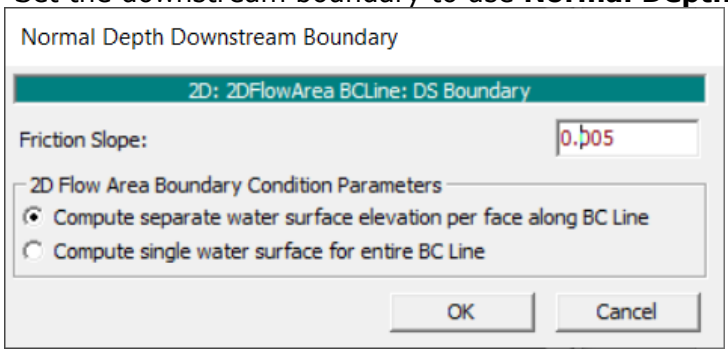
5. **Set up boundary condition lines**
    a. **Inflow**
    b. **DS Boundary**



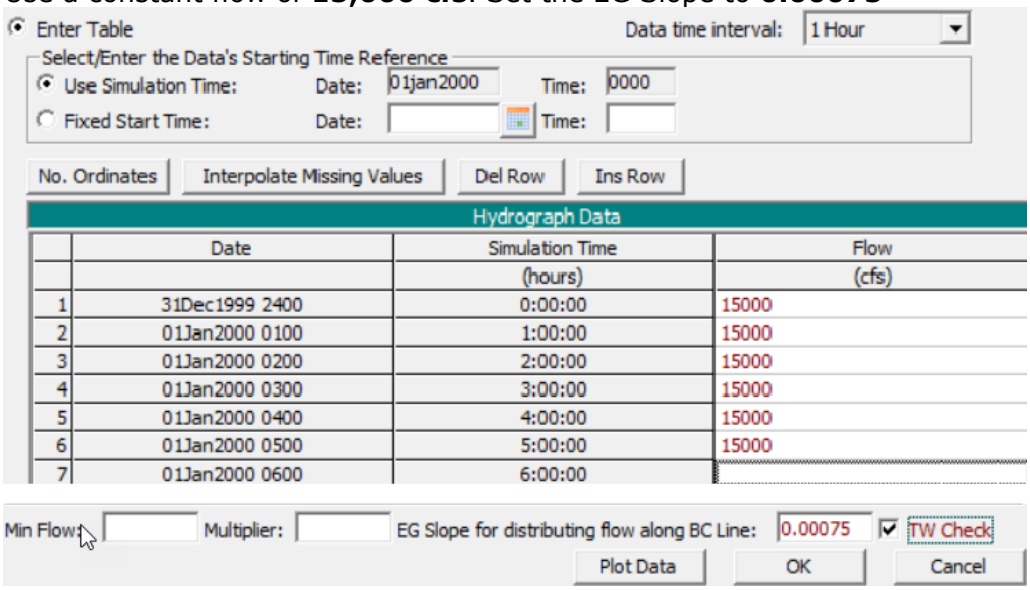
6. **Stop Editing** in RAS Mapper.
7. **Close RAS Mapper**
8. Open the **Geometric Data** editor.
    a. Open the initial Geometry
    b. Close the Geometric Data editor.

4 Enter Flow Data and Boundary Conditions

9. Open the **Unsteady Flow Data** editor.
10. Set the downstream boundary to use **Normal Depth**, s = **0.005**



11. Set the inflow to be a **Flow Hydrograph**
    Use a constant flow of **15,000 cfs**. Set the EG Slope to **0.00075**



	Date	Simulation Time (hours)	Flow (cfs)
1	31Dec1999 2400	0:00:00	15000
2	01Jan2000 0100	1:00:00	15000
3	01Jan2000 0200	2:00:00	15000
4	01Jan2000 0300	3:00:00	15000
5	01Jan2000 0400	4:00:00	15000
6	01Jan2000 0500	5:00:00	15000
7	01Jan2000 0600	6:00:00	

12. **Save** the flow data

5 Create a Plan and Simulate

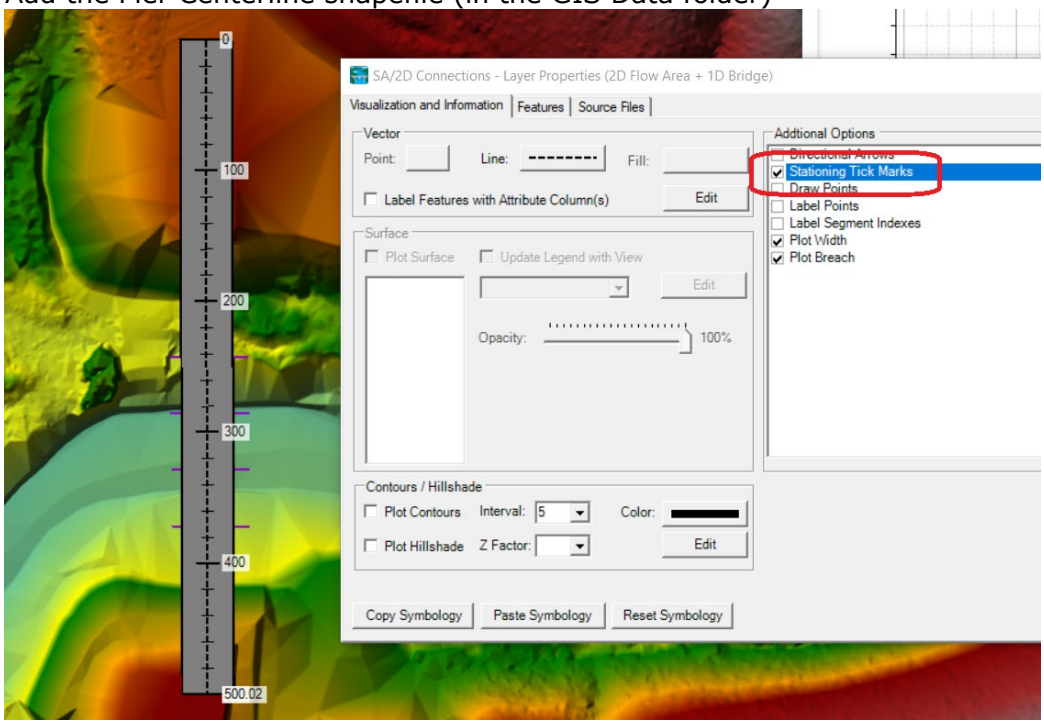
13. Open the **Unsteady Flow Analysis** window
14. Set up the time window, time step, and mapping output interval.
15. Set the **Computation Options**
    a. Set the Equation Set to **SWE-ELM (original/faster)** and the **Initial Conditions Time**

	Parameter	(Default)	2DFlowArea
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	SWE-ELM (original/faster)
7	Initial Conditions Time (hrs)		1
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	*None*	None
11	Longitudinal Mixing Coefficient	*0.3*	*0.3*
12	Transverse Mixing Coefficient	*0.1*	*0.1*
13	Smagorinsky Coefficient	*0.05*	*0.05*
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	All Available	All Available
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations	*0*	*0*
20	Maximum Iterations	*0*	*0*
21	Restart Iteration	*10*	*10*
22	Relaxation Factor	*1.3*	*1.3*
23	SOR Preconditioner Iterations	*10*	*10*

16. **Save** the plan data as Base Plan
17. **Compute**
18. **Computation Time Step Check** ensure solution is smooth and stable, pick a new time step and re-run if necessary.

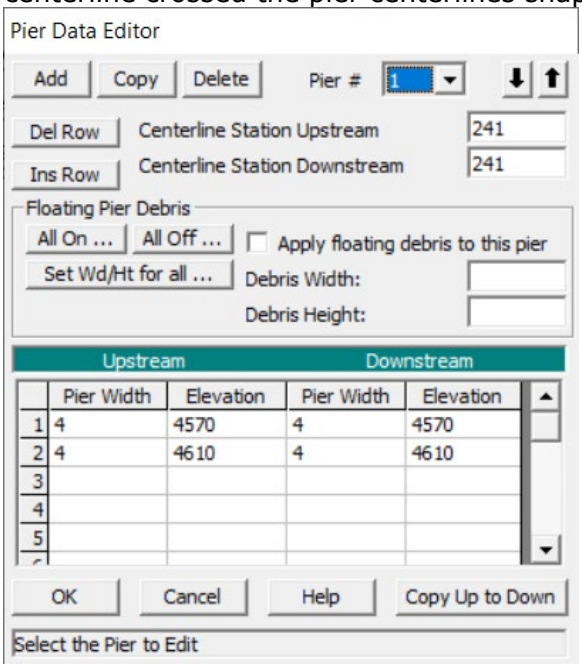
6 Create new Geometry and Plan with 1D Bridge

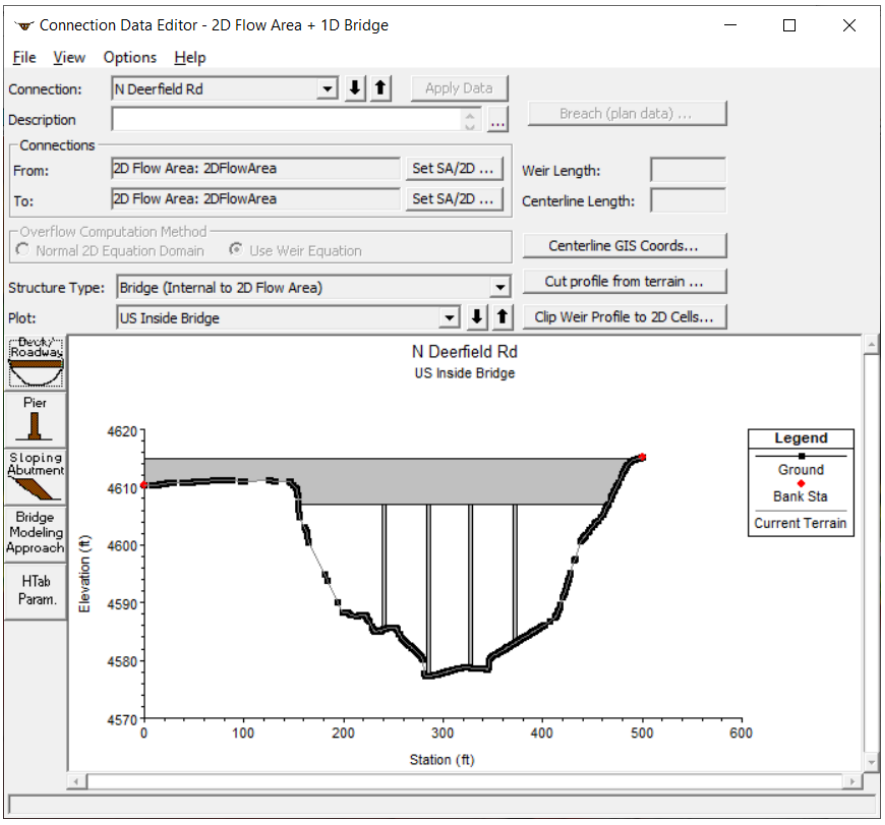
19. In RAS Mapper window use the "**Save Geometry as** …" menu option to copy the base geometry to start.
20. Start editing and draw a centerline for the bridge deck and set the width to **40** ft. (draw from left to right looking downstream, which will be top to bottom in this case).
21. Enforce the 2D cell spacing around the centerline as appropriate.
22. Add the Pier Centerline shapefile (in the GIS Data folder)



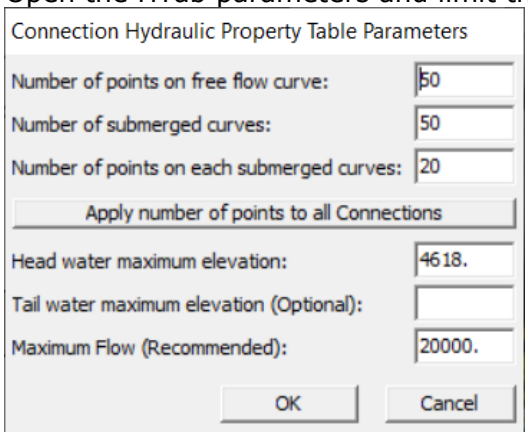
23. Turn on the stationing tick marks on the bridge centerline
24. Note the bridge centerline stations where the piers cross it, you will need these stations when entering the pier data.
25. Go the main **Geometry Schematic** and open the **2D Connection Data Editor**.
26. Ensure the structure type is modeled as Bridge (Internal to 2D Flow Area)
27. Add a deck roadway that spans the full range width of the XSs with a flat top roadway at an elevation of 4615 and a low chord at 4607 ft.

28. Set the upstream distance to **5**ft.
29. Select appropriate Weir Coefficient for this structure.
30. Add **4 Piers** that are **4ft** wide at the stations you noted earlier where the centerline crossed the pier centerlines shapefile.

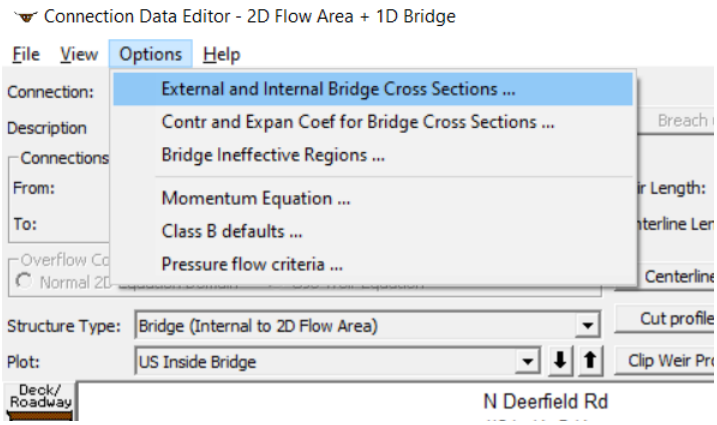




31. Open the **Bridge Modeling Approach** and turn on the **Momentum** method and select an appropriate Cd coeficient for square nosed piers.
32. Open the HTab parameters and limit the curves for this simulation.



33. Open the "External and Internal Bridge Cross Section" dialog.



34. Set the Manning's values for the 4 XS's for this structure to use a value or 0.04.
35. Save geometry file.
36. **Save Plan As**, to create another plan with this geometry.
37. **Compute**

7 Compare Results

38. Create a **Profile Line** for the river centerline. (turn on Plot Tick Marks to help find where the bridge is in the profile)
39. **Plot the WSE** and compare the results.

Question: What is the difference in WS between the plans at the bridge?

<u>Question</u>: Look at the family of bridge curves and for the flow through the bridge track back the HW to find the prescribed TW and try to verify the loses were applied correctly.

<u>Question</u>: Is the cell size adequate for modeling the terrain, bridge, piers, etc?