SMS 12.1 Tutorial
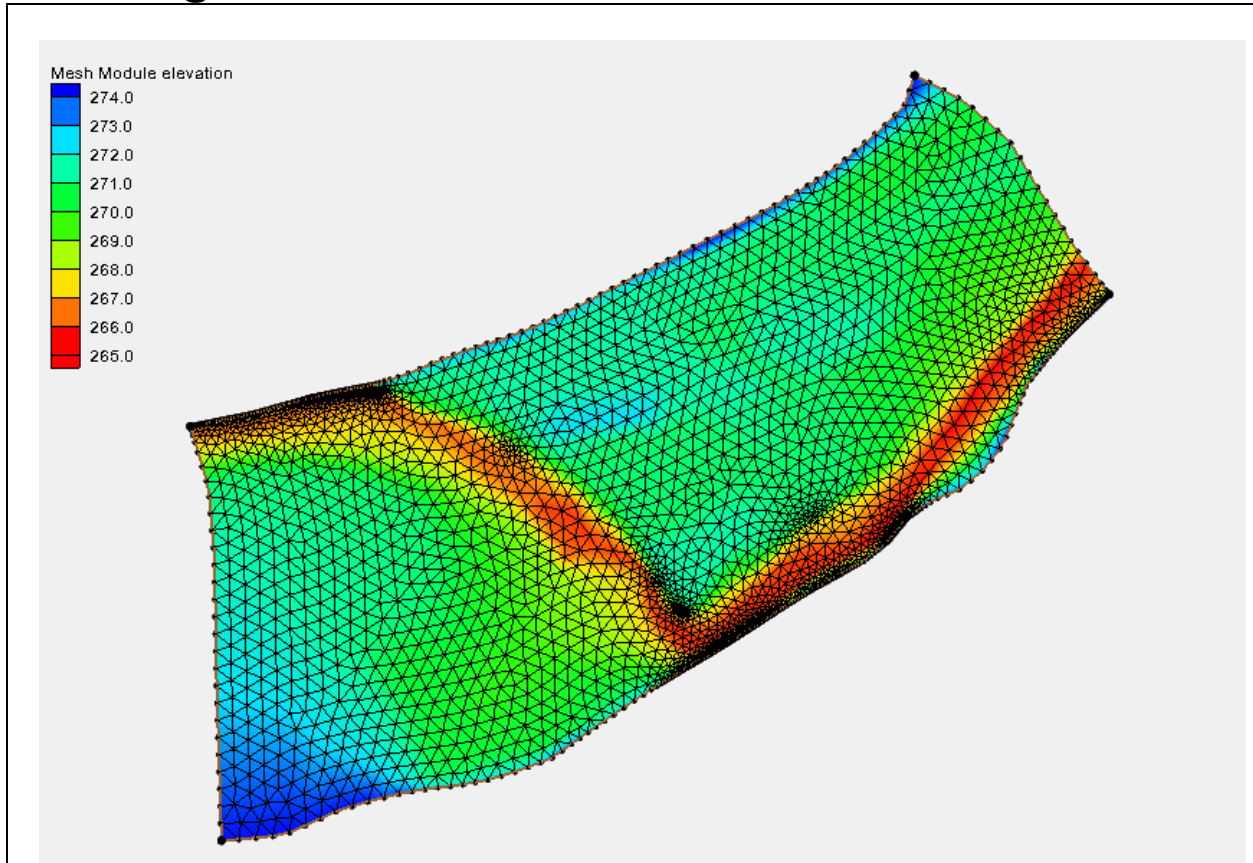
Creating a Size Function

Objectives

This lesson will instruct how to create and apply a size function to a 2d mesh model. Size functions can be created using various data. This tutorial will demonstrate how to create a size function based off of either depth, slope, or curvature.

Prerequisites	Requirements	Time
• Overview Tutorial	• Map Module • Scatter Module • Mesh Module	• 30-45 minutes

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1   Preprocessing

First, to create and change element size from a coverage, start with the following:

1. Right-click on the "Area Property" coverage in the Project Explorer and set the *Type* to *Models | ADH |* **ADH**.

2. Select the "Area Property" coverage to make it active

3. Using the **Create Feature Arc** ⌒ tool, click out four arcs forming a square.

4. Select the **Select Feature Vertex** ⚡ tool and highlight the three vertices.

5. Right-click and select the **Convert to Node** command.

6. Using the **Select Feature Point** ⚡ tool, click on the bottom left point.

7. In the edit window put in the coordinates "0.0" for *X* and *Y*.

8. Now click on the upper left point and assign its coordinates to "0.0" for *X* and "1000.0" for *Y*.

9. Click on the upper right and assign its coordinates as (1000,1000).

10. Click on the lower right point and assign its coordinates to be (1000,0). This is now a square map layer of 1000 ft^2.

11. Frame the square by clicking the **Frame** 🔍 button.

12. Right-click again on the Area Property coverage and select *Convert* | **Map→2d Scatter**.

13. In the *Map → Scatter* dialog, accept all defaults by clicking **OK**.

14. If any warning dialogs appear, click **OK**.

15. Once the scatter set is created, right-click on the "elevation" dataset and select **Rename.** Change the name to "size".

16. Click on the newly created scatter data in the project explorer to make it active.

17. Select the **Select Scatter Point** tool and click in the graphic window.

18. Right-click and choose **Select All**.

19. In the *Z* edit field put in "50". Keep in mind that this is not an elevation. It will be an element size. Figure 1 illustrates what it will look like.
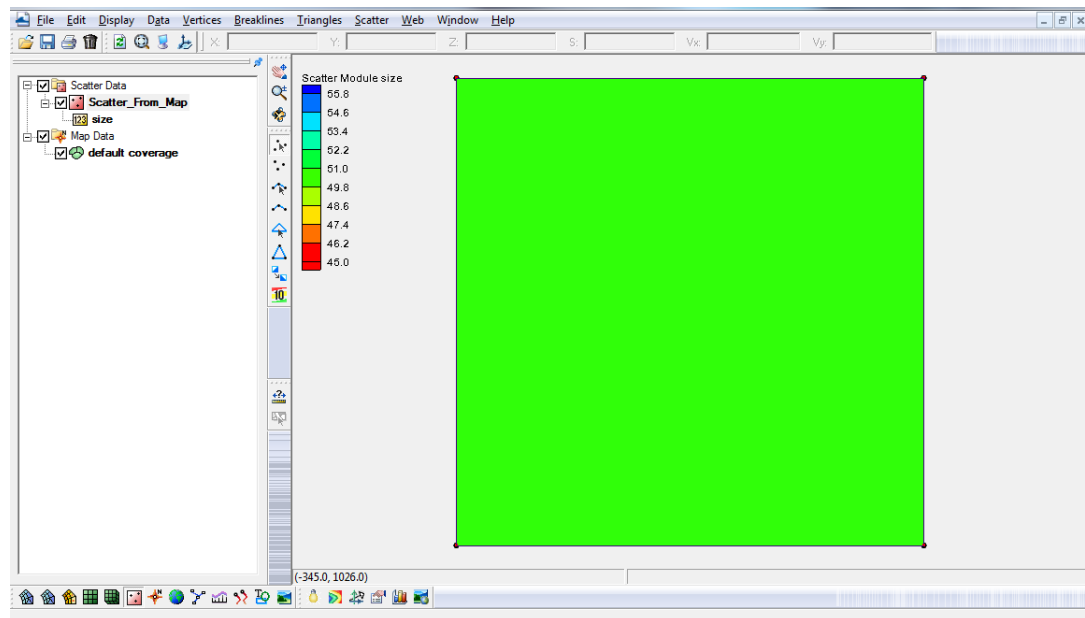

Figure 1   Pre-processing

2   Creating the Mesh

Now to create a mesh that illustrates the size of the elements. Follow these steps:

1. Click on the "Area Property" coverage to make it active.

2. Click on the *Feature Objects* menu item and choose **Build Polygons**.

3. Choose the **Select Feature Polygon** tool and double-click in the square. The *2D Mesh Polygon Properties* dialog opens.

4. Change the *Mesh Type* to "Scalar Paving Density" and click on the **Scatter Options** button. This brings up the *Interpolation* dialog.

5. In the *Interpolation* dialog, set the extrapolation *Single Value* to be "50".

6. Select the "size" as the *Scatter Set to Interpolate From*, then click **OK**.

7. Set the *Bathymetry Type* to "Scatter Set" and click on the **Scatter Options** button. The *Interpolation* dialog will appear again.

8. Repeat steps 5 and 6.

9. Close the *2D Mesh Polygon Properties* dialog by clicking **OK**.

10. Right-click on the "Area Property" coverage and select *Convert* / **Map→2d Mesh**.

11. A dialog will come up with the option to *Copy the coverage before meshing*. Leave the option checked. The coverage will be redistributed during meshing to create a new coverage. Click **OK** to create the mesh.

The project now has a mesh that has 20 elements across. Each element's length in this case is 50 feet. Figure 2 illustrates this.
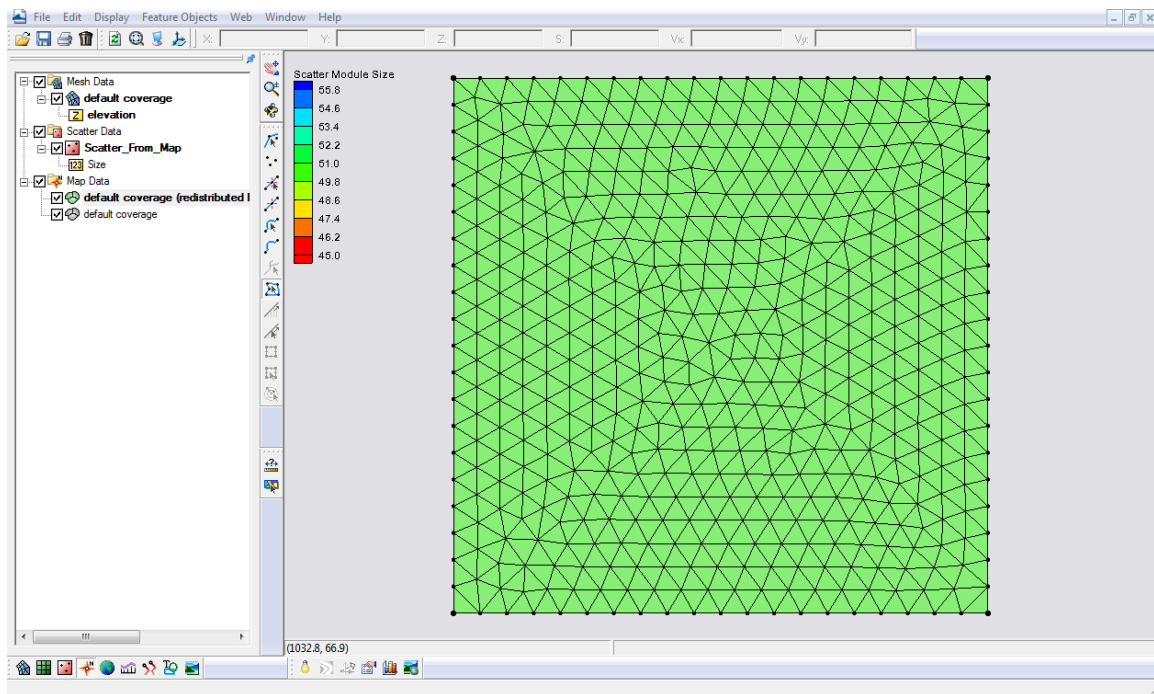
Figure 2   A created 2D Mesh

3   Size Functions

A size function determines the element size based off of a dataset that will be created by SMS. Each point is assigned a size value. This size value is the approximate size of the elements to be created in the region where the point is located. The mesh will be denser where the size values are smaller. Size functions can be based off of different criteria. This tutorial will show size functions based on either depth, slope, or curvature of the model.

4   Size Function Based on Depth

Many coastal models utilize a size function based on depth. As the depth gets shallower, the elements should get smaller. The model will become finer near areas of interest and coarser at deep water areas that are less significant.

1.   Select *File* / **Delete All.**

2. Select *File* / **Open.**

3. Using the *Open* dialog, open the "shin.pts" file.

4. If the *Open File Format* dialog appears, select *Use Import Wizard* and click **OK**.

5. In the *File Import Wizard*, make certain the *Space* option is toggled on, then click **Next**, then **Finish**.

6. Select *Display* / **Projection**. The *Display Projection* dialog should appear.

7. Select the *Global projection* option to bring up the *Select Projection* dialog. If this dialog doesn't appear automatically, use the **Set Projection** button.

8. In the *Select Projection* dialog, set the *Projection* to "UTM", *Zone* to "18 (78 W - 72 W - Northern Hemisphere)", *Datum* to "NAD27", *Planar Units* to "Meters". Select **OK** when done.

9. Back in the *Display Projection* dialog, make certain the *Vertical Units* are set to "Meters" then click **OK**.

10. Click on the "shin" scatter data item in the project explorer to make it active.

11. Right-click the "elevation" dataset underneath and use the **Rename** command to name it to "Positive Depth". This is just to distinguish the fact that this is a depth dataset rather than elevations.

12. With the shin scatter data still active, select *Data* / **Data Calculator**.

    To create a size function based on depth, the following equation is used:

$$\left(\left(\frac{positive\ depth - minimum\ depth}{maximum\ depth - minimum\ depth} \right) * (maximum\ size - minimum\ size) + minimum\ size \right)$$

13. In the *Data Calculator*, type in the following equation in the *Calculator* edit field:

$$(d1-1) / (62.0077-1) * (3000-500) + 500$$

14. Put "size_3000_to_500" as the *Output dataset name*, click **Compute** and then **Done**. The new dataset should appear in the project explorer under "shin".

15. Select *File* / **Open.**

16. Using the *Open* dialog, open the "shin.grd" file. A "Mesh" dataset should appear in the project explorer.

17. Right-click on "Mesh" in the Project Explorer and select **Reproject.**

18. In the warning dialog that appears, click **Yes** to continue. The *Reproject Object* dialog should appear.

19. In the *Current projection* portion of the dialog, toggle on the *Set* option.

20. Select the *Global projection* option, click the **Set Projection** button.

21. In the *Select Projection* dialog, change the *Projection* to "Geographic (Latitude/Longitude)", the *Datum* to "NAD83" with *Planar Units* of "ARC DEGREES" and click **OK**.

22. Back in the *Reproject Object* dialog, set the *Vertical Units* to "Meters".

23. Verify that the *New projection* section is set with the same coordinate system as the project (see step 8) and click **OK**. The mesh should now display on top of the scatter set.

24. Make sure the mesh module is active and right-click on the mesh item in the project explorer. Select *Convert* / **Mesh → Map**.

25. In the *Mesh → Map* dialog, select the option to convert *Mesh Boundaries → Polygons*.

26. Click **Create New Coverage**. The *New Coverage* dialog should appear.

27. In the dialog change the *Coverage Type* to *ADH*, change the *Coverage Name* to "ADH" and click **OK** twice to close both dialogs.

28. Select the "ADH" coverage to make it active, choose the **Select Feature Polygon** tool and double click in the middle of the polygon.

29. In the *2D Mesh Polygon Attributes* dialog, set the *Mesh Type* to "Scalar Paving Density"*, then click on the **Scatter Options** button.

30. In the *Interpolation* dialog, set the *Scatter set to interpolate from* as "size_3000_to_500". Click **OK**.

31. Back in the *2D Mesh Polygon Attributes* dialog, set the *Bathymetry Type* to "Scatter Set"*, then click on the **Scatter Options** button.

32. In the *Interpolation* dialog, select "Positive Depth" as the *Scatter set to interpolate from*. Click **OK**.

33. Close the *2D Mesh Polygon Attributes* dialog by clicking **OK**.

34. Right-click on the "ADH" coverage and select *Convert* / **Map → 2D Mesh**.

35. Click **OK** to the *2D Mesh Options* dialog.

36. Click **OK** to an extrapolation warning and a mesh will appear.

37. Be sure to turn off the scatter data to see the mesh. Figure 3 shows what it looks like. Notice how element size decreases as depth decreases. It may be helpful to turn on the *Contour* option in the *Mesh Display Options* .
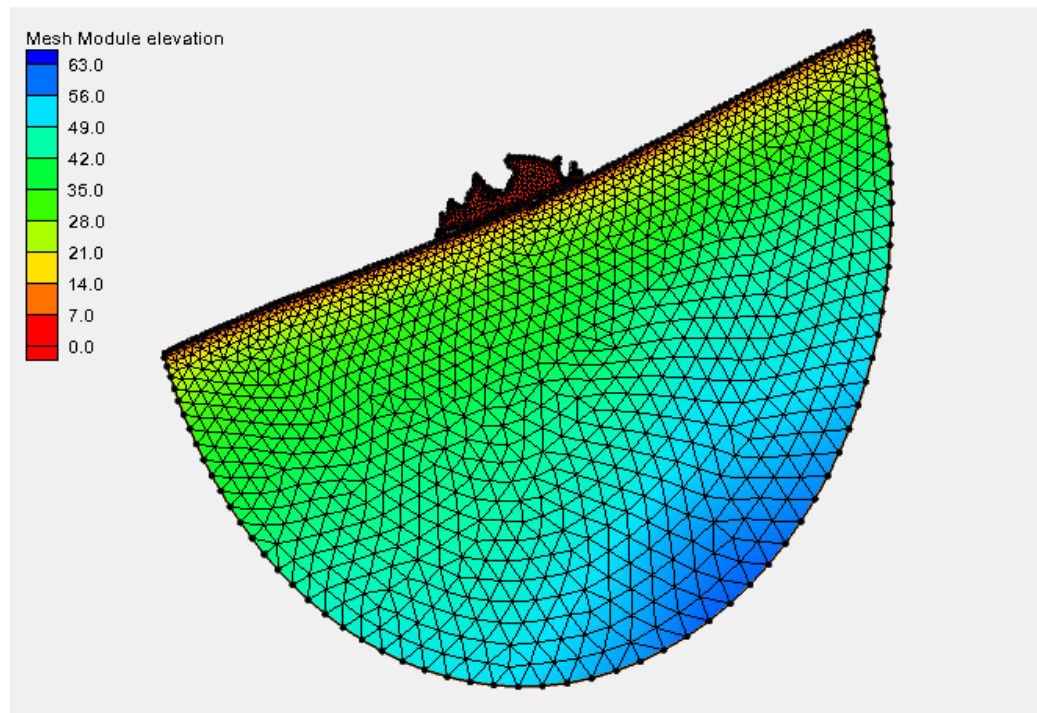
Figure 3   Mesh showing size function based on depth

4.1   Smoothing Data

Now that the project has a mesh, notice that the elements change size rather abruptly. In order to have the element size change more gradually, it's necessary to create a smoothing dataset.

1. Make sure the scatter module is active, and select *Data* / **Dataset Toolbox**.

2. In the *Dataset Toolbox* window, switch the tool to the *Smooth datasets* option on the left side, then choose *size_3000_to_500* as the dataset.

3. Set the *Area change limit* to "0.5", and the *Anchor type* to *Minimum value*. A minimum value anchor will ensure that the smallest element will stay the same size, and the bigger elements will change.

4. Set the *Output dataset name* to "Smooth_0.5".

5. Click **Compute**, then **Done**.

6. Click on the "ADH" coverage to make it active, and with the **Select Feature Polygon** tool, double-click in the polygon.

7. In the *2D Mesh Polygon Properties* dialog, make sure that the Mesh Type is still set to "Scalar Paving Density" and select the **Scatter Options** button.

8. In the *Interpolation* dialog, change the *Scatter set to interpolate from* to "Smooth_0.5" and then click **OK** twice to close both dialogs.

9. Right-click on the "ADH" coverage and select *Convert* / **Map →2D mesh**.

10. Click **OK** on the *2D Mesh Options* dialog.

11. Click **OK** to the extrapolation warning.

12. Notice that the element size changes a bit more gradually than before as shown in Figure 4.
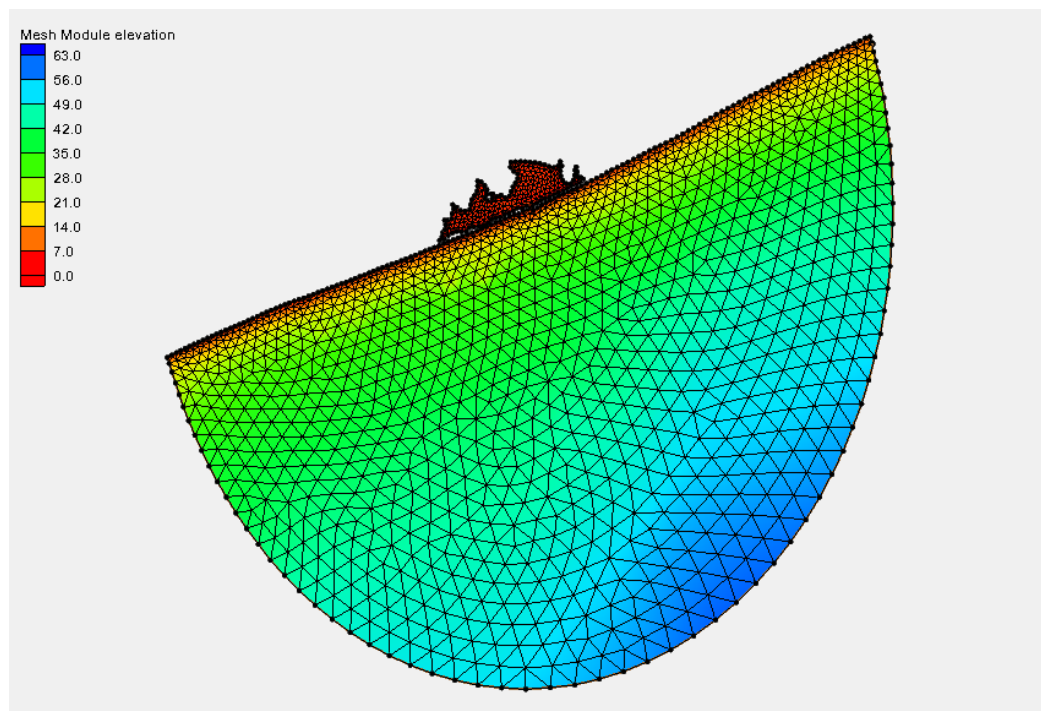
Figure 4   Mesh showing size function based on depth after smoothing

5   Size Function based on Slope

Size functions based on slope are helpful when analyzing slope data because as the rate of change of the gradient increases, the smaller the mesh element becomes. Size functions based on slope are mostly applied to river models. The tutorial will use survey data from the Cimarron river to create the size function.

5.1   Preprocessing

1.   Select *File* / **Delete All** to delete the shinnecock bay coastal model.

2.   Select *File* / **Open** and open the "Cimarron Survey 2005.h5" file.

3.   Select *Display* / **Display Options** to bring up the *Display Options* dialog.

4.   In the dialog, turn off the scatter set *Points* option, turn on the *Contours* option then click on the *Contours* tab.

5. In the *Contour* tab change the *Contour method* to "Color Fill". The contours may already be turned on. Figure 5 shows the contoured data.
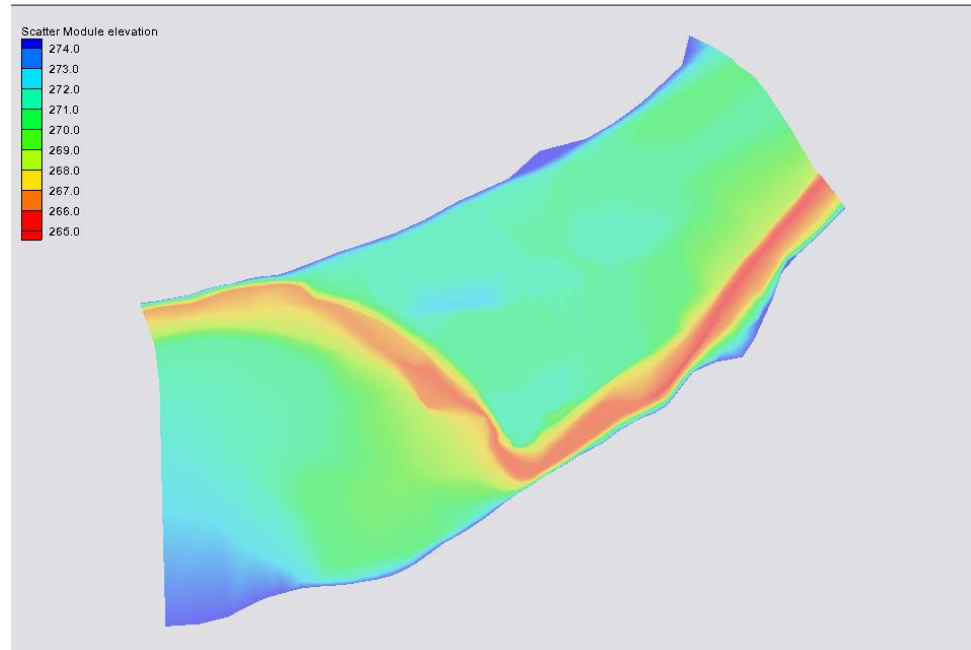

Figure 5   Scatter set using the contour color fill option

6. Right-click on the "Survey 2005" scatter data in the project explorer and select *Convert* / **Scatter Boundary →Map**.

7. Right-click the "Area Property" coverage and select **Rename**. Change the name to "Cimmaron River".

8. Right-click the coverage and set the *Type* to *Models* / *ADH* / **ADH**.

9. With the map module active, select the corner nodes with the **Select Feature Vertex** tool. Use the *Shift* key when selecting each corner.

10. When all four corners are selected, right-click and choose **Convert to Nodes**.

11. Figure 6 shows a node to the right of the lower left corner node. Select it with the **Select Feature Point** tool,
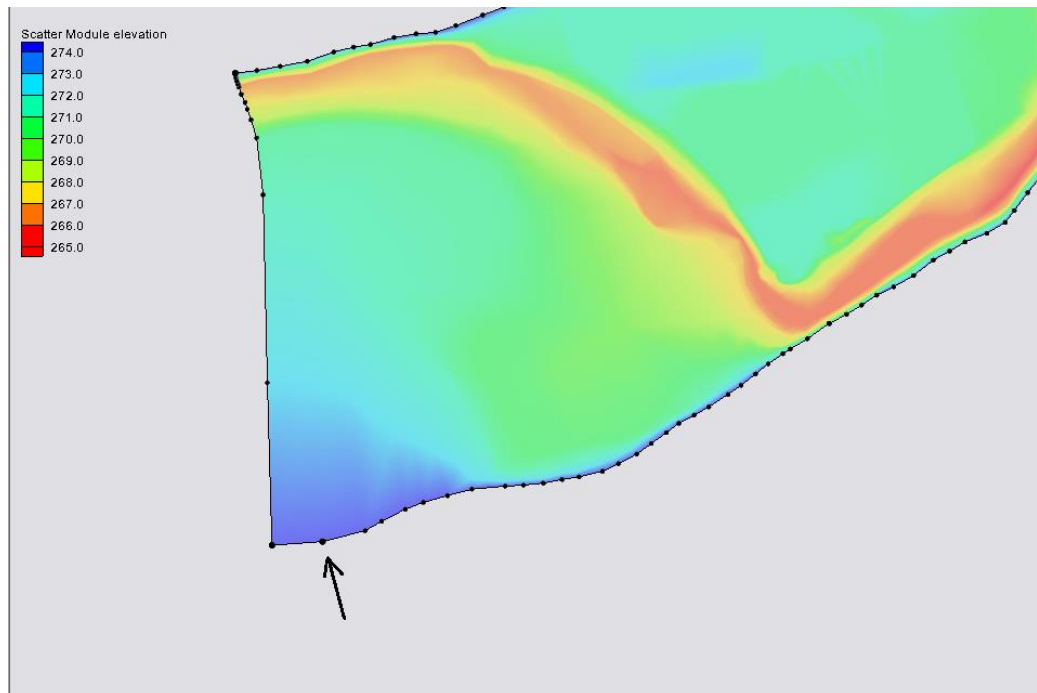
12. Right-click and choose **Convert to Vertex**.

Figure 6   Vertices converted to nodes

13. With the "Cimmaron River" coverage active, highlight the arcs using the **Select Feature Arcs** tool. Use the *Shift* key to make certain all of the arcs are included in the selection.

14. Right-click and select **Redistribute Vertices**.

15. In the *Redistribute Vertices* dialog, make sure that *Specify* is set to "Specified Spacing" and set the specified *Spacing* to be "200" m. Click **OK**.

16. In order to eliminate extrapolation values, make sure that the vertices lie within the scatter data. Use the **Select Feature Vertex** tool to move in each vertex inside the scatter set so that SMS does not extrapolate any values outside of the scatter data.

17. Use the **Select Feature Arcs** tool and select all 4 feature arcs.

18. Right-click and choose **Redistribute Vertices** again.

19. In the dialog, make sure that *Specify* is set to "Specified spacing" and set the specified *Spacing* to be "90" m now. Click **OK**. All of the vertices and nodes should be inside the scatter data. Figure 7 shows this.
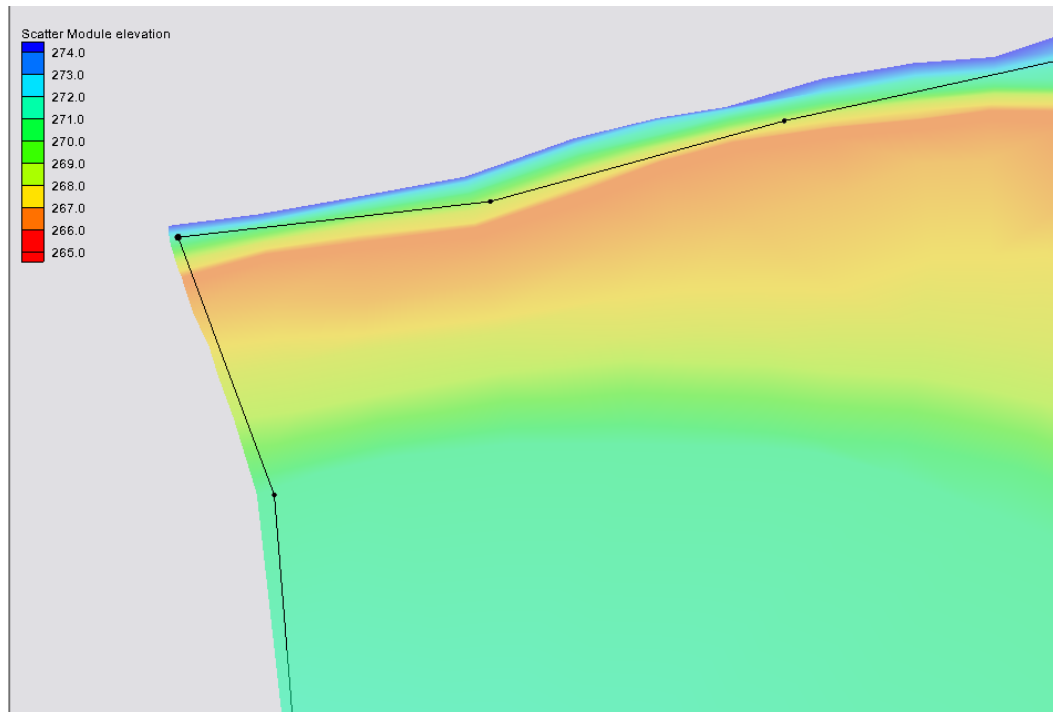
Figure 7   Vertices and nodes inside of the scatter data

5.2   Creating a Fixed Gradient Dataset

1. Click on the scatter item in the project explorer to make sure it is activated. Select *Data* / **Dataset Toolbox**.

2. Select *Geometry* in the *Tools* section. Choose "Elevation" as the *Dataset* and unselect *Gradient angle* and *Directional derivative*. Click **Compute** then **Done**. There is now a gradient dataset.

3. Right-click on the newly created dataset and select **Dataset Contour Options**.

4. Set the *Contour method* to "Color Fill". Toggle on *Specify a range* in the *Data range* section and specify the *Max* as "0.33" and *Min* as "0". Specifying this range for the contours helps us see the data we are interested in. Click **OK**.

5. Make sure the scatter data is active in the project explorer and go to *Data* | **Data Calculator**.

6. In the *Calculator* edit field, click on **min** then double-click on the *Geom Gradient* dataset adding it to the expression, and then replace the remaining "??" with "0.33". This creates a dataset where 0.33 is the fixed maximum gradient.

7. Enter an *Output dataset name* of "Geom Gradient Fixed". Click **Compute** then **Done**.

5.3   Creating the Size Function

1.   Go to *Data* | **Data Calculator** again. Next is to create our size function based on slope using this equation:

$$\max\ size - \left(\frac{(slope - \min\ slope)}{(\max\ slope - \min\ slope)} \right) * (\max size - \min size)$$

2. In the *Calculator* edit field, put in this equation:

      50 - ((d3-0)/(.33 - 0)) * (50 - 5)

3. Enter an *Output dataset name* of "Gradient Size 5to50" then click **Compute** and **Done**.

The project now has a size function based on slope. However, there is still one more dataset we need to create before we create our mesh.

5.4   Smoothing the Size Function

1.   Go back to *Data* | **Data Calculator**.

2. Choose *Smooth Datasets* in the tools section. In the *Datasets* section, make sure that "Gradient Size 5to50" is selected. Set the *Output Dataset name* to be "Gradient Size 5to50 Smooth 0.5". Then select **Compute** then **Done**.

5.5   Creating the Mesh

1. Make sure the Map module is active and select *Feature Objects* / **Build Polygons**.

2. Next use the **Select Feature Polygon** tool and double-click the map polygon.

3. In the *2D Mesh Polygon Properties* dialog, make sure that the *Mesh Type* is set to "Scalar Paving Density", and click on the **Scatter Options** button underneath.

4. In the *Interpolation* dialog, choose "Gradient Size 5to50 smooth 0.5" for the *Scatter Set to Interpolate From*, then click **OK**.

5. Make sure that *Bathymetry Type* is set to "Scatter Set" then click **Scatter Options**.

6. In the *Interpolation* dialog, choose "elevation" for the *Scatter Set to Interpolate From*, then click **OK** twice.

7. Now, right-click on the "Cimmaron River "coverage and select *Convert* / **Map →2D Mesh**.

8. In the *2D Mesh Options* dialog, click **OK**.

9. Now click **OK** again on the next two windows.

The project now has a mesh with finer elements to represent higher gradients.
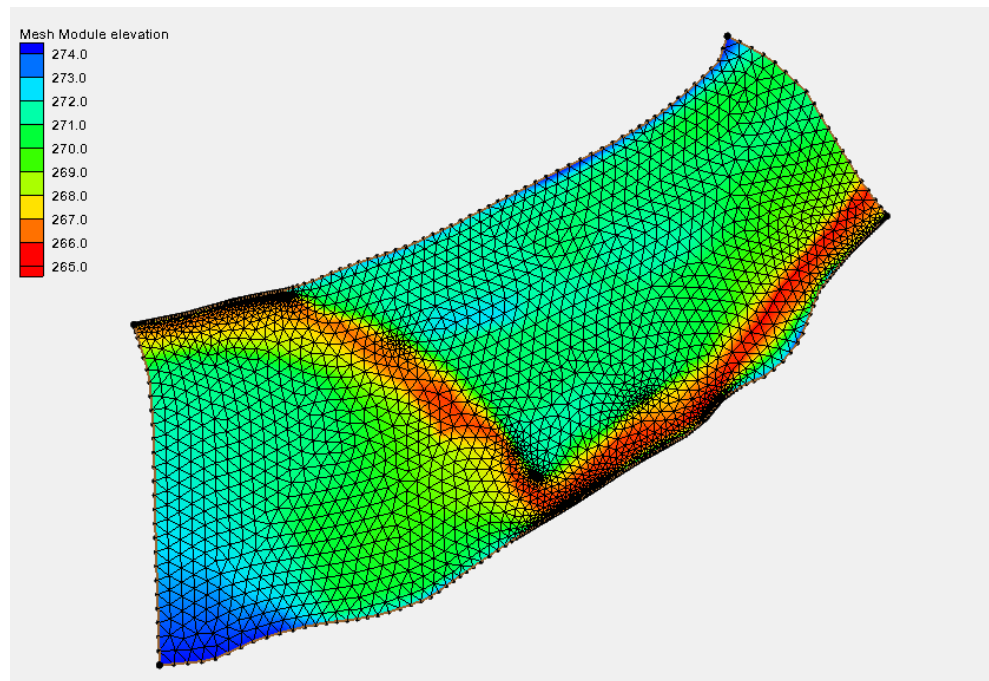
Figure 8   Mesh with finer elements to represent higher gradients

6   Size Function based on Curvature

A curvature dataset is made by taking the slope of the slope (gradient) data. To create a size function based on the curvature we will build upon the data that we already have.

6.1   Creating a Curvature Dataset

1. With the scatter module active, select *Data* | **Data Calculator**

2. Select *Geometry* in the *Tools* section. Select "Geom Gradient Fixed" as the *Dataset* to interpolate from. Uncheck *Gradient Angle* and *Directional derivative,* leaving only *Gradient* checked. Set the *Output Dataset Name* to be "Curvature". Click **Compute** and **Done**.

3. Right-click on the newly created dataset. Select **Info**.

4. In the *Dataset Info* dialog, copy the maximum. This will use this for a later equation. This is the same equation as previously used, found in step 1 of 5.3.

5. Close the *Dataset Info* dialog.

6.2   Creating the Size Function

1. Open the *Data Calculator* again, and in the *Calculator* edit field, put in the following equation:

    50 - ((d6-0) / (0.0488655 - 0)) * (50-5)

2. Set the *Output dataset name* to "Curvature size 5to50" and click Compute then Done.

6.3   Smoothing the Size Function

1. Go back to the *Data Calculator*.

2. Select *Smooth Datasets* from the *Tools* section and select *Curvature size 5to50,* then make sure the *Area change limit* is set to "0.5" and the *Anchor type* is set to *Minimum Value*.

3. Set the *Output dataset name* to "Curvature size 5to50 Smooth 0.5". Click Compute, then Done.

6.4   Creating the Mesh

1. With the "Cimmaron River" coverage active, choose the **Select Feature Polygon** tool and double-click the boundary polygon.
2. Make sure that the *Mesh Type* is set to "Scalar Paving Density", and click on the **Scatter Options** button underneath.
3. Choose "Curvature Size 5to50 smooth 0.5" for the *Scatter set to interpolate from*, then click **OK**.
4. Make sure that *Bathymetry Type* is set to "Scatter Set" then click **Scatter Options**.
5. In the *Interpolation* dialog, select "elevation" for the *Scatter set to interpolate from*, then click **OK** twice.
6. Now, right-click on the "Cimmaron River" coverage and select *Convert | **Map →2D Mesh**.
7. Click **OK** for the *2D Mesh Options* dialog.
8. Now click **OK** for the remaining two windows.

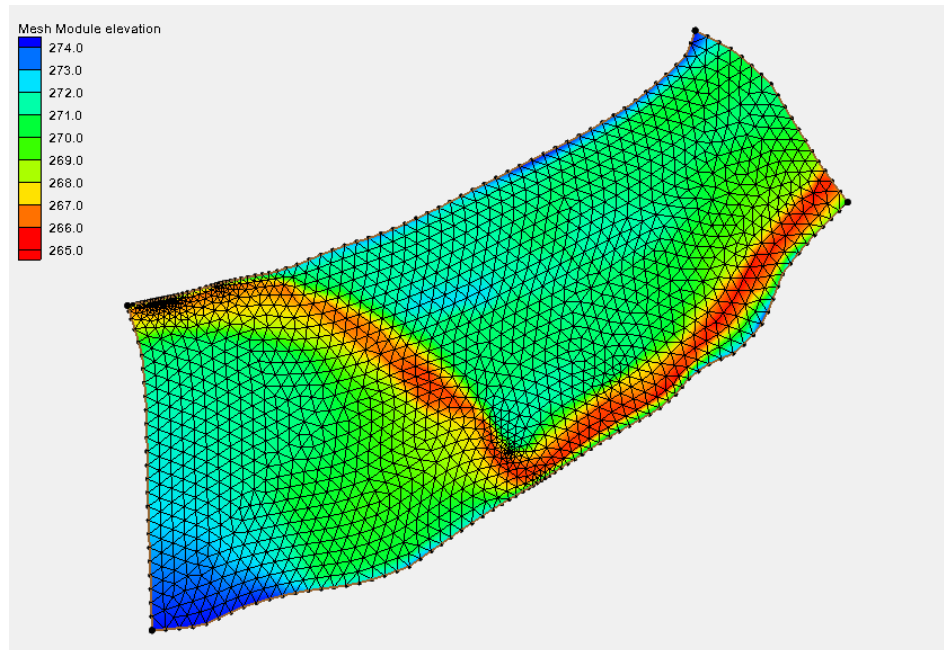There is now a mesh with finer elements to represent greater curvature.

Figure 9   Mesh with finer elements to represent greater curvature

7   Conclusion

Size functions can be created using many different types of datasets. Some datasets work better for different models. A size function in a coastal model would most likely be based on depth. A size function in a riverine model might be based on slope, etc.

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