GMS TUTORIALS

Stratigraphy Modeling – Boreholes and Cross Sections

The Borehole module of GMS can be used to visualize boreholes created from drilling logs. Also three-dimensional cross sections between boreholes can be constructed. These cross sections show the soil stratigraphy between two boreholes. Once a set of cross sections is built, they can be displayed in 3D space to help characterize and visualize the soil stratigraphy at a site.

In this tutorial you will learn how to construct a set of cross sections for site characterization using borehole data.

1.1 Outline

This is what you will do:

1. Import boreholes.
2. Display the borehole names and edit the materials.
3. Create and fill cross sections automatically and manually.

1.2 Required Modules/Interfaces

You will need the following components enabled to complete this tutorial:

- Sub-surface characterization.
- Geostatistics

You can see if these components are enabled by selecting the *File* | *Register*. If you do not have these components enabled, you can complete the tutorial in *Demo Mode*. You can switch to *Demo Mode* by selecting the *File* | *Demo Mode* menu command.

2 Getting Started

Let's get started.

1. If necessary, launch GMS. If GMS is already running, select the *File* | *New* command to ensure that the program settings are restored to their default state.

3 Reading Borehole Data

The first step in the construction of borehole cross sections is to create some boreholes. We will read in a set of previously defined borehole logs.

1. Select the *Open* button .
2. Locate and open the directory entitled **tutfiles\Stratigraphy Modeling\horizons**.
3. Change the *Files of type* to **Text Files (*.txt;*.csv)**.
4. Select the file named **holes.txt** and click on the *Open* button.

This brings up the *Text Import Wizard*. All kinds of data can be imported into GMS via the *Text Import Wizard*.

5. Turn on the *Heading row* option and click *Next*.
6. Change the *GMS data type* to **Borehole data** (not Borehole sample data).

Notice all the column types are automatically assigned based on the header row because GMS recognized the headings. You might want to take a minute and examine the format of the borehole file being imported.

7. Click *Finish*.
8. Select the *Oblique View* button .

You should now see a 3D view of the boreholes.

4 Displaying the Hole Names

Right now the boreholes probably appear very long and thin - so much so that you cannot distinguish the different materials. Let's adjust the borehole display options so we can see things better.

1. Select the *Borehole Data* folder in the *Project Explorer*.
2. Select the *Display Options* button.
3. Make sure the *Borehole Data* item in the list on the left is selected.

Take a minute to look at the display options available for boreholes. Ignore the right side of the dialog for now – we don't have sample data, only stratigraphy data.

4. Change the *Diameter* to **7**.
5. Turn on the *Hole names* option.
6. Select the *OK* button.

The boreholes should be more visible now and the names of the holes should appear at the tops of the holes.

5 Editing the Materials

Each of the colors represents a different type of soil. The file we just imported specified a material ID number for each section of each borehole. GMS created materials with those IDs and gave them default names and colors. Let's change the material names and colors.

1. Select the *Edit* | *Materials* menu command.
2. Double-click on **material_1** and change its name to "**Clean Sand**".
3. Click on the down arrow on the *Material color/pattern* button to change the color to green.
4. In a similar manner, rename **material_2** to "**Silty or Clayey Fine Sand**" and change its color to blue.
5. Also rename **material_4** to "**Silty Clay"** and change its color to red.
6. Turn on the *Display material legend* option.
7. Click *OK*.

6 Creating Blank Cross Sections

The next step is to create a set of blank cross sections. The set of cross sections will be "blank" because at this point we are indicating where the cross section should be, not what it should look like. The blank cross sections will appear as two lines connecting the tops and bottoms of the two boreholes. Cross sections created between two boreholes are named by the combination of the two holes' names. For example, a cross section created between holes 1G and 7G will be named as 1G-7G.

6.1 Auto-Create Blank Cross Sections

The easiest way to create blank cross sections is to do it automatically.

1. Select the *Boreholes|Auto-Create Blank Cross Sections* menu command.

Notice that GMS connects the holes with blank cross sections. GMS simply triangulates the boreholes to determine how to connect them.

6.2 Snapping the Cross Section Tops to a Surface

The top and bottom lines that define each cross section can be adjusted to match a TIN that defines each surface. You will now read in a TIN and snap the cross section tops to the TIN elevations.

1. Select the *Open* button .
2. Locate and open the directory entitled **tutfiles\horizons**.
3. Change the filter to **All Files (*.*)**.
4. Select the file named **top_elev.tin**.

You should now see a TIN in the graphics window.

5. Now select the *Boreholes|Advanced|Snap Cross Sections to TIN* command.
6. Turn on the *Snap Top to TIN* option and select *OK*.
7. Uncheck the check box next to the **top elevation** TIN in the *Project Explorer* to hide the TIN.

You should now be able to see that the cross section tops have been adjusted to match the TIN elevations.

Now let's see how to create cross sections manually. Before we do, we'll delete all the cross sections we just created.

1. Select the *Select Borehole Cross Sections* tool .

2. Select the *Edit*|*Select All* menu command.

3. Click the *Delete* key.

6.3 Manually Create Blank Cross Sections

The set of blank cross sections we will create are: 1G-7G, 7G-2G, 2G-5G, 4G-5G, 5G-6G, 6G-7G, 3G-6G, and 6G-8G.

1. Select the *Create Borehole Cross Sections* tool .

2. Click on hole **1G** to begin, then single click on hole **7G**, **2G**, **5G**, **6G** in sequence and double click on hole **8G** to end.

3. Create cross sections 3G-6G and 6G-7G by clicking on hole **3G** to begin, then single clicking on hole **6G**, and double clicking on hole **7G** to end.

4. Create cross section 4G-5G by clicking on hole **4G** to begin and double clicking on hole **5G** to end.

The "blank" cross sections should look like those in the figure below.

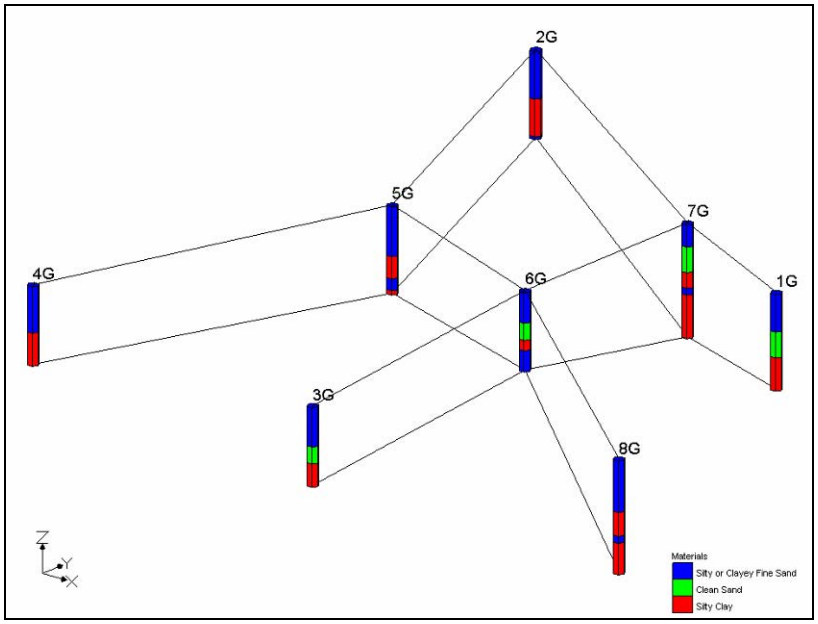

Figure 6.1 Blank Cross Sections

7 Auto-Fill Blank Cross Sections

You are now ready to delineate soil layers for the blank cross sections. We do this using arcs and polygons, just like the arcs and polygons in the *Map* module of GMS. If you are unfamiliar with the *Map* module, don't worry. It is not necessary for this tutorial.

The easiest way to fill the blank cross sections is to let GMS do it automatically.

1. Select the *Boreholes|Auto-Fill Blank Cross Sections* menu command.

The dialog that appears has two options: *Match using horizon IDs* and *Match using materials*. Horizons are discussed in the next tutorial, so we won't discuss them in detail here. However, you should know that it is preferable to first assign horizon IDs before using the *Auto-Fill* command, and to then use the horizon IDs to fill the cross sections. That way the cross sections are consistent with the horizon IDs. Since we have not done anything with horizon IDs yet, we will ignore them and use the *Match using materials* option.

2. Select the *Match using materials* option and click *OK*.

After a moment, GMS fills the blank cross sections.

8 Manually Fill Cross Sections 7G-2G

GMS cannot always automatically fill all cross sections. If two boreholes are too dissimilar, GMS cannot fill in the details of the cross section between the two holes. Or, if it can, the results may not be what you like. For these reasons, it is usually necessary to manually fill and edit cross sections.

With our relatively simple set of boreholes, GMS had no problem automatically filling all the cross sections. But we will illustrate how to do it manually anyway.

8.1 Building Cross Section 7G-2G

1. In the *Project Explorer*, expand the *Cross Sections* folder and double click on cross section **7G-2G**.

2. In the *Cross Section Editor,* click the *Delete All* button to delete all the existing polygons and arcs (the top and bottom arcs are not deleted).

3. Select the *Create Arc* tool .

4. Create all the arcs shown in Figure 8.1.

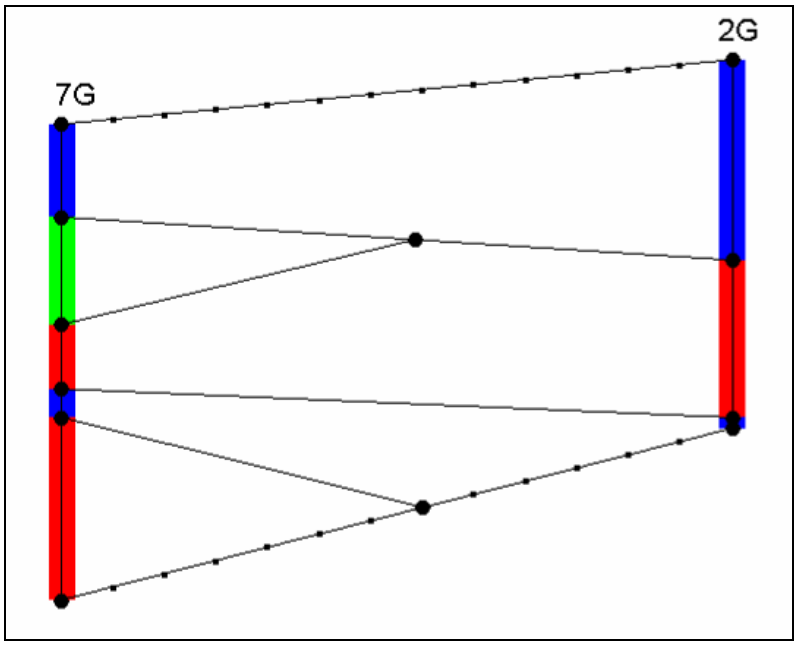

Figure 8.1 Cross Section 7G-2G

5. Select the *Build Cross-Section Polygons* button.

6. Select the *OK* button.

9 Manually Editing Multiple Cross Sections

GMS also allows you to edit multiple cross sections in the *Cross Section Editor*. This is useful when you are considering geologic trends from adjacent cross sections.

1. While holding down the *Shift* key select the following cross sections in the graphics window: **2G-5G**, **5G-6G**, and **6G-8G**.

2. Select the *Cross Section Editor* command from the *Boreholes* menu.

If desired you can maximize this dialog to better see the cross sections. Your dialog should look like the following.

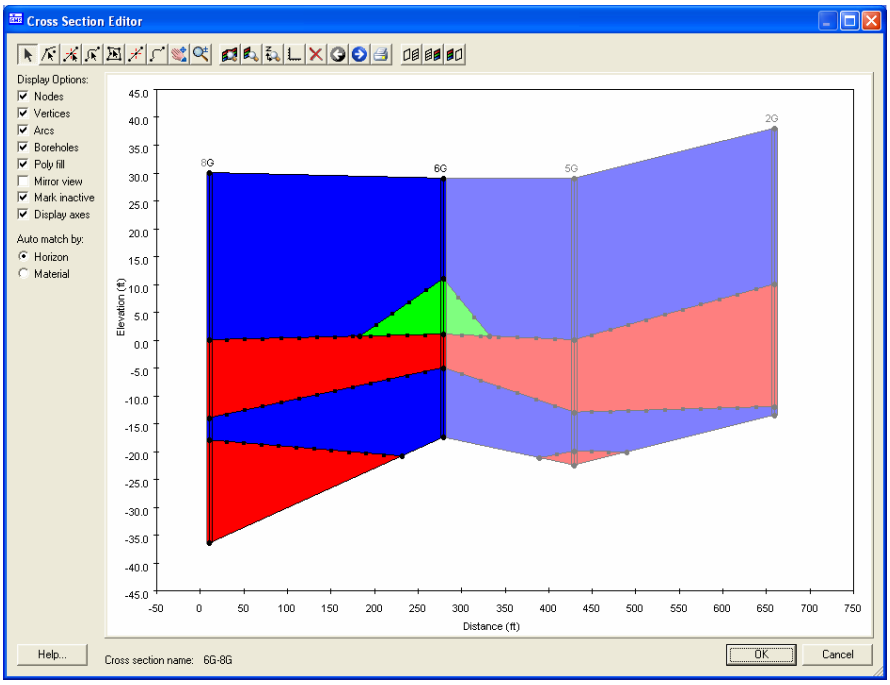

Figure 2 Multi-panel Cross Section Editor

Notice that the first panel from the left is brighter than the other panels in the dialog. This is the active panel that you can edit. You can change the active panel by selecting the Left or Right Arrow buttons . Let's edit the middle panel.

3. Click the *Right Arrow* button to make the middle panel available to edit.

4. Click the *Zoom to Panel* button so we can see this panel more clearly.

5. Click the *Delete All* button to delete all the existing polygons and arcs (the top and bottom arcs are not deleted).

6. Using the *Create Arc* tool make your cross section look like the following figure.

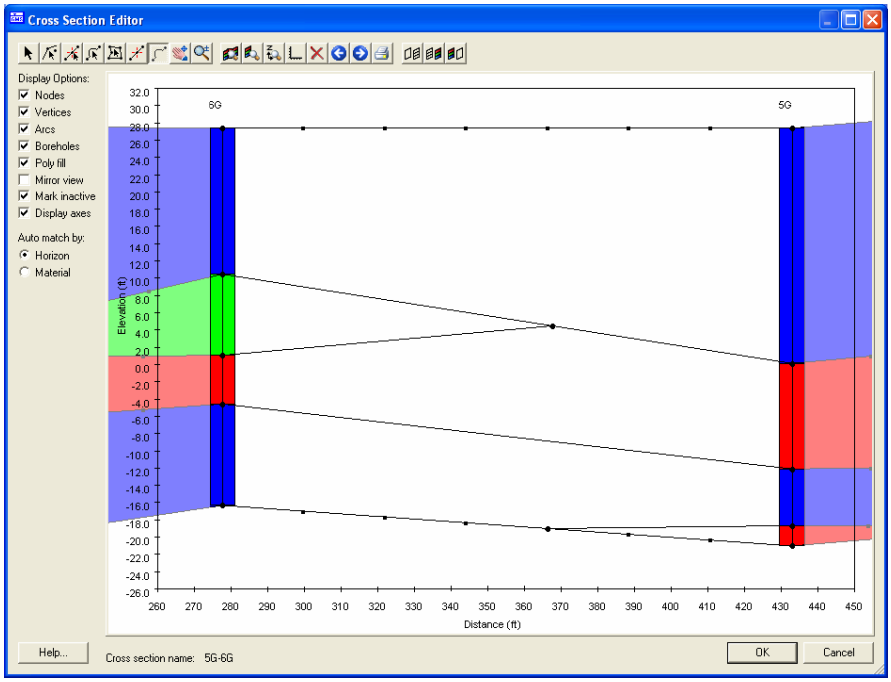

Figure 3 Panel 6G-5G in the Cross Section Editor

7. Now click the *Build Cross-Section Polygons* button so that the cross section will be filled with the materials.

8. Now click the *Frame All Cross Sections* button to see all of the cross sections again.

The *Cross Section Editor* also lets you adjust the plot that is displayed around the cross sections for high quality print outs. You can add titles as well as show grid lines on the plot.

9. Click the *Plot Options* button .

10. Enter **Section A-A'** in the *Title 1* edit field.

11. Click on the *Y-Axis* tab and toggle on the *Display grid* option in the middle of the dialog.

12. Select *OK* to exit the dialog.

13. Turn off the *Nodes*, *Vertices*, and *Mark inactive* options on the right side of the dialog. Your plot should now look something like this:

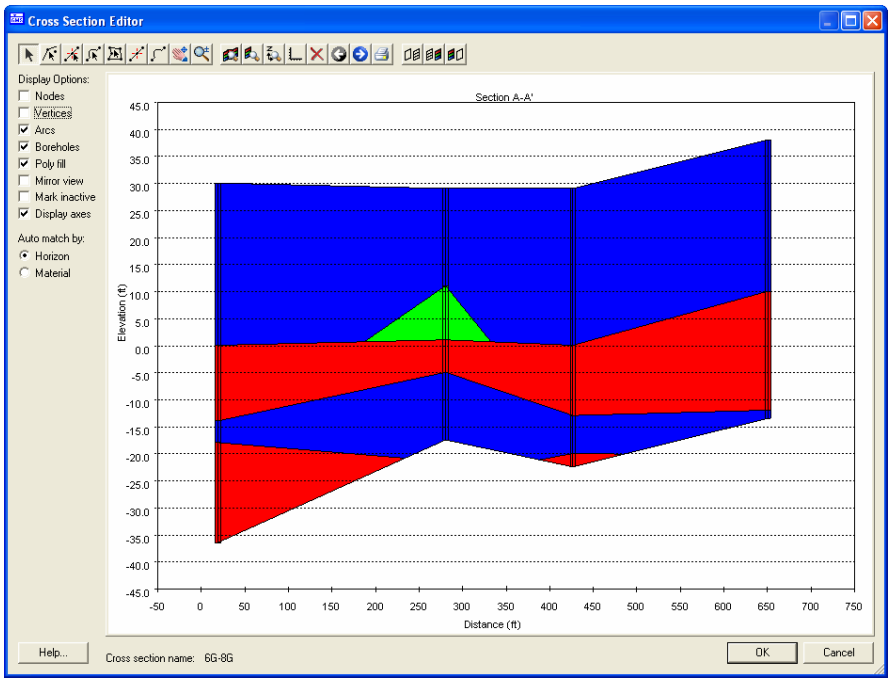

Figure 4 Multi-panel Cross Section Editor Ready for Printing

At this point you could also print this plot from the Cross Section Editor. If you wish to print your cross section then click the print button . You are now done editing the cross sections.

14. Select *OK* to exit the dialog.

10 Viewing the Stratigraphy

You're now done building the cross sections. Your cross sections should be similar to Figure 10.1 below.

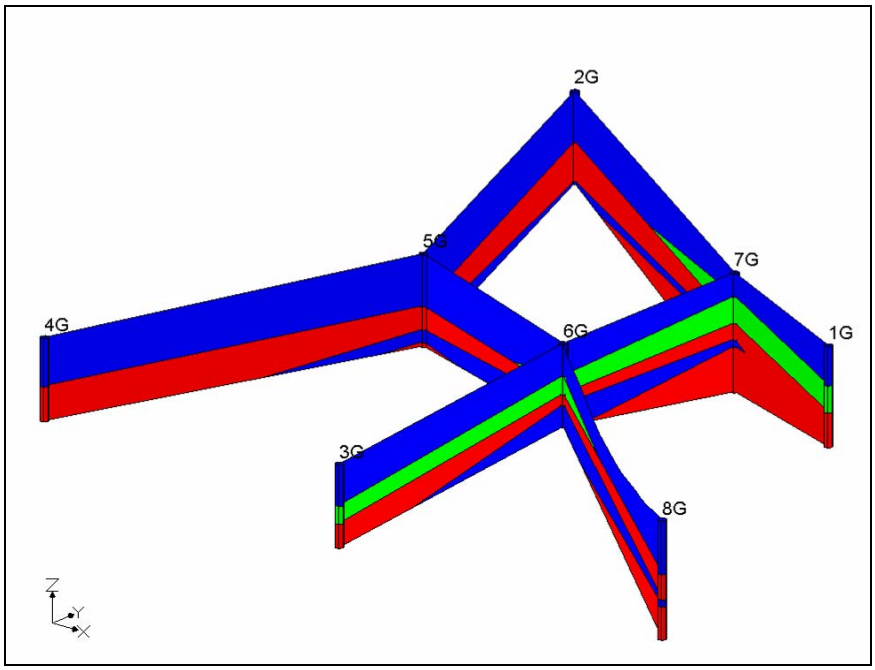

Figure 10.1 Site Stratigraphy

11 Conclusion

This concludes the tutorial. Here are the things that you should have learned in this tutorial:

- Boreholes can be imported via the *Text Import Wizard*.
- The display options for boreholes can be changed to aid in visualization.
- You can manually connect the boreholes to create cross sections or use the *Auto-Create Blank Cross Sections* command to create cross sections.
- When borehole cross sections are first created, they are blank.
- You can automatically fill cross sections using the *Auto-Fill Blank Cross Sections* command.
- The *Cross Section Editor* can be used to define how the soil layers are connected.
- Cross section arcs can be matched to a TIN.