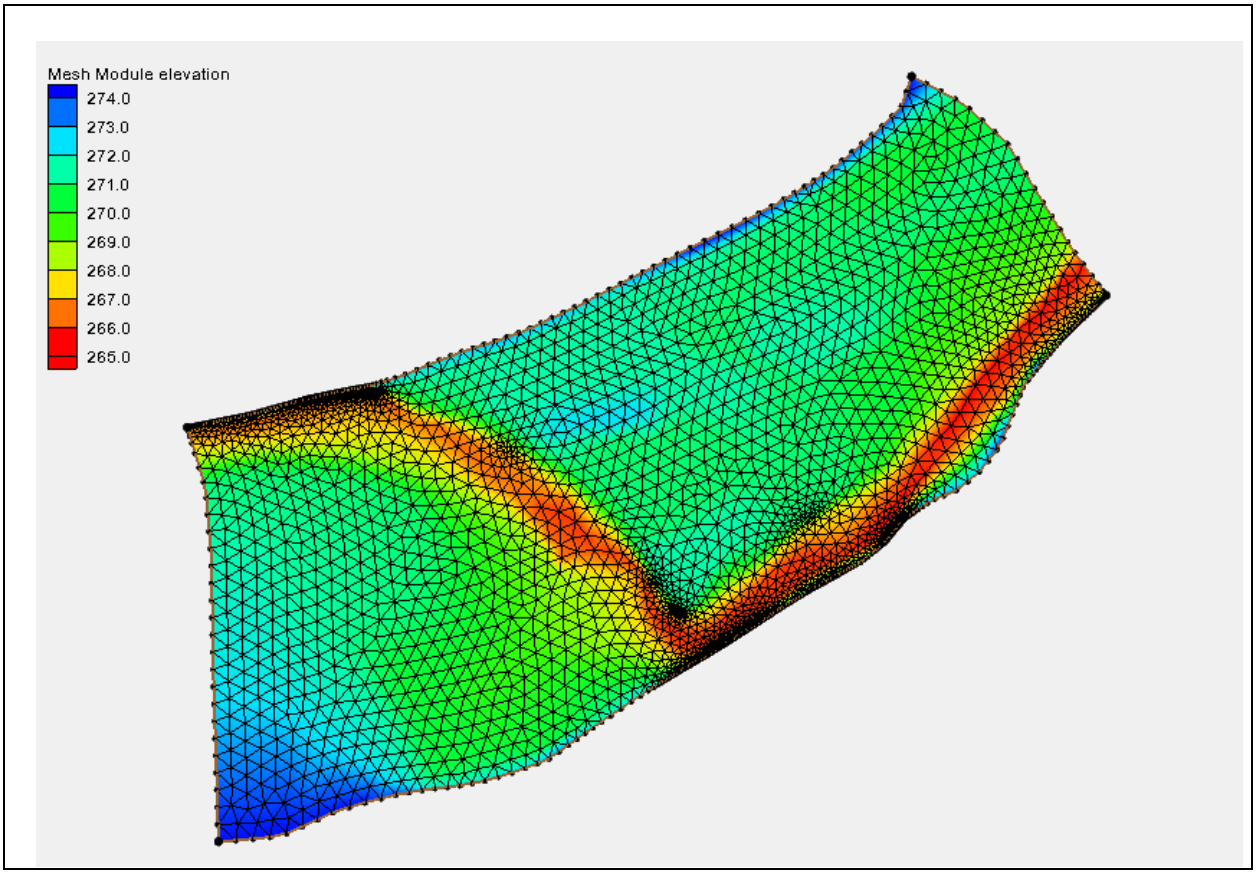
SMS

v. 12.3

SMS 12.3 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 depth, slope, or curvature.

Prerequisites

- Overview Tutorial

Requirements

- Map Module
- Scatter Module
- Mesh Module

Time

- 30–45 minutes

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1 Introduction

A size function determines the element size based on a dataset 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 on different criteria.

This tutorial will show size functions based on depth, slope, or curvature of the model.

2 Preprocessing

First to create the elements from a coverage and change the element size by doing the following:

1. Right-click on "Area Property" in the Project Explorer and select *Type* | *Models* | *ADH* | **ADH**.
2. Select " Area Property" to make it active
3. Using the **Create Feature Arc** tool, click out four arcs forming a square.

The exact placement of the square doesn't matter as the coordinates for each corner will be adjusted later.

4. Using the **Select Feature Vertex** tool, hold down the *Shift* key and select the three vertices.
5. Right-click and select **Convert to Nodes**.
6. Using the **Select Feature Point** tool, select the lower left node and enter "0.0" for both *X* and *Y* coordinates in the Edit Window.
7. Repeat step 6 for the upper left node, entering "0.0" for *X* and "1000.0" for *Y*.
8. Repeat step 6 for the upper right node, entering "1000.0" for both *X* and *Y*.

9. Repeat step 6 for the lower right node, entering "1000.0" for *X* and "0.0" for *Y*.
10. **Frame** the project.

This is now a square map layer of 1000 ft^2.

11. Right-click on "Area Property" and select *Convert* | **Map → 2D Scatter** to bring up the *Map → Scatter* dialog.
12. Click **OK** to accept the defaults and close the *Map → Scatter* dialog.
13. If advised there are no triangles to check, click **OK** to create the scatter set.
14. Right-click on "elevation" and select **Rename.**
15. Enter "size" and press *Enter* to set the new name.
16. Select "size" to make it active.
17. Using the **Select Scatter Point** tool, right-click in the Graphics Window and select **Select All**.
18. Enter "50.0" in the *Z* edit field.

Keep in mind that this is an element size, not an elevation.

19. Click **Display Options** to bring up the *Display Options* dialog.
20. Select "Scatter" from the list on the left.
21. On the *Scatter* tab, turn on *Points* and *Contours*.
22. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
23. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 1.

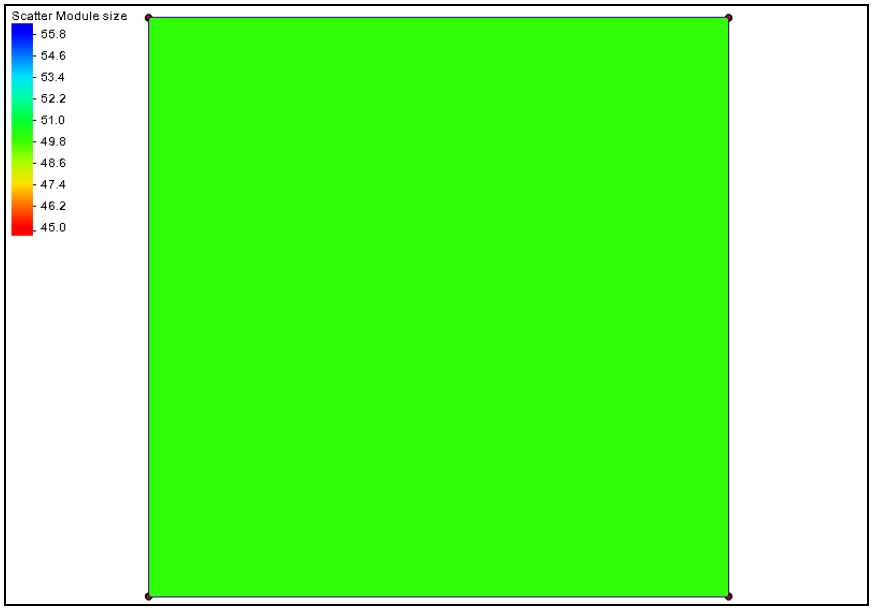

Figure 1 The initial project after adjusting element size and turning on contours

3 Creating the Mesh

Now to create a mesh that illustrates the size of the elements by doing the following:

1. Select "Area Property" to make it active.
2. Select *Feature Objects* | **Build Polygons**.
3. Using the **Select Feature Polygon** tool, double-click in the square to bring up the *2D Mesh Polygon Properties* dialog.
4. In the *Mesh Type* section, select "Scalar Paving Density" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
5. In the *Interpolation Options* section, enter "50.0" as the *Single Value*.
6. In the *Scatter Set to Interpolate From* section, select "size" from the tree list.
7. Click **OK** to close the *Interpolation* dialog.
8. In the *Bathymetry Type* section, select "Scatter Set" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
9. Repeat steps 5–7.
10. Close the *2D Mesh Polygon Properties* dialog by clicking **OK**.
11. Right-click on "Area Property" and select *Convert* | **Map→2D Mesh** to bring up the *2D Mesh Options* dialog.
12. Make sure that *Copy the coverage before meshing* is turned on and click **OK** to close the *2D Mesh Options* dialog and bring up the *Mesh Name* dialog.
13. Click **OK** to accept the default *Mesh name* and close the *Mesh Name* dialog.

The "Area Property" coverage was redistributed during meshing to create a new coverage. The project now has a mesh with 20 elements across (Figure 2). Each element's length in this case is 50 feet.

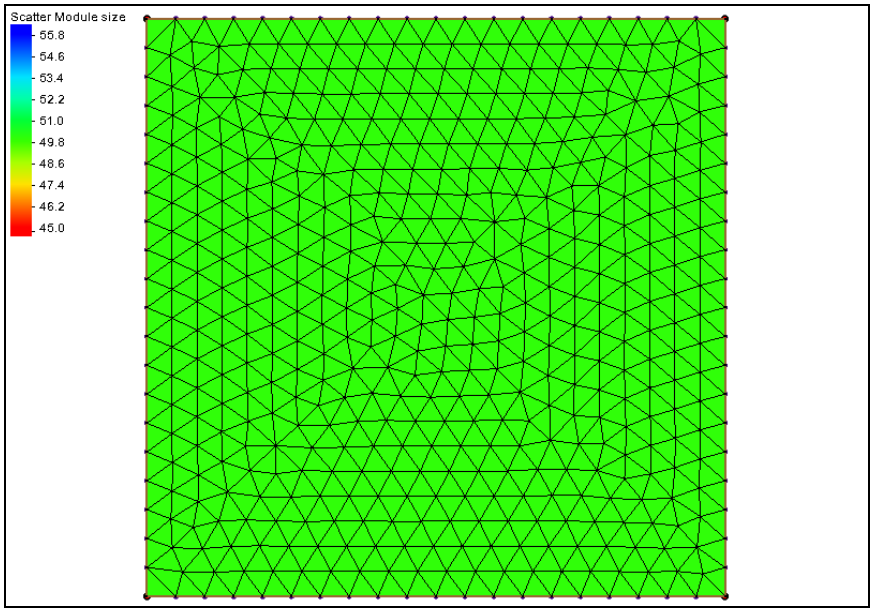

Figure 2 The new 2D mesh created from a redistributed coverage

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.

4.1 Importing and Setting Up the Scatter Set

To import the scatter set, do the following:

1. Select *File* | **Delete All**.
2. If asked to confirm deletion of all data, click **Yes**.
3. Select *File* | **Open...** to bring up the *Open* dialog.
4. Browse to the *Data Files*\ folder for this tutorial and select "shin.pts".
5. Click **Open** to exit the *Open* dialog and bring up the *Open File Format* dialog.
6. Select *Use Import Wizard* and click **OK** to close the *Open File Format* dialog and bring up the *Step 1 of 2* page of the *File Import Wizard* dialog.
7. In the *File import options* section, turn on *Space* and click **Next** to go to the *Step 2 of 2* page of the *File Import Wizard* dialog.
8. Click **Finish** to close the *File Import Wizard* dialog.

The project should appear similar to Figure 3.

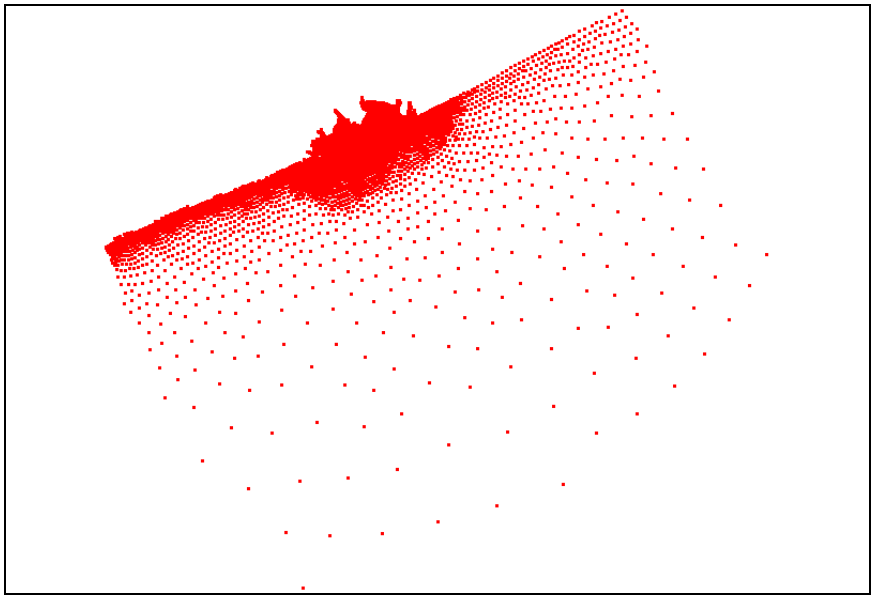

Figure 3 Initial Shinnecock Bay scatter set

Now to set up the projection for the scatter set by doing the following:

1. Select *Display* | **Projection…** to bring up the *Display Projection* dialog.
2. In the Horizontal section, select *Global projection* to bring up the *Select Projection* dialog. If this dialog doesn't appear automatically, click **Set Projection…** to bring up the dialog.

3. Select "UTM" from the *Projection* drop-down.
4. Select "18 (78 W -72 W - Northern Hemisphere)" from the *Zone* drop-down.
5. Select "NAD27" from the *Datum* drop-down.
6. Select "Meters" from the *Planar Units* drop-down.
7. Click **OK** to close the *Select Projection* dialog.
8. In the *Vertical* section, select "Meters" from the *Units* drop-down.
9. Click **OK** to close the *Display Projection* dialog.
10. Select "  shin" in the Project Explorer to make it active.
11. Right-click on "  depth_bathymetry" and select **Rename**.
12. Enter "Positive Depth" and press *Enter* to set the new name.

This identifies this as a depth dataset rather than an elevation dataset.

13. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
14. In the *Tools* section, select "Data Calculator" from the tree list.

The following equation is used to create a size function based on depth:

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

15. In the *Data Calculator* section, in the *Calculator* subsection, enter "(d1-1) / (62.0077-1) * (3000-500) + 500".
16. Enter "size_3000_to_500" as the *Output dataset name* and click **Compute**.
17. Click **Done**.

There should be a new "  size_3000_to_500" dataset under "  shin" in the Project Explorer.

4.2 Importing and Setting Up the Mesh

Do the following to import and set up the mesh:

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Select "shin.grd" and click **Open** to exit the *Open* dialog.

A new "  Mesh" should appear in the Project Explorer and the project should appear similar to Figure 4.

3. Right-click on "  Mesh" in the Project Explorer and select **Reproject** to bring up the *Reproject Object* dialog.
4. If warned about round-off errors, click **Yes** to continue.
5. In the *Current projection* section, turn on *Set*.

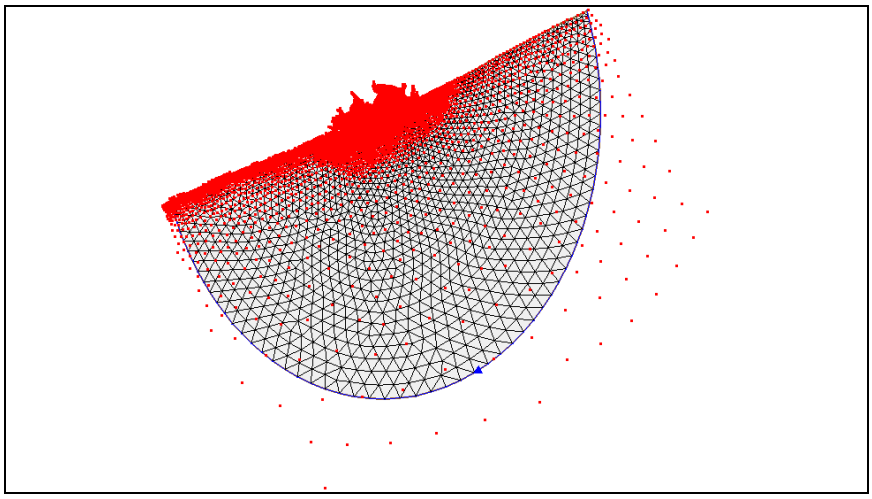

Figure 4 The imported "shin.grd"

6. In the *Horizontal* section, select *Global projection* and click **Set Projection…** to bring up the *Select Projection* dialog.
7. Select "Geographic (Latitude/Longitude)" from the *Projection* drop-down.
8. Select "NAD83" from the *Datum* drop-down.
9. Select "ARC DEGREES" from the *Planar Units* drop-down
10. Click **OK** to close the *Select Projection* dialog.
11. In the *Vertical* section, select "Meters" from the *Units* drop-down.
12. Verify that the *New projection* section is set to "UTM, Zone: 18 (78˚W - 72˚W – Northern Hemisphere), NAD27, meters". Make any necessary changes by following the appropriate step from steps 6–10 to adjust the settings.
13. Click **OK** to close the *Reproject Object* dialog.

Now to convert the mesh to polygons and create a new coverage.

1. Select "Mesh" to make it active.
2. Right-click on "Mesh" and select *Convert* | **Mesh → Map** to bring up the *Mesh → Map* dialog.
3. In the *Convert* section, select *Mesh Boundaries → Polygons.*
4. Click **Create New Coverage** to bring up the *New Coverage* dialog.
5. In the *Coverage Type* section, select *Models* | *ADH* | **ADH**.
6. Enter "ADH" as the *Coverage Name* and click **OK** to close the *New Coverage* dialog.
7. Click **OK** to close the *Mesh → Map* dialog.

To adjust the properties of the new mesh polygon, do the following:

1. Select "ADH" to make it active.

2. Using the **Select Feature Polygon** tool, double-click in the middle of the mesh polygon to bring up the *2D Mesh Polygon Properties* dialog.
3. In the *Mesh Type* section, select "Scalar Paving Density" from the drop-down and click **Scatter Options…** to bring up the Interpolation dialog.
4. In the *Scatter set to interpolate from* section, select "size_3000_to_500" from the tree list.
5. Click **OK** to close the *Interpolation* dialog.
6. In the *Bathymetry Type* section, select "Scatter Set" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
7. In the *Scatter set to interpolate from* section, select "Positive Depth" from the drop-down, then click **OK** to close the *Interpolation* dialog.
8. Close the *2D Mesh Polygon Attributes* dialog by clicking **OK**.
9. Right-click on "ADH" and select *Convert* | **Map → 2D Mesh** to bring up the 2D Mesh Options dialog.
10. Click **OK** to close the *2D Mesh Options* dialog.
11. Click **OK** to close the extrapolation warning and bring up a *Mesh Name* dialog.
12. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.
13. Turn off "Scatter Data" in the Project Explorer.
14. Click **Display Options** to bring up the *Display Options* dialog.
15. Select "2D Mesh" from the list on the left.
16. On the *2D Mesh* tab, turn on *Contours*.
17. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
18. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 5. Notice how element size decreases as depth decreases.

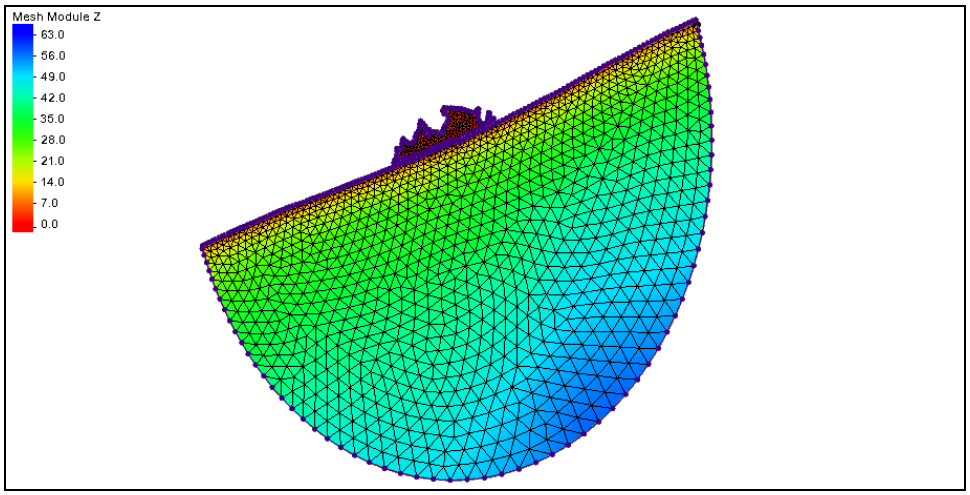

Figure 5 Mesh showing size function based on depth

4.3 Smoothing Data

Now that the project has a mesh, notice that the elements change size rather abruptly. To have the element size change more gradually, create a smoothing dataset.

1. Turn on "Scatter Data" and select "shin" to make it active.
2. Select *Data* | **Dataset Toolbox** to bring up the *Dataset Toolbox* dialog.
3. In the *Tools* section, select *Spatial* | **Smooth datasets** from the tree list.
4. In the *Smooth datasets* section, in the *Datasets* subsection, select "size_3000_to_500" from the tree list.
5. In the *Smoothing Options* subsection, enter "0.5" as the *Area change limit*.
6. Select *Minimum value* under *Anchor type*.

A minimum value anchor will ensure that the smallest element will stay the same size, and the bigger elements will change.

7. Enter "Smooth_0.5" as the *Output dataset name*.
8. Click **Compute**, then click **Done** to close the *Dataset Toolbox* dialog.
9. Select "ADH" to make it active.
10. Using the **Select Feature Polygon** tool, double-click on the mesh polygon to bring up the *2D Mesh Polygon Properties* dialog.
11. Make sure that "Scalar Paving Density" from the drop-down in the *Mesh Type* section, then click **Scatter Options…** to bring up the *Interpolation* dialog.
12. In the *Scatter set to interpolate from*, select "Smooth_0.5" from the tree list and click **OK** to close the *Interpolation* dialog.
13. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
14. Right-click on "ADH" and select *Convert* | **Map → 2D Mesh** to bring up the *2D Mesh Options* dialog.
15. Click **OK** to accept the defaults and close the *2D Mesh Options* dialog.
16. Click **OK** to close the extrapolation warning and bring up the *Mesh Name* dialog.
17. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.
18. Turn off "Scatter Data" in the Project Explorer.

Notice that the element size changes more gradually now (Figure 6).

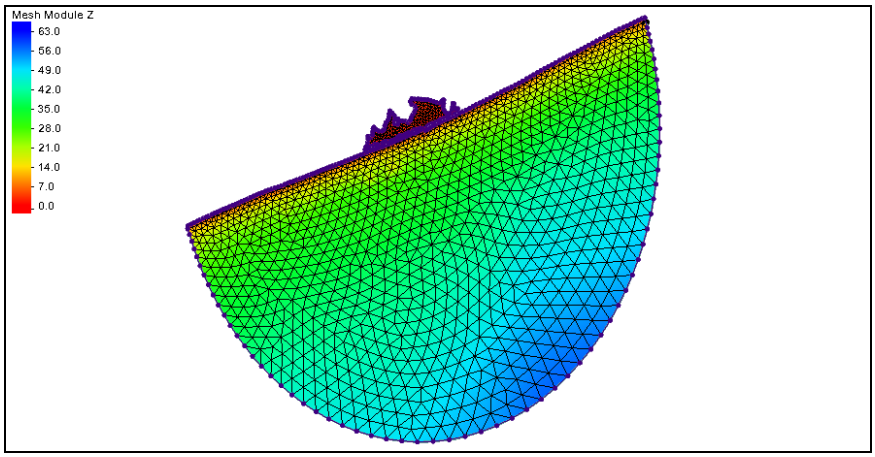

Figure 6 Mesh showing size function based on depth after smoothing

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. Survey data from the Cimarron River will be used here to create the size function.

5.1 Preprocessing

1. Select *File* | **Delete All** and click **Yes** when asked to confirm deletion.
2. Click **Open** to bring up the *Open* dialog.
3. Select "Cimarron Survey 2005.h5" and click **Open** to import the file and exit the *Open* dialog.

The project should appear similar to Figure 7.

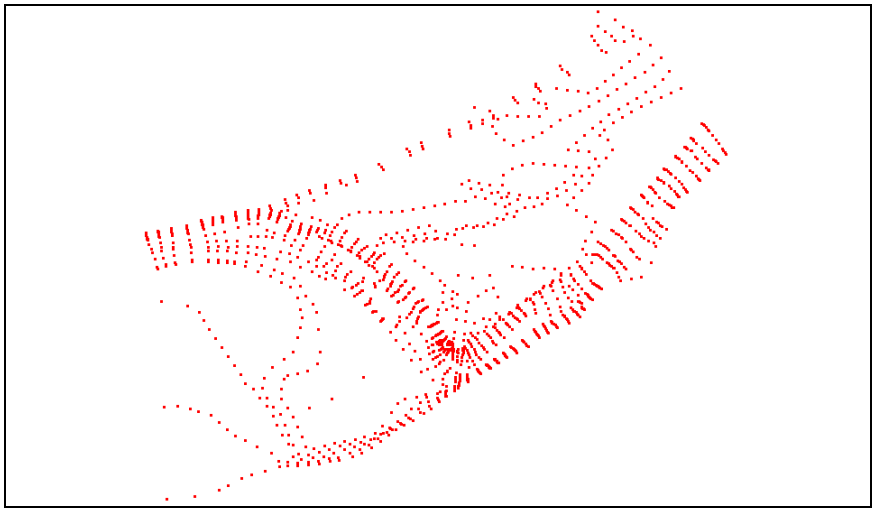

Figure 7 Imported "Cimarron Survey 2005.h5"

4. Click **Display Options** to bring up the *Display Options* dialog.

5. Select "Scatter" from the list on the left.
6. On the *Scatter* tab, turn off *Points* and turn on *Contours*.
7. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
8. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 8.

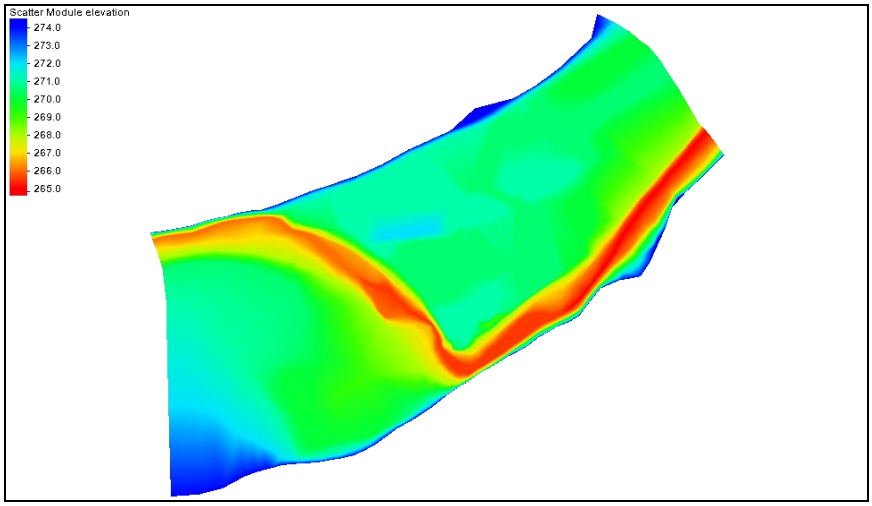

Figure 8 Scatter set using the contour color fill option

9. Right-click on "Survey 2005" and select *Convert* | **Scatter Boundary → Map** to bring up the *Select Coverage* dialog.
10. Select *Use existing coverage* and click **Select…** to bring up the *Select Tree Item* dialog.
11. Select "Area Property" from the tree list and click **OK** to close the *Select Tree Item* dialog.
12. Click **OK** to close the *Select Coverage* dialog.
13. Right-click on "Area Property" and select **Rename**.
14. Enter "Cimmaron River" and press *Enter* to set the new name.
15. Right-click on "Cimarron River" and select *Type* | *Generic* | **Mesh Generator**.
16. Using the **Select Feature Vertex** tool while holding down the *Shift* key, select the four corner vertices. **Zoom** in if necessary.
17. Right-click and select **Convert to Nodes**.
18. Using the **Select Feature Point** tool, select the node near the center of the bottom border (Figure 9) and *Delete* it.
19. Using the **Select Feature Arcs** tool with the *Shift* key held down, select each of the four arcs.
20. Right-click and select **Redistribute Vertices…** to bring up the *Redistribute Vertices* dialog.

21. In the *Arc Redistribution* section, select "Specified Spacing" from the *Specify* drop-down.
22. Enter "200.0" as the *Average spacing*.
23. Click **OK** to close the *Redistribute Vertices* dialog.

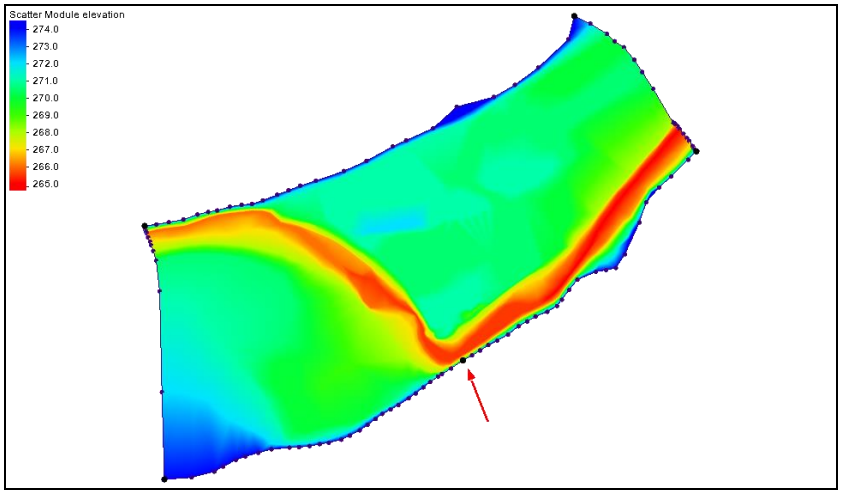

Figure 9 Node to convert to a vertex

Now to eliminate extrapolation values by making sure that all the vertices and nodes lie within the scatter data.

1. Using the **Select Feature Vertex** tool, move each vertex along the edge of the scatter set to the inside of the scatter set so that SMS does not extrapolate any values outside of the scatter data.
2. Repeat step 1 using the **Select Feature Point** tool, moving all four nodes within the scatter set.
3. Repeat steps 19–23, above, entering "90.0" as the *Average spacing*.
4. **Zoom** in and verify that all arcs are within the scatter set. If not, repeat steps 1–3 until they are.

All of the vertices and nodes should be inside the scatter data. A close-up of the top left corner of the scatter set is shown in Figure 10.

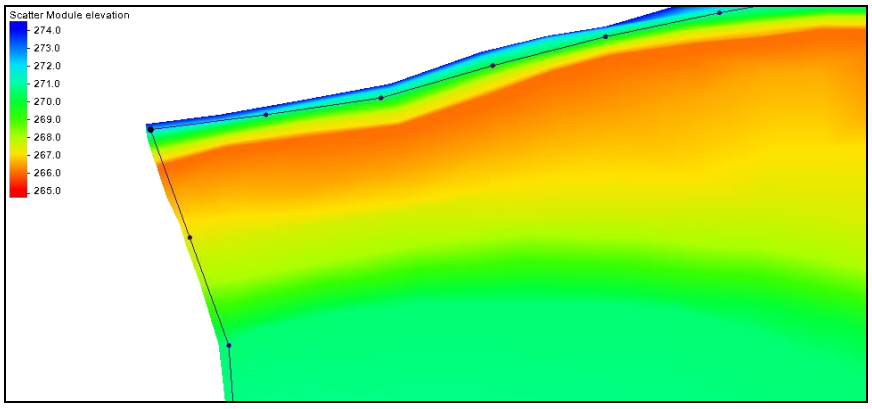

Figure 10 Vertices and nodes inside of the scatter data

5.2 Creating a Fixed Gradient Dataset

1. Select "Survey 2005" to make it active.
2. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
3. In the *Tools* section, select *Spatial* | **Geometry** from the tree list.
4. In the *Geometry* section, in the *Datasets* subsection, select "elevation" from the tree list.
5. Turn off *Gradient angle* and *Directional derivative*.
6. Click **Compute**, then click **Done** to close the *Dataset Toolbox* dialog.

There is now a new "Geom Gradient" dataset.

7. Right-click on "Geom Gradient" and select **Dataset Contour Options…** to bring up the *Dataset Contour Options – Geom Gradient* dialog.
8. In the *Contour method* section, select "Color Fill" from the first drop-down.
9. In the *Data range* section, turn on *Specify a range* and enter "0.0" for the *Min* and "0.33" as the *Max*.
10. Click **OK** to close the *Dataset Contour Options – Geom Gradient* dialog.

Specifying this range for the contours helps better display the data.

11. Select "Survey 2005" to make it active.
12. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
13. In the *Tools* section, select *Math* | **Data Calculator** from the tree list.
14. In the *Calculator* section, click **min**, and then double-click on "Geom Gradient" in the *Datasets* subsection tree list.
15. Highlight the "??" in the *Calculator* field and enter "0.33".

The equation in the *Calculator* field should now contain "min(d2,0.33)". This creates a dataset where "0.33" is the fixed maximum gradient.

16. Enter "Geom Gradient Fixed" as the *Output dataset name* and click **Compute**.
17. Click **Done** to close the *Dataset Toolbox* dialog.

There should be a new "Geom Gradient Fixed" dataset in the Project Explorer. The project should appear similar to Figure 11.

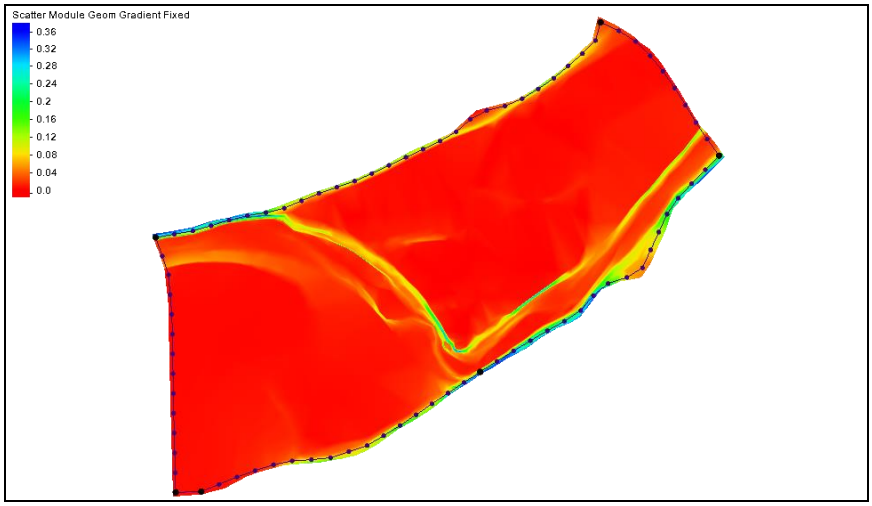

Figure 11 Fixed gradient

5.3 Creating the Size Function

Next, create a size function based on slope using this equation:

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

1. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
2. In the *Tools* section, select *Math* | **Data Calculator** from the tree list.
3. In the *Calculator* section, enter "50-((d3-0)/(0.33-0))*(50-5)".
4. Enter "Gradient Size 5to50" as the *Output dataset name* and click **Compute**.
5. Click **Done** to close the *Dataset Toolbox* dialog.

There should be a new "Gradient Size 5to50" dataset in the Project Explorer. The project should appear similar to Figure 12.

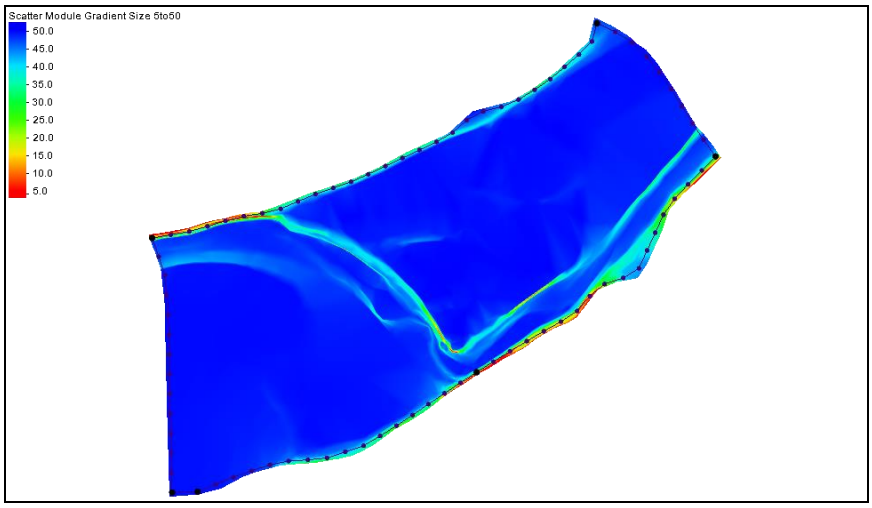

Figure 12 Gradient size 5to50

5.4 Smoothing the Size Function

One more dataset needs to be created before creating the mesh.

1. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
2. In the *Tools* section, select *Spatial* | **Smooth Datasets** from the tree list.
3. In the *Smooth datasets* section, in the *Datasets* subsection, select "Gradient Size 5to50" from the tree list.
4. Enter "Gradient Size 5to50 Smooth 0.5" as the *Output Dataset name* and click **Compute**.
5. Click **Done** to close the *Dataset Toolbox* dialog.

There should be a new "Gradient Size 5to50 Smooth 0.5" dataset in the Project Explorer. The project should appear similar to Figure 13.

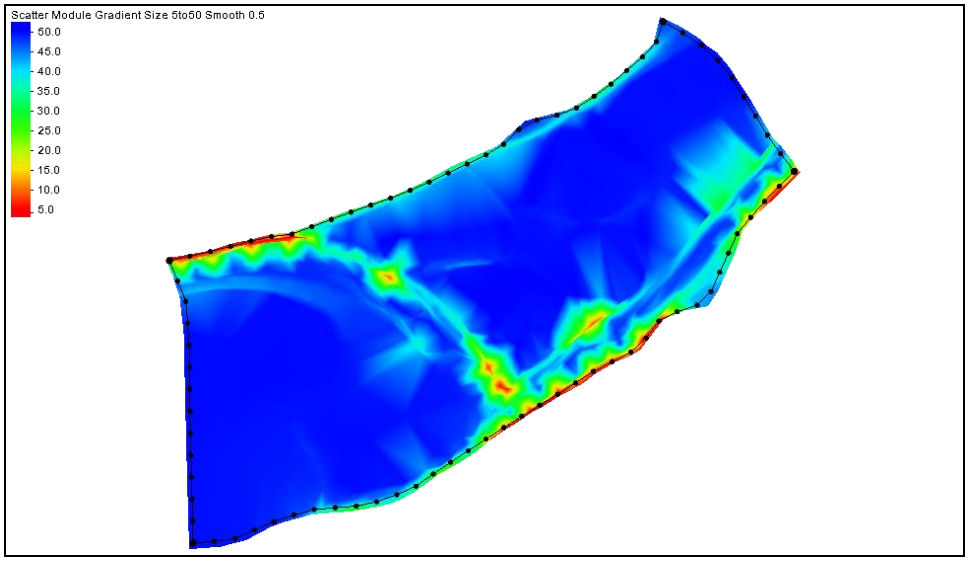

Figure 13 Smoothed size function based on slope

5.5 Creating the Mesh

1. Switch to the **Map** module.
2. Select *Feature Objects* | **Build Polygons**.
3. Using the **Select Feature Polygon** tool, double-click the map polygon to bring up the *2D Mesh Polygon Properties* dialog.
4. In the *Mesh Type* section, select "Scalar Paving Density" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
5. In the *Scatter Set to Interpolate From* section, select "Gradient Size 5to50 smooth 0.5" from the tree list and click **OK** to close the *Interpolation* dialog.
6. In the *Bathymetry Type* section, select "Scatter Set" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
7. In the *Scatter Set to Interpolate From* section, select "elevation" from the tree list and click **OK** to close the *Interpolation* dialog.
8. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
9. Right-click on "Cimmaron River "and select *Convert* | **Map → 2D Mesh** to bring up the *2D Mesh Options* dialog.
10. Click **OK** to accept the defaults and close the *2D Mesh Options* dialog.
11. Click **OK** when warned that the extrapolation value is not greater than the duplicate node tolerance, which brings up the *Mesh Name* dialog.
12. Click **OK** to accept the default *Mesh name* and close the *Mesh Na*me dialog.

The project now has a mesh with finer elements to represent higher gradients (Figure 14).

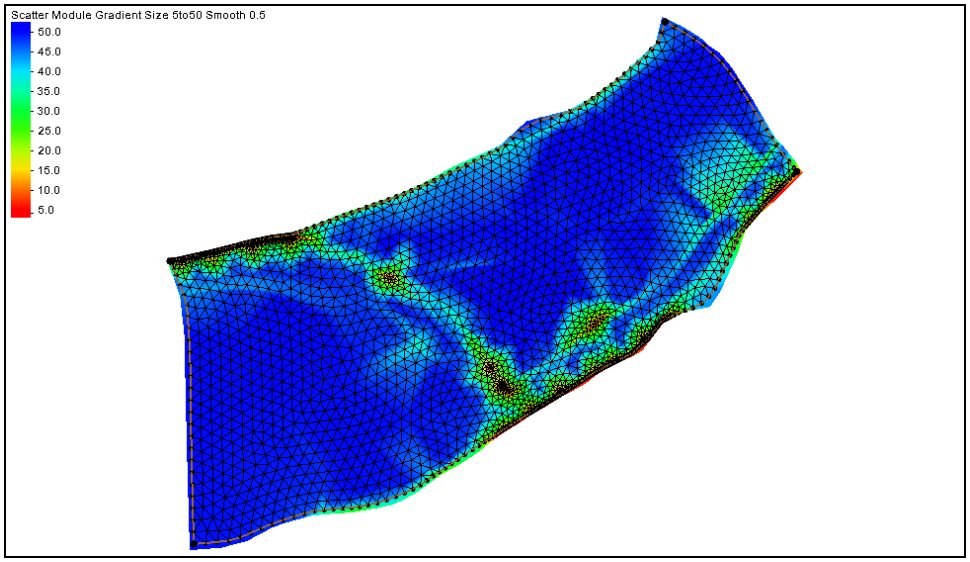

Figure 14 Mesh with finer elements to represent higher gradients

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 build upon the data already entered.

6.1 Creating a Curvature Dataset

1. Select "  Survey 2005" to make it active.
2. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
3. In the *Tools* section, select *Spatial* | **Geometry**.
4. In the *Geometry* section, in the *Datasets* subsection, select "Geom Gradient Fixed" from the tree list.
5. Turn off *Gradient Angle* and *Directional derivative*.
6. Enter "Curvature" as the *Output dataset name* and click **Compute**.
7. Click **Done** to close the *Dataset Toolbox* dialog.
8. Right-click on "  Curvature Gradient" and select **Info…** to bring up the *Dataset Info* dialog.
9. Select value for *Maximum* and press *Ctrl-C* to copy the value.

This value will be used for an equation in the next section.

10. Close the *Dataset Info* dialog by clicking the  at the top right corner of the dialog.

6.2 Creating the Size Function

1. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
2. In the *Tools* section, select *Math* | **Data Calculator**.
3. In the *Calculator* section, enter "50-((d6-0)/(0.0488655-0))*(50-5)" in the calculator field.
4. Enter "Curvature size 5to50" as the *Output dataset name* and click **Compute**.
5. Click **Done** to close the *Dataset Toolbox* dialog.

6.3 Smoothing the Size Function

1. Select *Data* | **Dataset Toolbox…** to bring up the *Dataset Toolbox* dialog.
2. In the *Tools* section, select *Spatial* | **Smooth datasets**.
3. In the *Smooth datasets* section, in the *Datasets* subsection, select *Curvature size 5to50*.
4. In the *Smoothing Options* section, enter "0.5" as the *Area change limit*.
5. Select *Minimum value* under *Anchor type*.

6. Enter "Curvature size 5to50 Smooth 0.5" as the *Output dataset name* and click **Compute**.
7. Click **Done** to close the *Dataset Toolbox* dialog.

6.4 Creating the Mesh

1. Select "Cimmaron River" to make it active.
2. Using the **Select Feature Polygon** tool, double-click the boundary polygon to bring up the *2D Mesh Polygon Properties* dialog.
3. In the *Mesh Type* section, select "Scalar Paving Density" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
4. In the *Scatter Set To Interpolate From* section, select "Curvature Size 5to50 smooth 0.5" from the tree list.
5. Click **OK** to close the *Interpolation* dialog.
6. In the *Bathymetry Type* section, select "Scatter Set" from the drop-down and click **Scatter Options…** to bring up the *Interpolation* dialog.
7. In the *Scatter Set To Interpolate From* section, select "elevation" from the tree list.
8. Click **OK** to close the *Interpolation* dialog.
9. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
10. Right-click on "Cimmaron River" and select *Convert* | **Map → 2D Mesh** to bring up the *2D Mesh Options* dialog.
11. Click **OK** to accept the defaults and close the *2D Mesh Options* dialog.
12. Click **OK** when advised regarding extrapolation values, which then brings up the *Mesh Name* dialog.
13. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.

There is now a mesh with finer elements to represent greater curvature (Figure 15).

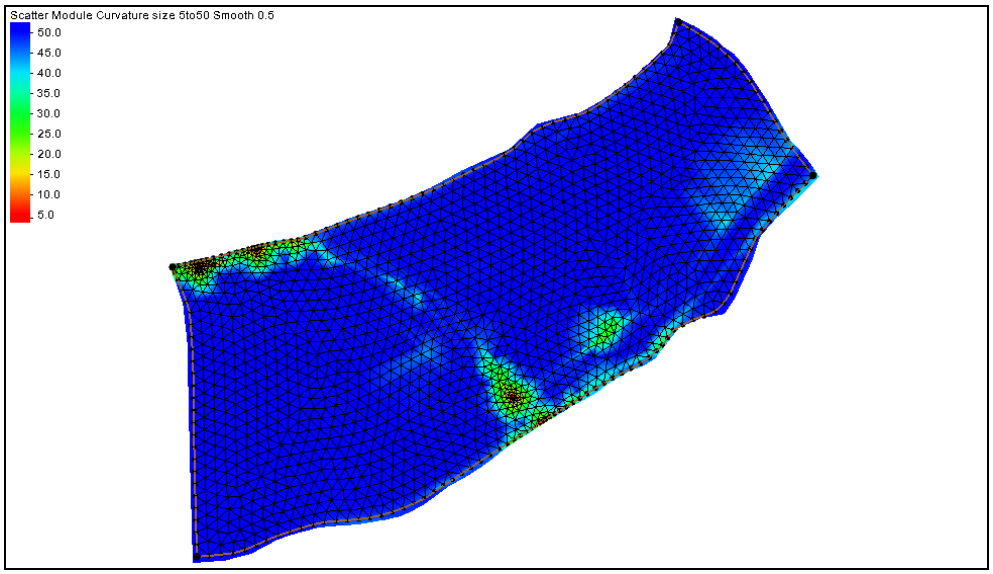

Figure 15 Mesh with finer elements to represent greater curvature

7 Conclusion

This concludes the "Size Functions" tutorial. 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.

Feel free to continue experimenting in SMS, or exit the program.