

ARC HYDRO GROUNDWATER TUTORIALS

Subsurface Analyst – Adding borehole log plots to cross sections

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. *Subsurface Analyst* is a subset of the AHGW Tools that is used to manage 2D and 3D hydrogeologic data, and create subsurface models including generation of borehole representations, cross sections, surfaces, and volumes.

In this tutorial we will learn how to create plots of borehole logs (e.g. geophysical data) data and add them to a 2D cross section map.

1.1 Background

Data used in this tutorial were made-up for demonstration in this tutorial. The geophysical logs do not reflect real datasets. The background cross section data are described in a separate tutorial: *Creating 2D Cross Sections*. Figure 1 shows the background cross section and layout map to which geophysical logs will be added. The green dots on the map represent wells that have related geophysical logs.

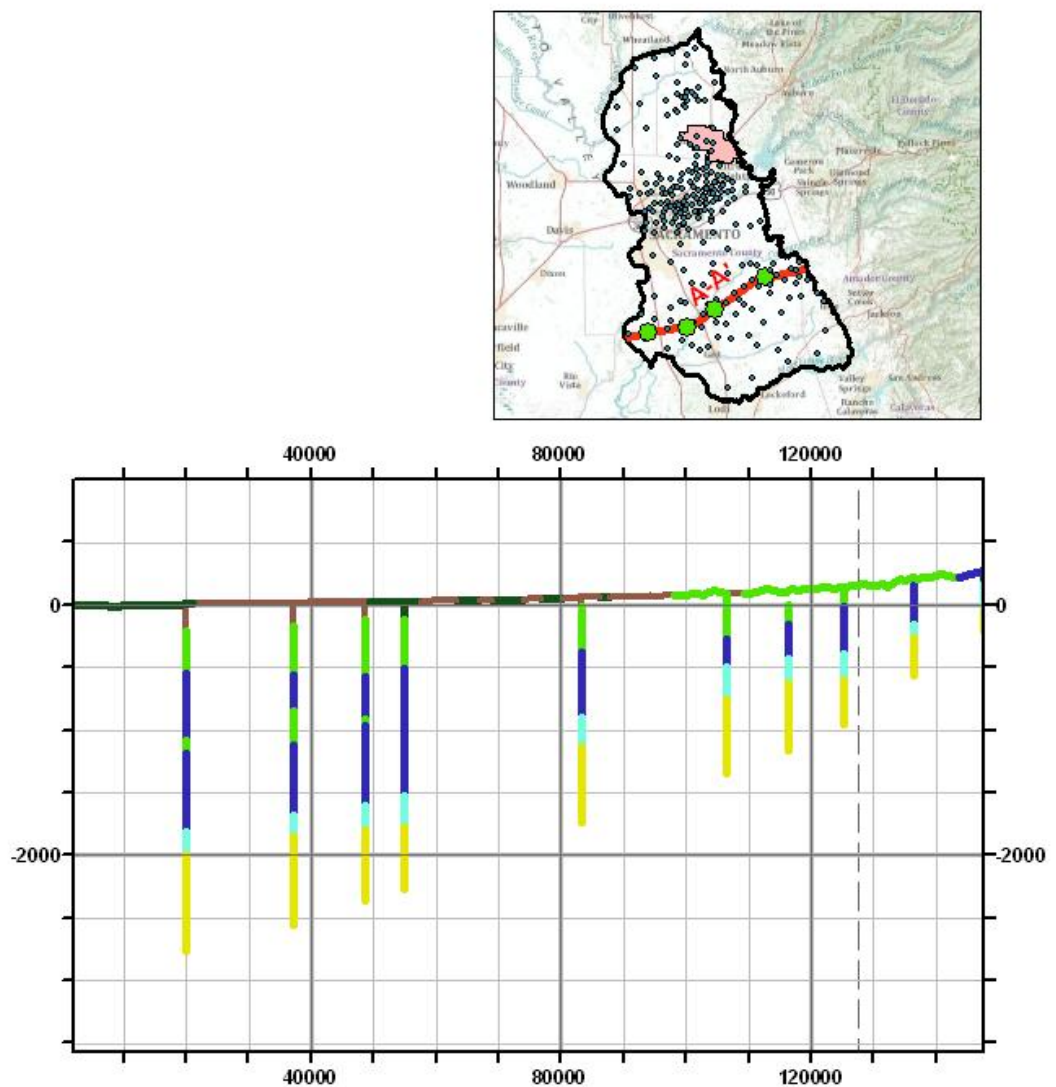


Figure 1 Background map and cross section to which borehole logs will be added.

1.2 Outline

The objective of this tutorial is to introduce the basic workflow and tools for adding borehole log plots to a cross section. The tutorial includes the following steps:

1. Understand the data structures used to store borehole logs.
2. Use the *Create Geophysical Plot Wizard* to add geophysical data onto an existing cross section.
3. Visualize and symbolize the plots in ArcMap.

1.3 Required Modules/Interfaces


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

- Arc View license (or ArcEditor\ArcInfo)
- Arc Hydro Groundwater Tools
- 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 the tutorial 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. Make sure the Arc Hydro Groundwater Toolbox is loaded. If it is not, add the toolbox by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox...* command. Browse to the top level of the *Catalog* and then browse down to the *Toolboxes/System Toolboxes* directory. Select the toolbox and select the *Open* button.
4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *Subsurface Analyst* toolset to expose the tools we will be using in this tutorial.

We will also be using the *Arc Hydro Groundwater 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. Select the *Geoprocessing / Options...* command.

7. Activate the option: “*Overwrite the outputs of geoprocessing operations*” as shown in Figure 2.
8. Enable the option to “*Add results of geoprocessing operations to the display*” as shown in Figure 2.
9. Select *OK* to exit the setup.

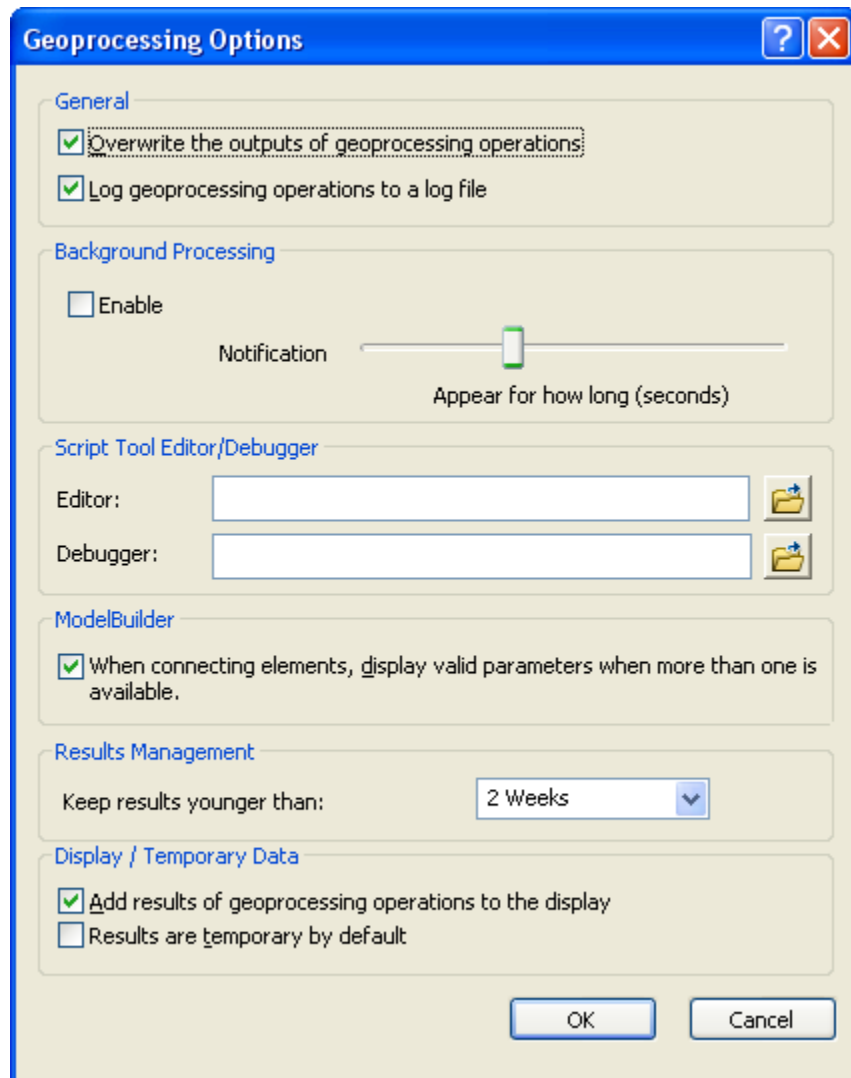


Figure 2 Setting Geoprocessing tools to overwrite outputs by default, and to add results of geoprocessing tools to the display.

3 Opening the Map

We will begin by opening a map containing some background data for the project.

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 *xs2d_logplot* folder and open the file entitled *Roseville_logplot.mxd*.

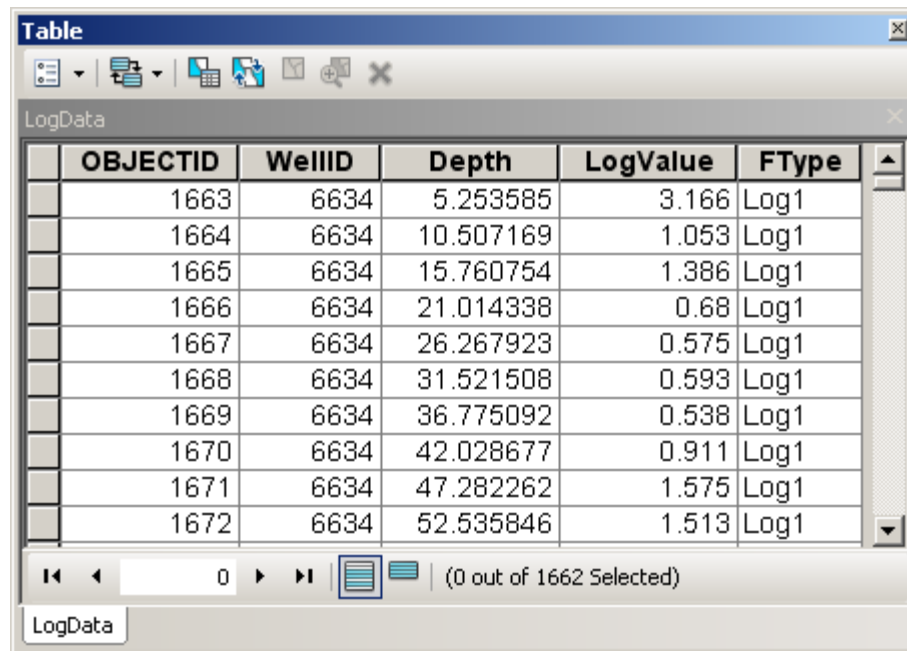
Once the file has loaded you will see a map of the model boundary with well features located within the model domain. You will also see a cross section in a separate data frame. The process of creating cross sections is described in detail in a separate tutorial: *Creating 2D Cross Sections*.

4 Data structure for storing borehole logs

Borehole information is stored in a Log table. Each row in the table represents a log value observed along the borehole. Data in the Log table are referenced to Well features. The WellID attribute in the Log table relates to the HydroID of a Well feature. Figure 3 shows an example of a Log table. Records in the table are indexed with a WellID to relate the vertical information with specific Wells. In addition, a Depth value defines the length along the borehole, and the FType defines the type of log data. The WellID, Depth, LogValue, and FType are recommended field names but can be modified.

To accommodate storing multiple logs of different types, we suggest three common approaches:

1. A separate table is created for each type of log.
2. All logs are stored in the same table and are differentiated by a different FType value.
3. Logs are stored in a single table but with a separate LogValue field for each log type. This option requires that all logs are sampled at the same depths along the well.



	OBJECTID	WellID	Depth	LogValue	FType
	1663	6634	5.253585	3.166	Log1
	1664	6634	10.507169	1.053	Log1
	1665	6634	15.760754	1.386	Log1
	1666	6634	21.014338	0.68	Log1
	1667	6634	26.267923	0.575	Log1
	1668	6634	31.521508	0.593	Log1
	1669	6634	36.775092	0.538	Log1
	1670	6634	42.028677	0.911	Log1
	1671	6634	47.282262	1.575	Log1
	1672	6634	52.535846	1.513	Log1

Figure 3 Log table containing geophysical logs along boreholes.

5 Adding Log Plots to a cross section

To create the log plots we use the Create Geophysical Plot Wizard:

1. Make sure that the **Layers** data frame is active (this data frame must be active when creating plots because it contains the well features).
2. Select the four wells along section A-A' highlighted in green as shown in Figure 4 (the wells may already be selected when you opened the map file).

Tip: You can use the *Select By Attribute* tool to select wells with the following expression: *HasLogData = 1*.

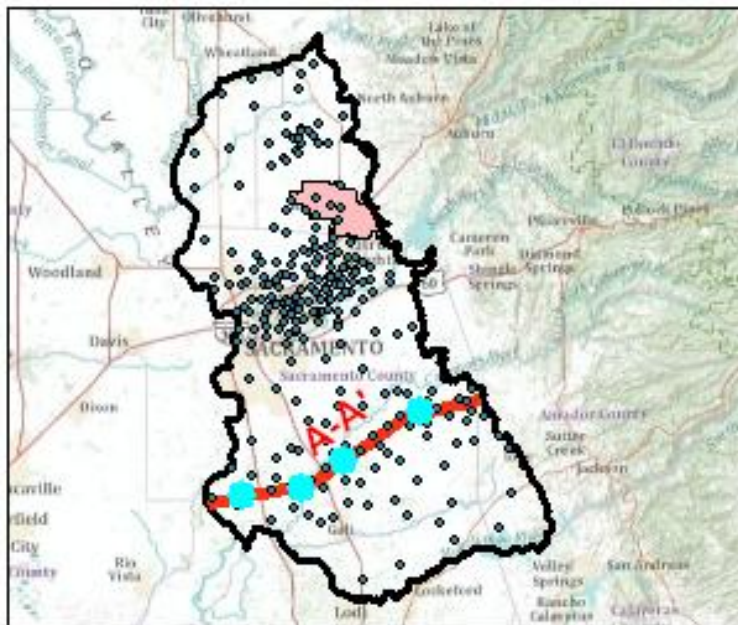



Figure 4 Map showing selected wells that have related log data.

3. Start the **Create Geophysical Plot Wizard**  available on the Arc Hydro Groundwater Toolbar.
4. With the wizard enabled **select section line A-A'** (shown in red).
5. The Wizard should open in Step 1 which defines the cross section setup:
 - Make sure the wizard shows that **4 wells are selected**.
 - Specify **HydroID** as the Well unique ID field.
 - Select **LandElev** as the Well reference elevation field.
 - Select the **LogData** table as the Data table.
 - Specify the **WellID**, **Depth**, and **LogValue** fields as the input fields.
 - Select **FType** as the Data type field. Then select **Log1** as the Data type value.
 - Enter **Log 1** as the Data type name.
 - Make sure the Vertical exaggeration is set to **20**.
 - Specify the **XS2D_Catalog** table for the XS2D Catalog Table input.
 - Make sure the **GeoPlot** feature datasets is the output workspace.
 - Select data frame **Section A-A'** as the Output Data Frame.

At this point your inputs should be similar to the ones shown in Figure 5.

Create Geophysical Plot Wizard

This wizard will help you create geophysical data plots for the selected section line.

Step 1: Cross Section Setup

Section Line Properties

Layer: SectionLine Length: 171492 (Foot_US)
 ID: 6475 Name: A-A'

Wells and Geophysical Data Table

Well layer: Well Data table: LogData
 Number of wells selected: 4 Well ID field: WellID
 Well unique ID field: HydroID Depth field: Depth
 Well reference elevation field: LandElev Data value field: LogValue
 Data type field: FType
 Data type value: Log1
 Data type name: Log1

Cross Section Setup

Vertical exaggeration: 20 XS2D Catalog Table: XS2D_Catalog
 Default output workspace: D:\Aquaveo\subsurface_analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot
 Data Frame: Section A-A'

Next > Cancel

Figure 5 Inputs for Step 1 in the Create Geophysical Plot Wizard

6. Select **Next** to continue to step 2 of the wizard.

In Step 2 of the wizard we define the plot and scale properties:

7. In Step 2 specify the following inputs:
 - **10,000** for the Plot width.
 - **1,000** for the Plot offset.
 - **0** as the Background vertical buffer.
 - For the Plot position select **Right**.

For the Scale Properties specify the following:

- **Log1** for the Scale label.
- **300** for the Scale vertical offset.

- **8** and **0** for the Maximum and Minimum scale values.
- **5** and **1** for the Number of major and minor ticks.
- **Top** for the Scale location.

At this point your inputs should be similar to the ones shown in Figure 6.

Create Geophysical Plot Wizard

Step 2: Scale

Plot Properties

Plot width (map units): 10000

Plot offset (map units): 1000

Background vertical buffer (map units): 0

Plot position: ☐ Left ☐ Center ☒ Right

Scale Properties

Scale label: Log 1

Scale vertical offset (map units): 300

Maximum scale value: 8

Minimum scale value: 0

Number of major ticks: 5

Number of minor ticks between major ticks: 0

Scale location: ☒ Top ☐ Bottom

Sample Plot and Scale

Legend

Line at left represents well and borehole location

A = Plot width

B = Plot offset

C = Background vertical buffer

Plot position is to the right of the well

D = Scale vertical offset

Scale location is to the top

< Back Next > Cancel

Figure 6 Inputs for Step 2 in the Create Geophysical Plot Wizard

8. Select **Next** to continue to Step 3

In Step 3 of the wizard we define the output feature classes:

9. Make sure the output feature classes are created in your target workspace (in this case in the GeoPlot feature dataset).
10. Select the **Overwrite exiting feature with same data type** option.

At this point your inputs should be similar to the ones shown in Figure 7.

Create Geophysical Plot Wizard

Step 3: Output Feature Classes

Log Feature Classes

Output log point feature class:
 J:\Aquaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_POINT_6475 ...

Output log line feature class:
 D:\Aquaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_LINE_6475 ...

Output log polygon feature class:
 quaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_POLYGON_6475 ...

Scale Feature Classes

Output scale bar feature class:
 juaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_SCALEBAR_6475 ...

Output scale major ticks feature class:
 subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_SCALEMAJORTICK_6475 ...

Output scale minor ticks feature class:
 subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_SCALEMINORTICK_6475 ...

Output scale vertical lines feature class:
 surface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_SCALEVERTICALLINE_6475 ...

Output scale background polygon feature class:
 surface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPLOT_SCALEBACKGROUND_6475 ...

Miscellaneous Options

Append new feature or overwrite: ☐ Append ☒ Overwrite existing feature with same data type

< Back Finish Cancel

Figure 7 Inputs for Step 3 in the Create Geophysical Plot Wizard

11. Select **Finish** to run the wizard.

Upon completion a new set of feature classes is added to the map. If you look at the cross section A-A' data frame you should see the log plots added to the cross section adjacent to the wells. You can change the symbology of the features and activate labels.

12. Add labels to the scale bar features based on the ScaleName attribute by right-clicking on the XS2D_GEOPLOT_SCALEBAR_6475 layer and selecting the Label Features option.

At this point your cross section should be similar to the one shown in Figure 8.

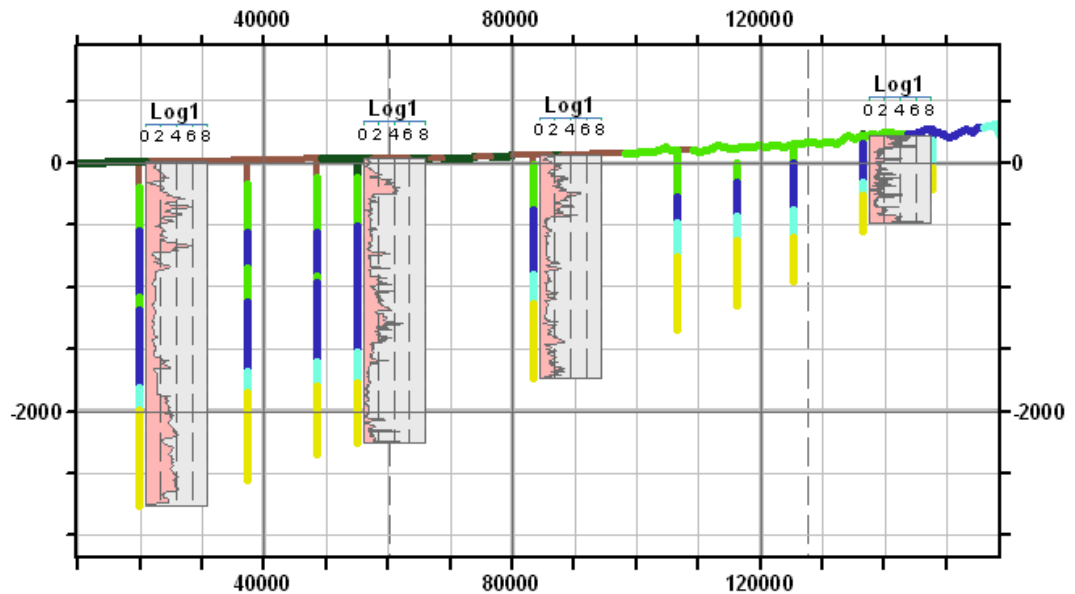


Figure 8 Log plots added to cross section A-A'

6 Understanding log plots

Log plots are constructed by a set of eight feature classes, three defining the scale bar, three for the plot, and two for the plot background. You can modify the symbology for each of the feature classes individually and use the regular labeling options in ArcMap to show labels on the scale bar and tick marks, as shown in Figure 9. You may want to experiment with the plots by toggling on and off the different features in the plot.

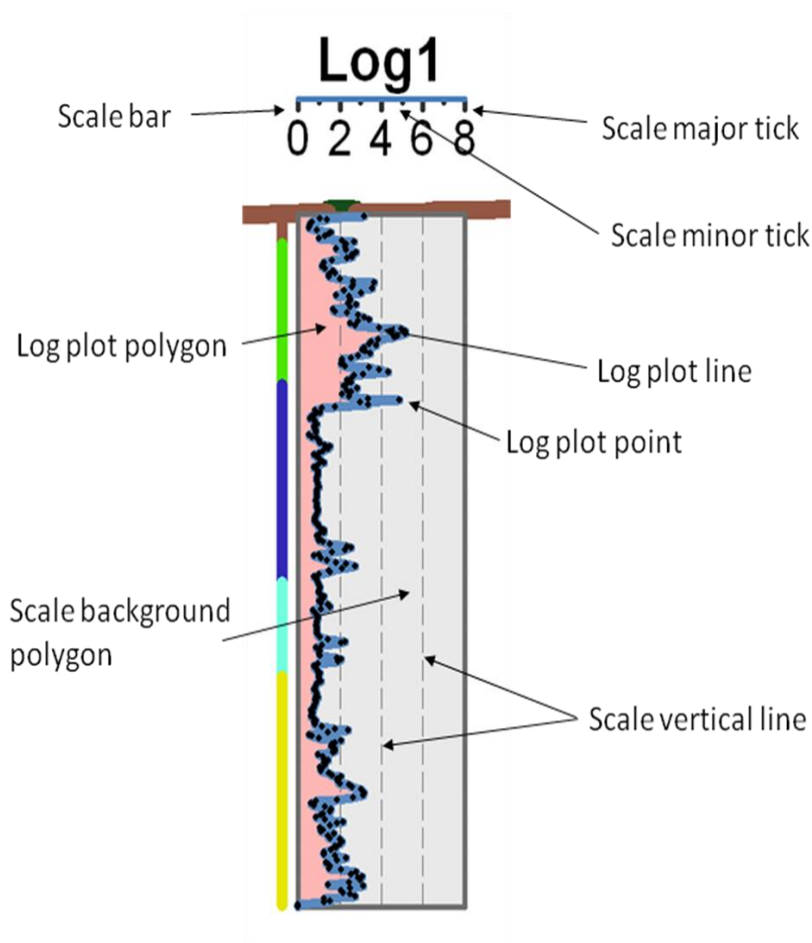



Figure 9 Structure of a log plot.

7 Adding multiple log plots to a cross section

It is possible to add multiple log plots and display them together in one cross section. The process of adding an additional log plot is the same as adding the first one (as described in section 5). The differences are that you can select a different source table and/or fields and specify an offset such that both plots can be displayed together. To add an additional log plot:

1. Make sure that the **Layers** data frame is active.
2. If not already selected, select the 4 wells along section A-A' highlighted in green as shown in Figure 4.
3. Start the **Create Geophysical Plot Wizard**  available on the Arc Hydro Groundwater Toolbar.
4. With the wizard enabled **select section line A-A'** (shown in red).

5. The Wizard should open in Step 1 which defines the cross section setup:
 - Make sure the wizard shows that **4 wells are selected**.
 - Specify **HydroID** as the Well unique ID field, and select **LandElev** as the Well reference elevation field.
 - Select the **LogData** table as the Data table.
 - Specify the **WellID**, **Depth**, and **LogValue** fields as the input fields.
 - Select **FType** as the Data type field. Then select **Log2** as the Data type value.
 - Enter **Log 2** as the Data type name.
 - Make sure the Vertical exaggeration is set to **20**.
 - Specify the **XS2D_Catalog table** for the XS2D Catalog Table input.
 - Make sure the **GeoPlot** feature datasets is the output workspace.
 - Select data frame **Section A-A'** as the Output Data Frame.

At this point your inputs should be similar to the ones shown in Figure 10.

Create Geophysical Plot Wizard

Create Geophysical Plot Wizard

This wizard will help you create geophysical data plots for the selected section line.

Step 1: Cross Section Setup

Section Line Properties

Layer: SectionLine

Length: 171492 (Foot_US)

ID: 6475

Name: A-A'

Wells and Geophysical Data Table

Well layer: Well

Number of wells selected: 4

Well unique ID field: HydrolD

Well reference elevation field: LandElev

Data table: LogData

Well ID field: WellID

Depth field: Depth

Data value field: LogValue

Data type field: FType

Data type value: Log2

Data type name: Log2

Cross Section Setup

Vertical exaggeration: 20

XS2D Catalog Table: XS2D_Catalog

Default output workspace

D:\Aquaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot

Data Frame

Output Data Frame for Geophysical Data: Section A-A'

Next >

Cancel

Figure 10 *Inputs for Step 1 in the Create Geophysical Plot Wizard for adding an additional log plot to the cross section*

6. Select **Next** to continue to step 2 of the wizard.

In Step 2 of the wizard we define the plot and scale properties:

7. In Step 2 specify the following inputs:

- **10,000** for the Plot width.
- **12,000** for the Plot offset.
- **0** as the Background vertical buffer.
- For the Plot position select **Right**.

For the Scale Properties specify the following:

- **Log2** for the Scale label.
- **300** for the Scale vertical offset.
- **60** and **0** for the Maximum and Minimum scale values.
- **4** and **1** for the Number of major and minor ticks.
- **Top** for the Scale location.

At this point your inputs should be similar to the ones shown in Figure 11.

Create Geophysical Plot Wizard

Step 2: Scale

Plot Properties

Plot width (map units): 10000

Plot offset (map units): 12000

Background vertical buffer (map units): 0

Plot position: ☐ Left ☐ Center ☒ Right

Scale Properties

Scale label: Log 2

Scale vertical offset (map units): 300

Maximum scale value: 60

Minimum scale value: 0

Number of major ticks: 4

Number of minor ticks between major ticks: 1

Scale location: ☒ Top ☐ Bottom

Sample Plot and Scale

Legend

Line at left represents well and borehole location

A = Plot width

B = Plot offset

C = Background vertical buffer

Plot position is to the right of the well

D = Scale vertical offset

Scale location is to the top

< Back Next > Cancel

Figure 11 Inputs for Step 2 in the Create Geophysical Plot Wizard for adding an additional log plot to the cross section

8. Select **Next** to continue to Step 3

In Step 3 of the wizard we define the output feature classes:

9. Make sure the output feature classes are created in your target workspace (in this case in the GeoPlot feature dataset).
10. Select the **Append** option. This ensures that the original plots are preserved and are not overwritten.

At this point your inputs should be similar to the ones shown in Figure 11.

Create Geophysical Plot Wizard

Step 3: Output Feature Classes

Log Feature Classes

Output log point feature class:
 J:\Aquaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_6475 ...

Output log line feature class:
 D:\Aquaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_LINE_6475 ...

Output log polygon feature class:
 quaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_POLYGON_6475 ...

Scale Feature Classes

Output scale bar feature class:
 juaveo\subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_SCALEBAR_6475 ...

Output scale major ticks feature class:
 subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_SCALEMAJORTICK_6475 ...

Output scale minor ticks feature class:
 subsurface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_SCALEMINORTICK_6475 ...

Output scale vertical lines feature class:
 surface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_SCALEVERTICALLINE_6475 ...

Output scale background polygon feature class:
 surface analyst\XS2D_logplot\Roseville_logplot.mdb\GeoPlot\XS2D_GEOPOINT_SCALEBACKGROUND_6475 ...

Miscellaneous Options

Append new feature or overwrite: ☒ Append ☐ Overwrite existing feature with same data type

< Back Finish Cancel

Figure 12 Inputs for Step 3 in the Create Geophysical Plot Wizard

11. Select **Finish** to run the wizard.

Upon completion a new set of features is appended to the existing feature classes. If you look at the cross section A-A' data frame you should see the additional log plots added to the cross section adjacent to the first set of plots as shown in Figure 13.

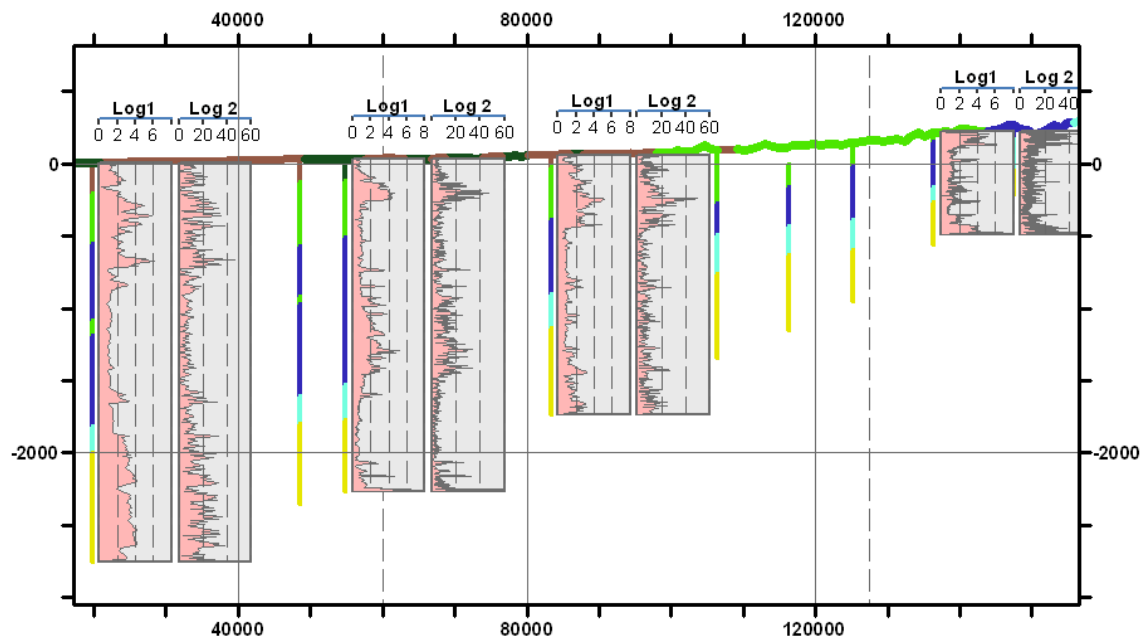


Figure 13 Two sets of log plots added to a cross section

By changing the plot parameters you have the flexibility to customize the display of the plots on the cross section. Another common option is to display the plots stacked together as shown in Figure 14.

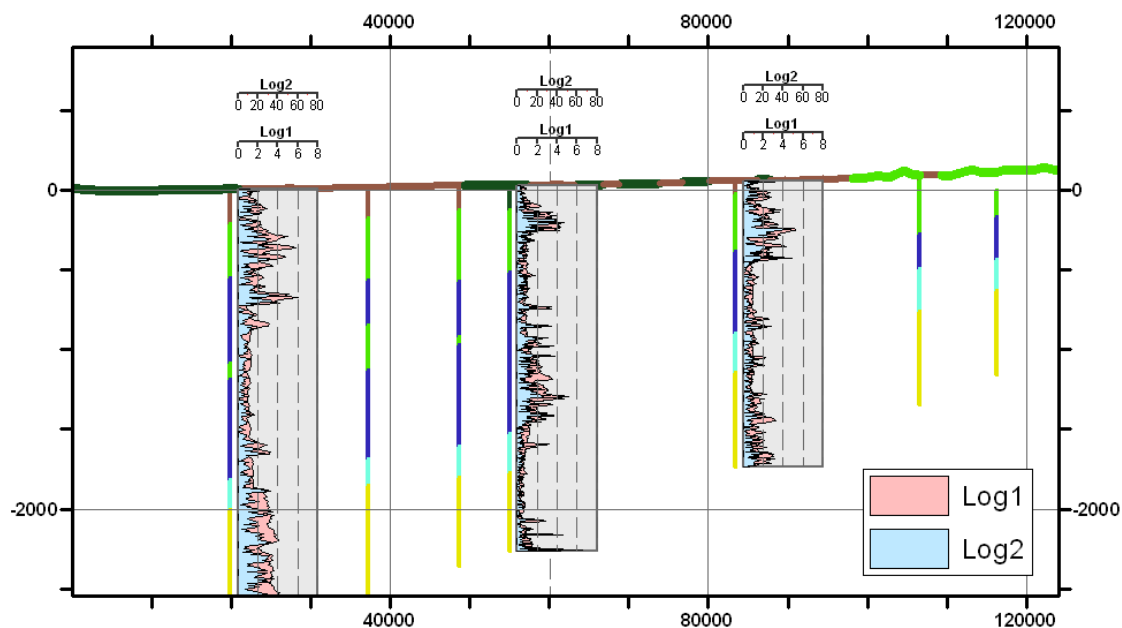


Figure 14 A display of two stacked logs added to a cross section

8 Conclusion

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

- Borehole log data are stored in tabular format and can be added as log plots to cross sections in ArcMap.
- The Create Geophysical Plot Wizard is used to automate the process of creating log plots.
- Log plots are created from a set of feature classes defining the plot, the scale, and the plot background.
- Multiple log plots can be added to a cross section and custom layouts can be created.