

ARC HYDRO GROUNDWATER TUTORIALS

Working with Borehole Data

Arc Hydro Groundwater (AHGW) is a geodatabase design for representing groundwater datasets within ArcGIS. The data model helps to archive, display, and analyze multidimensional groundwater data, and includes several components to represent different types of datasets, including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models.

The *Arc Hydro Groundwater Tools* help to import, edit, and manage groundwater data stored in an AHGW geodatabase. This tutorial illustrates how to use the tools to manage borehole data and create 3D representations of hydrostratigraphy. A basic familiarity with the AHGW data model is suggested, but not required, prior to beginning this tutorial.

1.1 Outline

In this tutorial, we will be working with borehole data developed as part of project for creating a groundwater simulation model near the city of Roseville in the Sacramento valley, California. We will complete the following tasks:

1. Create a geodatabase to store well and borehole information.
2. Import a set of borehole data into an AHGW geodatabase.
3. Explore the borehole logs.
4. Generate and view 3D BoreLines derived from the borehole data.

1.2 Required Modules/Interfaces


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

- Arc View license (or ArcEditor\ArcInfo)
- 3D Analyst.
- AHGW Tutorial Files.

The *AHGW Tools* requires that you have a compatible ArcGIS service pack installed. You may wish to check the *AHGW Tools* documentation to find the appropriate service pack for your version of the tools. The tutorial files should be downloaded to your computer and saved on a local drive.

2 Getting Started

Before opening our map, let's ensure that the AHGW tools are correctly configured.

1. If necessary, launch *ArcMap*.
2. If necessary, open the *ArcToolbox* window by clicking on the *ArcToolbox* icon .
3. If you have not already done so, add the *AHGW Toolbox* by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox...* command. Browse to the *C:\Program Files\Aquaveo\Arc Hydro Groundwater Tools* directory and select and open the *Arc Hydro Groundwater Tools.tbx* file.
4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *Subsurface Analyst* toolset to expose the *Subsurface Analyst* tools.

Note that many of the geoprocessing tools in the AHGW Toolbox can also be accessed from the *AHGW Toolbar*. The toolbar contains additional user interface components not available in the toolbox. If the toolbar is not visible, do the following:

5. Right-click on any visible toolbar and select the *Arc Hydro Groundwater Toolbar* item.

When using geoprocessing tools you can set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

6. Open *ArcScene/ArcCatalog* (if not already open).
7. Select the *Geoprocessing / Geoprocessing Options...* command.

8. Activate the option: “*Overwrite the outputs of geoprocessing operations*” as shown in Figure 1.
9. Enable the option to “*Add results of geoprocessing operations to the display*” as shown in Figure 1.
10. Select *OK* to exit the setup.

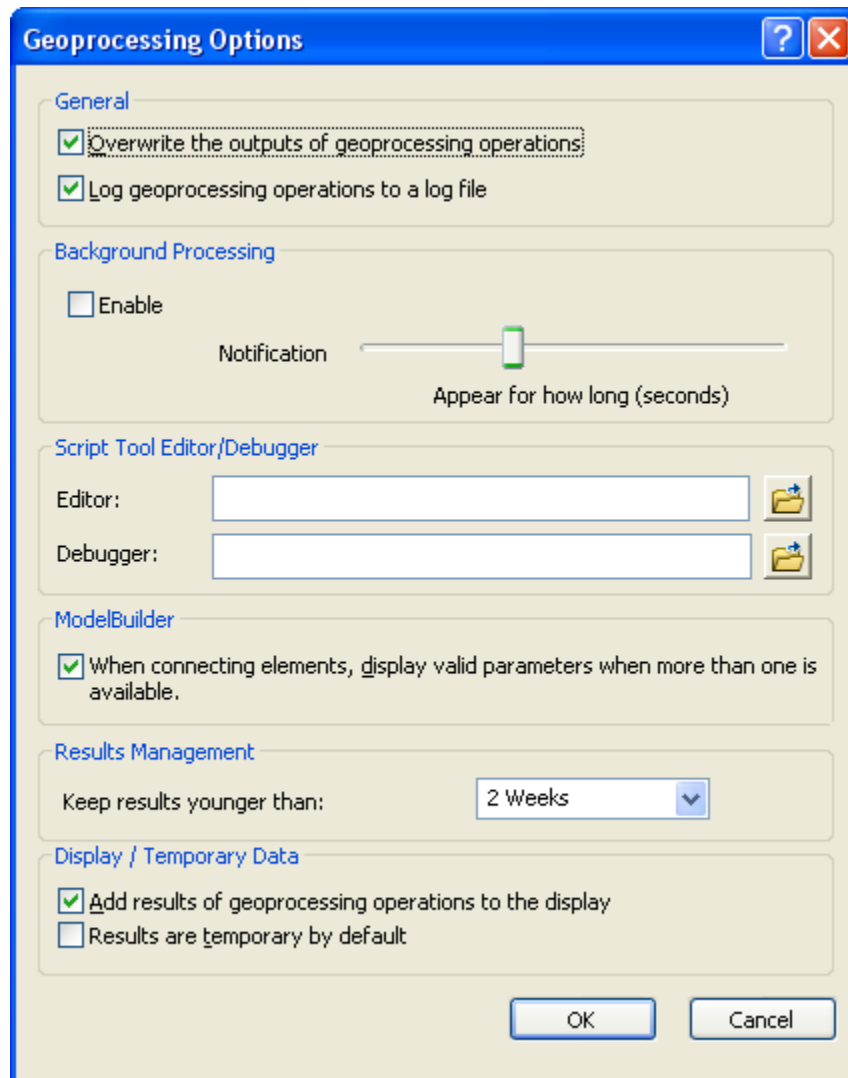


Figure 1 Setting Geoprocessing tools to overwrite outputs by default, and to add results of geoprocessing tools to the display.

3 Opening the Scene

We will begin by opening a scene of the model area.

1. Select the *File / Open* command and browse to the location on your local drive where you have saved the AHGW tutorials. Browse to the *subsurface analyst/boreholes* folder and open the file titled **boreholes.sxd**.

You should see a scene containing a DEM of the model domain (Figure 2).

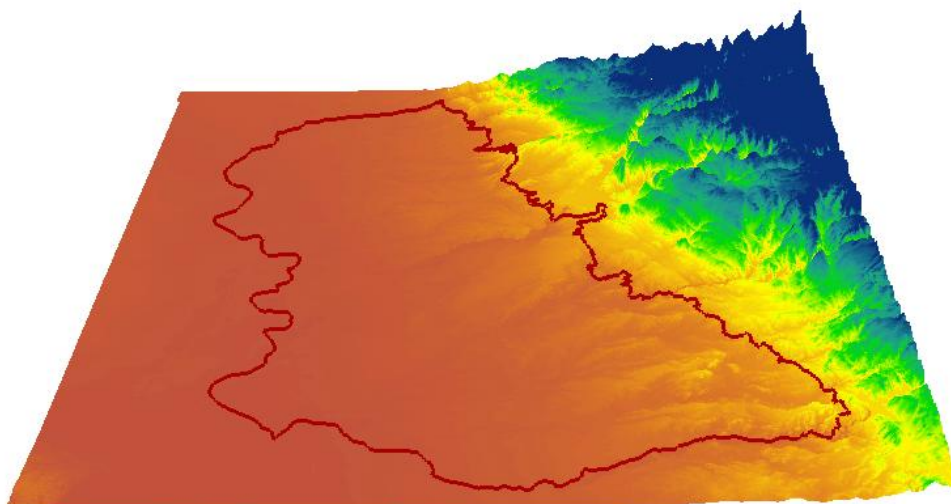




Figure 2 Scene of the Roseville model domain on top of a DEM of the region.

4 Creating the geodatabase

We will create a geodatabase with feature classes and tables to store the information necessary for the tutorial.

1. Select the *Create Blank AHGW Geodatabase* tool available in the *Groundwater Analyst* toolset.
2. For the Geodatabase Location browse to the **boreholes** folder.
3. For the Geodatabase Name specify Boreholes.

4. In the Spatial Reference, select the button on the right . This will open the *Spatial Reference Properties* interface. Select the *Import* option ,

and browse to the **ModelBoundary.shp** file located in the tutorial folder. Your interface should be similar to the one shown in Figure 3.

5. Select *OK*.

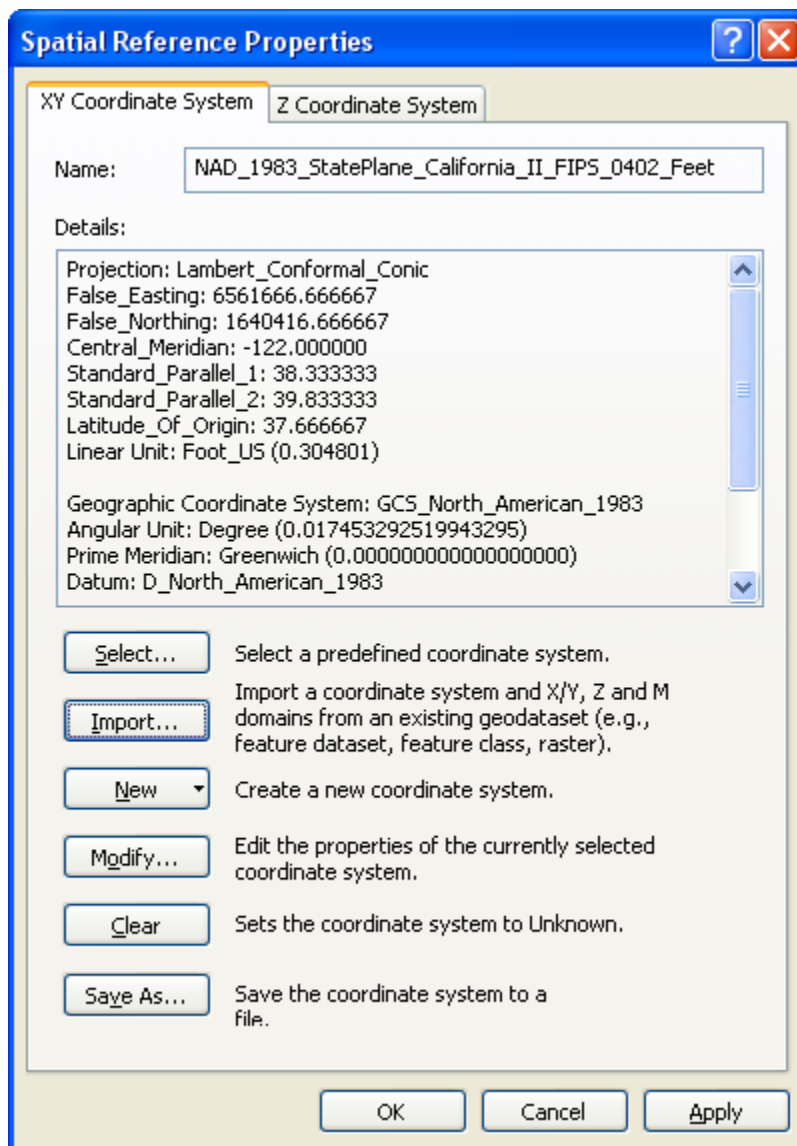


Figure 3 Setting the spatial reference for the new geodatabase.

6. Leave the *Use Personal Geodatabase* option checked.

Next, you will select the datasets to be included in the new geodatabase.

7. From the *Framework Datasets* select the **Well** feature class.
8. From the *Subsurface Datasets* select the **BoreholeLog** and **HydrogeologicUnit** tables, and the **BoreLine** feature class.

The tool inputs should be similar to the ones shown in Figure 4.

9. Select *OK* to run the tool.
10. Click on the *Close* button when the tool has finished.

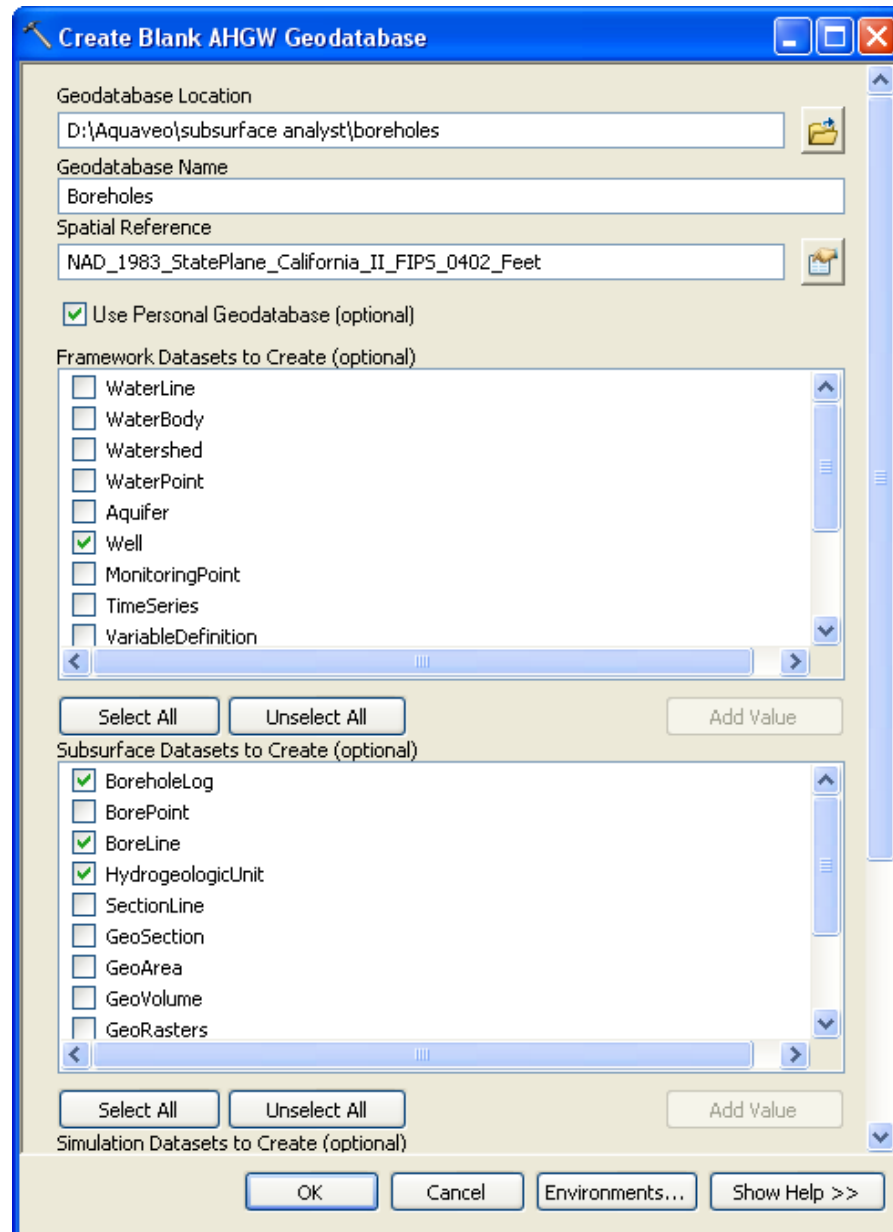



Figure 4 Inputs for the Create Blank AHGW Geodatabase tool.

When the tool has finished the Well and BoreLine feature classes should be added to the scene, as well as the BoreholeLog and HydrogeologicUnit tables (you might need to select the *List by Source* option  in the table of contents to view the tables).

Next, we will import data into the empty tables and features classes created.

5 Importing well features

To import well features we will use the *Text Import Wizard* available in the AHGW toolbar.

1. Select the *Arc Hydro GW / Text Import* command in the AHGW Toolbar.
2. Navigate to the *boreholes* folder where the tutorials are stored on the local drive and open the *wells.txt* file.
3. For the first step of the *File Import Wizard*, select options as shown in Figure 5.

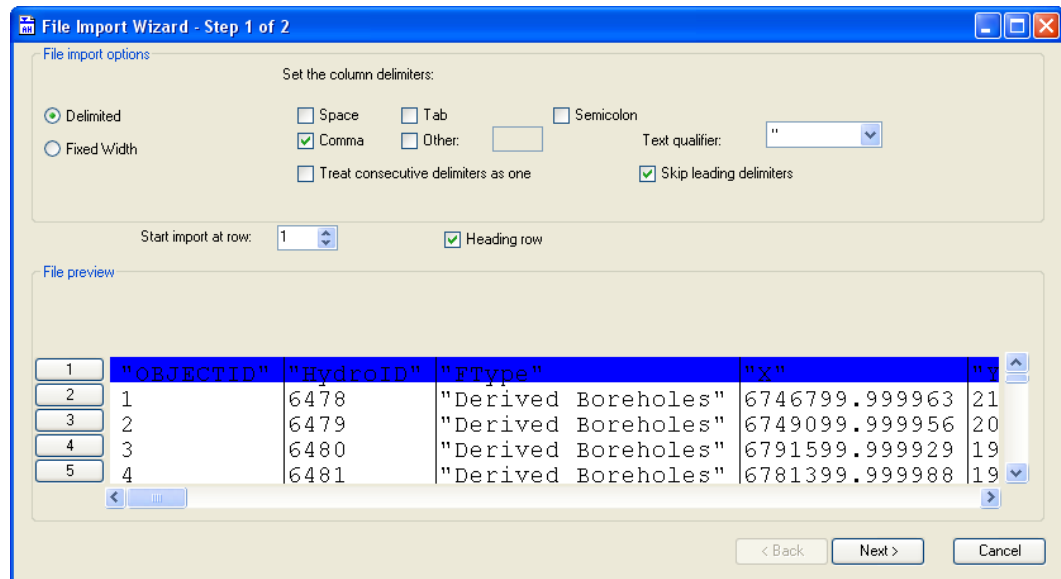


Figure 5 Importing well features, settings for the First Step of the File Import Wizard.

4. Click on the *Next* button to go to the next step of the *File Import Wizard*.

In the next step of the wizard we indicate the type of data we are importing and specify how each of the columns in the file is linked to fields in the target feature class/table. The contents of the file are shown in the table at the bottom of the dialog. For each column that we wish to import, we will select the appropriate field name in the *Type* row. By default, <not mapped> is selected for each column indicating that the column will not be imported to a field in the target table.

5. Make sure that the **Well** feature class is selected in the *Create Features/Rows in:* combo box.

6. Make sure that the fields are mapped correctly as described in the table below and shown in Figure 9Figure 6 (most of the fields should be matched automatically).

| Header | Type |
|----------|--------------|
| OBJECTID | <Not Mapped> |
| HydroID | HydroID |
| FType | FType |
| X | X |
| Y | Y |

The settings should be similar to the ones shown in Figure 6.

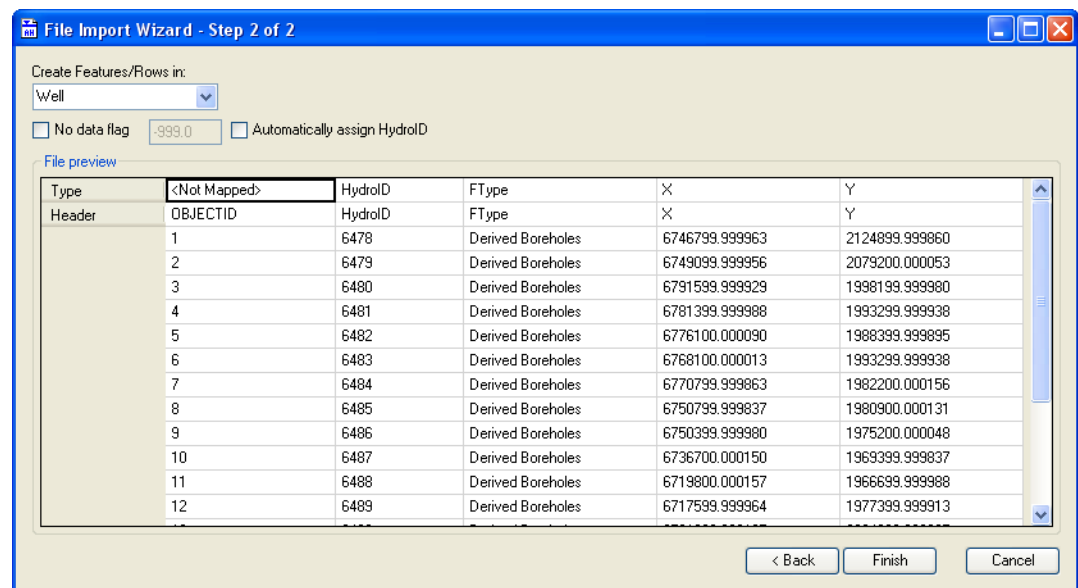

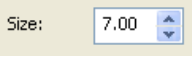


Figure 6 Importing well features, settings for the Second Step of the File Import Wizard.

7. Click on the *Finish* button.
8. Click *OK* at the prompt to confirm the import.

To better visualize the well features created:

9. Right-click on the *Well* layer and select the *Properties* command.

10. Select the *Symbology* tab, select the *Symbol* command  and increase the size of the symbol to **7** .

11. Select *OK*.

12. Select the *Base Heights* tab and select the *Floating on custom surface option*, make sure the **revised30m** DEM is specified as the surface.
13. Select *OK* to exit the *Layer Properties* interface.

The well features should be visual in the scene as shown in Figure 7.

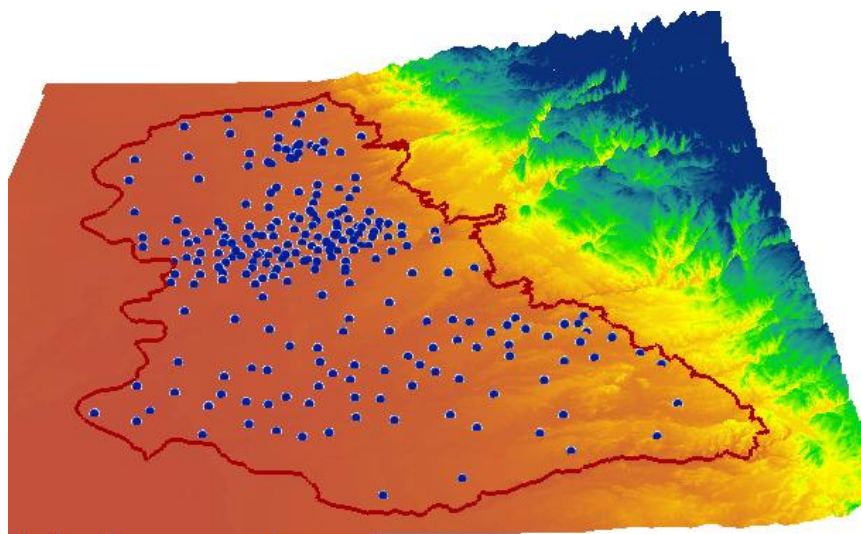


Figure 7 Well features shown in ArcScene floating on top of a DEM.

The HydroID of the well features is the key identifier for the features. Borehole information will be related to the well points by referencing the HydroID of the well.

Next we will import borehole data.

6 Importing Borehole Data

The Well feature class consists of points defining the XY locations of wells in the model domain. In this step, we will import a text file containing data from borehole logs associated with the wells. The records in this file will be added to the *BoreholeLog* table. Each record in the table represents a contact or elevation in the borehole at which the soil type changes from one material to another. These records define the stratigraphy at the location the borehole is drilled. We will import the records using the *Text Import* command in the AHGW Toolbar.

1. Select the *Arc Hydro GW / Text Import* command in the AHGW Toolbar.
2. Navigate to the *boreholes* folder where the tutorials are stored on the local drive and open the *boreholes.txt* file.
3. For the first step of the *File Import Wizard*, select options as shown in Figure 8.

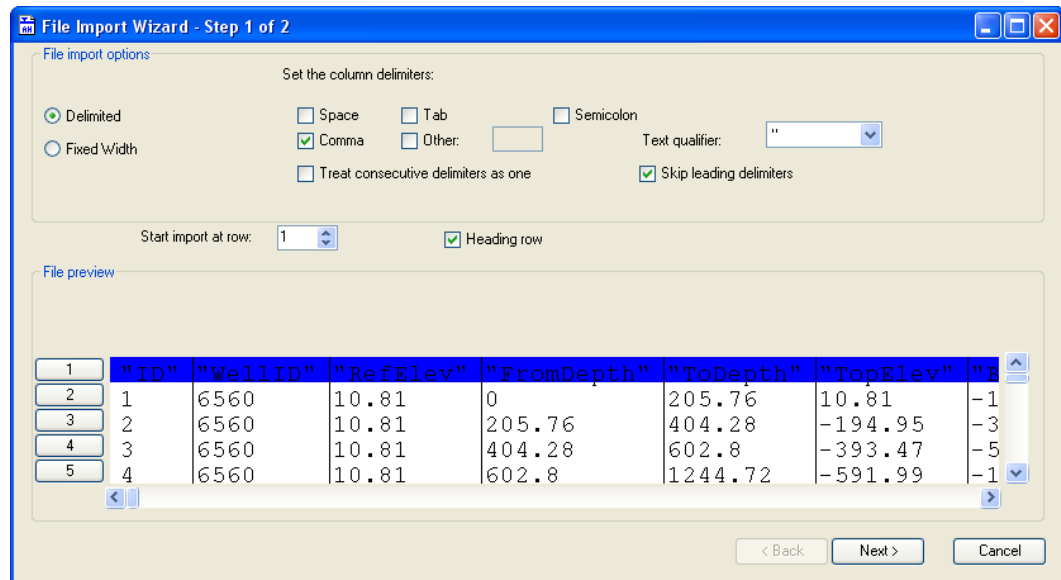


Figure 8 Importing borehole data, settings for the First Step of the File Import Wizard.

- Click on the *Next* button to go to the next step of the *File Import Wizard*.
- Make sure that the **BoreholeLog** table is selected in the *Create Features/Rows in:* combo box.
- Make sure that the fields are mapped correctly as described in the table below and shown in Figure 9 (most of the fields should be matched automatically).

| Header | Type |
|------------|--------------|
| ID | <Not Mapped> |
| WellID | WellID |
| RefElev | RefElev |
| FromDepth | FromDepth |
| ToDepth | ToDepth |
| TopElev | TopElev |
| BottomElev | BottomElev |
| ElevUnits | ElevUnits |
| HGUID | HGUID |
| LogType | LogType |

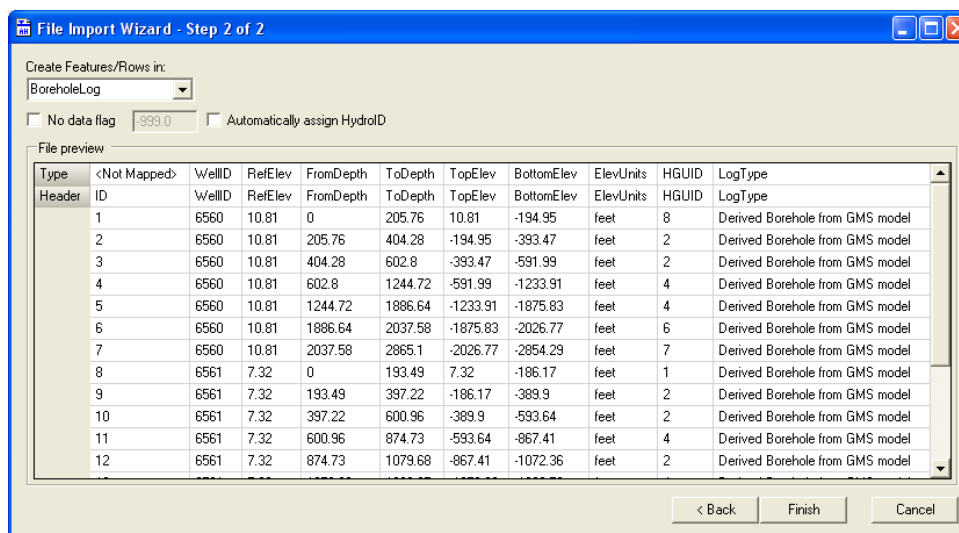


Figure 9 Importing borehole data, settings for the Second Step of the File Import Wizard.

7. Click on the *Finish* button.
8. Click *OK* at the prompt to confirm the import.

To view the new records in the *BoreholeLog* table:

9. Click on the *List By Source* tab in the TOC window.
10. Right-click on the *BoreholeLog* table and select the *Open* command.

The first column in the table (*WellID*) relates to the *HydroID* of the corresponding well. *TopElev* and *BottomElev* define the top and bottom elevation of the borehole segment represented by each record. The *HGUID* relates to the HydroID of a hydrogeologic unit defined in the *HydrogeologicUnit* table. Several of the features in the AHGW data model are used to model different representations of the same HGU's. For example, boreholes, GeoSections, and GeoVolumes, are different representations of the same formations. Thus, a common table is used to store summary information about HGU's and the various features are related using an HGUID field.

Next, we will import data into the *HydrogeologicUnit* table.

7 Importing Hydrogeologic Unit Data

The borehole logs imported in the previous steps include a reference to hydrogeologic units. The reference is based on a HGUID field that points to definitions of hydrogeologic units.

We will import the hydrogeologic unit records using the *Text Import* command in the AHGW Toolbar.

1. Select the *Arc Hydro GW / Text Import* command in the AHGW Toolbar.
2. Navigate to the *boreholes* folder where the tutorials are stored on the local drive and open the *HGUs.txt* file.
3. For the first step of the *File Import Wizard*, select options as shown in Figure 10.

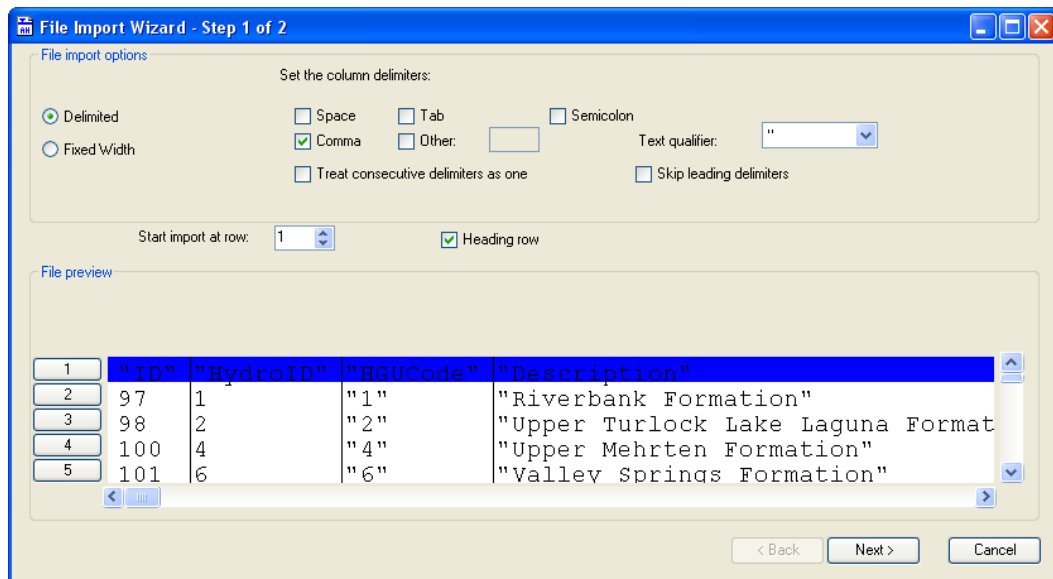


Figure 10 Importing hydrogeologic unit data, settings for the First Step of the File Import Wizard.

4. Click on the *Next* button to go to the next step of the *File Import Wizard*.
5. Make sure that the **HydrogeologicUnit** table is selected in the *Create Features/Rows in:* combo box.
6. Make sure that the fields are mapped correctly as described in the table below and shown in Figure 11 (most of the fields should be matched automatically).

| Header | Type |
|-------------|--------------|
| ID | <Not Mapped> |
| HydroID | HydroID |
| HGUCode | HGUCode |
| Description | Description |
| HGUName | HGUName |

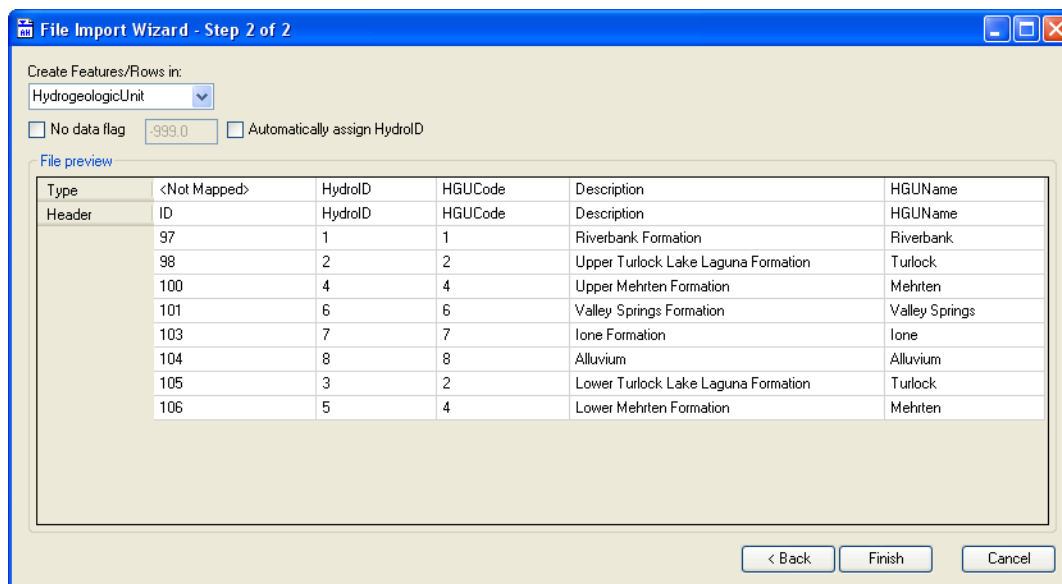


Figure 11 Importing hydrogeologic unit data, settings for the Second Step of the File Import Wizard.

7. Click on the *Finish* button.
8. Click *OK* at the prompt to confirm the import.

To view the new records in the HydrogeologicUnit table:

9. Click on the *List By Source* tab in the TOC window.
10. Right-click on the *HydrogeologicUnit* table and select the *Open* command.

The first column in the table (*HydroID*) is the unique identifier of the unit. Data in the BoreholeLog table are classified using a HGUID identifier. The records relate to the HydrogeologicUnit table via the HydroID–HGUID association.

You can view the indexing of the units in the table and the description of the units. Notice that there are two indexing systems. The HydroID is unique for every row in the table. HGUCODE and HGUNAME fields can be used to describe grouping of units. For example the Turlock and Mehrtten units can be divided into upper and lower sections, or grouped into single units.

11. Close the *HydrogeologicUnit* table.
12. Click on the *List By Drawing Order* tab in the TOC window.

8 Using the Borehole Editor

The BoreholeLog table is used to store vertical measurement records associated with a set of boreholes (i.e., wells). The set of records associated with a given well define a vertical profile of the hydrogeology of a site as shown in Figure 12. Later in the tutorial we will create 3D lines from the BoreholeLog table that can be viewed in ArcScene. However, we will first use the *Borehole Editor* provided in the AHGW Subsurface Analyst to view borehole log data for individual wells inside of ArcMap.

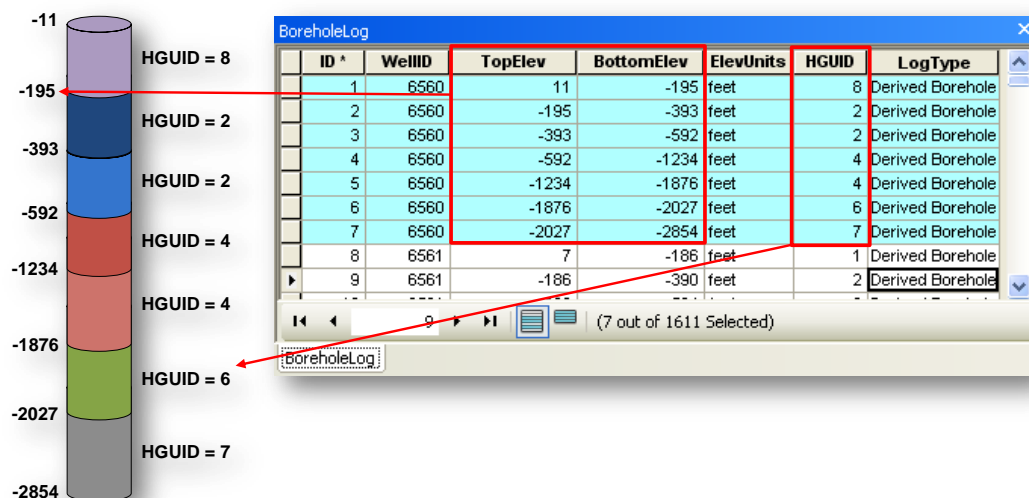



Figure 12 Borehole Profile Defined by Data in the BoreholeLog Table.

1. Save the *boreholes.sxd* document.
2. Close the *boreholes.sxd* ArcScene document.
3. Open ArcMap and open the *boreholes.mxd* map document.

You should see a map of the model region with a set of well features in it. If the Well features are not loaded in the map you can load them using the Add Data  button and browsing to the **Boreholes.mdb/Framework** feature dataset created in previous steps.

4. Select the *Subsurface | Borehole/Well Editor* command in the AHGW Toolbar.

The first step in using the Borehole Editor is to select the appropriate Well feature class, BoreholeLog table, and fields that relate the two.

5. Using the four combo boxes in the middle of the Borehole Editor, select the Well feature class, HydroID field, BoreholeLog table, and WellID field as shown in Figure 13.

The Optional Unit combo box is optional and allows us to view a second field (such as material, material ID, stratigraphic unit, etc.) from the BoreholeLog table. If the optional field is populated a second plot will be displayed to the right of the HGU plot.

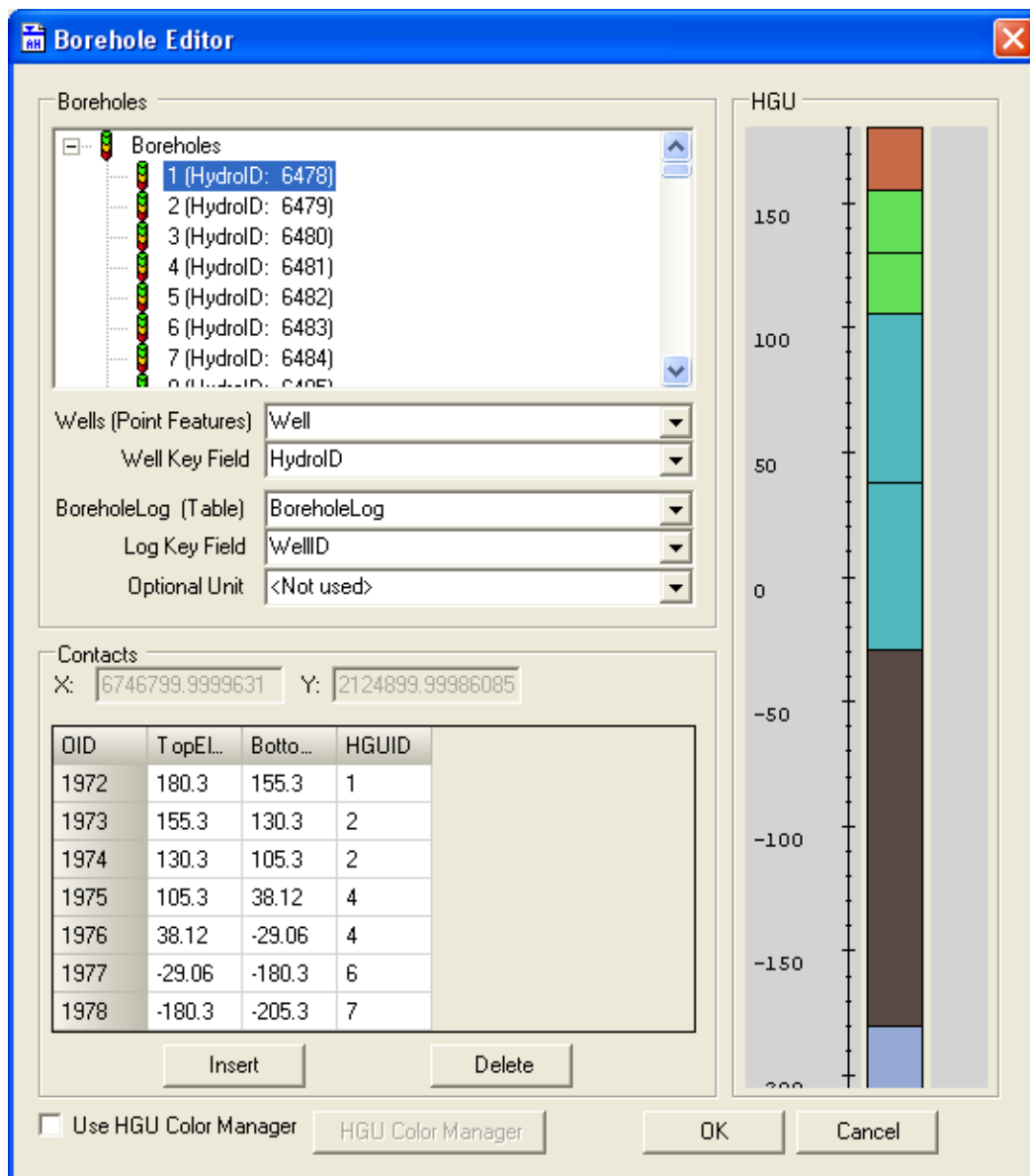


Figure 13 Settings for the Borehole Editor.

The Borehole Editor can work on a selection set of Well features. If none of the wells in the feature class are selected, all wells in the feature class are listed at the top of the Borehole Editor. The first number is the Object ID of the corresponding well and the second number is the HydroID. The data associated with a particular borehole can be viewed by selecting one of the wells in the list. A plot of the borehole is shown on the right side of the Borehole Editor and a simplified representation of the records in the BoreholeLog table associated with the borehole is displayed in the list at the bottom of the Borehole Editor.

- Click on some of the boreholes to view the stratigraphy along a number of boreholes. Notice that the selected borehole is also highlighted in the map.

Note that the Borehole Editor can be used to add/delete records in the BoreholeLog table using the Insert and Delete buttons at the bottom of the Borehole Editor. The Borehole Editor can also be used to modify records in the BoreholeLog table (such as assigning an HGUID based upon a material field). The changes made here are saved as edits to the BoreholeLog table when the *OK* button is clicked.

The color scheme of the borehole plot can be controlled via the HGU Color Manager. This color manager is based on the HydrogeologicUnit table which defines a set of Hydrogeologic units for the project. To enable the HGU Color Manager:

- Enable the color manager by selecting the *Use HGU Color Manager* toggle.

When the color manager is setup a field containing the colors is added to the HydrogeologicUnit table. This field stores the selected colors that can then be applied to different feature classes to help symbolize 3D Hydrogeologic models including borehole stratigraphy, cross sections, and volumes. To modify the colors using the color manager:

- Select the *HGU Color Manager* button to launch the manager.
- Select the *Setup* button to open the HGU Setup interface.
- Select the **HydrogeologicUnit** table as the HGU Table.
- Specify the **HydroID** and **HGUName** fields as shown in Figure 14.

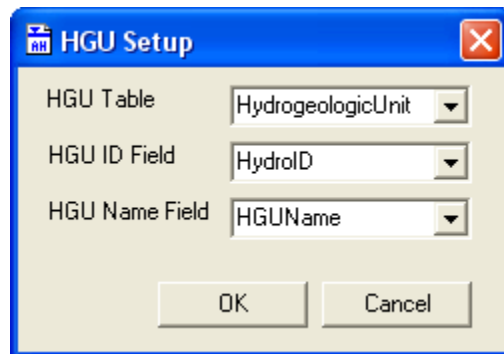


Figure 14 Setup of the Hydrogeologic unit color manager.

- Click on *OK* to exit the setup.
- You can assign the symbology from the HGU Color Manager interface by selecting a color for each unit, as shown in Figure 15 and selecting the *Save and Exit* command.

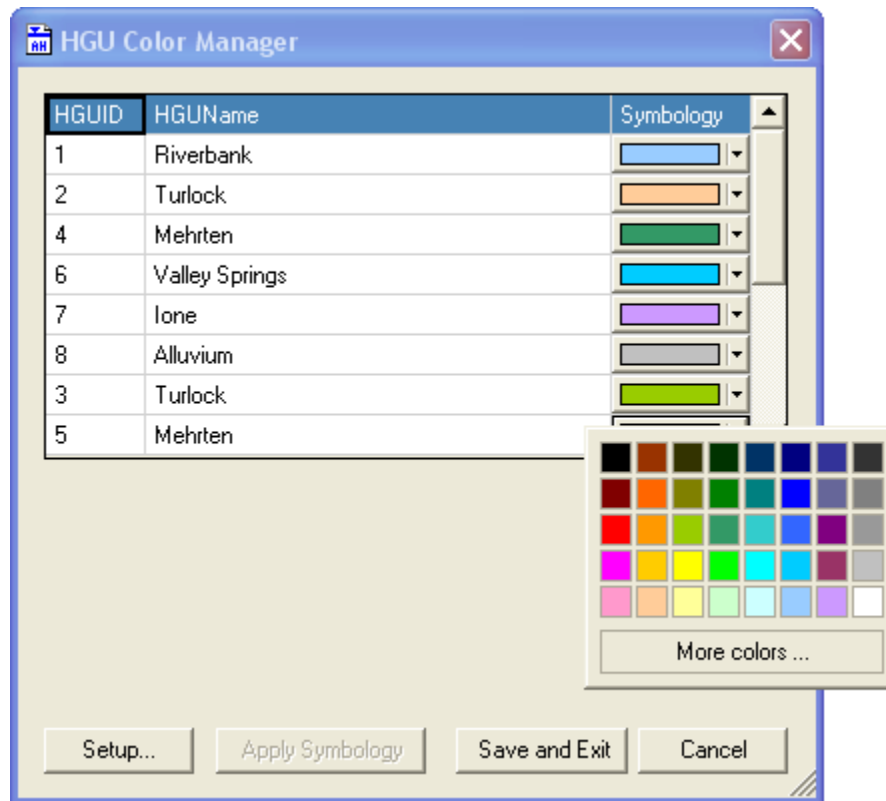


Figure 15 HGU Color manager for controlling the symbology of Hydrogeologic units.

Once you exit the color manager the colors of the borehole plot should update to match the ones specified in the color manager.

14. Click on *OK* to exit the *Borehole Editor*.

9 Creating 3D BoreLines

Next, we will use a geoprocessing tool to generate a 3D view of the borehole logs. This tool uses the Well features and the BoreholeLog table to build 3D “borelines” that can be rendered in ArcScene.

1. Close the *Boreholes.mxd* ArcMap document.
2. If necessary, open ArcScene and open the *boreholes.sxd* scene.
3. Double-click on the *Create Borelines* tool in the *AHGW Tools | Subsurface Analyst | Features* toolset.
4. Enter the settings as shown in Figure 16.
5. Click on the *OK* button.
6. Click on the *Close* button when the tool has finished.

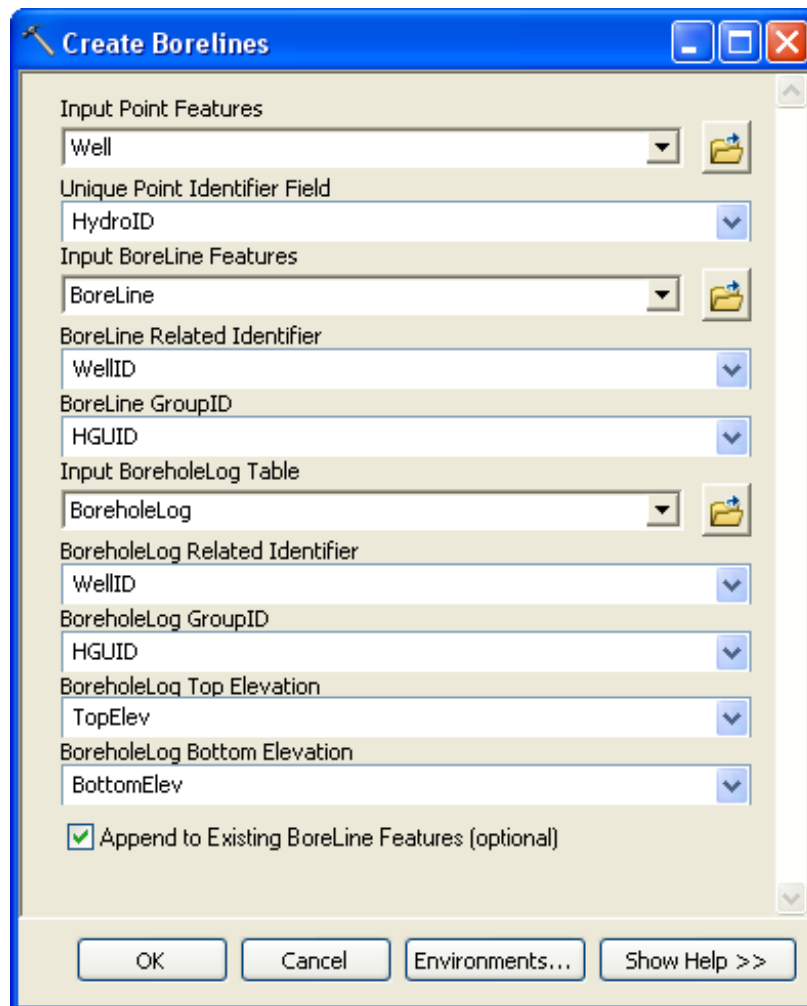


Figure 16 Settings for the Create Borelines Tool.

You should now see a set of short 3D lines below the well points. We will make some adjustments so that the lines are more visible. First, we will make the lines wider.

7. Right-click on the *BoreLine* layer and select *Properties*.
8. Click on the *Symbology* tab.
9. In the *Show* section select the *Categories | Unique values* option and the *HGUID* field as the *Value Field* (as shown in Figure 17). Click *Add All Values* and then adjust the symbol widths to a value of **8.0**. Don't worry if the colors don't exactly match.
10. Click on the *OK* button.

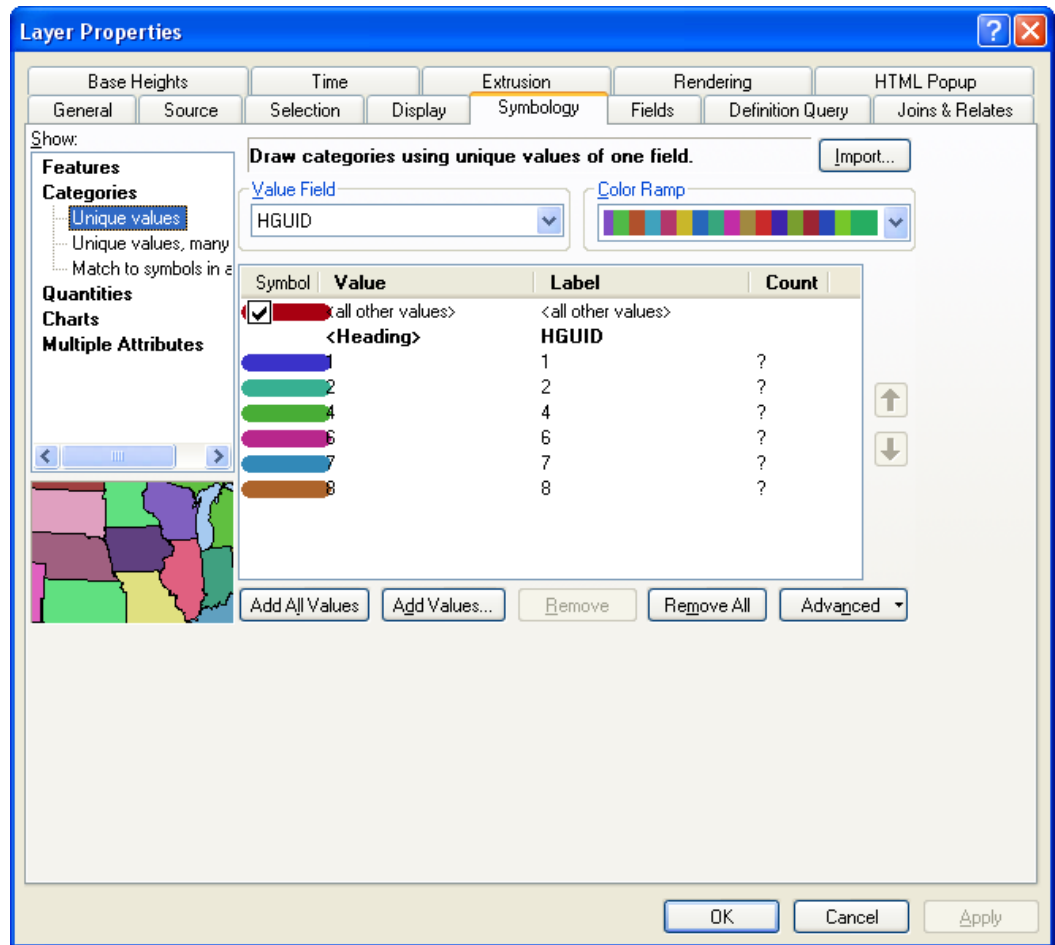


Figure 17 Boreline Symbology Settings.

The BoreLines are stored in a 3D line (Polyline Z) feature class. To view the BoreLine features:

11. Right-click on the *BoreLine* layer in the TOC window and select the *Open Attribute Table* command.

Note that the table includes many of the same fields as the BoreholeLog table. The values for the TopElev, BottomElev, WellID, and HGUID fields have all been extracted from the BoreholeLog table.

12. Close the attribute table.

10 Using the HGU Color Manager

You can use the HGU Color Manager to control the colors of the BoreLine features so they match the colors you previously defined.

1. Select the *HGU Color Manager* command in the *Subsurface* menu in the AHGW Toolbar.
2. Click on the *Setup* button.
3. Change the settings to match those shown in Figure 18.
4. Click on the *OK* button.

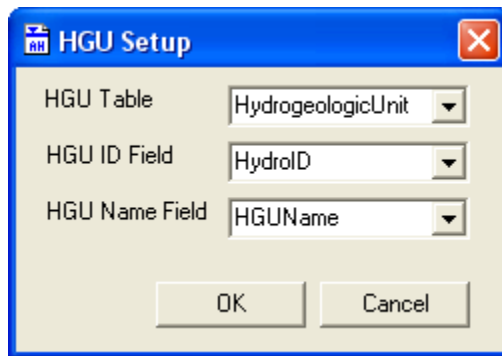


Figure 18 Settings for the HGU Setup Dialog.

Note that the colors we selected in the HGU Color Manager in ArcMap were saved to the HydrogeologicUnit table and are now displayed in the HGU Color Manager in ArcScene. You can apply this same color scheme to your borelines or modify the colors scheme.

5. Turn off the *Well* option in the *Apply* column at the bottom, as shown in Figure 19.



Figure 19 Settings for the HGU Color Manager.

6. Click on the *Apply Symbology* button to apply your changes.
7. Click the *Save and Exit* button to save your changes to the HydrogeologicUnit table and close the HGU Color Manager.

Note that the selected color scheme has been applied to the BoreLine layer.

11 Conclusion

This concludes the tutorial. Here are some of the key concepts in this tutorial:

- Well features can be imported using the text import wizard.
- Borehole log data can be imported and associated with well features.
- Hydrogeologic units can be imported and stored in the HydrogeologicUnit table.
- The Borehole Editor is used to view and edit individual boreholes.
- BoreLine features are created from the BoreholeLog table.
- The HGU Color Manager is used to apply a common color scheme to all features associated with a set of common hydrogeologic units.