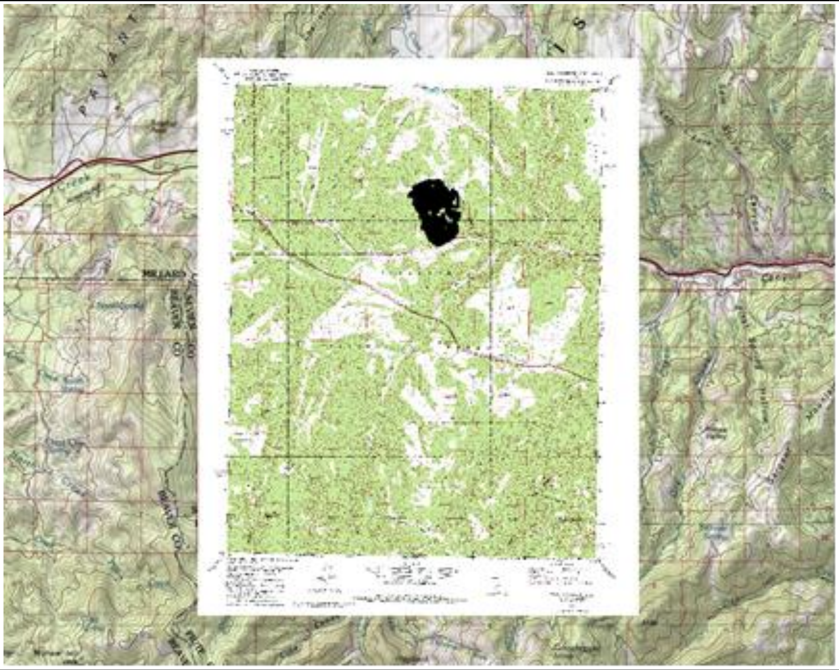
WMS 11.4 Tutorial

Using TINs

Import, view, edit, convert, and digitize triangulated irregular networks



Objectives

This tutorial will demonstrate how to import survey data in an XYZ format and digitize elevation points using contour imagery. It will also show how to edit and merge TINs and convert between DEMs and TINs. Finally, it will demonstrate how to export TIN contours to a CAD file.

Prerequisite Tutorials

- None

Required Components

- WMS Core

Time

- 20–40 minutes

1 Introduction

Triangulated Irregular Networks (TINs) are constructed from a scattered set of *xyz* vertices. They can be used for visualization, as background elevation maps for generating new TINs or DEMs, or to obtain cross sections for hydraulic models. WMS has powerful tools for importing and manipulating TIN data.

This tutorial will discuss and demonstrate:

- Importing survey data
- Digitizing data
- Triangulation
- Automated and manual TIN editing
- Creating a TIN using a conceptual model
- Converting a TIN to a DEM

2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **Don't Save** to clear all data.

The graphics window of WMS should refresh to show an empty space.

3 Importing Survey Data

1. Select *File* | **Open…** to bring up the *Open* dialog.

2. Select "Text File (*.txt)" from the *Files of type* drop-down.
3. Browse to the *tins\tins* folder and select "surveytm.txt".

This is a tab delimited file exported from a spreadsheet application.

4. Click **Open** to exit the *Open* dialog and bring up the *Step 1 of 2* page of the *File Import Wizard* dialog.
5. Click **Next >** to accept the defaults and go to the *Step 2 of 2* page of the *File Import Wizard* dialog.
6. Select "Survey Data" from the *WMS data type* drop-down.
7. In the spreadsheet in the *File preview* section, Select "X", "Y", and "Z" from the drop-downs in the *Type* row for the first, second, and third columns, respectively.
8. Click **Finish** to close the *File Import Wizard* dialog and finish importing the text file.
9. Right-click on " surveytm" under " Terrain Data" in the Project Explorer and select **Display Options…** to open the *Display Options* dialog.
10. Select "TIN Data" from the list on the left.
11. On the *TIN* tab, turn on *Unlocked Vertices*.
12. Click **OK** to close the *Display Options* dialog.

The points from the "surveytm.txt" file should now be visible (Figure 1).

Figure 1 Points in the imported TIN

13. Select *Display* | **Display Projection...** to bring up the *Display Projection* dialog.
14. In the *Horizontal* section, select *Global Projection* to bring up the *Horizontal Projection* dialog.
15. Enter "NAD 1927 UTM Zone 12N" in the *Filter strings* field.
16. Select "NAD 1927 UTM Zone 12N" from under "NAD 1927" in the list field above *Filter strings*.
17. Click **OK** to close the *Horizontal Projection* dialog.
18. In the *Vertical* section, select "Feet (U.S. Survey)" from the *Units* drop-down.
19. Click **OK** to close the *Display Projection* dialog.

20. Select **Yes** if a message appears saying that the horizontal and vertical units are inconsistent.

4 Getting a Background Image

Start with opening an image file to use as reference for the rest of the tutorial.

1. Click **Open** to bring up the *Open* dialog.
2. Select "trailmountain.tif" and click **Open** to import the image and exit the *Open* dialog.
3. **Zoom** in to the TIN vertices.
4. Turn off " trailmountain.tif" in the Project Explorer and **Frame** the project.

This zooms in on the TIN vertices.

5. Turn on " trailmountain.tif" after framing.

5 Digitizing Data

The Digitize Mode allows maps to be quickly digitized or updated with additional vertices.

1. Select *Display* **|** *Toolbars* **| Digitize** to turn on the Digitize Mode toolbar at the bottom of the WMS screen (Figure 2).

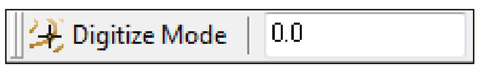


Figure 2 Digitize Mode toolbar

2. Click **Digitize Mode** on the toolbar to turn on digitize mode.
3. Enter "**6800"** in the white box to the right of the **Digitize Mode** button.
4. Switch to the **Terrain Data Module** .
5. Using the **Add Vertices** tool, digitize the 6800 foot contour (the darker line touching the large "26" near the middle of the screen) by using the background image to add vertices. Only digitize within the same area as the existing TIN vertices.
6. Click **Digitize Mode** on the toolbar to turn off digitize mode.
7. Select *Display* **|** *Toolbars* **| Digitize** to turn off the *Digitize* toolbar.

6 Merging TINs

It is sometimes desirable for elevation data from different sources to be merged together into a single TIN or DEM, especially when building a hydraulic model. For example, survey data representing the bathymetry of a stream channel may be stored as contours in a CAD program. That data can then be merged with DEM data from the USGS. In some cases, it is necessary to cut cross sections that include both the channel geometry (obtained from a survey of the channel) and the floodplain (obtained from a USGS DEM).

Merging two or more elevation data sources into a single TIN is a 3-step process. First, make sure the coordinate systems of each set of elevation data match. All the elevation data needs to line up, and all the elevations should be in either US Customary or SI units. Second, convert each set of elevation data to a separate TIN. Third, merge all of the TINs into a single TIN using the Merge TINs command. This section of the tutorial shows how to use these three steps to merge separate elevation sources in WMS.

6.1 Importing a CAD File

1. Click **New**.
2. Click **Don't Save** if asked to save changes.
3. Select *File* | **Open** to bring up the *Open* dialog.
4. Select "tmcontours.dwg" and click **Open** to exit the *Open* dialog.

This file is from a CAD program and contains contours for a small area (Figure 3).

Figure 3 Imported CAD contour file

6.2 Converting the CAD Contours to Arcs

The elevation data in this file will be merged with data from a DEM, but first it must be converted to a TIN. To convert the DWG file to a TIN, first convert the contour lines to arcs, redistribute vertices on the arcs, and convert the arcs with the redistributed vertices to a TIN. Normally, it is not recommended to convert contour lines directly to a TIN because the vertices along each contour line might be at a random or undesirable spacing to generate a quality TIN.

1. Right-click on " tmcontours.dwg" under the " CAD Data" folder and select *Convert* | **Feature Objects…** to bring up the *CAD → Feature Objects* dialog.
2. Uncheck the check boxes on rows 1 and 2, leaving *CAD layers_arcs* turned on.
3. Click **OK** to close the *CAD → Feature Objects* dialog and bring up the *Clean Options* dialog.
4. Click **OK** to close the *Clean Options* dialog and open the coverage *Properties* dialog.
5. Select "General" from the *Coverage type* drop-down.
6. Enter "CAD Layers" as the *Coverage name*.

7. Click **OK** to close the *Properties* dialog and create the " CAD Layers" coverage.
8. Right-click on " CAD Data" under the " GIS Data" folder and select **Delete**.
9. Switch to the **Map Module** and select the **Select feature Arc** tool.
10. Select *Edit* **| Select All** to select all feature arcs.
11. Select *Feature Objects* **| Redistribute…** to bring up the *Redistribute Vertices* dialog.
12. In the *Arc Redistribution* section, enter "20.00" as the *Average Spacing***.**
13. Click **OK** to close the *Redistribute Vertices* dialog.

When redistributing the vertices, WMS interpolates elevations for any new vertices on the arc from existing arc vertices.

6.3 Converting the CAD File to a TIN

Now that the vertices on the arcs have been redistributed to a more even spacing, convert the contours to a TIN.

1. Select *Feature Objects* **| Arcs → TIN Vertices**.
2. Select *Display* **| Display Options…** to bring up the *Display Options* dialog.
3. Select "TIN Data" from the list on the left.
4. On the *TIN* tab, turn on *Triangles*.
5. Click **OK** to close the Display Options dialog.
6. Right-click on the " New tin" and select *Triangles* **| Triangulate** on the pop-up menu.

WMS will create triangles throughout the TIN (Figure 4).

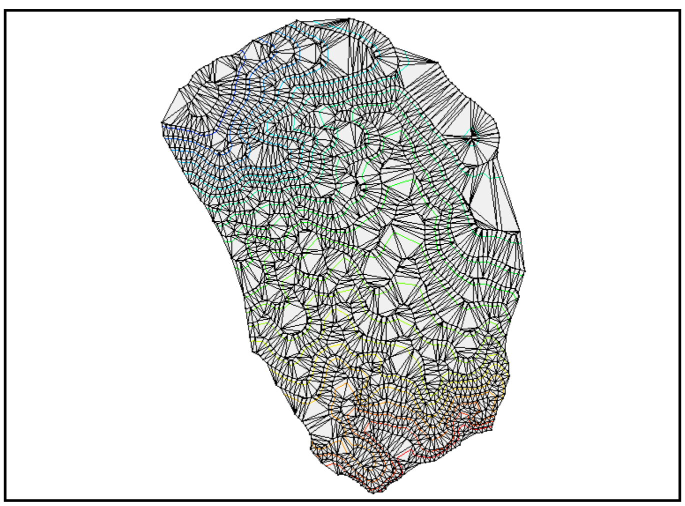


Figure 4 Triangulated TIN

7. Switch to the **Map Module**.
8. Select *Feature Objects* **| Delete** to bring up a confirmation dialog.

9. Click **OK** to delete all of the original contour data.
10. Right-click on " New tin" and select **Rename**.
11. Enter "CAD Contours" and press *Enter* to set the new name.

The TIN has now been created, but the projection has not yet been defined.

1. In the Project Explorer, right-click on " CAD Contours" and select *Projection* | **Projection**.
2. In the *Horizontal* section, select *Global Projection* to bring up the *Horizontal Projection* dialog.
3. Enter "NAD 1927 UTM Zone 12N" in the *Filter strings* field.
4. Select "NAD 1927 UTM Zone 12N" from under "NAD 1927" in the list field above *Filter strings*. This option may also be listed under "Recent Projections".
5. Click **OK** to close the *Select Projection* dialog.
6. In the *Vertical* section, select "NGVD 29(US)" from the *Datum* drop-down.
7. Select "Feet (U.S. Survey)" from the *Units* drop-down.
8. Click **OK** to close the *Projection* dialog.
9. Click **Yes** if asked to continue with inconsistent horizontal and vertical units.

6.4 Importing the DEM File

1. Click **Open** to bring up the *Open* dialog.
2. Select "trailmountain.dem" and click **OK** to exit the *Open* dialog.
3. Right-click on "trailmountain.dem" and select *Convert To* | **DEM** to bring up the *Resample and Export Raster* dialog.
4. Click **OK** to accept the defaults and close the *Resample and Export Raster* dialog.

The USGS DEM file has now been imported, and the TIN is visible near the top of the DEM (Figure 5).

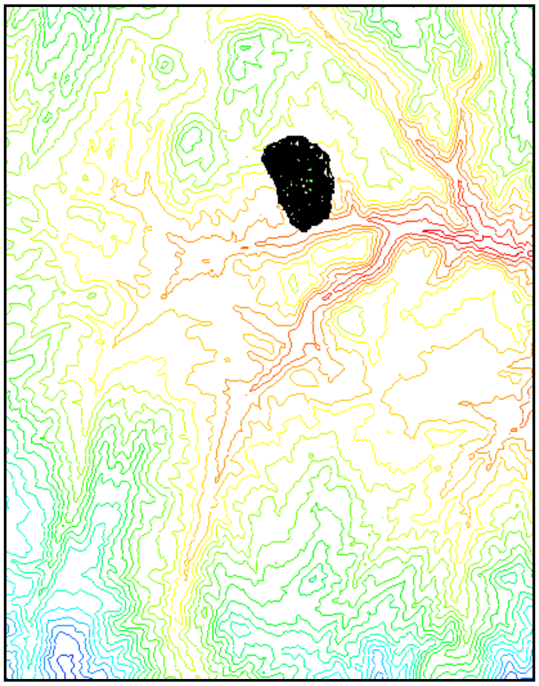


Figure 5 TIN (black) with imported DEM

6.5 Reprojecting the CAD TIN

To merge the imported DEM with the TIN created from the CAD contours, convert the DEM to a TIN and make sure all the TINs are in the same coordinate system. The XY projection of the DEM and TIN are currently in meters in the same UTM coordinate system, however, the elevations on the DEM are in meters while the elevations on the TIN are in feet. The vertical units for the "CAD Contours" TIN will need to be reprojected to "Meters" so that the units are consistent.

1. Right-click on " CAD Contours" and select *Projection* | **Reproject…** to bring up the *Reproject Object* dialog.
2. In the *Project Projection* section, turn on *Set*.
3. In the *Horizontal* section under *Project Projection*, select *Global Projection*.
4. Click **Set Projection…** to bring up the *Select Projection* dialog.
5. Enter "NAD 1927 UTM Zone 12N" in the *Filter strings* field.
6. Select "NAD 1927 UTM Zone 12N" from under "NAD 1927" in the list field above *Filter strings*. This option may also be listed under "Recent Projections".
7. Click **OK** to close the *Select Projection* dialog.
8. In the *Vertical* section, select "NGVD 29(US)" from the *Projection* drop-down.
9. Select "Feet (U.S. Survey)" from the *Units* drop-down.
10. Click **OK** to close the *Projection* dialog.
11. Click **Yes** if asked to continue with inconsistent horizontal and vertical units.

6.6 Converting the DEM to a TIN

The projections of the TIN and DEM are now consistent. But, before merging anything, the DEM must be converted to a TIN.

1. Right-click on " trailmountain.dem" and select *Convert* | *DEM* → *TIN* | **All…** to bring up the *DEM Conversion Options* dialog.
2. Turn on *Delete DEM.*
3. Click **OK** to accept the other settings and close the *DEM Conversion Options* dialog.

The DEM TIN may appear solid black. This is because the triangles for the DEM TIN are very small.

6.7 Merging the TINs

Now that both the CAD data and DEM data have been converted to TINs, they can be merged into a single TIN.

4. Right-click on " CAD Contours" and select **Merge…** to bring up the *Merge TINs* dialog.
5. Between the *Available TINs* and *TINs to Merge* lists, click **All** → to move both TINs in the *Available TINs* list to the *TINs to Merge* list.

To merge these TINs together and delete any regions of overlap between the TINs, order the TINs in the correct order in the list of TINs to merge. They should be ordered in the priority used for merging TINs. Put the least accurate TIN at the top, the most accurate at the bottom.

6. In the lower section, select *Delete overlapping regions*.
7. In the *TINs to Merge* list, select "CAD Contours" and click **Move down** so it is at the bottom of the list.
8. Click **OK** to close the Merge TINs dialog.

The merging may take a few minutes to complete, depending on the speed of the computer being used. Once completed, a new " Merged Tin" will appear in the Project Explorer.

9. In the Project Explorer, hold down the *Ctrl* key and select " CAD Contours" and " New tin".
10. Press **Delete** to remove these TINs.

A merged TIN has now been created that is a combination of the " CAD Contours" and the USGS DEM (" New tin"). This TIN can be used for hydraulic modeling or converted to a DEM so it can be used for hydrologic modeling.

7 Triangulation

Before proceeding with the tutorial, delete the existing data, import a TIN, and triangulate the data.

1. Select *File* | **New** .

2. Click **Don't Save** if asked to save changes.
3. Select *File* **| Open** to bring up the *Open* dialog.
4. Select "digitizetm.tin" and click **Open** to import the TIN and exit the *Open* dialog.
5. Right-click on " New tin" and select *Triangles* **| Triangulate**.

The imported TIN should now have triangles connecting all the points (Figure 6). If they are not visible, they can be turned on in the *Display Options* dialog, as explained in Step 6.3.

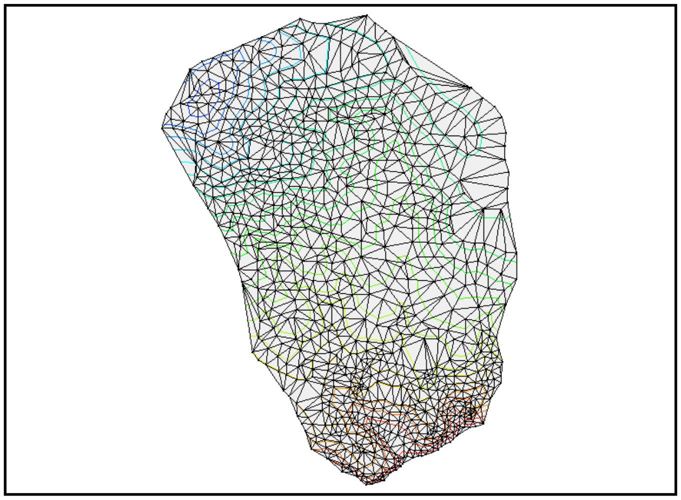


Figure 6 The TIN is now triangulated

8 Automated TIN Editing

WMS has automated methods of editing TINs to provide a representation of terrain that is useful for drainage analysis. These methods include data transformations and eliminating flat triangles and pits, but they are seldom needed since flat triangles and pits pose few problems when using the DEM-based watershed delineation tools in WMS. Data transformations may be useful for repositioning data if it is not originally located in the correct position because of survey errors or an unknown coordinate system. After transforming coordinates, always set the display projection system if it is known.

8.1 Transformations

Move the cursor over the TIN and notice that the *Z* values in the help strip at the bottom of the WMS window are in feet. Because the *XY* values on this particular TIN are in meters, the *X*, *Y*, and *Z* units should all be in meters, so they match when delineating a watershed. In this section, the *Z* values are converted from feet to meters. This is normally done using the coordinate conversion tool, but the transform tool can be used to accomplish the same thing.

1. Select *TIN* **|** *Vertices* **| Transform…** to bring up the *Transform TIN* dialog.
2. In the first section, enter "**0.3048"** for the *Z* in the *Scale* column.

This changes the elevation units from feet to meters. Notice that there are several other options for transforming TIN vertices, including options to translate and rotate vertices on the entire TIN. These will not be used at this time.

3. In the lower section, turn on *Frame image after transformation*.
4. Click **OK** to close the *Transform TIN* dialog.

Move the cursor over the TIN and notice that the *Z* values in the help strip are now in meters. Elevation values should be in the 1900–2300 range.

8.2 Converting a TIN to a DEM

If delineating a watershed, convert the TIN to a DEM. This section demonstrates how to delineate a watershed from a TIN by converting the TIN to a DEM.

1. Right-click on " New tin" and select *Convert* **| TIN → DEM** to bring up the *Convert TIN to DEM* dialog.
2. Below the drop-down, enter "10.00" as both the *cell width* and *cell height***.**
3. Click **OK** to close the *Convert TIN to DEM* dialog.
4. In the Project Explorer, hide " New tin".

Notice that the TIN disappeared, leaving only the contour lines.

5. Switch to the **Drainage** module.
6. Select *DEM* **| Compute Flow Direction/Accumulation…** to bring up the *Flow Direction/Accumulation Run Options* dialog.
7. Click **OK** to accept the defaults and close the *Flow Direction/Accumulation Run Options* dialog and bring up the *Units* dialog.
8. Click **OK** to accept the defaults and close the *Units* dialog and bring up the *Model Wrapper* dialog.
9. When TOPAZ finishes, turn on *Read solution on exit* and click **Close** to close the *Model Wrapper* dialog.
10. Select *Display* **| Display Options…** to bring up the *Display Options* dialog.
11. Select "DEM Data" from the list on the left.
12. On the *DEM* tab, click **Change Units…** to bring up the *Units* dialog.
13. Under *Parameter* units change *Basin Areas* to "Acres" and click **OK** to exit the *Units* dialog.
14. Enter "0.1" (acres) as the *Min Accumulation For Display*.
15. On the *DEM* tab, turn on *Flow Accumulation*.
16. Click **OK** to close the *Display Options* dialog.
17. **Zoom** in to the outlet area of the main stream system (Figure 7).
18. Using the **Create outlet point** tool, create an outlet similar to as shown in Figure 7.

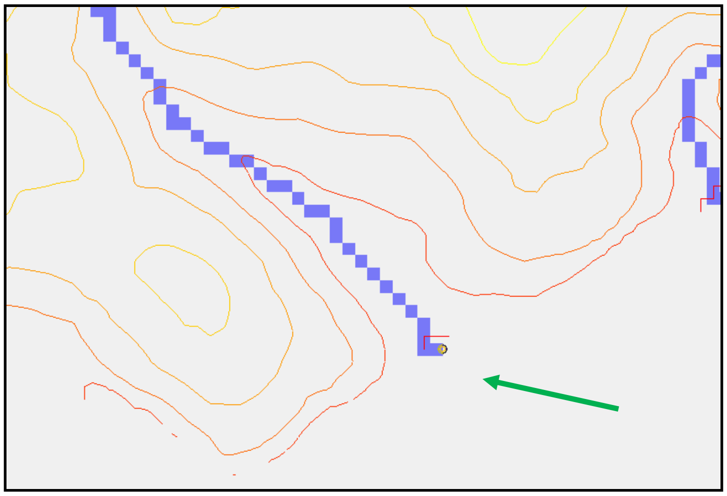


Figure 7 DEM outlet (green arrow)

19. Select *DEM* | **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.
20. Click **OK** to accept the defaults, close the *Stream Feature Arc Options* dialog, and open the *Units* dialog.
21. Click **OK** to accept the defaults, delineate the watershed, compute the basin data, and close the *Units* dialog.
22. **Frame** the project.
23. Click **Display Options** to bring up the *Display Options* dialog.
24. Select "Map Data" from the list on the left.
25. On the *Map* tab select "Drainage" from the *Coverage type* drop-down.
26. Turn on the *Color Fill Polygons* option.
27. Below the *Legends* section, click **Set Polygon Transparency…** to bring up the *Set Feature Polygon Transparency* dialog.
28. Set *Transparency* to "75%" and click **OK** to close the *Set Feature Polygon Transparency* dialog.
29. Select "DEM Data" from the list on the left.
30. Verify that the *Min Accumulation For Display* is set to "0.1" (acres).
31. Click **OK** to close the *Display Options* dialog.

A drainage boundary based on the DEM and drainage basin data is visible (should look similar to Figure 8).

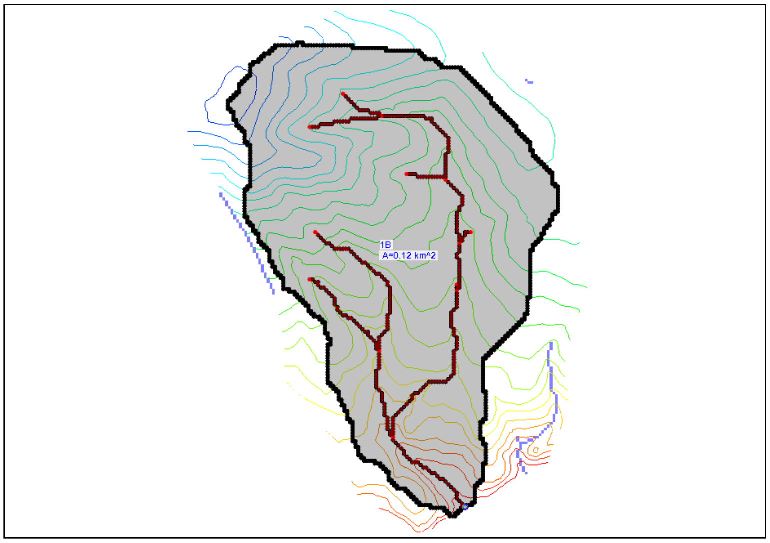


Figure 8 The drainage basin is now visible

9 Conclusion

This concludes the "Using TINs" tutorial. The following topics were discussed and demonstrated:

- How to import survey data
- How to digitize data
- Triangulation
- Automated TIN editing
- Manual TIN editing
- How to create a TIN using a conceptual model
- How to convert a TIN to a DEM

