

SMS 11.1 Tutorial

Scatter Data - TINs



Objectives

This workshop covers the basics of working with TINs (triangulated irregular networks) using the scatter module of SMS. We will cover importing TIN data, editing and filtering data, and exporting TIN data.

Prerequisites

- None

Requirements

- Scatter Module
- Map Module

Time

- 45-60 minutes

Data Files



The data files you will use in this exercise include:

- cimarron_survey_tab.txt
- ge_highres (JPEG Image)
- ge_highres.wld (world file for JPEG image)
- Raster-in.xyz
- stmary.dxf
- stmary.xyz

Importing Topographic Data – Cimarron Survey Data

A common method of obtaining data points for two-dimensional hydrodynamic modeling is from scattered survey points or cross sections. SMS can import delimited text files which can then be triangulated. We will import data from the file “cimarron_survey_tab.txt”.

To import the “cimarron_survey_tab.txt” file:

1. Select *File* | *Open* .
2. Open the file “cimarron_survey_tab.txt”.
3. The first step of the *File Import Wizard* gives you the option to specify delimiters and specify a starting point for importing. The defaults are fine for this data set, so click on the *Next* button.
4. Make sure the *SMS data type*; option is set to *Scatter Set*. This tells SMS to bring these points into the program as scatter points. Note also that the toggle is set to have SMS triangulate the points into a TIN.
5. Click the *Finish* button.
6. If the Scatter set does not appear, go to *Display* / *Display Options* and under the scatter tab toggle on *Points*. Click OK.
7. Click on the frame  macro. The scatter set will appear.
8. The XYZ data points from the file are converted into a TIN.

We want to adjust our display settings to see the triangles as well as the surface data.

1. Select *Display* | *Display Options*.

2. Toggle on *Triangles* and *Contours*.
3. Under the *Contours* tab, change the *Contour Method* to *Color Fill*.
4. Click *OK* to exit the *Display Options* dialog.
5. The resulting image should appear similar to Figure 1.

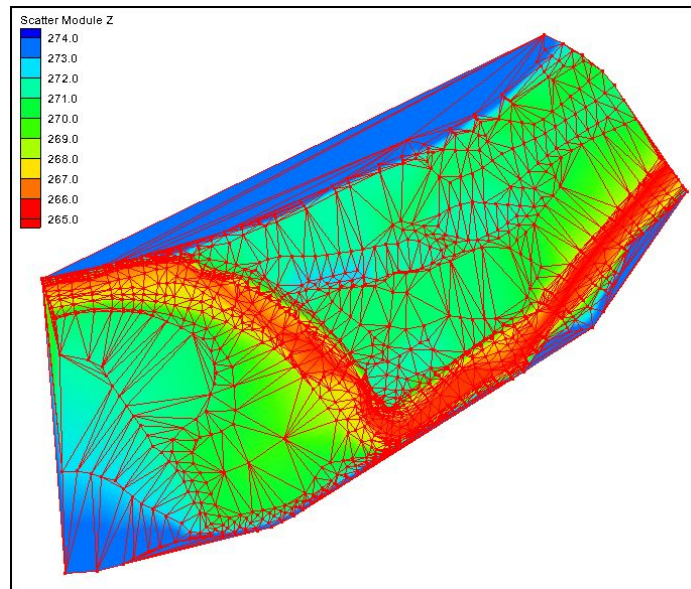


Figure 1. The triangulated and contoured data points

Editing TIN Data

Deleting Boundary Triangles

The triangulation process creates triangles from all the points in the set. It uses a boundary called a convex hull. This results in areas being included in the surface that are not really represented well by the points. For example, if the survey includes cross sections around a bend of a river, but does not have data points on the inside overbank, the surface will cover the inside overbank, but will not represent any data in that region. In a similar fashion, long skinny triangles may be formed around the edge of the surface that connect points that are a long ways from each other, and don't represent the surface. To make the surface represent the conditions being modeled, we want to delete these extra triangles.

Triangles can be deleted in different ways. A common and intuitive method is to select (by clicking) a triangle and then delete it. However, this method can be time consuming if a very large data set is being used.

SMS includes a utility called the Process Boundary Triangles function. This utility speeds up the process of identifying and possibly removing unwanted boundary triangles. It selects boundary triangles that have an edge ratio higher than a user specified value. The edge ratio of a triangle is calculated by dividing the length of the triangle edge on the boundary by the length of the smallest triangle edge.

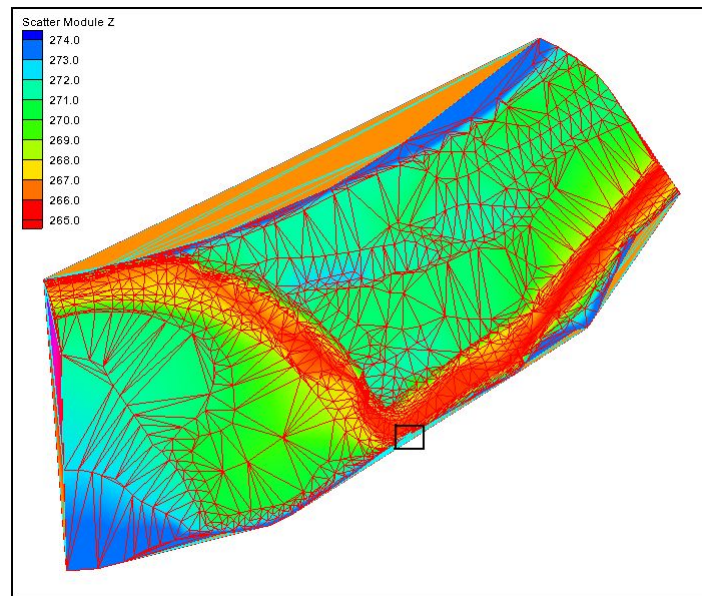


Figure 2 Zoom area

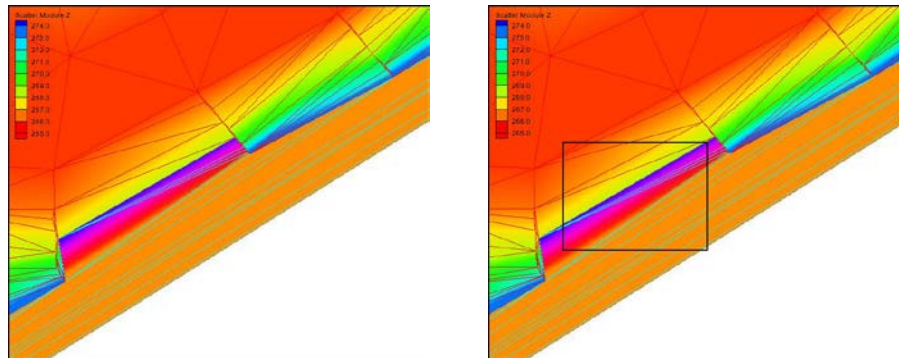
To delete unwanted boundary triangles:

1. Select *Triangles / Process Boundary Triangles...* from the menu.
2. The best edge ratio can be found by trial and error. Set the edge ratio to 1 and select "Preview". The display will update, highlighting the triangles that are connected to the boundary with an edge ratio greater than 1. In this case "connected" means all triangles between that location and the boundary have an edge ratio greater than 1. Note that a large portion of the surface is selected. The utility can't distinguish between skinny triangles that actually represent the surveyed region, and undesirable boundary triangles. That means care must be used to select an edge ratio. Try a few values and use preview to see how many triangles would be affected.

3. For consistency in this exercise, enter 36.00 for the edge ratio and select preview. This value for the edge ratio selects mostly undesirable thin triangles. However, there are some triangles on the bottom that are selected just because of the high resolution of the cross section sampling. These triangles need to be unselected before deleting, so make sure that the "Select" toggle is on instead of the "Delete" toggle and click "OK".
4. Zoom in to the bottom of the data set as shown in Figure 2.

SMS provides several modifier keys that can be used in connection with the graphical selection tools to make it easy to perform a number of selection related tasks. If the "Shift" key is pressed, newly selected items are toggled. If the "Alt" key is pressed, newly selected items are selected if they were not previously selected (nothing is unselected). If both the "Alt" and "Shift" are pressed, newly selected items are removed from selection list (nothing is added).

1. Make sure the *Select Triangle* tool is selected.
2. Holding Alt and Shift, drag a box around the triangles that we want to deselect (as shown in Figure 3 b). All selected triangles, whose centroid lies inside this box, will be deselected.
3. Delete the selected triangles by pressing the delete key.



(a). Zoomed region


(b). Deselection box.

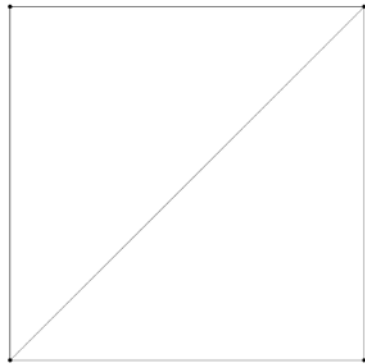
Figure 3 Unselecting selected triangles.

This process does not remove all undesirable boundary triangles. Manual selection and deletion of boundary triangles, or applying this process with multiple edge ratios or after some manual removal may be required. In this situation, both the upstream and downstream ends of the river still have long skinny triangles that must be deleted manually because the survey data is so dense.

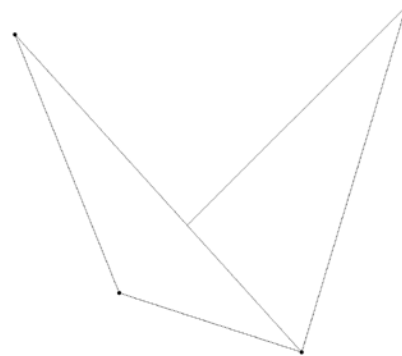
Solving Triangulation Issues

SMS builds a triangulation that conforms to the Delaunay criterion which is intended to create triangles that are as close to equilateral triangles as the data sampling will allow. In general, this avoids skinny triangles. While this is a good general triangulation strategy, it doesn't always represent the surface well. This section will walk you step by step on how to swap edges to improve surface definition. A numerical model cannot represent a set of physical conditions, if the surface it is based on is incorrect. Care should be taken to ensure the TIN is accurate.

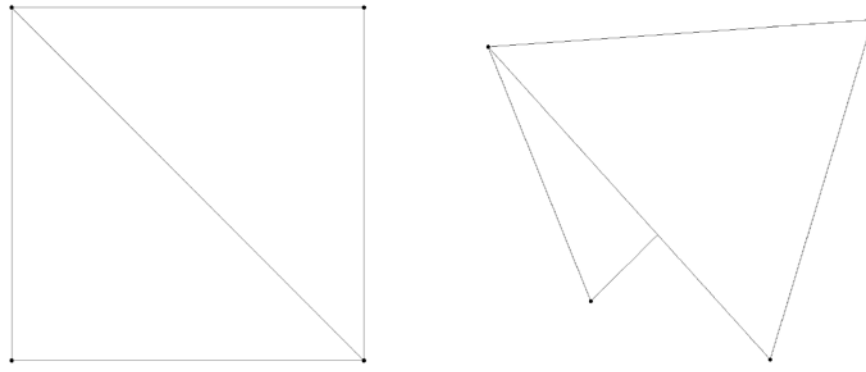
How vertices are connected into triangles has a large effect on the surface that is represented. Connecting vertices differently will give different surfaces. Consider the simple triangulation shown in Figure 4(a). When the surface is viewed from an angle, Figure 4 (b) can be seen. Notice how the triangulation creates a trough or channel. Figure 4(c) shows the same set of points after the common triangle edge (diagonal of the quadrilateral) is swapped. When viewed from an angle as seen in Figure 4(d), it is observed that instead of the trough that was formed before, a ridge or dam is formed. This simple example illustrates that the direction of the triangles edges can drastically changed the surface created by the triangulation. This is why the *Swap Edge*  tool is very important and has to be used carefully to better define channels, etc.



(a). Planar view of Triangulation.



(b). Oblique view showing triangles.



(c). Triangulation after swapping edges. (d). Oblique view after swapping edges.

Figure 4 Differences that are made by swapping triangle edges

Manually Swap Edges

The first editing tool we will utilize is a manual edge swap. This method is intuitive, but may involve a lot of effort. It is illustrated here because many situations require manual clean up and the process is the basis for all of the TIN editing techniques.

1. Select *Display | Display Options*. Make sure the *Scatter Module* is selected and switch to the *Contours* tab.
2. Set the *Contour Method* to *Color Fill and Linear*.
3. Click on the *Line color* button and change the width to 2. Click OK.
4. Click on the *Color Ramp* button. In the *Color Option* dialog change the *Palette Method* to *Intensity Ramp*. Move the arrow on the left in the *Current Palette* range out of the black. Click *OK* to exit.
5. Back in the *Display Options* dialog, toggle on *Specify a range* and enter 265 for the minimum and 271 for the maximum.
6. Set the number of contours to 13 in *Contour Interval*. Click *OK* to exit.

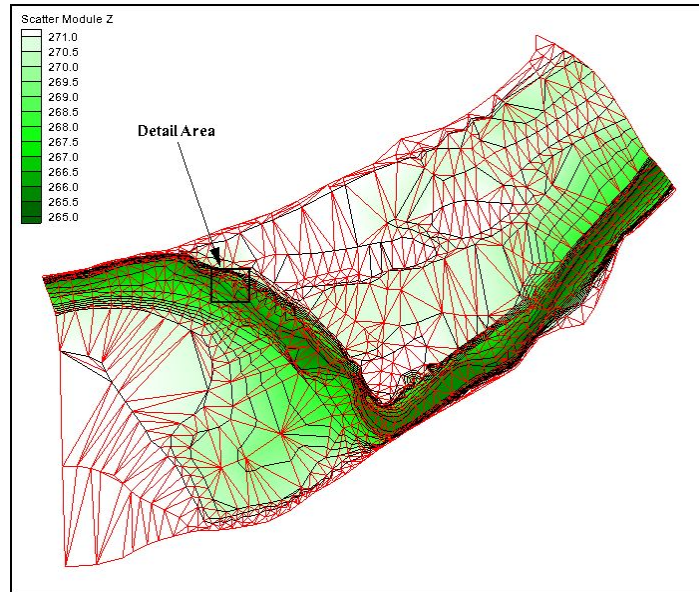



Figure 5 Manual swap detail area.

7. With the *zoom tool*  zoom to the detail area as shown in Figure 5.
8. After zooming, the screen should look like Figure 6. Note the linear contour around the edges to be swapped. It is not smooth or straight. In fact, two contours actually converge to a single line. This is possible if a vertical cliff exists, but is not likely in this situation. Natural contours tend to be smooth. A good guideline is to swap edges so that linear contours are smooth.

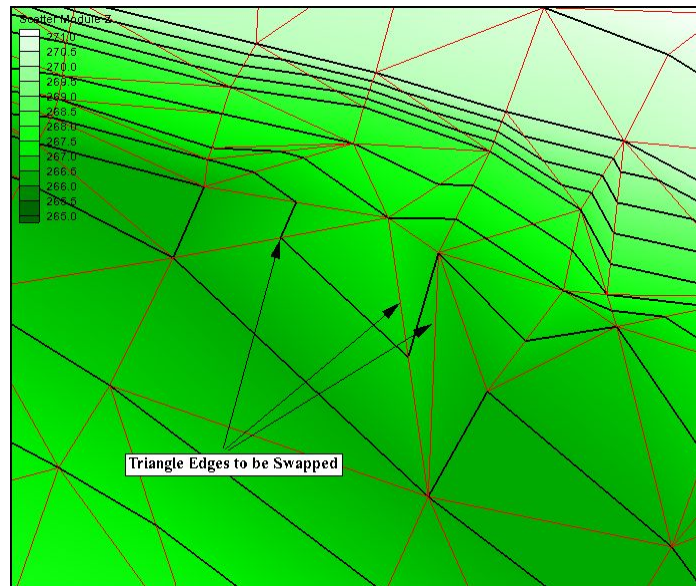



Figure 6 Zoomed out area showing triangle edges to be swapped

To fix triangles:

1. Select the *Swap Edge*  tool from the *Toolbox*.
2. Click on each of the three edges identified in Figure 6. The TIN should be edited to appear like Figure 7. Note how the two contours are now distinct and much smoother.

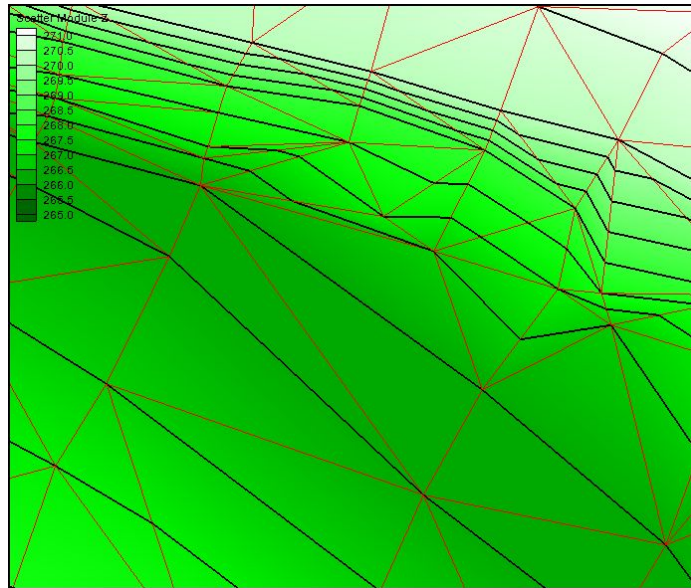


Figure 7 Figure showing triangle after edge has been swapped

A word of caution when using the swap tools, if you are not very careful with regards to where you click, you may actually swap a different edge than the desired edge and the quality of your surface can suffer. As you swap edges, make sure that the surface you want to represent is being defined accurately.

Adding Breaklines to Smooth Contours

While it is always possible to get the surface you want by swapping edges, it is often time consuming and may be impractical. If you know you want a feature represented in a TIN such as the bottom of a channel, bank, or man-made feature it might be time consuming to determine all the right edges to swap to connect the feature. Breaklines can be used in these cases to force triangle boundaries along a feature. Breaklines can also be imported in various formats as part of the scattered data (from your surveyor) and SMS also includes the capability to create breaklines from CAD or GIS data.

As noted above, an easy way to spot triangulation problems is to look for jagged contour lines. Breaklines can be used to connect vertices of similar elevations to prevent jagged contours. The following steps illustrate how to use breaklines to edit the TIN. Since we are not working directly with the edges, it helps to turn them off. This unclutters the display and simplifies interaction with the scattered data points. It is also useful to use 3D views to understand the shape of the surface. Normally to do this, you will rotate the view and experiment with your surface. In this case, a view will be specified for you as an illustration.

1. Select *Display | Display Options*. Make sure the *Scatter Module* is selected.

2. Turn on the display of *Points*. Click on the point symbol and set the *Size* to 4. Click OK.
3. Turn off the display of *Triangles*.
4. Select the *General* options from the list on the left. In the *General* tab, turn off the Auto z-mag and set the Z-mag to 10.
5. In the *View* tab, click *View angle* then set the *Bearing* to 30, the *Dip* to 50, the *Looking at point* to (648700.0, 3984000.0, 2675.0), and the *Width* to 800. Click OK to exit. The resulting view should be similar to that shown in Figure 8.

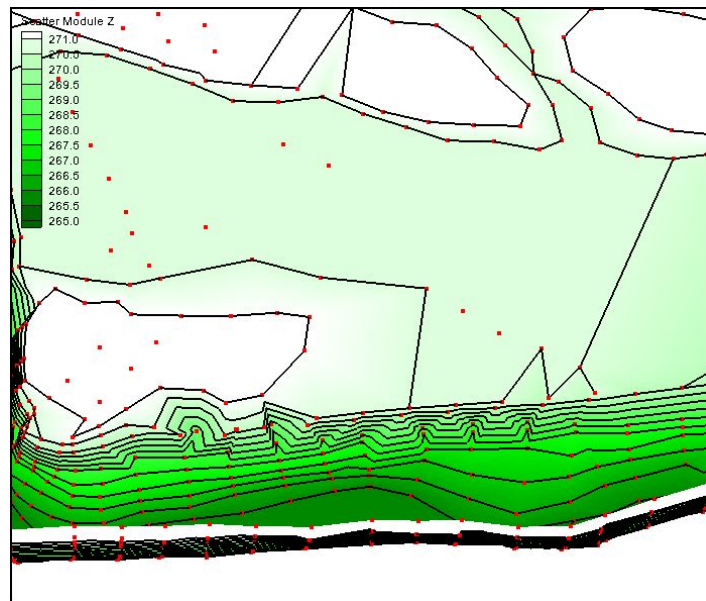


Figure 8 Angle (oblique) view of contours and points.

6. Note how the contours tend to connect the vertices of common elevation. However, they connect with very crooked lines. A breakline, connecting vertices with straight lines, can force the triangulation to follow those straight lines.

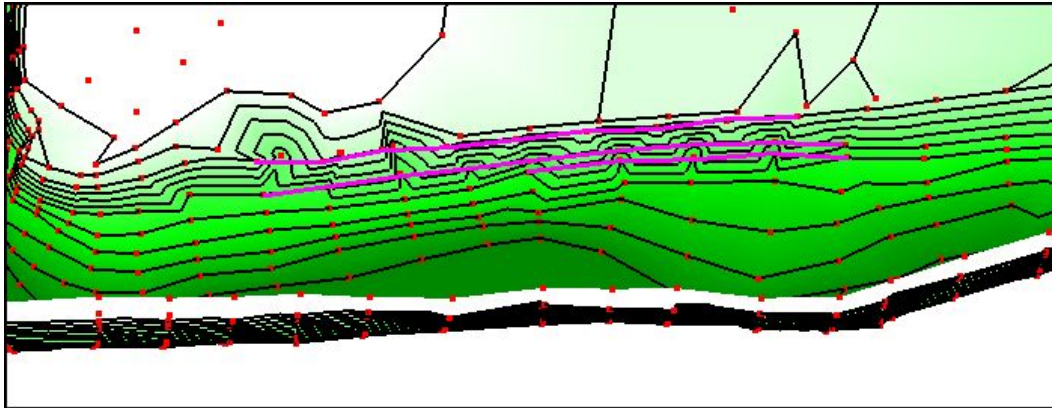


Figure 9 Connectivity for breaklines on the bank..

7. Using the *Create Scatter Breakline* tool, add breaklines along the bank of the channel. Do this by clicking on the scatter points with common elevations as shown in Figure 9 (This illustrates three separate breaklines). End a breakline with double clicking on the last point.
8. Switch to the *Select Breakline* tool, select each breakline and right click. From the *Breaklines* drop-down menu, select *Force Breakline*. The screen should now look like Figure 10

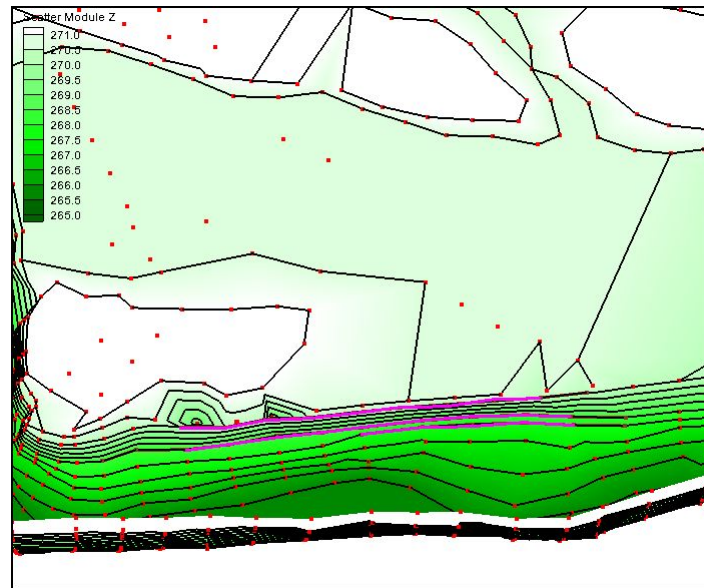



Figure 10 TIN with breaklines forced

9. After the Force breakline command, the breakline can be deleted by using Scatter Breakline and delete tools.

These breaklines smoothed out one section of the bank. You may want to experiment with the 3D view to get a better impression of the surface. More breaklines can be added around the scatter set to force the triangulation in other areas.

Even with the ability to force breaklines, cleaning up an entire survey can still be very time consuming. An updated and cleaned up file of the scatter set has been provided.

To view the updated surface, select *File | Open*  and click on the file “cimarron_updated.sms”. The final scatter set should be like Figure 11. You can also display the breaklines in this file to see the 26 created line used for cleanup.

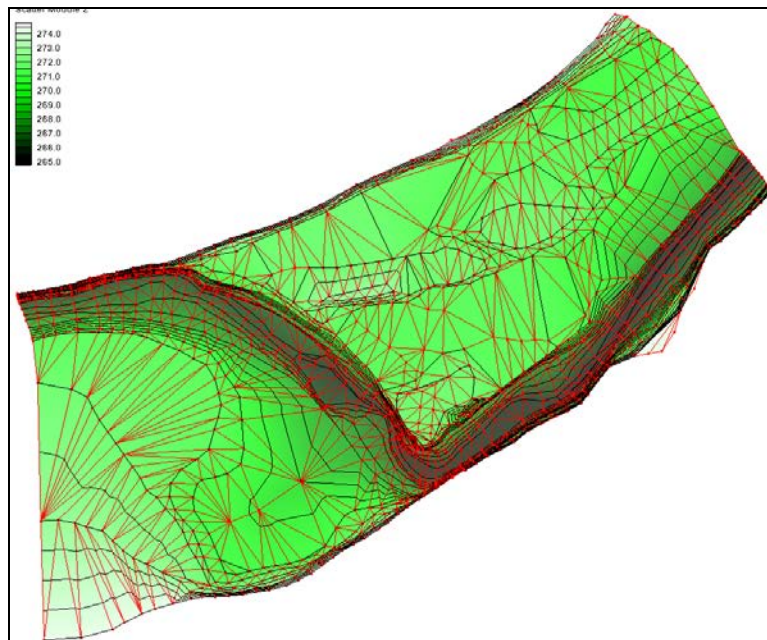



Figure 11 Clean TIN of the Cimarron River.

Modifying Scatter Sets

Scatter sets may not represent all the features or the area being modeled and therefore need enhancement. Verifying the TIN with another data source, such as an aerial photo or topographic map can ensure the adequacy of the surface for modeling purposes. Some features may be too small to have been captured in the survey, but still have significant impact on the hydrodynamics of the region. Other features, such as man made structures (embankments or levees) may not have existed at the time of the survey. Remember that

features change over time, so verification must include data from the appropriate time period.

To import the image file:

1. Select *File* | *Open* .
2. Open the JPEG file “ge_highres”. If asked whether to generate pyramids or not, click *Yes*.
3. Click on the plan view icon to ensure you are in plan view to make the image visible.
4. Once image is loaded, we would like to see through the scatter data to see road. To do this, select *Display* | *Display Options* and select *Scatter* from the list.
5. Turn off the points and turn on the triangles.
6. Select the *Contours* tabs and set the *Transparency* to 70%. Click *OK* to exit the *Display Options* dialog. The graphics window should look like Figure 12.

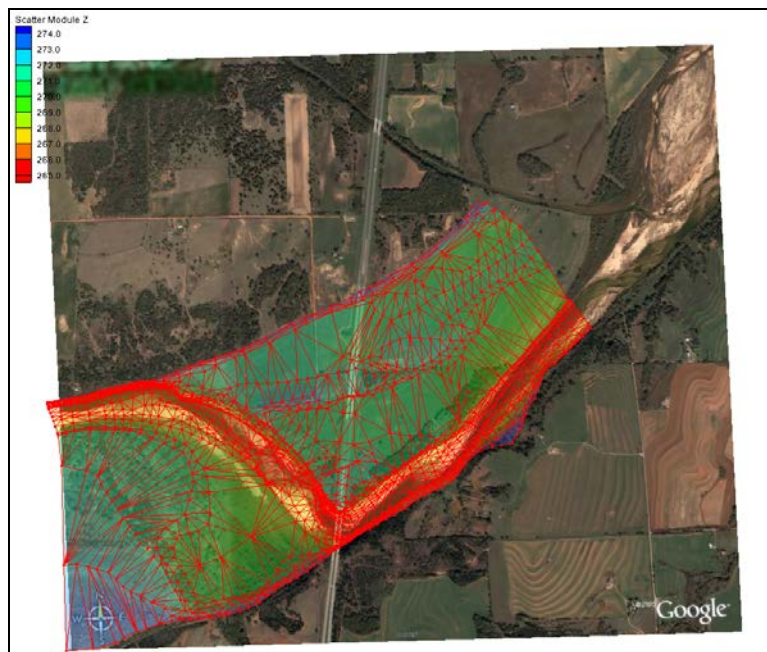


Figure 12 TIN with background image.


The aerial photo reveals that a roadway cuts through this domain. The survey and TIN surface do not represent the roadway embankment. This may have been intentional, if the study was intended to compare preconstruction conditions to post construction or if a modified structure is desired. In any event, the TIN would require modification to

accurately represent the flood plain and the roadway with its embankment. There are several methods available for incorporating a feature into a TIN. These include:

1. Using the stamped feature option in SMS (refer to the *Feature Stamping* tutorial for details on this process).
2. Merge another TIN into the current surface.
3. Add vertices at specified points or along feature lines.

The first two options are illustrated in the Feature Stamping tutorial and will not be discussed in this exercise.

Adding and Editing TIN Vertices

Digitization to add points to a scatter set functions in SMS after a surface is created just as when starting out. Using the *Create Scatter point*  tool, new scatter vertices can be placed at any location simply by clicking at that location. The elevation of the point defaults to the current elevation. Changing the elevation of a newly created point, using the Z edit field, changes the current elevation.

Vertices can also be moved interactively by dragging the individual entities. To prevent accidental edits to scattered vertex locations, SMS includes an option to lock the vertices in the *Vertices* menu.

When adding a structure, such as a roadway embankment, it may be tedious to insert each vertex one at a time. An alternative is to use a feature line. The feature line is an arc in a coverage in the Map module. SMS includes features to convert CAD files or GIS files to feature arcs. Refer to *Overview*, *GIS* and *Observation* tutorials as well as to the section at the end of this tutorial for more description of these processes.

For this exercise, the roadway is a straight line with a constant elevation, so we will simply create the feature arcs interactively. To do this:

1. Zoom in to the bottom of the TIN as seen in Figure 13.
2. Select the “default coverage” in the *Project Explorer* and select the *Create Feature Arc* tool.
3. Create two arcs as shown in Figure 13. No intermediate points are required at this time. Select the two arcs and change their elevations to 273 ft using the Z edit field.

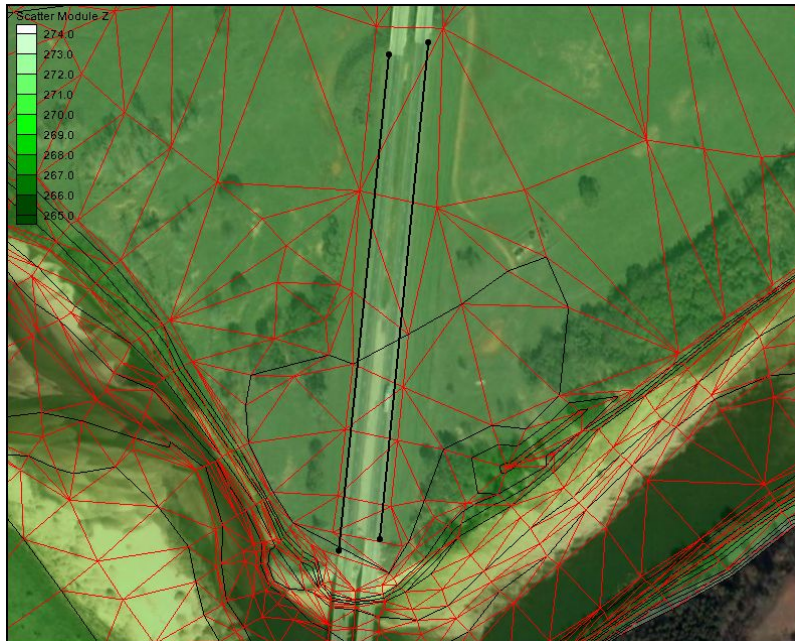


Figure 13 Arcs along embankment edges.

4. With both arcs still selected, right click on either and select *Redistribute Vertices* ...
5. In the redistribution dialog, make sure *Specified Spacing* is the redistribution option and enter a value of 50 ft. This is the approximate spacing of the vertices in the TIN. It is useful to be consistent with spacing when possible and it is not excessive. The resulting arcs, with their distributed vertices should appear as shown in Figure 14. Click *OK*.
6. Right click on the "default coverage" in the *Project Explorer* and select the *Convert > Map -> 2D Scatter* command.
7. In the *Map->Scatter* dialog, make sure *Arc elevation* is selected as the *Scatter Point Z-Value Source* and click *OK*. SMS creates a new scatter set, with breaklines along the arcs. (Note that there are other options to provide z values for the newly created points. This gives you more flexibility.)
8. Select the newly created scatter set.
9. Select the *Merge Sets* command in the *Scatter* menu. Select the toggle next to both scatter sets and click *OK*. A new scatter set is created that includes points and breaklines along the edges of the roadway embankment. (Note: refer to the Feature Stamping Tutorial to learn more about the merging options.)

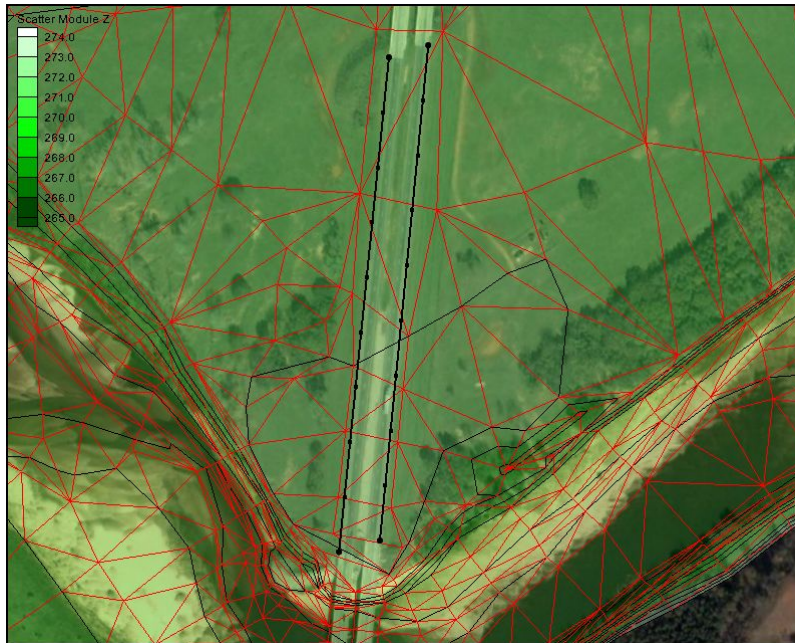


Figure 14 TIN with additional inserted points.

Exporting to Tabular Data

TIN data can be exported into a tabular format from SMS for use in other software. To export the existing data:

1. Select *File | Save As* and save the file as “cimarron_updated_tabular” and change the type to *Tabular Data files*.
2. In the *Export Tabular File* dialog, change the *Number of Columns* to 4.
3. In the first column, click on the *Data...* button to open the *Format Column Data* dialog. Change the *Data Type* to *Vertex Id* and click OK.
4. In second column, click on the *Data...* button and change it to x location. Similarly change the third column to y location and the fourth column as elevation.
5. Toggle on *column headings*.
6. Change the headings to “Vertex Id”, “X”, “Y” and “elevation” respectively. Click *OK* to exit dialog.

Filtering Data in large files

Sometimes available data can be rather large which could result in time consuming processing. In the case where the available data is too large to effectively process, SMS provides different ways to filter certain data points that are not important for later simulations.


For this part of the tutorial, a set of evenly distributed cross section data points are defined in the file “Raster-in.xyz” and these data points will be read into SMS using two types of filter options.

File Import Filter Options

Input data files can be large. They may have higher resolution that is needed or cover a larger area that is needed for a specific project. In those situations, it is useful to limit the data imported into SMS. SMS provides options to perform this filtering. Before we import the file, change the display options to show the points.

1. Select *File* | *Delete All* to clear out the data in SMS.
2. Select *Display* | *Display Options*.
3. Turn off the toggle *Show option pages for existing data only*
4. In the *Scatter* tab, make sure *Triangles* are off and *Points* are on.
5. Click on the red square next to *Points* to change the symbol attributes. Change the symbol from a square to a circle and increase the size to 8. Click *OK*.
6. Toggle on *Use contour Color Scheme* for the *Points*.
7. Set the inactive color to a purple or magenta color.
8. Click *OK* to exit the *Display Options* dialog.

Now, we will import the “Raster-in.xyz” file multiple times to illustrate the options. First, to import the entire file:

1. Select *File* | *Open* .
2. Open the file “Raster-in.xyz”.
3. The first step of the *File Import Wizard* gives you the option to specify delimiters and specify a starting point for importing. The defaults are fine for this data set, so click on the *Next* button.
4. Ensure the *SMS data type:* option is set to *Scatter Set*. This tells SMS to bring these points into the program as scatter points. Note also that the toggle is set to

have SMS triangulate the points into a TIN. Triangulation is not needed for this tutorial so it can be toggled off.

5. Click the *Finish* button. SMS reads in the raster data and converts each point to a scattered vertex. This may take a few minutes due to the fact that there are over 561000 points in this data set. (Figure 15)
6. Repeat steps 1-4 to read in the “Raster-in.xyz” file again but this time with filtering. We will compare the two resulting scatter sets to understand the differences made by filtering. The data will be loaded as “Raster-in (2)”
7. In step 2 of the *File Import Wizard*, click on the *Filter Options* button. The different options allow for only certain sections of the data to be read into SMS. Sections can be read into SMS in 3 different ways:
 - nth Point. This option allows only the nth points to be selected, n being any positive whole number. The whole area will be read into SMS but will be less dense and easier to work with if the file is significantly big.
 - Area. This option can be used when only a section of the data is needed. A rectangle of data will be selected with specified X and Y coordinates.
 - Grid. This option is similar to the filtering by nth point except that it is done on a grid basis.
8. In the *File Import Filter Options* dialog, choose *nth point* as the *Filter Type* and import every 4th point. Click OK to exit dialog.
9. Click the *Finish* button. SMS will create the second scattered data set. Its display will appear almost identical to the other one. (Figure 15)

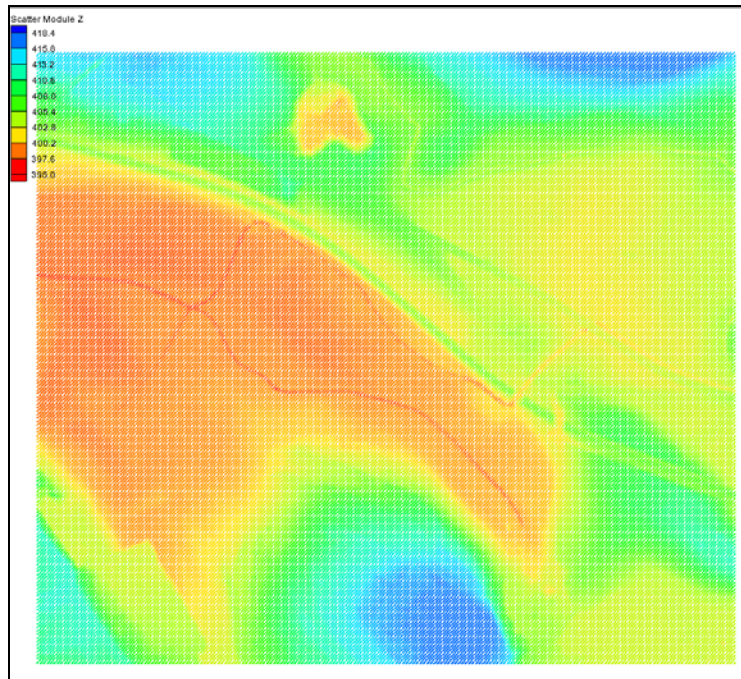


Figure 15 Scatter set for raster data

Once the file has been loaded two times, make sure that both scattered data sets are turned on (toggle boxes next to each should be checked), and that “Raster-in” is selected. *Zoom in* to the top left corner of the data set. The magenta points are the filtered data. Only those exist in the filtered set. The unfiltered scattered data set includes all of the points.

Filtering based on Angle

Now we will investigate another filtering option that is available after a file has been imported into SMS.

1. Uncheck the toggle next to the filtered data set "Raster-in (2)" to turn it off.
2. Select the "Raster-in" scattered data set in the *Project Explorer* to make it active and frame the data.
3. Select the *Triangulate* command in the *Triangles* menu. These filtering options operate on the TIN and therefore require triangulation.

Another way to filter data involves the removal of redundant data. This data does not add any details to the TIN surface. For example, when a point lies in the plane of all the surrounding points, no new features are represented and that point is superfluous.

In the next filtering option, the user can specify a tolerance angle. Each data point is checked to see if it is within that tolerance of being flat. (Note: a dot product of the "normal vectors" is used to determine this - see Figure 16). Vertices that are deemed to be redundant are deleted.

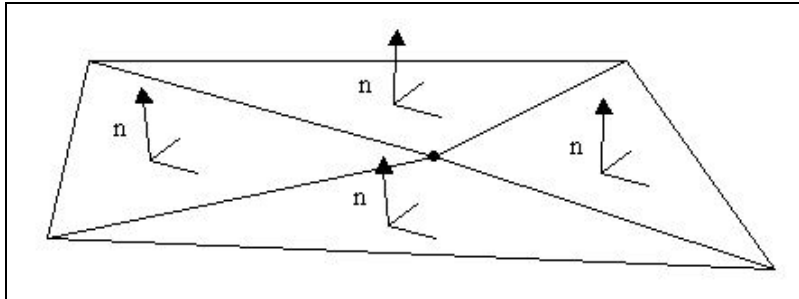


Figure 16 Triangles with relatively same normals.

To filter based upon normal angle:

1. You may want to save a copy of your data set that has not been filtered. Therefore, it is a good idea to create a copy, and filter the copy. To do this, right click on the "Raster-in" data set and select *Duplicate*. Select the duplicate and rename it set to "Raster-in - 2 degree filter"
2. Select *Data | Filter...*
3. Change the Filter angles to 2 degrees and click *OK*. It might take a little while for the all data points to be found and deleted. In this case around 50,000 points can be deleted. This represents about 9% of the total. (Note: SMS re-triangulates the remaining points, so any editing of the TIN you may have performed on the original will be lost.) The screen should now look like Figure 17. Notice the blank spaces where the data has been deleted.

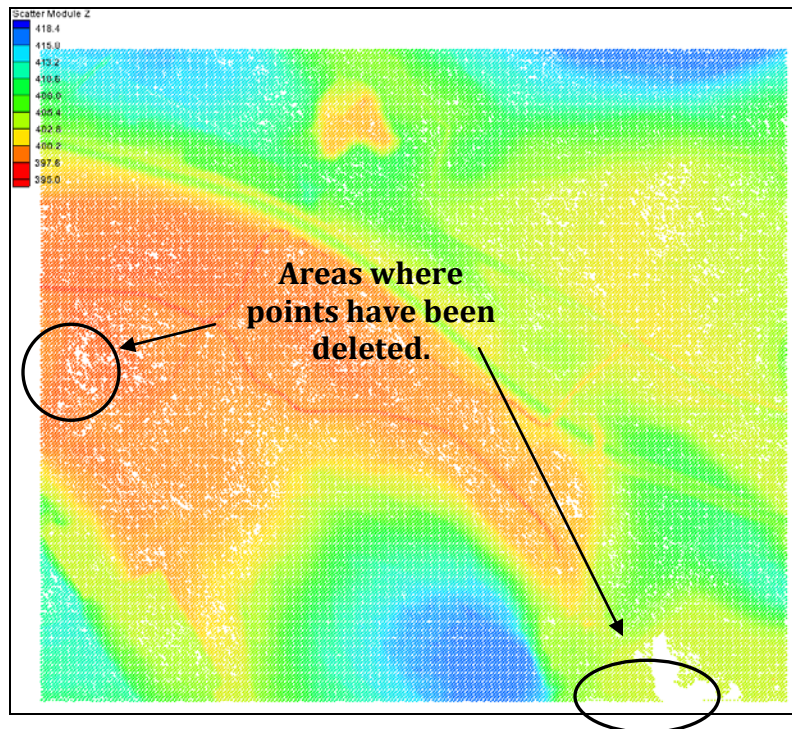



Figure 17 Scatter set after filtering by angles.

Converting DXF files to Scatter Data

SMS can import many files generated by other software in their native format. One of the files that can be imported are DXF files (AutoCAD files) which are vector drawing data used for background display or for conversion to feature objects.

For this part of the tutorial, the file stmary.dxf will be imported into SMS as a scatter data set.

To import the “stmary.dxf” file:

1. Select *File* | *Delete All* to clear out the data in SMS.
2. Select *File* | *Open* .
3. Open the file “stmary.dxf”. Notice that in the *Project Explorer* there is a *CAD Data* section with a set of contours. The graphics window displays those contours.

4. In order to convert CAD data to scatter data, it needs to be changed to Map Data. To do this, right-click on “CAD Data” in the Project Explorer and select *Convert -> CAD -> Map* from the drop-down menu.
5. There will be a new coverage named “CAD” created. Select this coverage to make the Map Module active.
6. Right-click on the “CAD” coverage and select *Convert -> Map -> 2D Scatter* from the menu.
7. In the *Map -> Scatter* dialog, leave everything unchanged and click OK. SMS does a duplicate point check as it creates the scattered data set. Since the spacing of the points along the contours in the CAD data is fairly high resolution. This process takes a few minutes.
8. Zoom in to the top west part of the scatter set in order to better see scatter points and scatter breaklines. Turn off the “CAD” map coverage in order to see the scatter set better.

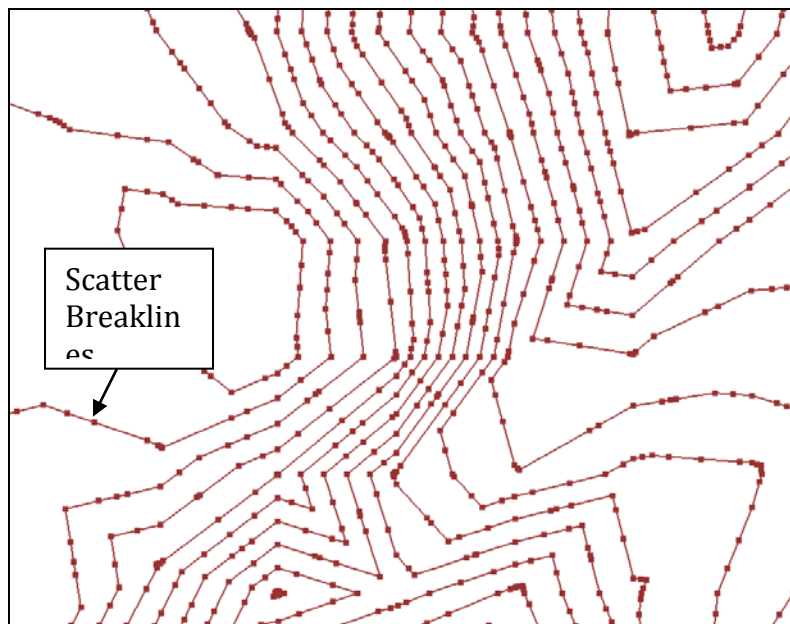



Figure 18 Scatter points and Breaklines

Breaklines

In some situations, agencies provide data that includes scatter breakline information. Since these breaklines generally improve surface representation SMS supports a few standard file formats for breaklines. This section illustrates how to import this data.

For this part of the tutorial, the file `stmary.csv` will be imported into SMS as a scatter data set.

To import the “`stmary.csv`” file:

1. Select *File | Open* .
2. Open the file “`stmary.csv`”. Since this is a commas separated values file, it may be interpreted in a variety of ways. SMS will ask for a format. Select the *Use Import Wizard* option and click OK.
3. In the File Import Wizard, click Next in step 1.
4. In Step 2, make sure that the SMS data type is set to Scatter. In the preview window, change the mapping of the fourth column to Breakline. This will open up the Scatter Breakline Options dialog.
5. Toggle on *Tags* and then turn on *Continue* and *End*. Change *Start* to 1, *Continue* to 2 and *End* to 4. (Note: there are other options for defining breaklines in tabular data. These include named breaklines, for which each breakline has a specific name. When name changes, SMS starts a new breakline. If name is blank the vertex will not be in a breakline).
6. Click OK and Finish to exit dialogs and import data.

When SMS reads the survey file, it creates a new scattered data set that could be combined with the scattered data set from the CAD file. Both sets include breaklines to ensure the TIN surface is true to the original surface.

Conclusion

This concludes the *TIN tutorial*. You should now be familiar with some of the features that *SMS* provides for importing and editing the TIN Data. You may continue to experiment with the interface or you may exit the program.

If you wish to exit *SMS* at this point:

Choose *File / Exit*. If asked to save, click the *No* button. You should have already saved it.