Mesh Development Workshop

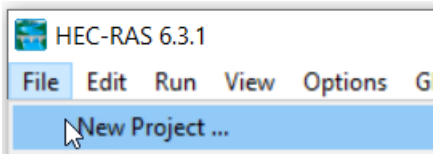
This workshop will guide you through mesh development practices. We will start with a terrain of the Little Bayou Meto Cutoff in Pool 2 of the Arkansas River. This bend was a dredging hotspot for years. But the District built four structures, increased sediment transport through this bend, and eliminated dredging.

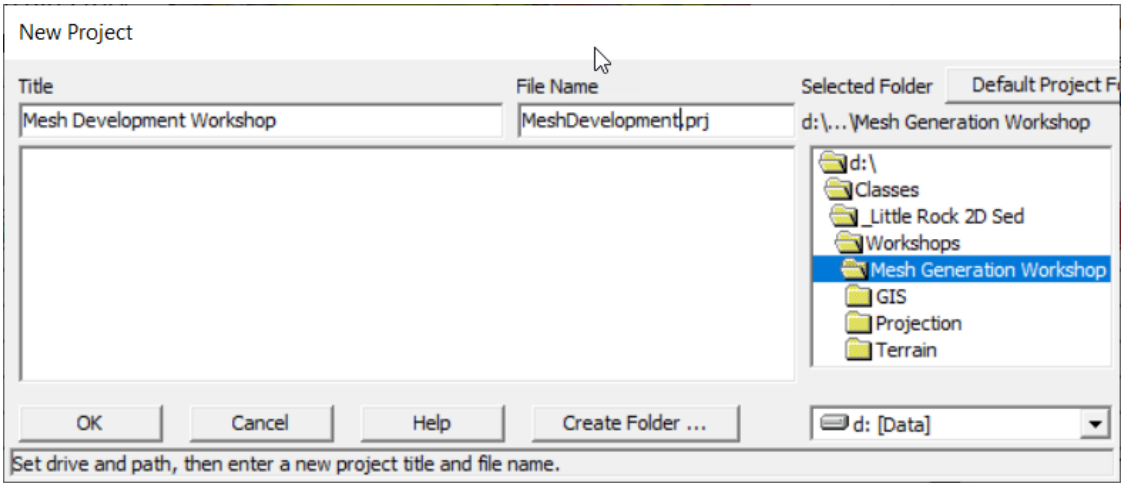
You will start with a terrain, a projection file, and a 2D area shape file. You will use these basic raw materials to build an aligned mesh with a few, critical linear features.

Warning: The models in this workshop are intended for pedagogical purpose only. They have been simplified and modified to fit into a brief workshop and should not be used for scientific or engineering analysis.

Part 1: Importing Terrain and 2D Perimeter

1. **Create a New Project** in the workshop directory. Call it "Mesh Development Workshop." You may want to manually edit your abbreviated "File Name"

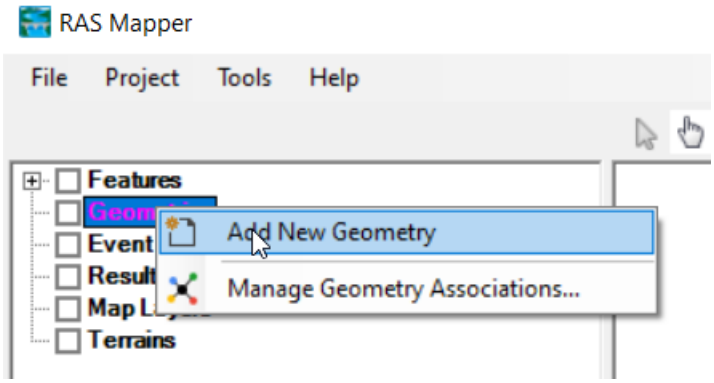




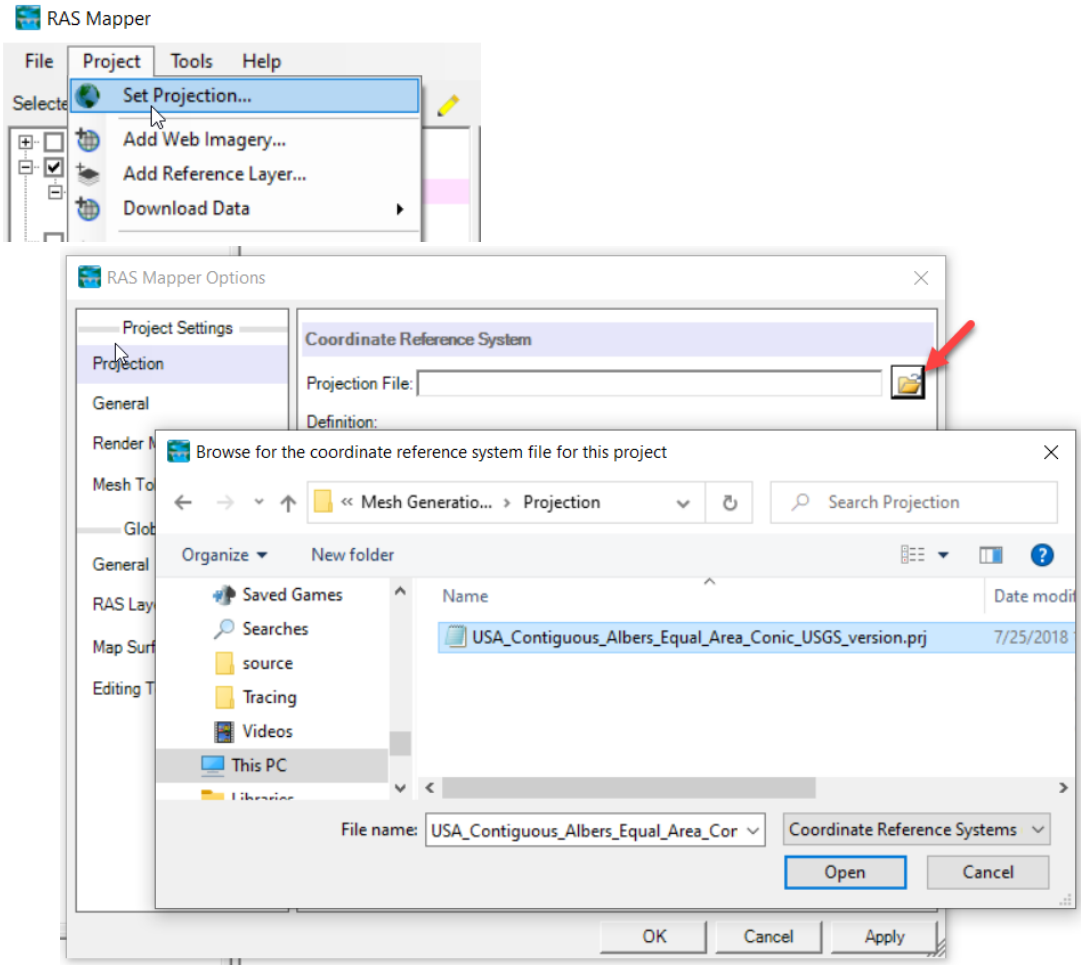
Click "OK" on the US Customary Units notification.

2. Open RASMapper

3. **<u>Add New Geometry</u>**: *Right* click on **Geometries** in the Mapper Tree and Select **Add New Geometry**. Give the geometry file an informative name.

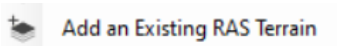


4. **<u>Define the Projection</u>**. Choose the **Project→Set Projection** menu. The projection is in the *Projection* folder in the workshop files. Press the folder to navigate to the file and select it.

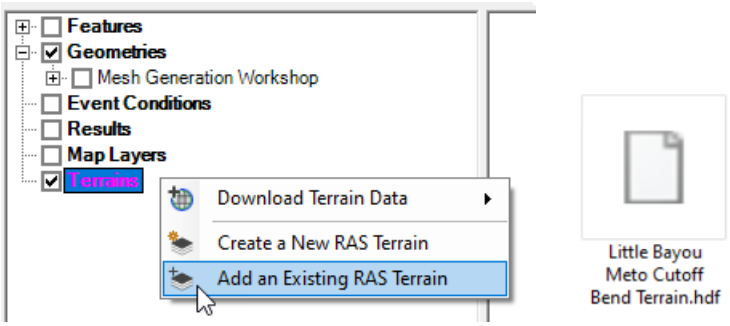


Once you select the Projection USA_Contiguous_Albers_Equal_Area_Conic_USGS_version.prj file, press **Open** and then back in the main projection editor press **Apply**.

Note: Projection files have the same extension as HEC-RAS project files (*.prj) so I like to keep the projection in a separate folder.

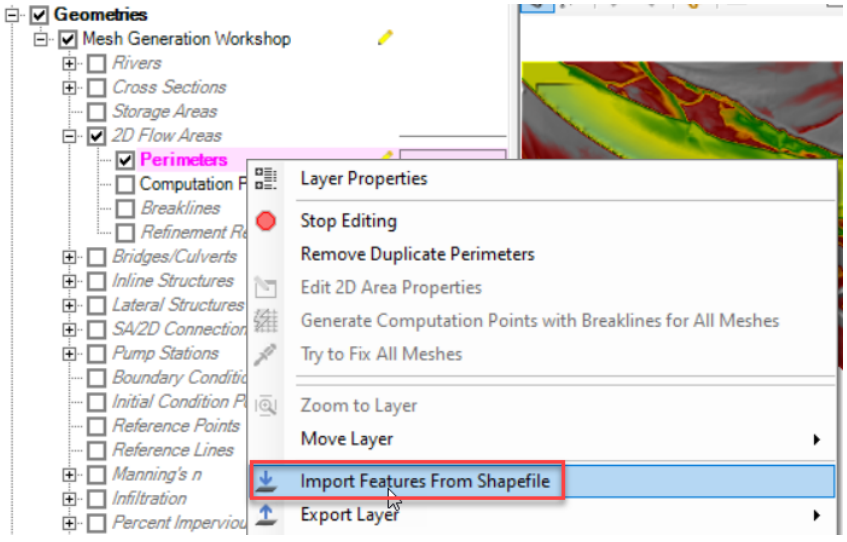
5. **Load the Terrain**: For this exercise we have clipped the terrain to focus on the local Little Bayou Meto Cutoff model. Navigate to **Terrains** at the bottom of the RASMapper tree. Right click on **Add an Existing RAS Terrain.** 

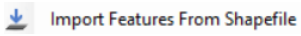
Navigate to the Terrain sub-folder in the workshop folder and select **Little Bayou Metro Cuttoff Bend Terrain.hdf**. This will load the local terrain file.



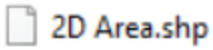
6. **Import 2D Area Perimeter**: In most projects you would draw the perimeter of your 2D area at this point, but to expedite the workshop and focus on the most important elements, you will import the 2D Area Perimeter from a shape file. Right click on the geometry you created above, under the **Geometries** node on the RASMapper tree. Select **Edit Geometry**.

The geometry tree will expand to include all the possible geometry components. Turn on the **2D Flow Areas** tree node, expand it, and turn on **Perimeters.**

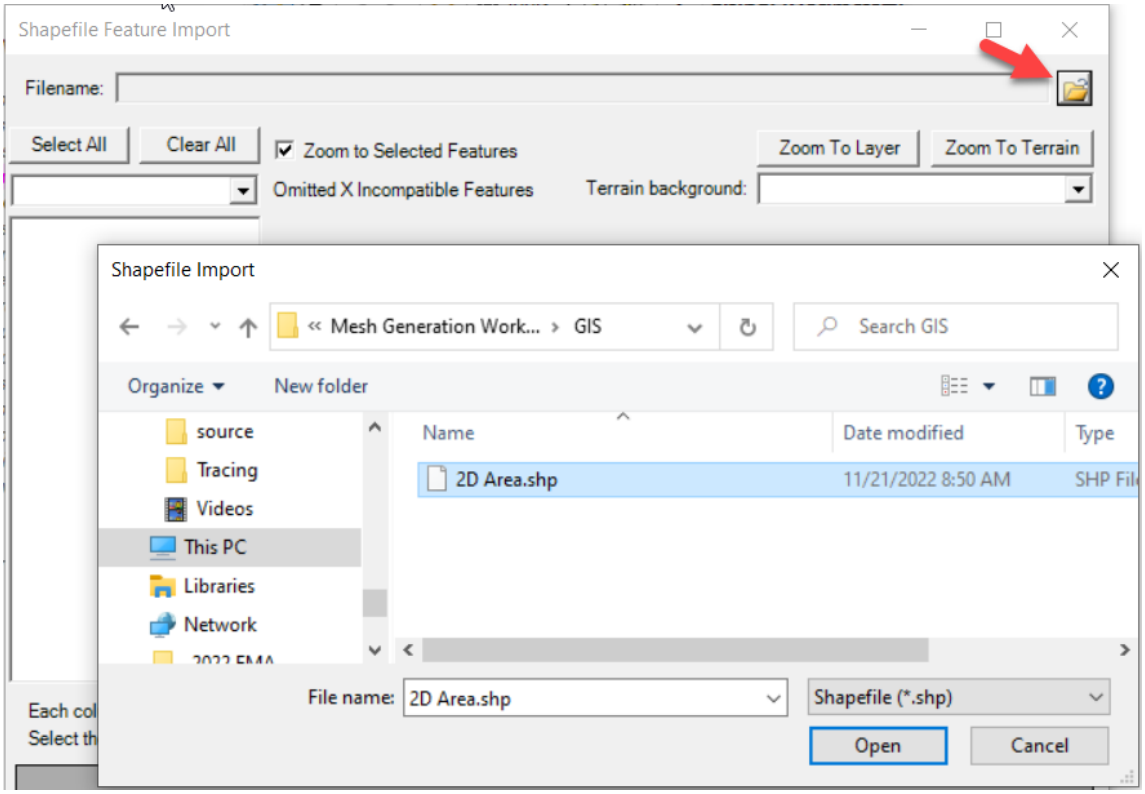


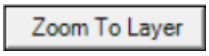
Right click on **Perimeters** and select **Import Features From Shapefile**. 

Navigate to the **GIS** sub-folder of the workshop files and select the shape file **2D Area.shp**

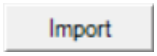


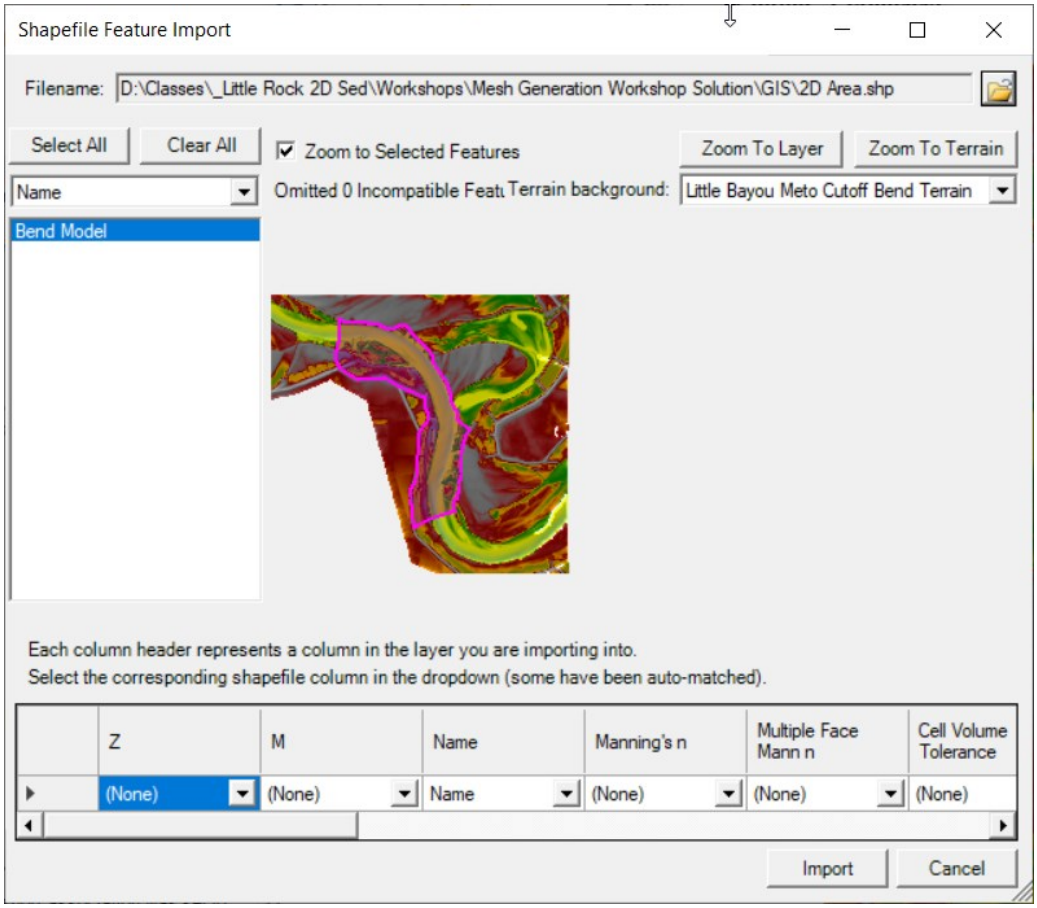
This will launch an editor. Navigate to the shape file in the **GIS** folder provided with the workshop materials. Press **Open**.



You can press the **Zoom to Layer** button 

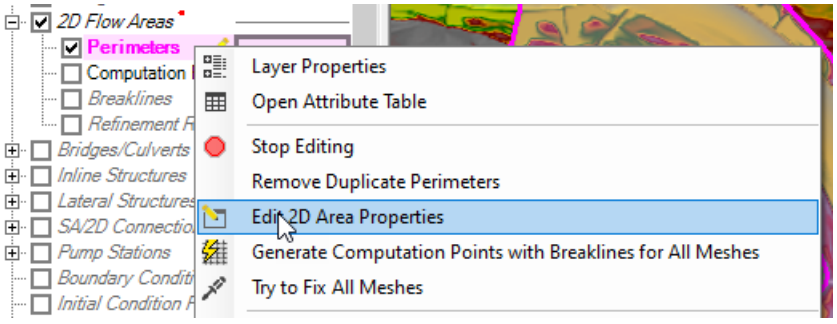
to automatically zoom to this feature.

Then press the **Import** button. 



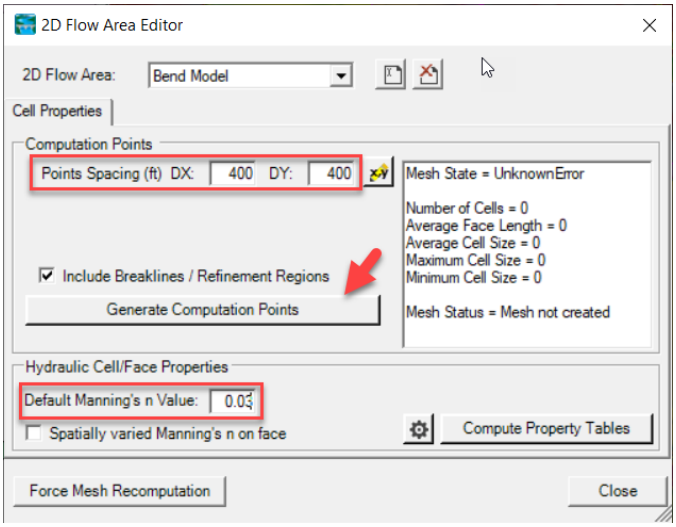
Part 2: Choose Initial Mesh Resolution

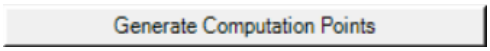
7. **Open 2D Area Properties**: Right click **Edit 2D Area Properties** to set the initial mesh properties.



8. **Set Initial Mesh properties**: Right click **Edit 2D Area Properties** to set the initial mesh properties. You will only use this mesh spacing outside the channel (you will define the channel in following steps) and you will add additional resolution to the floodplain with Breaklines. So you can choose a relatively coarse cell spacing at this point.

   Set your **Point Spacing** to **Dx=400, Dy=400**



You will also use a land use layer to define your n-value later. For now, chose an approximate channel n-value. Press the **Generate Computation Points** button. 

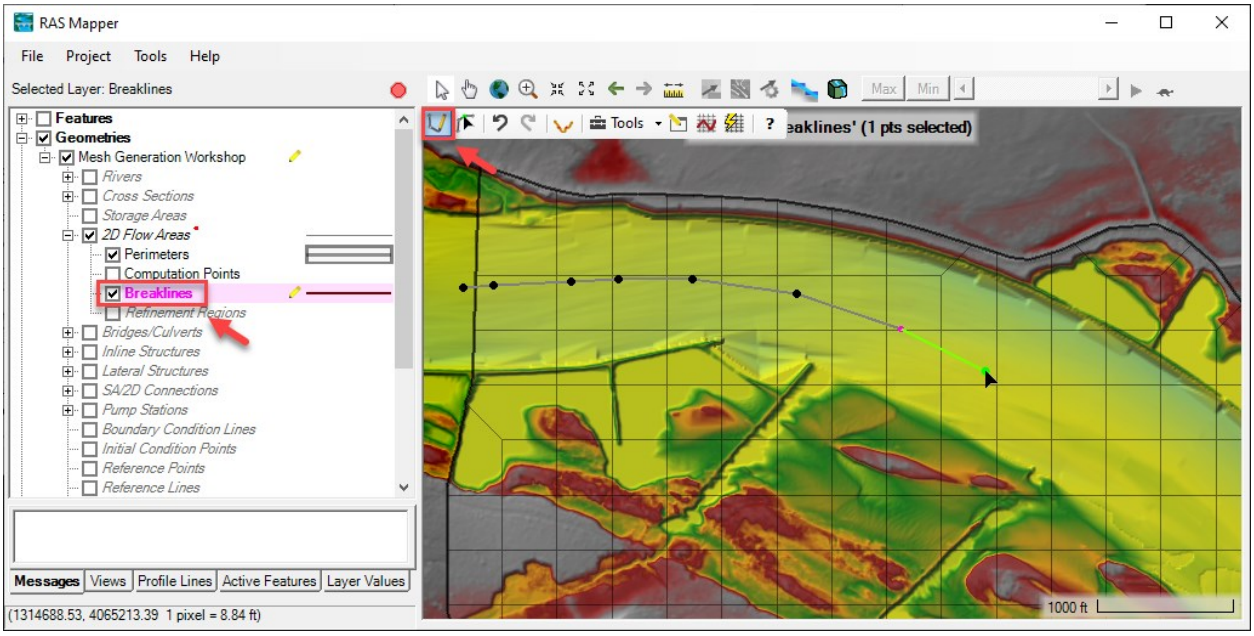
How many cells does your mesh start out with before you refine it? _____

How many cell-widths is the channel? _____ Is this enough? _____

Part 3: Align Channel Cells with a Breakline

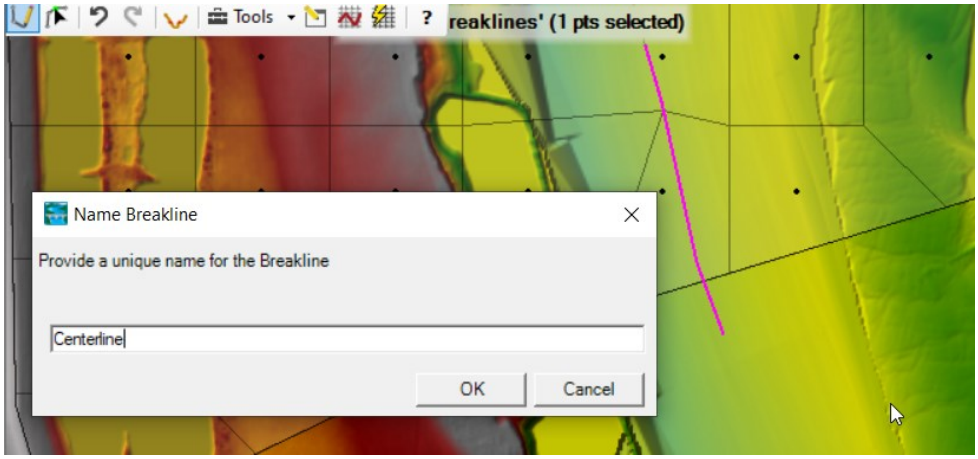
9. **Draw a Centerline.** Next you will align the channel cells with the direction of flow and refine the cell spacing in the channel with a channel breakline. Click on **Breaklines** under **2D Flow Areas** in your **Geometry**. If you are already editing, you do not need to start, if not, right click and start editing.

   Choose the drawing tool to draw a centerline breakline.



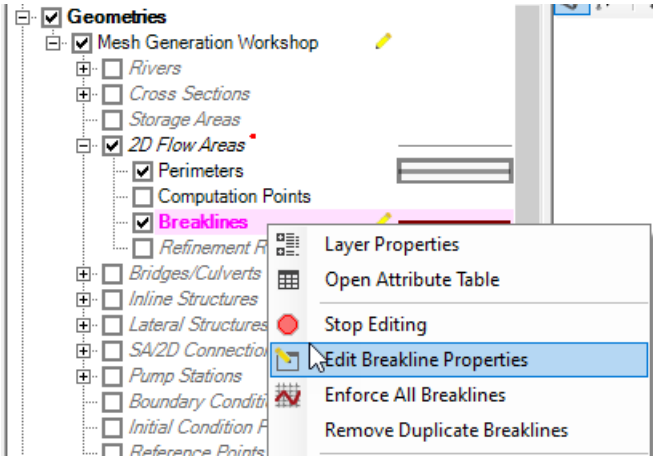
This breakline should follow the full distance of the channel and should be as close to the center of the channel as possible (e.g. this is a centerline not a thalweg line following low invert).

Double click at the downstream end and give the breakline an informative name (e.g. “Centerline”)



10. **<u>Select Channel Resolution and Replicates</u>**. If you enforce the breakline at this point, it will just generate a single set of 400 ft cells on either side of your centerline, which would be better than the current mesh, but not sufficient for a sediment model.

    Right click on **Breakline** and Select **Edit Breakline Properties**. Define the **Near Spacing** and the **Near Repeats**. Experiment with these different options to figure out how they work and get an appropriate, aligned, cell spacing (e.g. ≥5 cells across the channel).

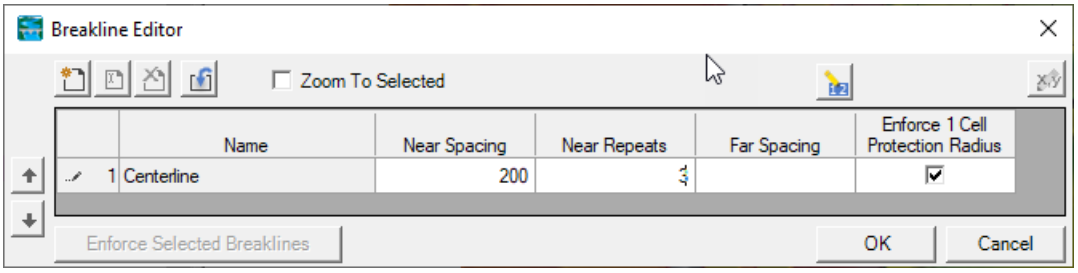


After you select the breakline properties, press the **Enforce All Breaklines** button or right click on the centerline and select **Enforce Breakline.** Enforce Breakline

What is a good cell spacing? _____

How many Near Repeats do you need to get complete channel coverage? _____

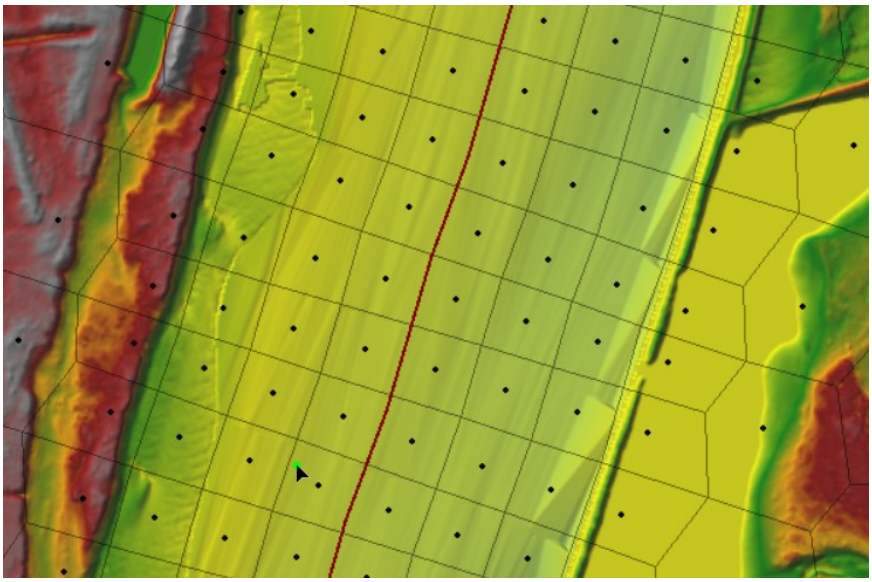
The workshop solution used the following breakline properties.



An operational model with more tolerance for longer runtimes might consider a smaller cell spacing.

11. **Evaluate Mesh**. Evaluate your mesh. How does it look?

What does your mesh need? _____



The centerline breakline aligns cells with the channel. But the banks do not align with high ground. The model should meet all three requirements:

- Cells aligned with flow
- Appropriate cell resolution in the channel
- Cell faces follow high ground at the channel banks

This step addressed the first two requirements. The next step will address the third.

Part 4: Define Channel Extents with a Refinement Region

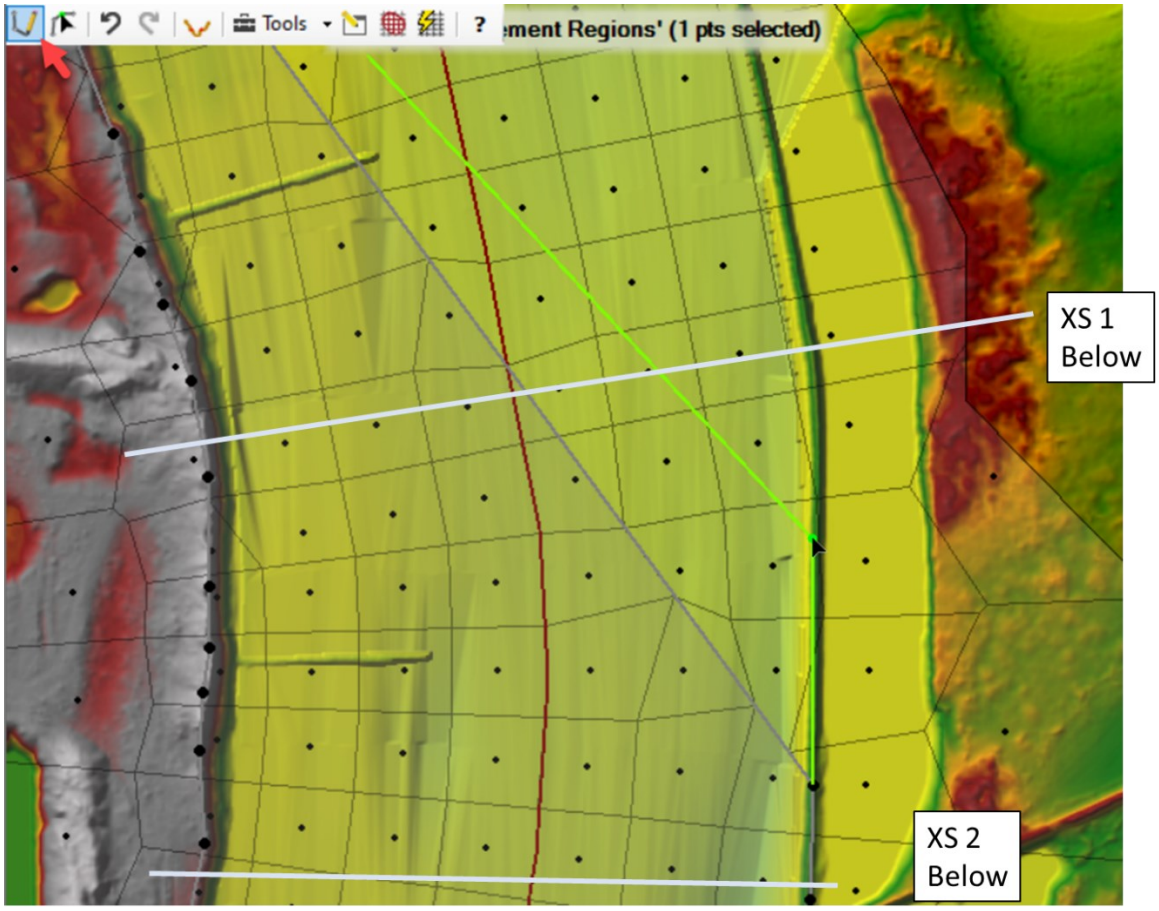
There are two basic approaches to fulfilling the three mesh requirements described above.

i. The three-breakline approach uses a centerline breakline and breaklines along the high ground or inflection point at each bank.

ii. The breakline-refinement region approach uses a breakline for the centerline and a refinement region to outline the channel extents.

Both approaches are appropriate. But the HEC-RAS manual recommends the **breakline-refinement region** approach, and it is usually a little easier, so you will use a refinement region to define the channel in this workshop.

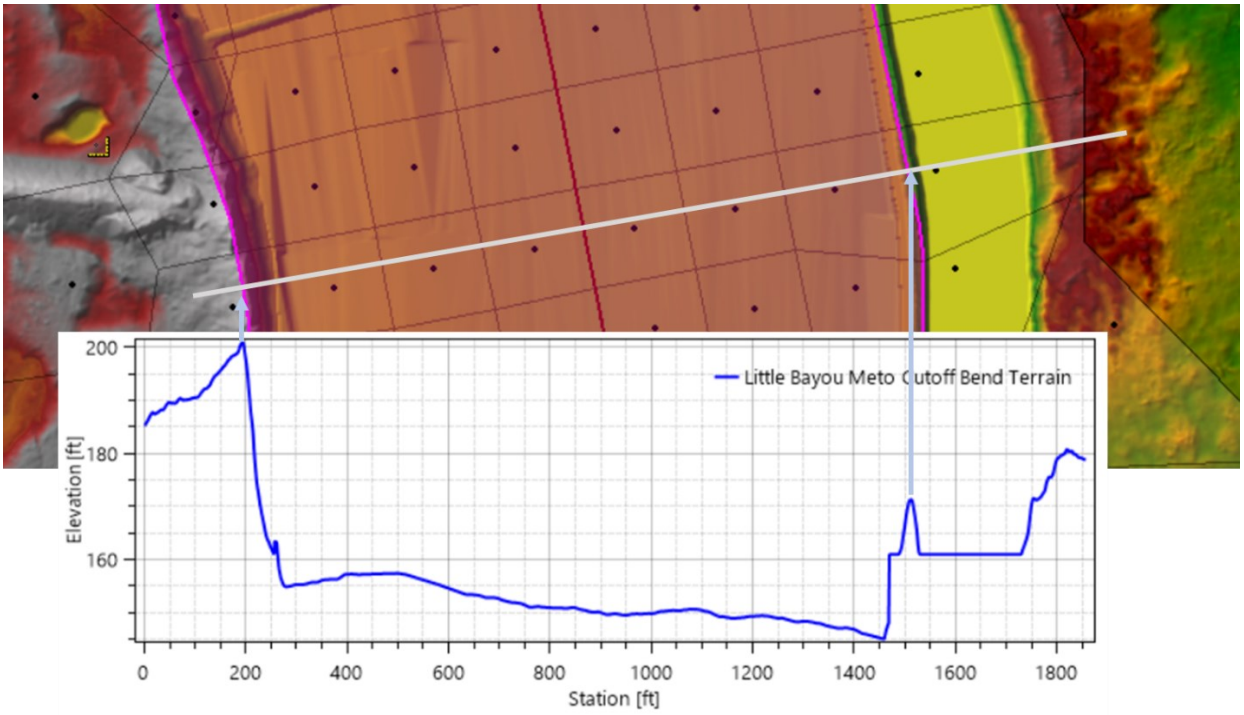
12. **Outline the Channel with a Refinement Region**. Click on **Refinement Region** under the **Geometry→2D Flow Areas** portion of the RASMapper tree (right click and **Start Editing** if you are not editing). Select the Draw tool and outline the channel with the Refinement Region.

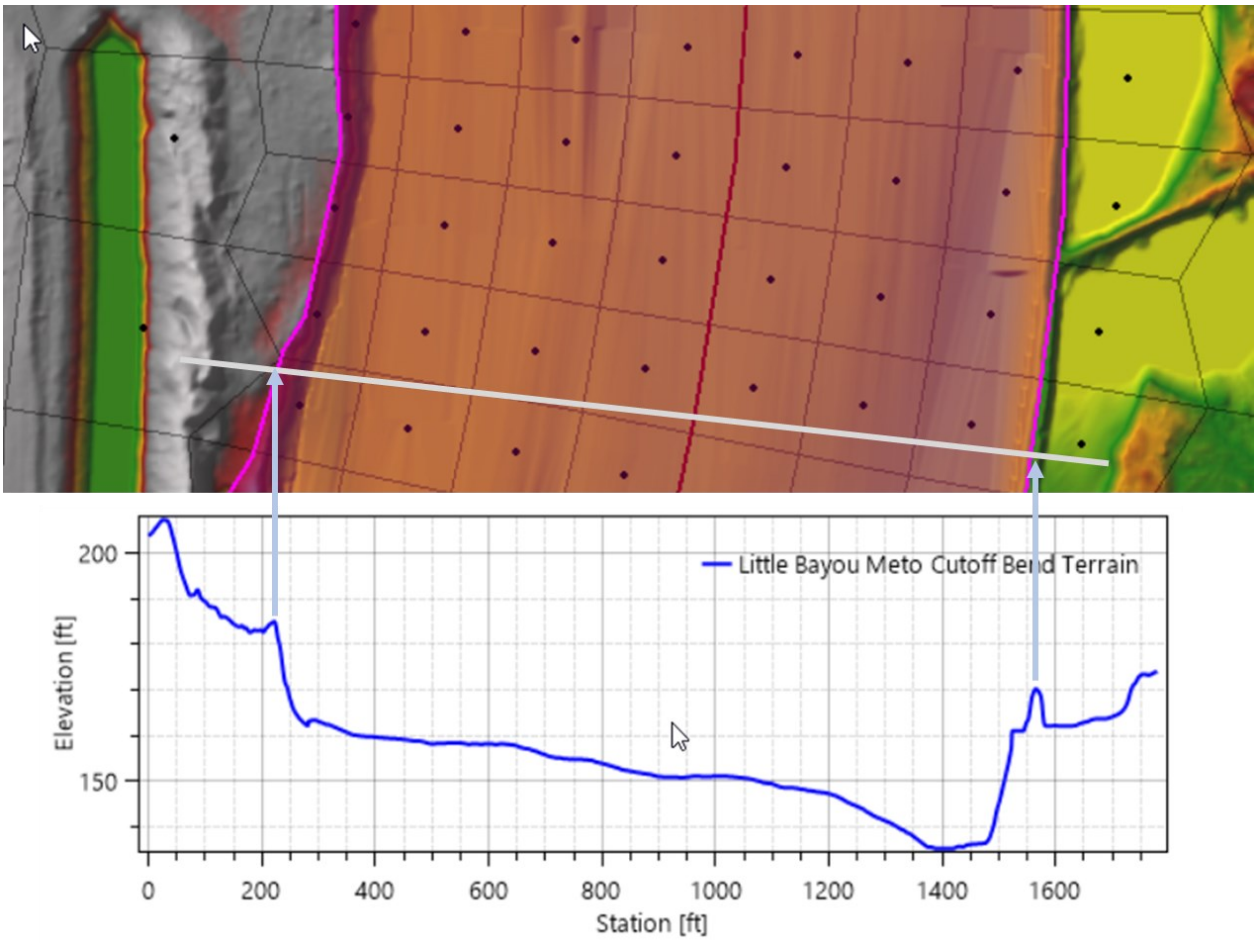


Placing the channel-defining refinement region is not always intuitive. The two cross sections indicated in the figure above are plotted in the figure below, and the illustrate the two most common approaches.

XS 1 is a little bit simpler case. The channel has high ground on both sides to follow, one is a natural ridge, and the other is a linear structure. The linear structure on the east bank is a little more complicated, but the model must have cell faces along the linear structure, so you can either use the refinement region to follow this structure and a breakline to follow the high ground, or visa versa.

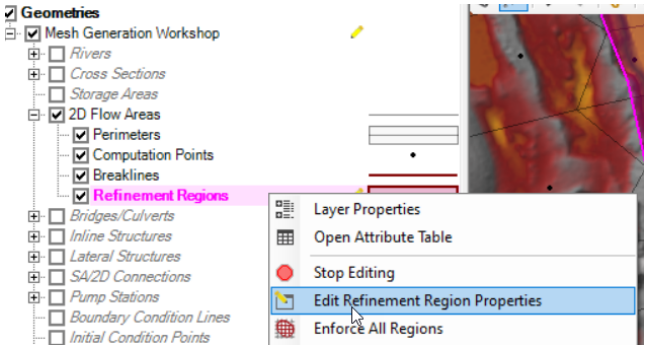
XS2 has the same linear structure, high ground on the east bank, but has a more gradual bank transition on the west bank. For banks like the west bank, without a clear high ground (which will be most of them in natural rivers) you will want to trace the bank inflection point (like you would in a 1D model). Then use a breakline to align cell faces with the high ground farther from the channel.


Little Bayou Meto Cutoff Bend Terrain
Elevation [ft]
200
180
160
0
200
400
600
800
1000
1200
1400
1600
1800
Station [ft]

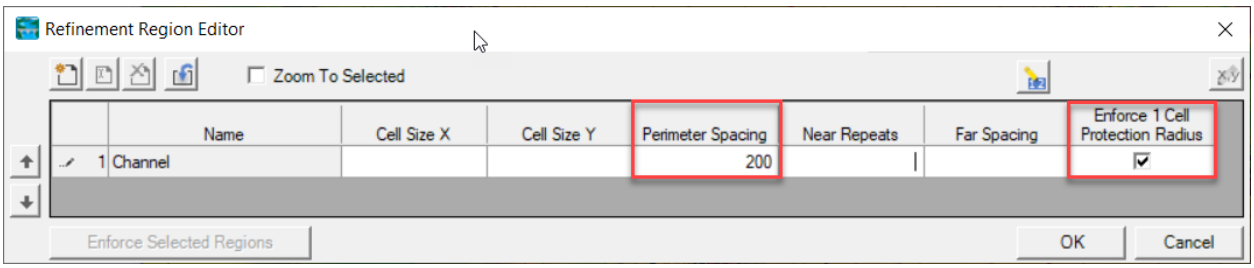

Little Bayou Meto Cutoff Bend Terrain
Elevation [ft]
200
150
0
200
400
600
800
1000
1200
1400
1600
Station [ft]

13. **<u>Define Refinement Region Properties</u>**. One of the limitations of the refinement region is that it only allows orthogonal cells outside of the near repeats. So you will essentially use the refinement region as a bounding breakline.

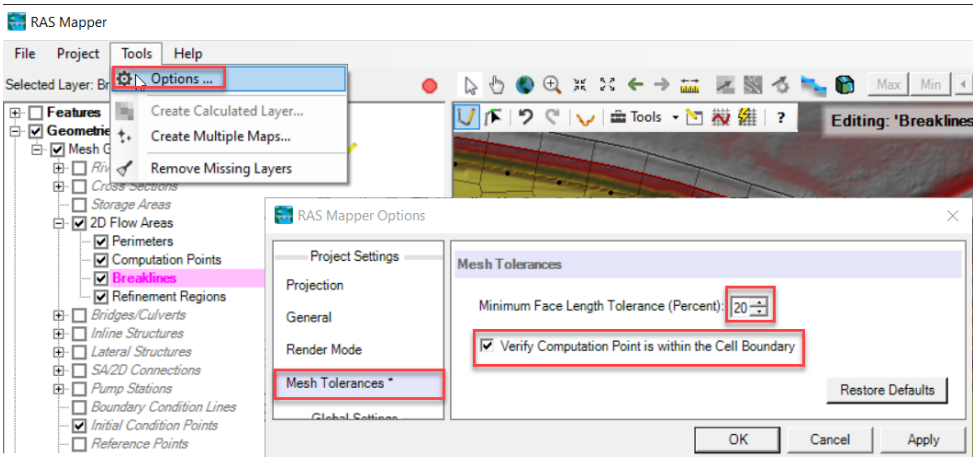
    Right click on the **Refinement Region** node under the **2D Area** in Mapper and select **Edit Refinement Region Properties**.



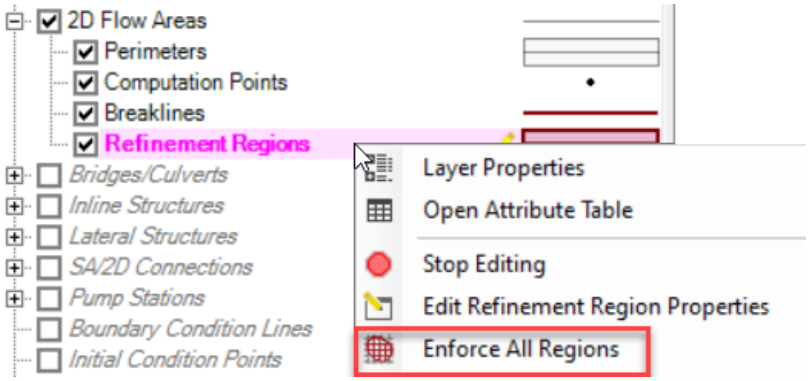
    Leave the **Cell Size X** and **Cell Size Y** blank because these will fill your region with orthogonal cells. You will only use the perimeter spacing. Set the **Perimiter Spacing** to the same cell spacing you used for your centerline breakline and make sure the **Enforce 1 Cell Protection Radius** is selected. Leave everything else blank.

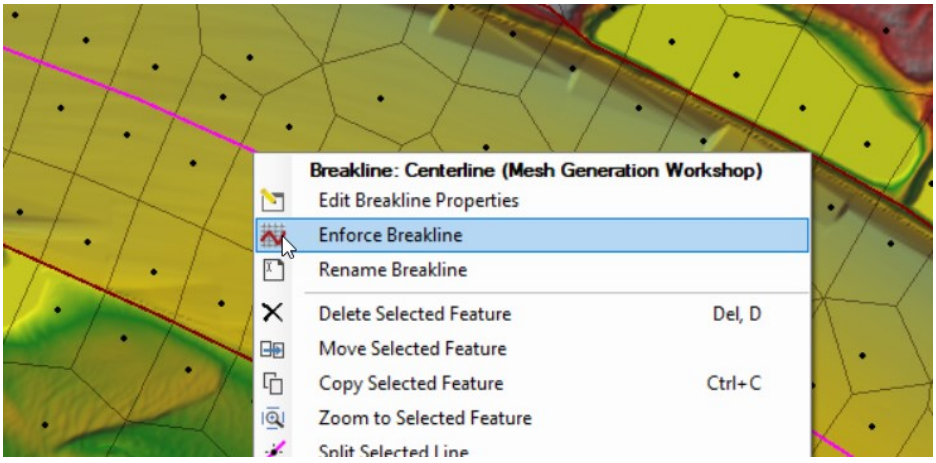


14. **<u>Set Mesh Tolerance</u>**. Before you enforce these features, increase the **Minimum Face Length Tolerance** to avoid small faces. Increase this tolerance to 20%. Choose the Tools→Options menu and click on **Mesh Tolerances** under **Project Spacing**, The default is 5%. Increase this to 20%. And while you are here, select **Verify Computation Point is Within the Cell Boundary**.

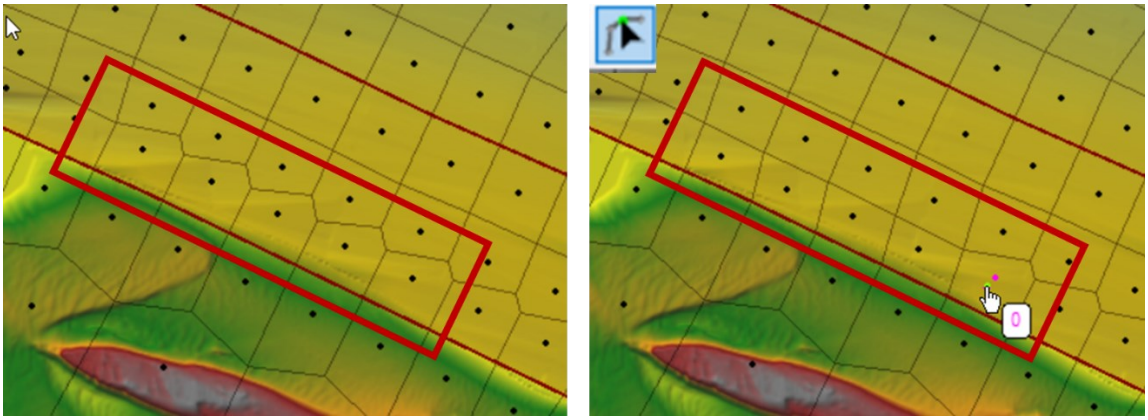


15. **<u>Enforce Refinement Region and Channel Breakline</u>**. Right click on the **Refinement Region** and choose **Enforce All Regions**. Then Enforce your centerline breakline .





At this point, I usually use edit the cell centers to align some of the channel cells that automatically formed with more than 4 faces, and can be easily aligned by moving the center point a little. If you see regions like this, experiment with finishing the alignment manually.

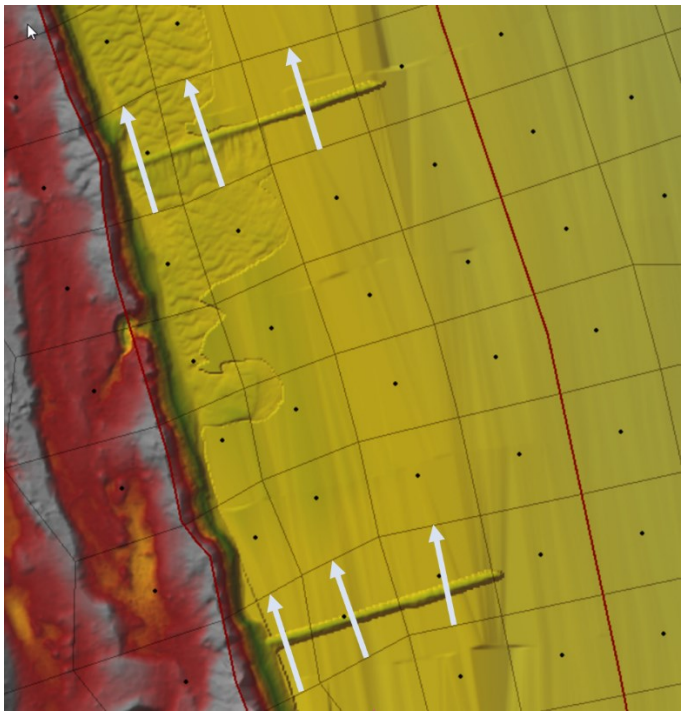


Part 5: Define Linear Channel Features with Breaklines

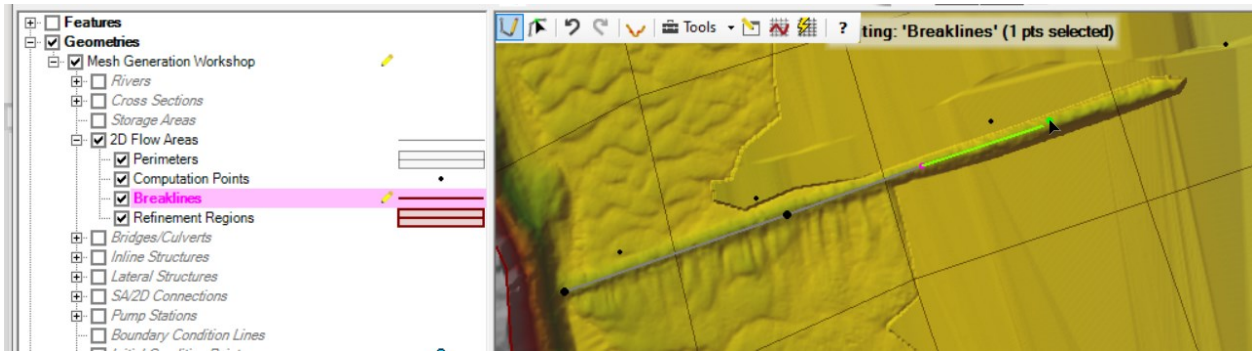
16. **Add Breaklines Along the Four Channel Features**. After you are reasonably satisfied with your basic channel mesh, it is time to add breaklines to align cell faces with any linear features in the channel.

    It is particularly important to use breaklines to align cell faces with structure in models like this, where linear, river engineering, structures influence flow and sediment (especially this model, where these are *the* feature you are evaluating).

    Find the four structures along the right (west) bank of the channel (see map on the first page). Unless you got very lucky, these structures will be almost "invisible" to the subgrid model[1] unless the cell faces follow the feature.



    Add a breakline along the center of each structure, along its entire length.



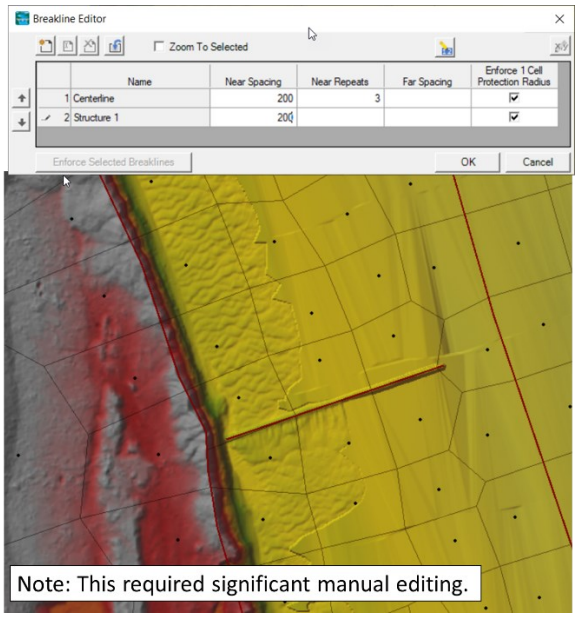
[1] They will be included in the cell's elevation-volume curve, but that effect will be trivial. The important influence is in the elevation-area curve at the cell faces, but the cell face must follow the structure to include this effect.

What mesh resolution should you choose around this feature? _____

You must choose a mesh resolution around the structure, otherwise it will default to 400ft.

200 ft will give it a similar resolution to the rest of the channel.

100 ft will provide more resolution around the feature (Near Repeats could also add local resolution) but could increase run time (especially if you use the automatic, courant-informed, time step tool).

Note: Breaklines in RAS do not always behave the way you expect, and sometimes interact with other breaklines in unexpected ways. This task may require some manual editing.

A couple options are illustrated below.