ARC HYDRO GROUNDWATER TUTORIALS

Working with Non-Vertical 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 non-vertical borehole data and create 3D representations of hydrostratigraphy in non-vertical boreholes. A basic familiarity with the AHGW data model is suggested, but not required, prior to beginning this tutorial.

1.1 Outline

This tutorial will be working with non-vertical borehole data near the city of Roseville in the Sacramento Valley, California. Data used in this tutorial is mock data and is used for illustrative purposes only. The tutorial covers how to:

1. Import a set of non-vertical borehole data into an AHGW geodatabase.
2. Explore the borehole logs.
3. De-survey the borehole logs.
4. Generate and view 3D BoreLines derived from the non-vertical borehole data.

1.2 Required Modules/Interfaces

The following components must be enabled in order to complete this tutorial:

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

The *AHGW Tools* require 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 scene, let's ensure that the AHGW tools are correctly configured.

1. If necessary, launch *ArcScene*.
2. Open the ArcToolbox window by clicking **ArcToolbox**  .
3. If "  Arc Hydro Groundwater Tools" is not in the list of available toolboxes, follow steps 4–6. If it is already listed, skip to step 7.
4. Right-click anywhere in the ArcToolbox window and select **Add Toolbox…** to bring up the *Add Toolbox* dialog.
5. Browse to the *Toolboxes\System Toolboxes* folder and select "Arc Hydro Groundwater Tools.tbx".
6. Click **Open** to exit the *Add Toolbox* dialog.
7. Expand "  Arc Hydro Groundwater Tools".
8. Expand "  Subsurface Analyst" toolset to see 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:

9. Right-click on any visible toolbar and select **Arc Hydro Groundwater Toolbar** to make it visible. Feel free to dock it at the top of the ArcMap window.

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

10. Select *Geoprocessing* | **Geoprocessing Options…** to bring up the *Geoprocessing Options* dialog.

11. In the *General* section, turn on *Overwrite the outputs of geoprocessing operations*.

12. In the *Display / Temporary Data* section, turn on *Add results of geoprocessing operations to the display*.

13. Click **OK** to exit the *Geoprocessing Options* dialog.

3 Opening the Scene

Begin by opening a scene of the model area:

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

2. Browse to the *Tutorials\subsurface analyst\non_vertical_boreholes* folder.

3. Select "nv_boreholes.sxd" and click **Open** to exit the *Open* dialog and import the model file.

A scene should appear containing a DEM of the model domain and a set of well features (Figure 1).

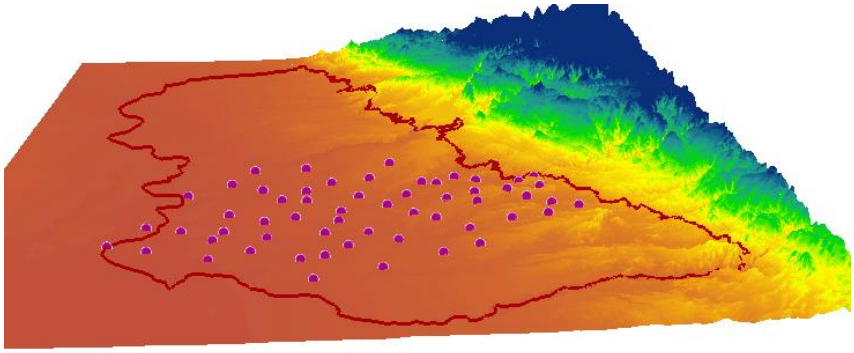


Figure 1 Scene of the Roseville model domain with well features shown on top of a DEM.

4 Non-Vertical Borehole Data

Stratigraphy records in non-vertical boreholes are usually stored as survey data in the form of Azimuth, Dip, and Length. Azimuth describes the direction in which the borehole is drilled and is usually given as an angle measured from the north, and Dip defines the vertical angle of the borehole and can be measured as an angle from a horizontal or vertical plane (Figure 2). Length is the distance along the borehole and is usually measured from a reference point, either the land elevation at the borehole location or from the top of casing.

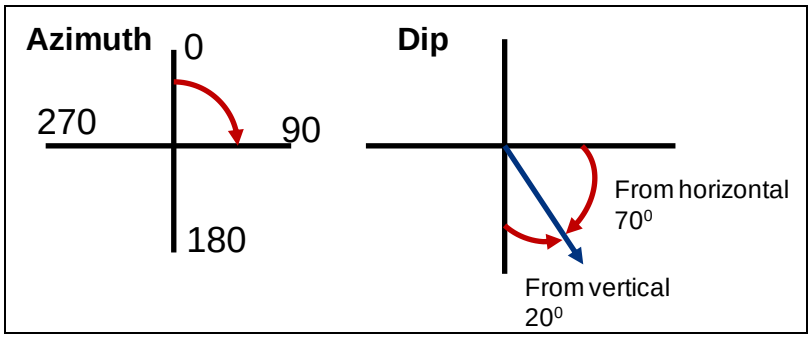


Figure 2 Azimuth and Dip define the orientation of the borehole in 3D space.

The survey data is later de-surveyed to X, Y and Z coordinates, and then 3D tools are applied to create 3D features for visualizing and analyzing the data in a GIS (Figure 3).

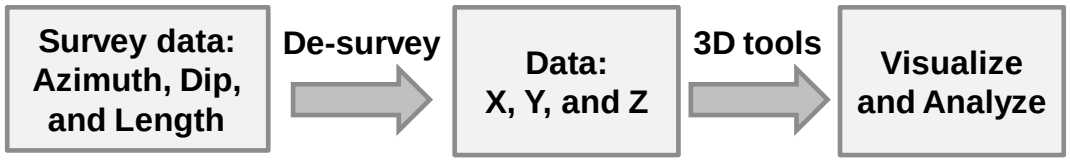


Figure 3 Process of creating 3D features from survey data.

5 Importing Borehole Data

The nv_wells feature class consists of points defining the XY locations of wells in the model domain. In this step, a text file containing data from borehole logs associated with the non-vertical wells will be imported. The records in this file will be added to the *Survey* table. Each record in the table represents a contact or elevation along the borehole at which the stratigraphy changes from one unit to another.

The **Text Import** command in the AHGW Toolbar allows importing the records by doing the following:

1. Select the *Arc Hydro GW* | **Text Import** command in the AHGW Toolbar to bring up an *Open* dialog.

2. Navigate to the *non vertical boreholes* folder where the tutorial files are stored on the local drive.

3. Select the file "Survey.txt" and click **Open** to start the *File Import Wizard*.

4. For the first step of the *File Import Wizard*, enable the *Comma* delimiter only and the *Heading row* option.

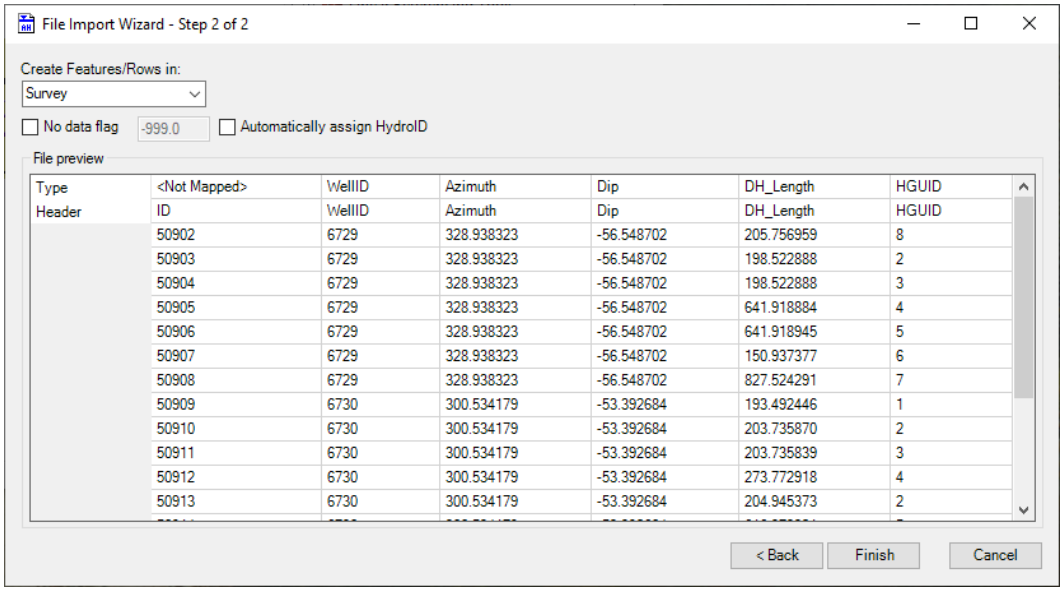
5. Click on the **Next** button to go to the next step of the *File Import Wizard*.

In the next step of the wizard, indicate the type of data being imported 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 to be imported, select the appropriate field name in the *Type* row. By default, <not mapped> is selected for some columns indicating that the columns will not be imported to a field in the target table.

6. Make sure that the "Survey" table is selected in the *Create Features/Rows in:* combo box.

7. Make sure that the fields are mapped correctly as shown in Figure 4 (the fields should be matched automatically).



Type	<Not Mapped>	WellID	Azimuth	Dip	DH_Length	HGUID
Header	ID	WellID	Azimuth	Dip	DH_Length	HGUID
	50902	6729	328.938323	-56.548702	205.756959	8
	50903	6729	328.938323	-56.548702	198.522888	2
	50904	6729	328.938323	-56.548702	198.522888	3
	50905	6729	328.938323	-56.548702	641.918884	4
	50906	6729	328.938323	-56.548702	641.918945	5
	50907	6729	328.938323	-56.548702	150.937377	6
	50908	6729	328.938323	-56.548702	827.524291	7
	50909	6730	300.534179	-53.392684	193.492446	1
	50910	6730	300.534179	-53.392684	203.735870	2
	50911	6730	300.534179	-53.392684	203.735839	3
	50912	6730	300.534179	-53.392684	273.772918	4
	50913	6730	300.534179	-53.392684	204.945373	2

Figure 4 Settings for the Second Step of the File Import Wizard.

8. Click on the **Finish** button to close the *File Import Wizard*.

9. Click **OK** at the prompt to confirm the import.

To view the new records in the Survey table:

10. Select the **List By Source** tab in the *Table of Contents* window.

11. Right-click on "Survey" and select **Open** to bring up the *Table* dialog.

The first column in the table (*WellID*) relates to the *HydroID* of the corresponding well. 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. To view the *HydrogeologicUnit* table:

12. Close the Survey *Table* dialog.

13. Right-click on "HydrogeologicUnit" and select **Open** to bring up a *Table* dialog.

In this table view the indexing 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 Mehrten units can be divided into upper and lower sections, or grouped into single units.

14. Close the HydrogeologicUnit *Table*.

15. Select the **List By Drawing Order** tab in the *Table of Contents* window.

6 De-Surveying Borehole Data

1. Expand the "Features" toolset under the "Subsurface Analyst" toolset.
2. Double-click on the "Desurvey Borelog" tool to open the *Desurvey Borelog* dialog.
3. Specify the input parameters as follows:
   - *Input Well Features* to "nv_wells".
   - *Well Ground Elevation (if not Z enabled)* to "LandElev".
   - *Input Log Tabel* to "Survey".
   - *Log Table WellID Field* to "WellID".
   - *Log Table Azimuth Field* to "Azimuth".
   - *Log Table Dip Field* to "Dip".
   - *Log Table Distance (Measurement) Field* to "DH_Length".
   - *Log Table HGUID Field* to "HGUID".
   - In the *Log Table Fields of Interest* section, click **Select All**.
4. Click on **OK** to close the *Desurvey Borelog* dialog and run the tool.

A new "Desurvey" table should be created and added to the map. If desired, open the Desurvey table to see that the table contains X, Y, and Z coordinates, and an HGUID field. The table also contains a field named *BoreOrder* that defines the ordering of the contacts along the borehole.

7 Creating 3D BoreLines

Next, use a geoprocessing tool to generate a 3D view of the borehole logs. This tool uses the well features and the Desurvey table to build 3D "borelines" that can be rendered in ArcScene.

1. Double-click on the "  Create Non-Vertical Borelines" tool to open the *Create Non-Vertical Borelines* dialog.

2. In the dialog, enter the following:

   - *Input Well Features* to "nv_wells".
   - *Input Desurvey Table* to "Desurvey".
   - *Input BoreLine Features* to "nv_BoreLine".

3. Click **OK** to close the *Create Non-Vertical Borelines* dialog and run the tool.

4. Click on the *Close* button when the tool has finished.

A set of 3D lines should appear below the well points (if they do not appear, right-click on the "nv_BoreLine" layer in the Table of Contents and select **Refresh**). Adjustments should be made so that the lines are more visible. First, make the lines wider by doing the following.

5. Right-click on the "nv_BoreLine" layer and select **Properties…** to open the *Layer Properties* dialog.

6. Select the *Symbology* tab.

7. In the *Show* section select *Categories* | *Unique values*.

8. Change *Value Field* to "HGUID".

9. Click **Add All Values** button.

10. Change a *Color Ramp* if desired.

11. Right-click the *Symbol* header above the line symbols and select **Properties for All Symbols...** to open the *Symbol Selector* dialog.

12. Adjust the symbol *Width* to a value of "8.0".

13. Click **OK** to close the *Symbol Selector* dialog.

14. Click **OK** to close the *Layer Properties* dialog.

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

15. Right-click on the "nv_BoreLine" layer in the *Table of Contents* window and select **Open Attribute Table** to bring up a *Table* dialog.

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

16. When done, close the attribute *Table* dialog.

8 Using the HGU Color Manager

Use the HGU Color Manager to control the colors of the BoreLine features so they match the colors previously defined.

1. Select the *Subsurface* | **HGU Color Manager** command in the AHGW Toolbar to open the *HGU Color Manager* dialog.
2. Click **Setup** to open the *HGU Setup* dialog.
3. Change the settings to the following:
4. *HGU Table* to "HydrogeologicUnit".
5. *HGU ID Field* to "HydroID".
6. *HGU Name Field* to "Description".
7. Click **OK** to close the *HGU Setup* dialog.
8. Back in the *HGU Color Manager* dialog, turn off the *nv_Well* option in the *Apply* section.
9. If desired, select the color scheme for the different units.
10. Click **Apply Symbology** to apply the changes.

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

11. Click **Save and Exit** to save the symbology and exit the *HGU Color Manager* dialog and to apply the changes.

The colors are stored in the HydrogeologicUnit table; this enables later use of the same color scheme and applying it to different feature classes.

9 Conclusion

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

- Non-vertical borehole log data can be imported and associated with well features.
- Non-vertical survey data is de-surveyed to transform azimuth, dip, and length values to z, y, and z coordinates.
- Non-vertical BoreLine features are created from the de-survey data.
- The *HGU Color Manager* is used to apply a common color scheme to all features associated with a set of common hydrogeologic units.