Steady Flow Modeling with HEC-RAS

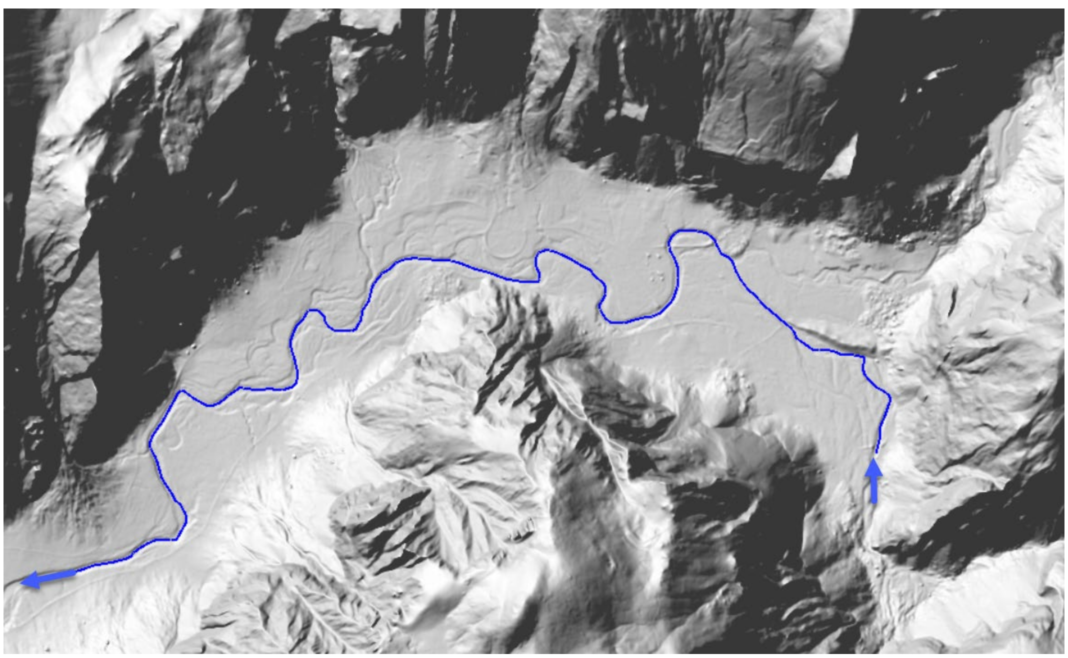
Workshop

1 Objective

In this workshop, you will learn how to create a 1D model with HEC-RAS of the main channel and floodplain area. This workshop will require you to acquire terrain datasets, create a terrain model, lay out cross sections, provide steady flow information, downstream boundary conditions, add land cover data and associate Manning's n values, refine the model, and perform model runs. You will also attempt to calibrate the model using observed high water mark information using the capabilities in HEC-RAS to adjust Manning's n values.

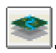
2 Background

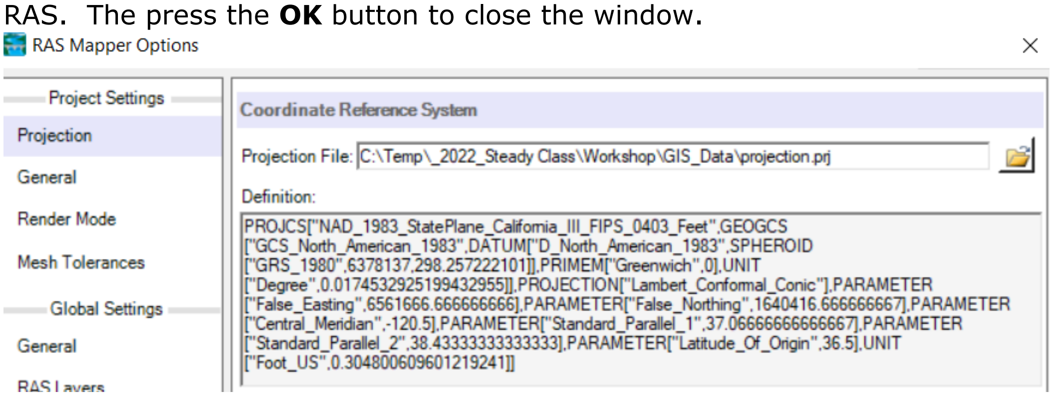
You will be working on the Merced River in the Yosemite Valley. Steady flow data will be used for the inflow and a Normal Depth Boundary Condition will be used for the downstream boundary.



3 Create a New RAS Project and Set the Projection

This part of the workshop will guide you through the process of importing terrain data. The terrain data will be used as the basis for the mesh used for 2D hydraulic computations.

1. **Start HEC-RAS**.
2. Start a NEW project using **File | New Project…** Go to the workshop directory for this workshop ("Merced River") and then providing a **Title** and **File Name**. Press **OK** to save it.
3. Launch **RAS Mapper** .
4. Select **Project | Set Projection.** Select the Folder button at the top left and navigate to the "**River.prj**" provided in the "GIS_Data" folder. Select and Open this file. This sets the coordinate system for all the data you will view in RAS. The press the **OK** button to close the window.

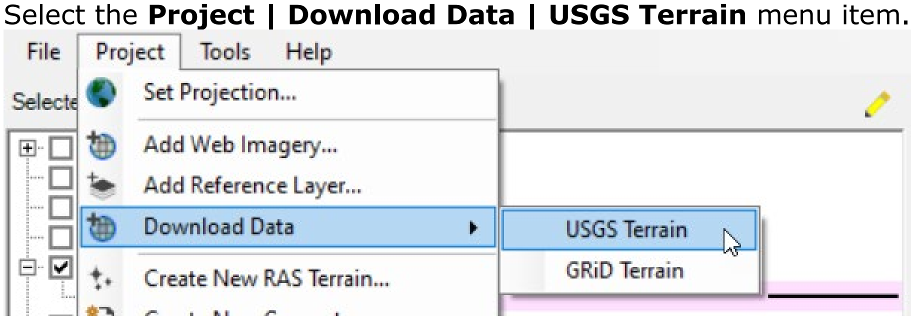


5. Add the "**River**" shapefile to RAS Mapper from the "GIS_Data" folder.
6. Right-click on the **River** layer and **Zoom to Layer**

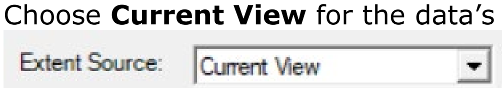
4 Download Terrain Data

*** If you don't have internet access, skip this step and use the terrain data provided in the "**Terrain\USGS_Data**" folder. ***

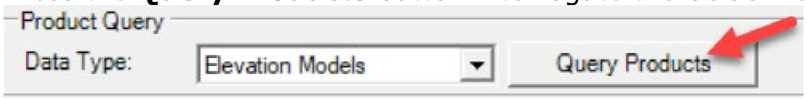
7. Select the **Project | Download Data | USGS Terrain** menu item.



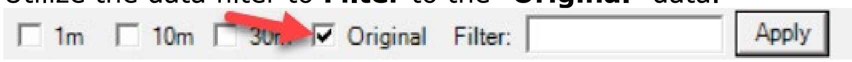
8. Choose **Current View** for the data's extent.



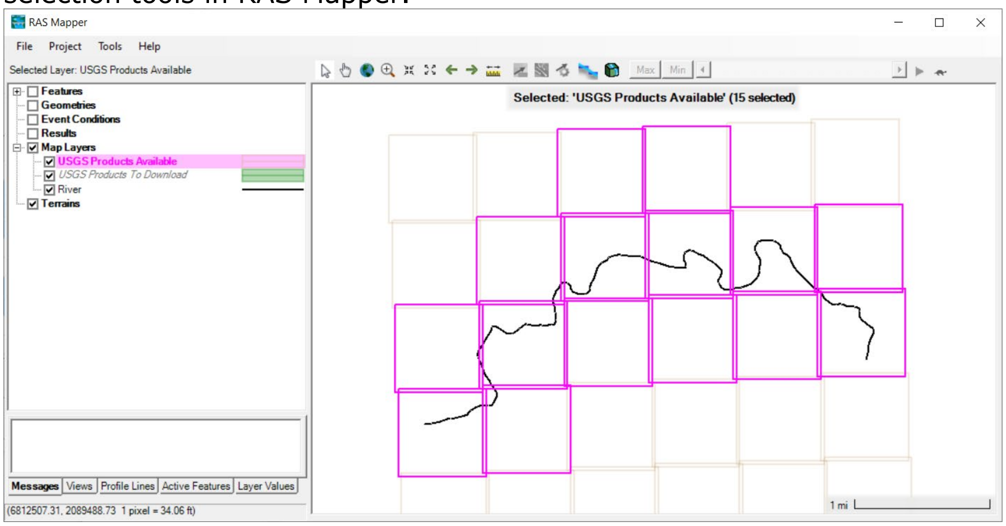
9. Press the **Query Products** button interrogate the USGS web service.



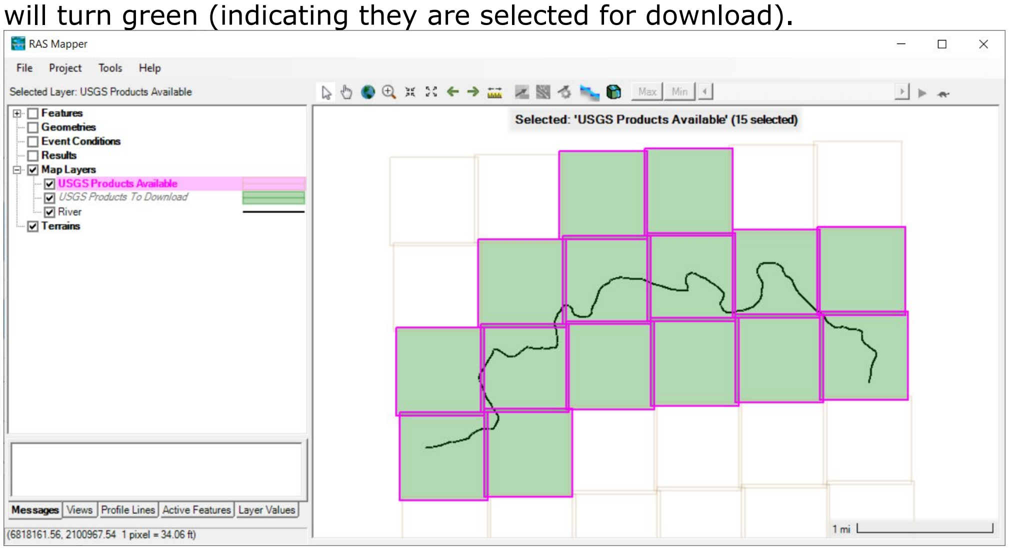
10. Utilize the data filter to **Filter** to the "**Original**" data.



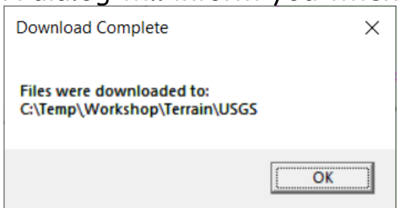
11. **Select** the terrain tiles that cover the valley floodplain using the graphical selection tools in RAS Mapper.



12. Click the **Add Selected** button from the Download Terrain dialog.
The check boxes will be filled in for the selected datasets and the terrain tiles will turn green (indicating they are selected for download).



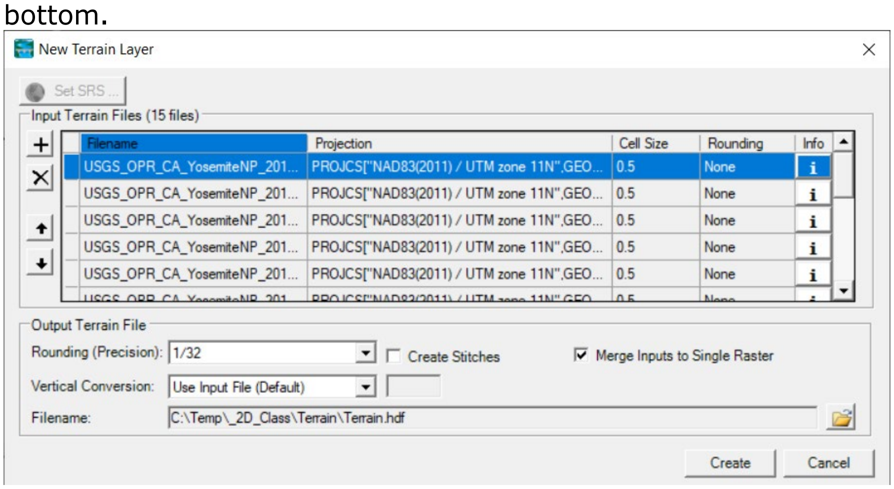
13. Press the **Start Download** button.
A dialog will inform you when the download is complete.



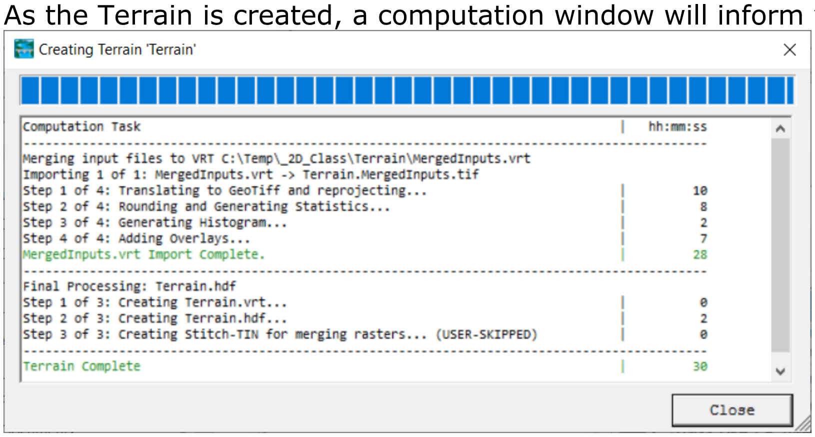
14. **Close** the Terrain Downloader.

5 Terrain Model Preparation

15. Import terrain data for use in RAS by selecting the **Project | Create New RAS Terrain** menu item.
16. Click the **Add Files** + button and navigate to the "**Terrain\USGS**" folder.
17. Select **ALL** of the files (Ctrl+A) and then press the **Open** button at the bottom.



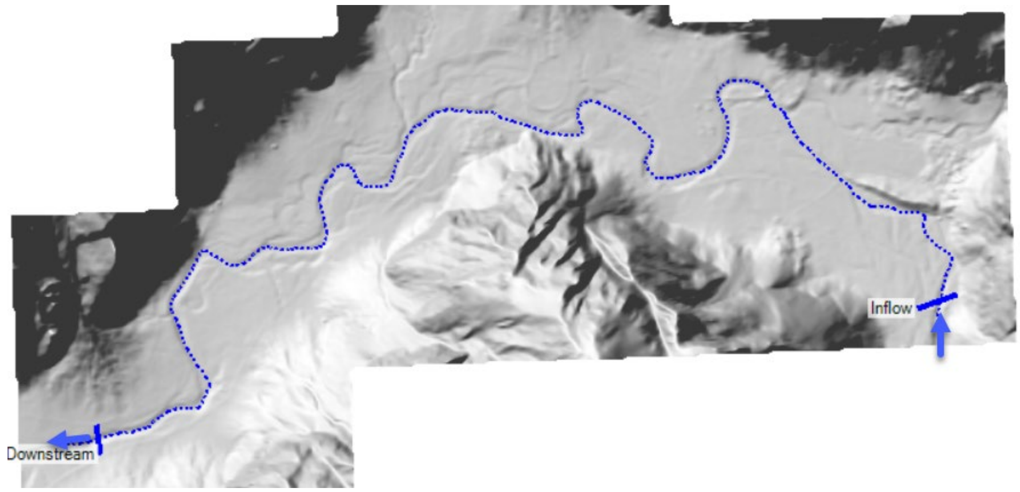
18. Click the **Merge Inputs to Single Raster** checkbox.
19. Press the **Create** Button.
As the Terrain is created, a computation window will inform you of progress.



20. When the terrain process is finished, select **Close** on the processing window, this will close both windows. Turn on the Terrain Layer.

21. **Right-click** on the Terrain Layer and choose **Zoom to Layer** (if necessary to see the terrain).
22. **Double-click** on the **Terrain** Layer to access its Properties.

Below is what the terrain should look like. Also shown are all the boundary condition locations for this workshop.



6 Initial Model Creation

In this part of the workshop, you will create the initial model. This rough model will provide and understanding of the floodplain from which you can improve the hydraulics model. The rough model will allow you to answer simple questions such as listed below.

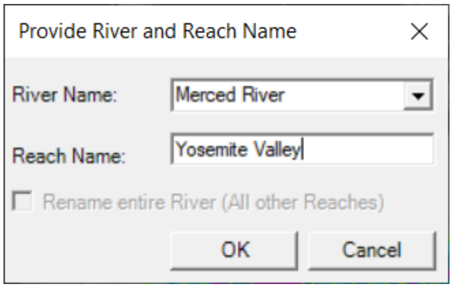
- Where does water go and what is the extent of the floodplain?
- What velocities does the river experience?
- Where is flow rapidly varied?
- What is controlling where flow goes and are there major obstructions to flow?

6.1 Create the 1D Geometry

23. Choose the **Project | Create New Geometry** menu item. Enter "**Base**" for the name. Press **OK** to create the geometry layer.
24. **Select** new Geometry Layer and press the **Edit** button.
25. **Create the River Centerline**
    a. **Copy** and **Paste** the river centerline from the "River" shapefile (previously loaded) to the **River** Layer. – or – you could import the river using the shapefile importer. – or – you could create it by hand

b. Using the **Edit** tool and right-click on the River line and select **Rename River Reach**.

c. Rename the River Reach to "**Merced River**", "**Yosemite Valley**".

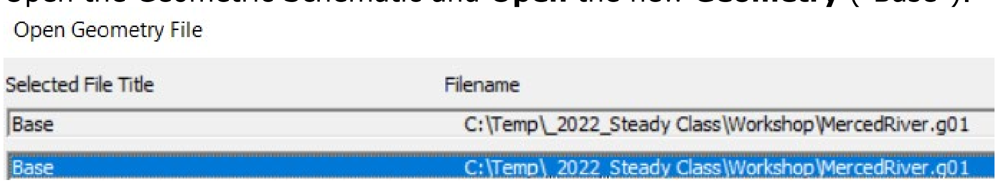


26. **Create Cross Sections**

    a. Select the Cross Sections layer and lay out cross sections to properly capture the floodplain.

27. **Stop Editing** and **Close** RAS Mapper.

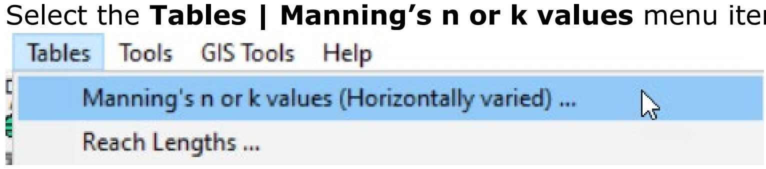
28. Open the Geometric Schematic and **Open** the new **Geometry** ("Base").



29. Stop Editing to **Save** the Geometry!

30. Enter **Manning's n value** data

    a. Select the **Tables | Manning's n or k values** menu item



    b. Set all of the n values to **0.04**.

31. Open the **Reach Lengths** data table – notice the Left, Channel, and Right lengths are all the same. Why is that do you think?

32. **Close** the Geometric Editor.

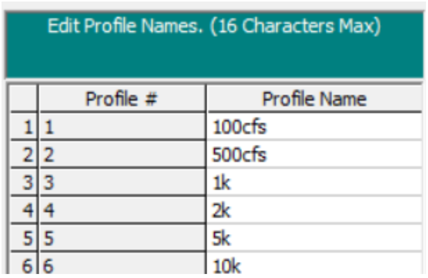
6.2 Enter the Flow Data

33. Open the Steady Flow Data Editior.

34. Enter **6** for the number of profiles.

35. Enter flows of **100**, **500**, **1000**, **2000**, **5000**, and **10000** cfs.

36. Select the **Options | Edit Profile Names** menu item and provide names for each flow.



	Profile #	Profile Name
1	1	100cfs
2	2	500cfs
3	3	1k
4	4	2k
5	5	5k
6	6	10k

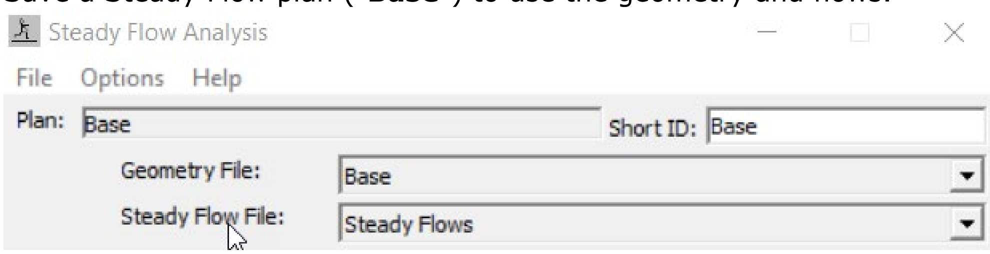
37. Enter a **Normal Depth** boundary condition.

    What slope should you use? Does it matter?

38. Save the Steady Flow data when complete (call it "**Steady Flows**").

6.3 Plan and Simulation

39. Save a Steady Flow plan ("**Base**") to use the geometry and flows.



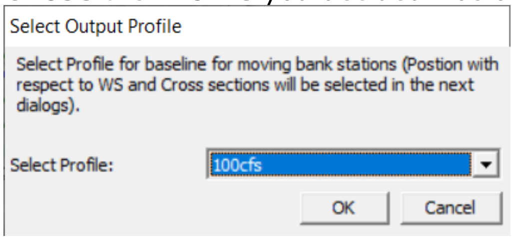
40. Run the simulation (press the **Compute** button).

6.4 Set the Bank Stations

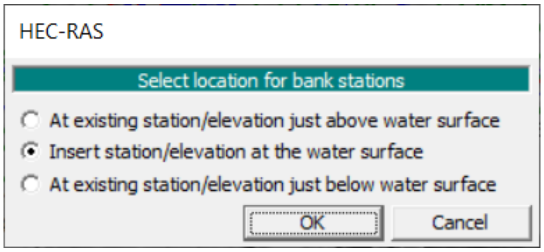
You can use a base run to set the bank stations for all the cross sections.

41. After you have run the model, look at the inundation results in **RAS Mapper**.
42. Plot individual cross sections using the **XS Plot** in either the main interface or RAS Mapper.
43. **Determine** which WS Profile looks to be at the channel banks.
44. Open the Geometric Data Editor.
45. Select the **Tools | Channel Bank Station Locations** menu item.

46. **Chose** the **Profile** you decided was at the channel banks.



47. **Choose** how to **insert** the Bank Stations.



6.5 Establish Flow Path Lines

If you have time, set up the Flowpaths Layer. If not, skip this step.

48. In RAS Mapper, Edit the Base geometry.

49. Select the **Flowpaths** Layer and create a flow path line in the left and right overbank.

50. **Stop Editing**, when finished.

6.6 Re-run the Model

51. **Compute** the **Base** plan.

52. Evaluate the results.

7 Model Refinement

Once you have a working model, you can use it to inform you on how to improve/refine the model to better represent real-world conditions. This is where you'd refine the cross section layout, move bank stations, realign flow paths, etc.

7.1 Create a Copy of the Geometry

You will want to keep a copy of the old mesh and work on a new one (you never know when you might want to go back, but you will certainly want to compare to see progress).

53. Open **RAS Mapper**

54. Right-click on the base Geometry and choose **Save Geometry As**.

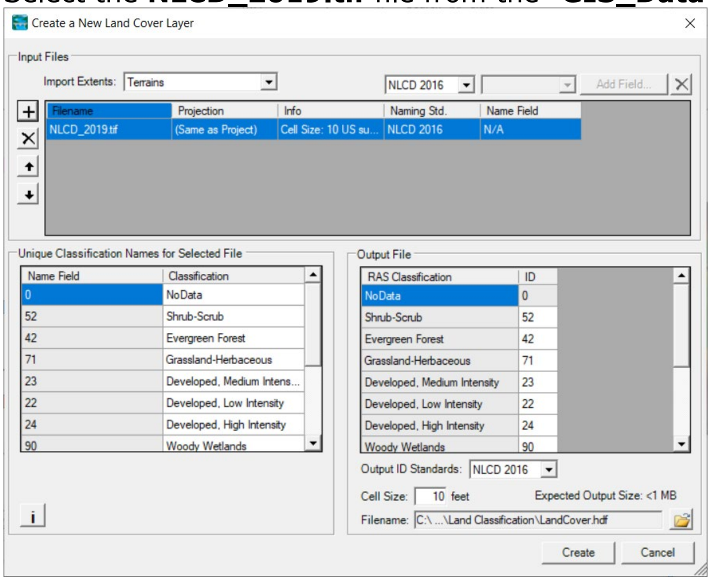
55. Provide a new name ("**Refined**").

7.2 Land Cover Data

Utilize the 2019 NLCD dataset provide for you to compute hydraulics using spatially varied Manning's n Values.

56. Choose the **Project | Create New RAS Layer | Land Cover Layer**

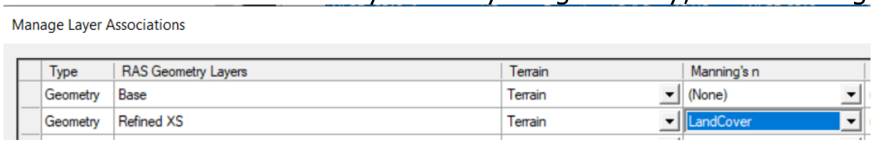
57. Select the **NLCD_2019.tif** file from the "**GIS_Data**" folder.



58. Press the **Create** button

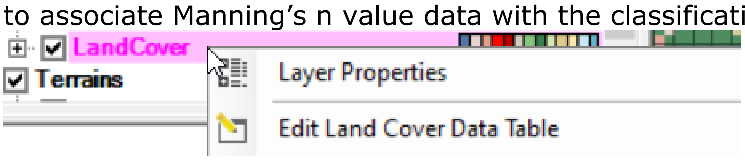
59. **Close** the compute window when finished.

60. Associate the LandCover layer with your geometry, in the dialog that appears.

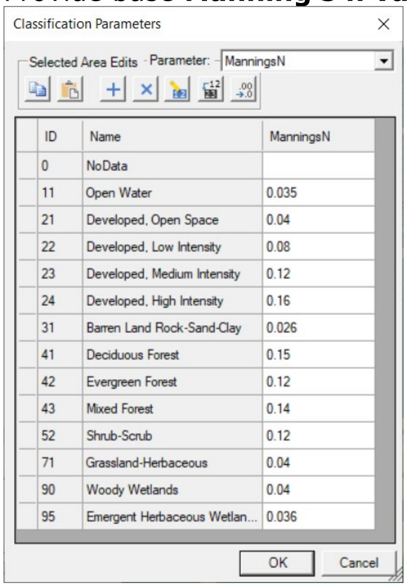


7.3 Manning's n values

61. Right-click on the LandCover layer and select **Edit Land Cover Data Table** to associate Manning's n value data with the classification scheme.



62. Provide base **Manning's n values** in the table provided.

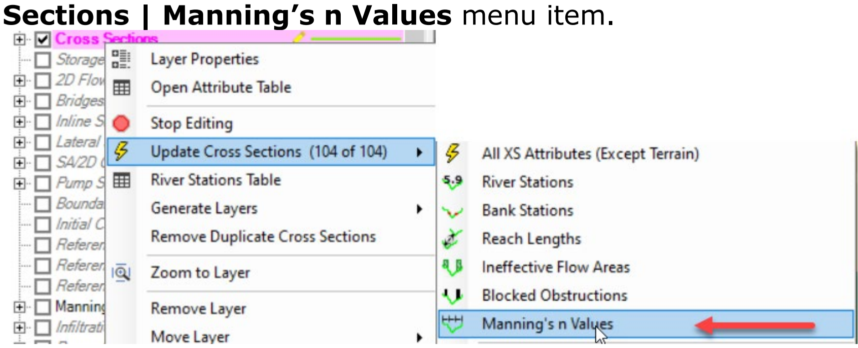


ID	Name	ManningsN
0	NoData	
11	Open Water	0.035
21	Developed, Open Space	0.04
22	Developed, Low Intensity	0.08
23	Developed, Medium Intensity	0.12
24	Developed, High Intensity	0.16
31	Barren Land Rock-Sand-Clay	0.026
41	Deciduous Forest	0.15
42	Evergreen Forest	0.12
43	Mixed Forest	0.14
52	Shrub-Scrub	0.12
71	Grassland-Herbaceous	0.04
90	Woody Wetlands	0.04
95	Emergent Herbaceous Wetlan...	0.036

63. Update the Cross Sections with Manning's n values for the cross sections.

   a. **Start Editing** the new Geometry

   b. Select the Cross Section Layer and choose the **Update Cross Sections | Manning's n Values** menu item.



   c. You can see if it worked by turning on the Cross Section Layer Plot Option | Manning's n Values.

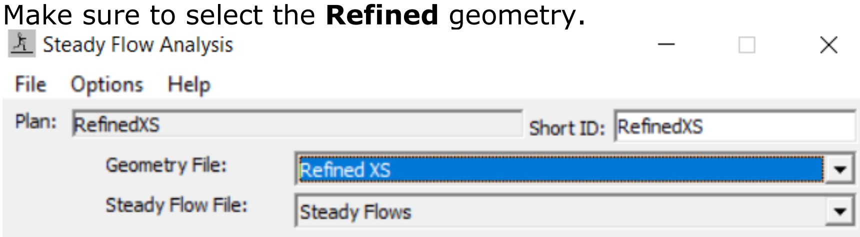
   d. **Stop Editing** and Save Edits.

7.4 Plan and Simulation

64. Open the Steady Flow Analysis window and create a new Plan using the refined geometry using the **File | Save Plan As** menu option.

65. Provide a new Title and Name ("**Refined**").

66. Make sure to select the **Refined** geometry.

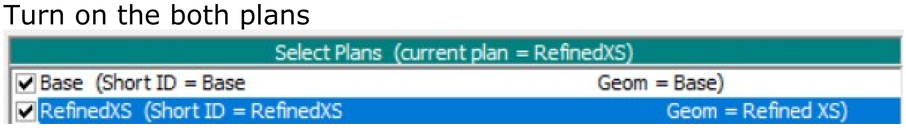


67. Run the simulation (press the **Compute** button).

7.5 Evaluate/Compare Results

Plot the Water Surface Profile Results comparing the two plans.

68. Plot them using the **Profile Plot**
    a. Compare plans by selecting the **Options | Plans** menu item.
    b. Turn on the both plans



69. Plot them in **RAS Mapper**
    a. Select the River centerline layer you added at the start of the project. Right-click on the line and choose **Save as Profile Line**. Provide a name.
    b. Turn on the **WSE** layer for both results
    c. Highlight the **Results** group layer, press the **Max** button on the Animation control.
    d. Click on the **Profile Lines** tab (lower left corner).
    e. Right-click on the **River** line and select the **Plot Profile | WSE** menu item

How do the results compare?

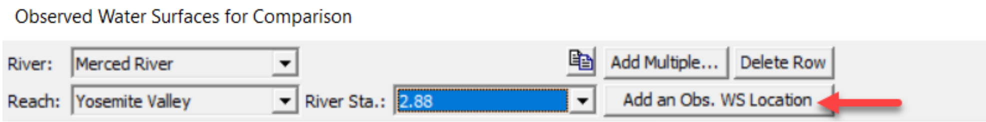
7.6 Observed Data

At this point we don’t really know how are model is doing. We can use observed data to help inform us and how to refine the model. Add an Observed High Water Mark (at the Bridge, at the Yosemite Falls Vantage Point, near River Station 2.88 based on the provided river centerline).

70. Open the **Steady Flow Data editor**.

71. Select the **Options | Observed WS** menu item.

72. Select the river station 2.88 (yours may vary) and **Add the Observed WS Location**.



73. Enter a WSE of **3966ft** for the 10,000cfs profile.

74. Save, and Close the Unsteady Flow Editor

75. **Re-run** the simulation

How do the results compare with the observed data? How can you improve the results?

7.7 Improve Manning's Data

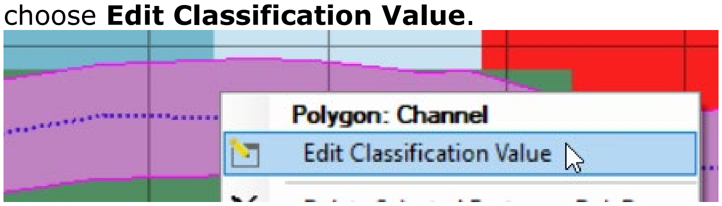
76. Select the **LandCover | Classification Polygons** layer

77. **Start Editing**

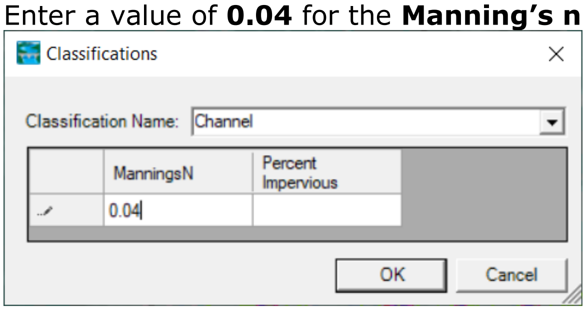
78. Right-click on the **Classification Polygons** and choose the **Import Features from Shapefile** menu option

79. Select the "**Channel_Polygon**" shapefile in "**GIS_Data**" folder.

80. Switch to the Edit Tool and then right-click on the new channel shape and choose **Edit Classification Value**.



81. Enter a value of **0.04** for the **Manning's n value**.



82. **Stop Editing** and Save edits.

83. Update the Cross Sections with Manning's n values for the cross sections.

    a. **Start Editing** the new Geometry

    b. Select the Cross Section Layer and choose the **Update Cross Sections | Manning's n Values** menu item.

c. **Stop Editing** and Save Edits.

84. **Re-run and Compare results.**

How do the results compare with the Observed High Water Mark data?

What else can you do to improve the model?

8 Sensitivity Analysis – Bonus Material

As time allows perform sensitivity analysis.

85. How sensitive is the model to the downstream boundary?
86. What do the model results show if you increase or decrease the Manning’s n values?