ARC HYDRO GROUNDWATER TUTORIALS

Subsurface Analyst – Creating 2D 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. This includes several components to represent different types of datasets such as representations of aquifers, 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. This tutorial will demonstrate how to create cross sections by combining data from different sources including geologic maps, surfaces, and borehole stratigraphy.

Subsurface Analyst includes tools for creating 3D cross sections and volumes from a set of surfaces. The 3D features can be viewed in ArcScene or can be transformed to 2D so they can be displayed in ArcMap. The workflow and tools for creating 3D features are described in a separate tutorial.

1.1 Background

Data used in this tutorial are based on data from a study in the city of Woburn conducted by the USGS. The data were modified for the purposes of the tutorial. The site location is shown in (Figure 1).

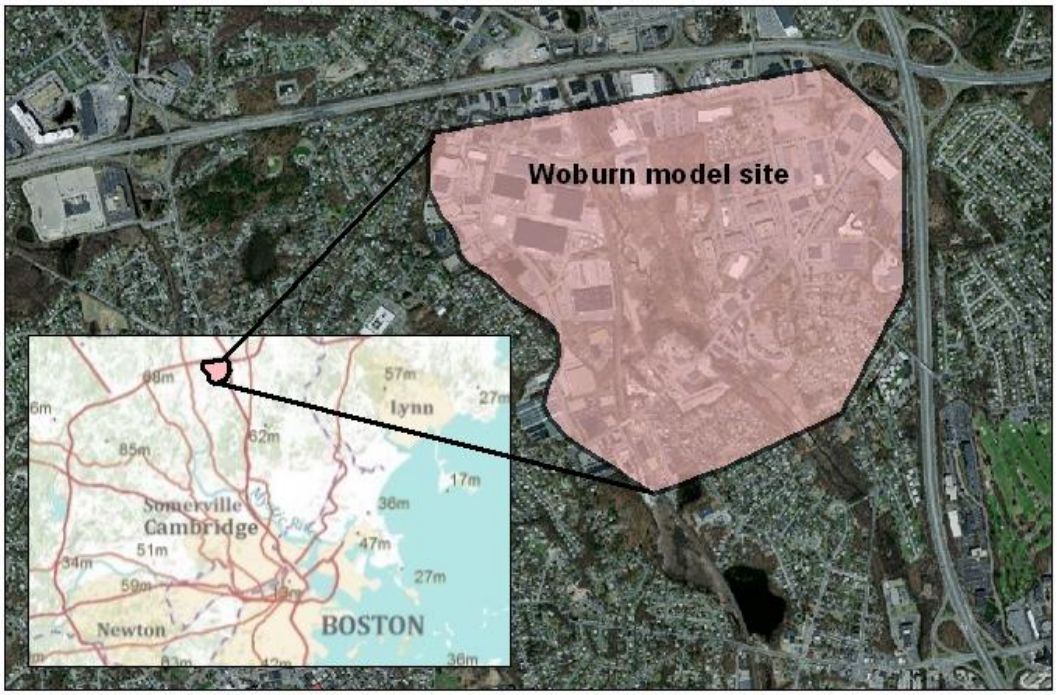


Figure 1 Location of the Woburn Model.

For the purpose of this tutorial, three primary hydrogeologic units were defined. The base of the model domain is deep gravel, the middle part is alluvium consisting of sand and silt, and the top unit is a peat layer that is limited to the river area. Figure 2 shows the sequence of formations used in the model. Each of the units is indexed by a hydrogeologic unit identifier (HGUID), and the unit properties are defined in the HydrogeologicUnit table.

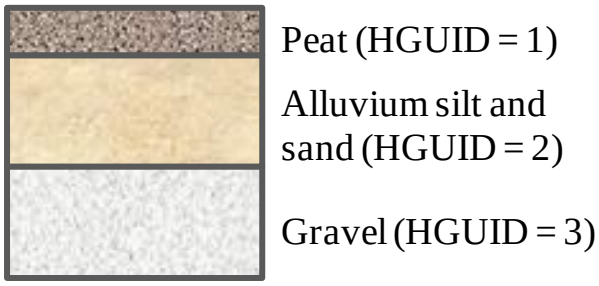


Figure 2 Hydrostratigraphic units in the model area.

1.2 Outline

The objective of this tutorial is to introduce the basic workflow and tools for creating 2D cross sections (XS2D). It will cover the following tasks:

1. Reviewing the structure of the data model classes needed for working with 2D cross sections.
2. Sketching section line features.
3. Running the XS2D Wizard to set up a new XS2D data frame and corresponding feature classes.
4. Creating XS2D Lines representing the intersection of the ground surface DEM with a set of outcrop polygons.
5. Sketching cross section panels in the XS2D data frame in ArcMap.
6. Adding an XS2D Line representing the water table to the cross section.
7. Building 3D GeoSections from the sketched cross section, and visualize the new GeoSection features in ArcScene.

1.3 Required Modules/Interfaces

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

- Arc View license (or ArcEditor\ArcInfo)
- 3D Analyst
- Arc Hydro Groundwater Tools
- Arc Hydro Groundwater Tutorial Files

The AHGW Tools require that there is a compatible ArcGIS service pack installed. Check the AHGW Tools documentation to find the appropriate service pack for your version of the tools. *3D Analyst* is required for the last section of the tutorial for visualizing 3D features. If *3D Analyst* is not available, skip these parts of the tutorial. The tutorial files should be downloaded and saved on a local drive.

2 Getting Started

Before opening the map, ensure that the AHGW Tools are correctly configured.

1. If necessary, launch *ArcMap*.
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".

Note that many of the geoprocessing (GP) 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 you can set the tools 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 Map

Begin by opening a map containing some background data for the Woburn project.

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Browse to the *Tutorials\subsurface analyst\XS2D basic* folder.
3. Select "woburn.mxd" and click **Open** to exit the *Open* dialog and import the model file.

Once the file has loaded, a map of the model area will appear (Figure 3). The map includes a boundary of the model domain, polygons representing outcrops, and wells within the model domain that have related borehole stratigraphy. A Digital Elevation Model (DEM) raster representing the land surface elevation over the model domain and a raster representing the water table surface are also available.

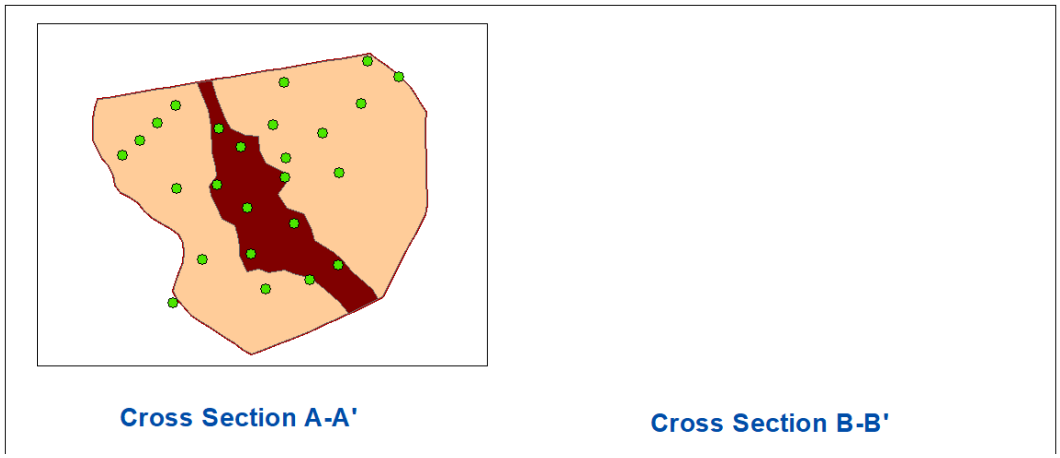


Figure 3 Model domain

4 Representing 2D Cross Sections in the AHGW Data Model

Before starting to create cross sections, it is helpful to review the component of the AHGW Data Model we will be using. The AHGW Data Model includes a number of components used for different purposes. The Hydrostratigraphy component includes data structures for representing 2D and 3D hydrostratigraphy, including the creation of 2D cross sections (Figure 4).

SectionLine is the central feature class used to manage cross sections. Each SectionLine represents a cross section in map view. SectionLine features are indexed with a HydroID, which uniquely identifies them within the geodatabase. To create a vertical (profile) view of the cross section along the SectionLine, each SectionLine feature is associated with multiple feature classes representing the two-dimensional cross section, and these are given the "XS2D" prefix.

Common XS2D feature classes are:

- XS2D_Panel – polygon features representing cross section "panels".
- XS2D_BoreLine – vertical lines representing hydrostratigraphy along selected boreholes adjacent to the SectionLine.
- XS2D_PanelDivider – vertical guides showing the location where a SectionLine changes direction.
- XS2D_MajorGrid and XS2D_MinorGrid – grid lines showing the vertical and horizontal scales in an XS2D data frame.

Additional feature classes can be added to represent items such as land surface elevation, water table, faults, etc.

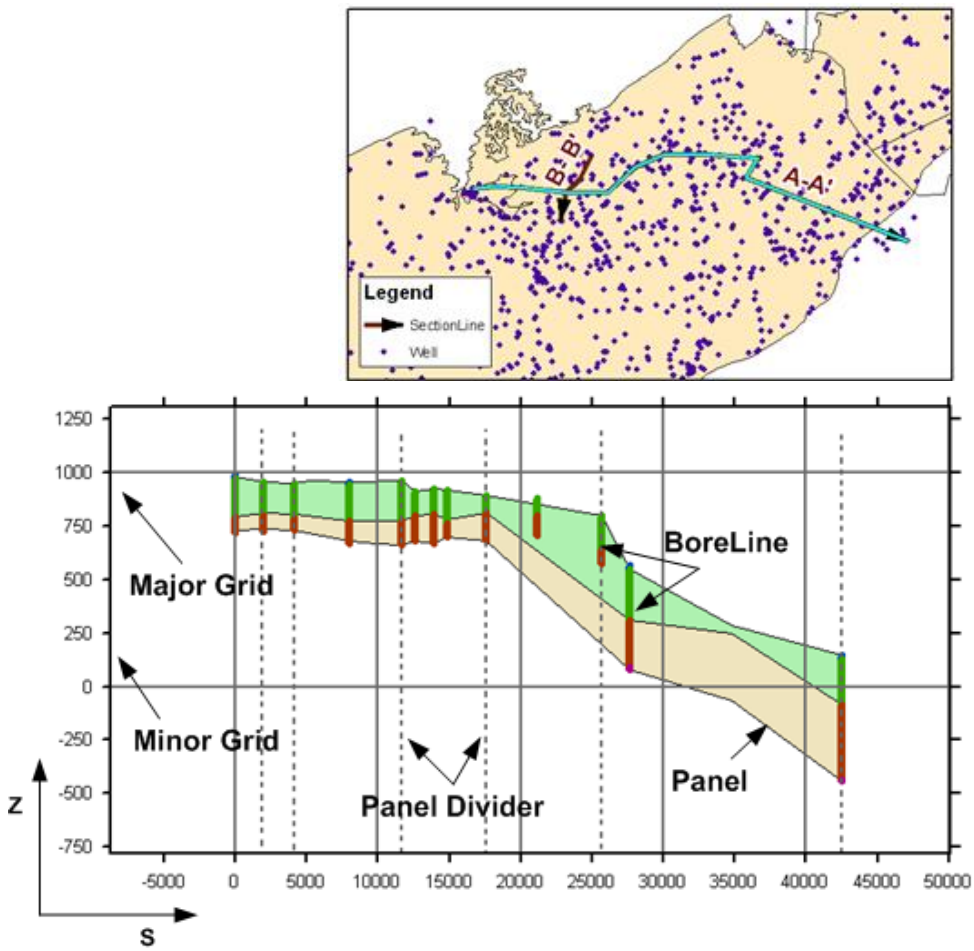
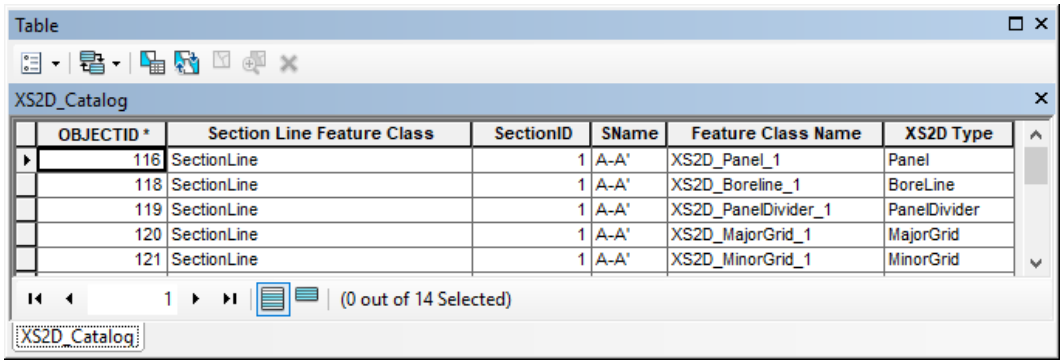


Figure 4 Datasets used for creating 2D cross sections.

Each of the 2D cross sections is generated in a separate data frame in ArcMap. The XS2D feature classes are created in an {S, Z} coordinate system that is unique for each cross section. The S coordinate represents the length along the SectionLine (equivalent to the x-direction in the XS2D data frame) and the Z coordinate represents the vertical dimension (the y-direction in the XS2D data frame). In addition, XS2D features can be scaled

(exaggerated) in the Z dimension for better visualization. *Subsurface Analyst* includes a number of tools for transforming features between a "real" coordinate system (X, Y, and Z) and a 2D coordinate system (S, Z), and for scaling features.

The XS2D_Catalog table is used for managing XS2D feature classes. The Catalog lists the XS2D feature classes related with each SectionLine feature. The SectionID field in the XS2D_Catalog references a HydroID of a SectionLine feature, thus creating a relationship between SectionLines (defined in real world coordinates) and XS2D feature classes. An example of a typical XS2D_Catalog table is shown in Figure 5. Notice that all feature classes in the catalog end with a number (in this example 1) that references the HydroID of the related section line.



OBJECTID *	Section Line Feature Class	SectionID	SName	Feature Class Name	XS2D Type
116	SectionLine	1	A-A'	XS2D_Panel_1	Panel
118	SectionLine	1	A-A'	XS2D_Boreline_1	BoreLine
119	SectionLine	1	A-A'	XS2D_PanelDivider_1	PanelDivider
120	SectionLine	1	A-A'	XS2D_MajorGrid_1	MajorGrid
121	SectionLine	1	A-A'	XS2D_MinorGrid_1	MinorGrid

Figure 5 Example XS2D_Catalog used for managing XS2D feature classes and establishing a relationship between the XS2D features and a SectionLine feature.

5 Sketching SectionLine features

The first step will be to create a set of section line features from which the 3D features will be derived. The section line features will be drawn on the model map. The map includes a boundary defining the extent of the 3D model, well features, and outcrops as shown in Figure 6.

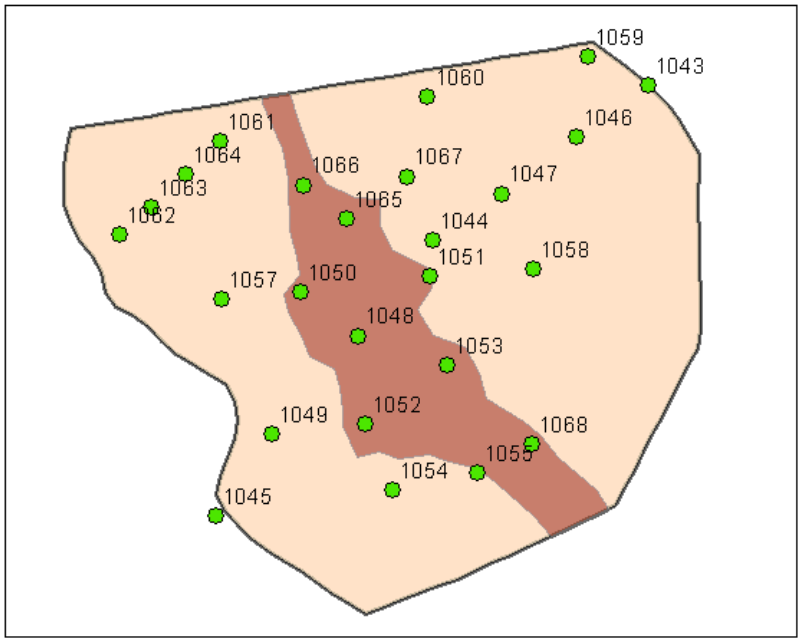


Figure 6 Map containing the model boundary, wells, and outcrops.

To start sketching section lines:

1. If the *Editor Toolbar* is not already visible, click the **Editor Toolbar** icon.

2. Select **Start Editing** in the *Editor* menu of the *Editor Toolbar*.

3. In the *Create Features* window select the "SectionLine" symbology. This will enable editing of section lines.

4. Select the **Straight Segment** tool from the *Editor Toolbar*.

5. Sketch two section lines covering the model domain, as shown in Figure 7 starting with the sketch line labeled "A-A'". Make sure that the section lines do not extend beyond the model domain.

Tip: The direction of digitization defines the orientation of the cross section data. The 0 grid line (representing the beginning of the section line) will be on the left side of the data frame. For section lines going east-west, start the sketch on the west side and sketch to the east side. This will ensure that the cross section and map data are visually compatible.

6. Right-click on "SectionLine" in the Table of Contents and select **Open Attribute Table** to bring up a *Table* dialog.

7. In the *SName* attribute, enter "A-A'" for the first sketched section lines and "B-B'" to the second sketched lines.

At this point the map should be similar to the one shown in Figure 7.

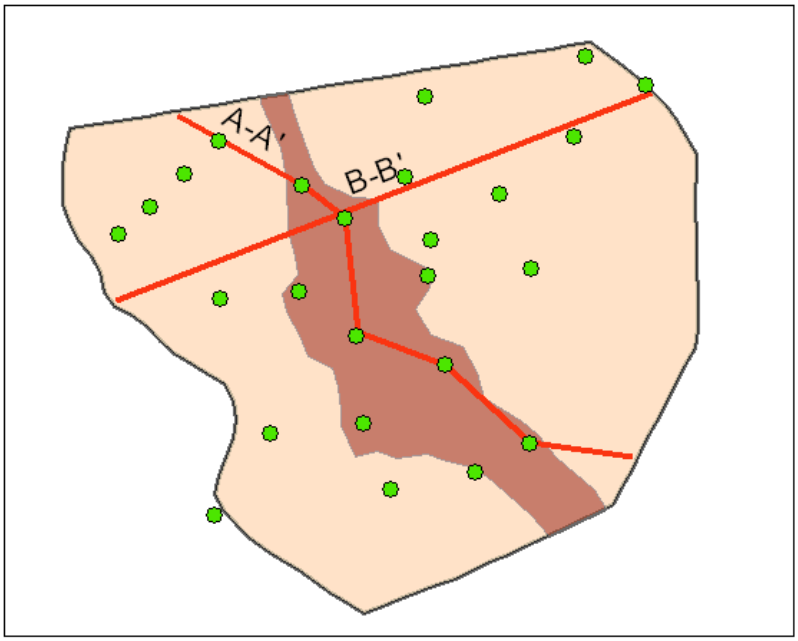


Figure 7 Section lines sketched within the model boundary.

Next, assign vertical exaggeration values to the section lines. The cross section features will be scaled based on the vertical exaggeration attribute.

8. In the SectionLine *Table*, click **Clear Selected Features** to clear the selection.
9. Right-click on the *Vertical Exaggeration* field and select **Field Calculator** to open the *Field Calculator* dialog.
10. In the *VertExag2D=* field, enter "20" for the vertical exaggeration value**.**
11. Click **Save** to exit the *Field Calculator*.
12. Close the SectionLine *Table* dialog.
13. Select **Save Edits** in the *Editor* menu of the *Editor Toolbar*.
14. Select **Stop Editing** in the *Editor* menu of the *Editor Toolbar*.

After creating the features, HydroID values need to be assigned to them. The HydroID is the unique identifier of the feature within the geodatabase, and is used to create relationships between tables and feature classes. There are tools to help you manage your HydroIDs. The tool uses a UniqueID table to track the addition of HydroIDs in the geodatabase (The table has already been created using the Create Unique ID Table tool available in the Groundwater analyst toolset).

15. In the *Arc Toolbox*, expand "Groundwater Analyst" then expand "Time Series".

16. Double-click "Assign HydroID GW" to open the *Assign HydroID GW* dialog.

17. Set *Input UniqueID Table* to "UNIQEID".

18. Set *Input Features to Assign HydroID* to "SectionLine".

19. Set *HydroID Field of Input Features* to "HydroID".

20. Select **OK** to close the *Assign HydroID GW* dialog and run the tool.

If desired, open the attribute table of the SectionLine layer to see that HydroIDs were assigned to the features.

6 Running the XS2D Wizard

The *XS2D Wizard* creates a new set of feature classes for representing a 2D cross section based on a specific SectionLine feature. The wizard creates a new data frame to which the XS2D feature classes (XS2D_Panel, XS2D_BoreLine, XS2D_PanelDivider, XS2D_MajorGrid, and XS2D_MinorGrid) are added. Using a separate data frame for each 2D cross section allows us to visualize the features from each cross section independently.

Before actually running the XS2D Wizard you can select a set of wells to be included in the process of creating a 2D cross section. Borehole data related to these wells will help guide the cross section dimensions and borehole stratigraphy will be added to the cross section.

1. Select SectionLine A-A' using the **Select Features** tool.

2. Select *Selection* | **Select By Location** to open the *Select By Location* dialog.

3. In the *Selection Method:* section, select the "Select features from" option.

4. In the *Target layer(s):* section, turn on the "Well" item.

5. In the *Source layer:* section, select the "SectionLine" item.

6. Enable the *Use Selected Features* option.

7. In the *Spatial selection method for target layer feature(s):* section, select the "are within a distance of the Source layer feature" option.

8. Turn on *Apply a search distance* and enter a buffer distance of "200' feet. Note that it might be necessary to modify the buffer distance depending on how the section line is sketched to select 5–6 wells.

9. Click **OK** to close the *Select by Location* dialog and create the selection.

After applying the selection you should have six wells selected in the map as shown in Figure 8.

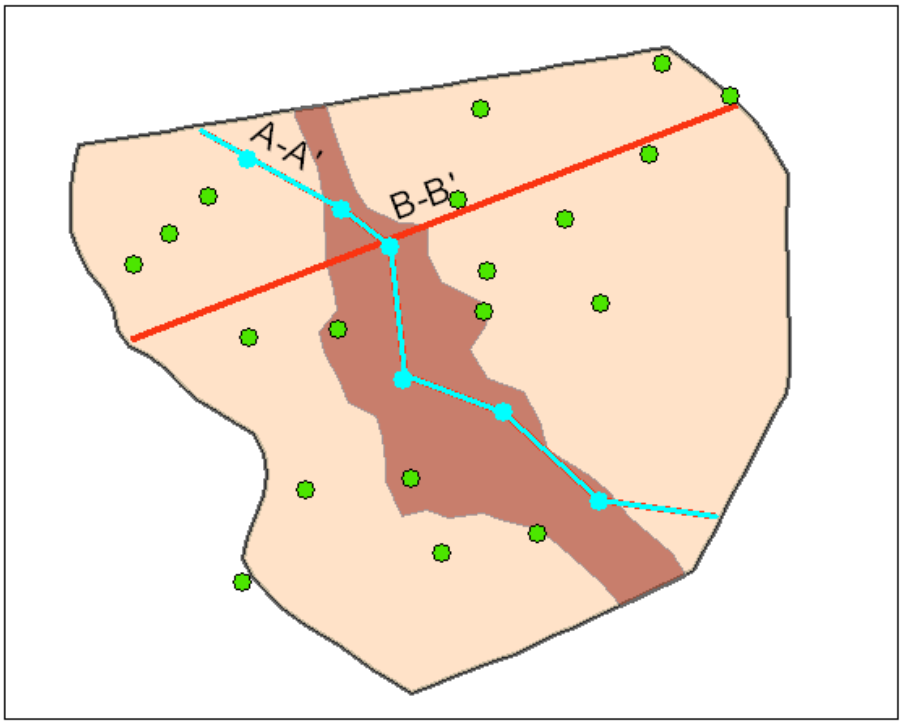


Figure 8 Selected features after applying the Select By Location with a buffer of 200 feet.

Next, run the XS2D Wizard to create a new cross section. The XS2D Wizard is based on a selected section line and the wizard runs one cross section at a time. To start the XS2D Wizard:

10. Select the **XS2D Wizard** icon in the *Arc Hydro Groundwater Toolbar*.

11. With the tool activated, click on a SectionLine feature (it is fine if the section line is already selected) to launch the *2D Cross Section Wizard*.

The XS2D Wizard will create a set of feature classes and a new data frame for the selected SectionLine. *Step 1* of the wizard shows the SectionLine properties (HydroID, Name, and Length). In addition the well feature class and borehole log table can be specified. If desired, specify to use well and borehole log data. Also, if needing to specify the vertical exaggeration (default is the vertical exaggeration value read from the SectionLine feature), select the XS2D_Catalog table used to manage the XS2D feature classes and set the default output workspace.

At this point the inputs should be similar to the ones shown in Figure 9.

12. Make sure the *Default output workspace* points to the *woburn.mdb\Data* feature dataset.

13. Select **Next** to move to the next step in the wizard.

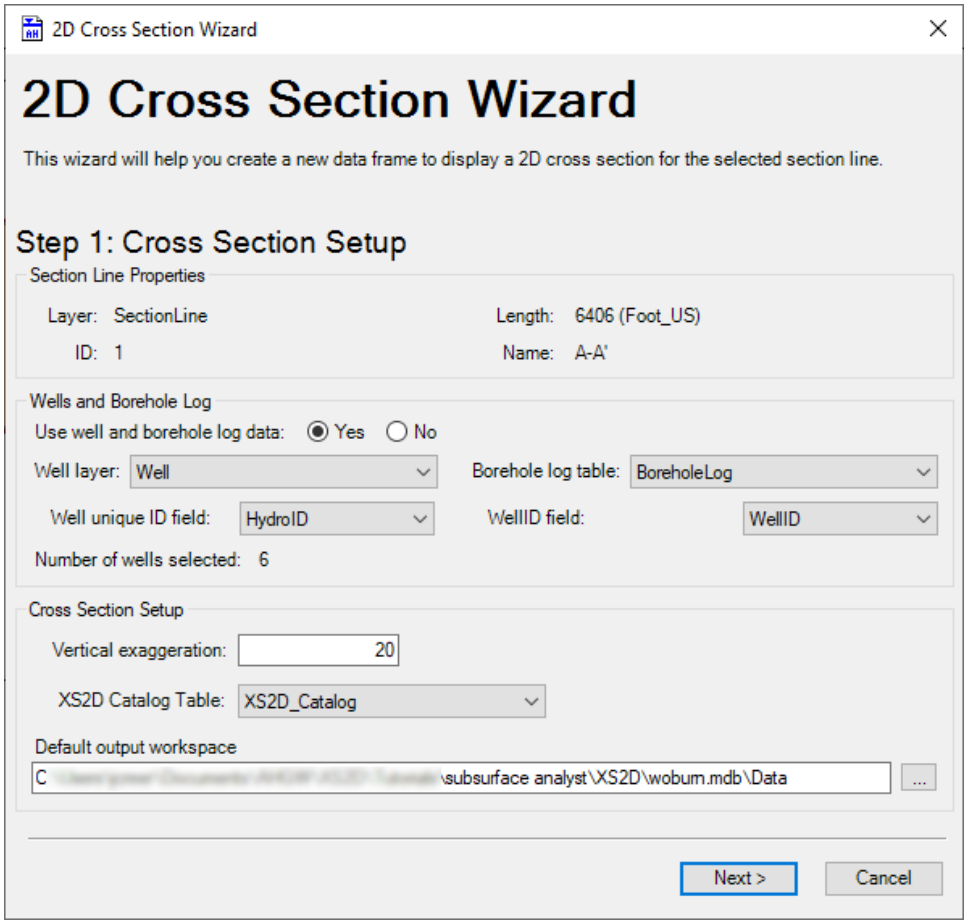


Figure 9 Settings for step 1 in the XS2D Wizard.

Step 2 in the wizard is used to set up the appropriate panel, boreline, and panel divider feature classes. It can also specify the elevations for drawing panel dividers. Notice that by default the created XS2D feature classes are located in the default output workspace, and the HydroID of the section line for this cross section is appended as a prefix to the feature class names. This naming convention is not mandatory, but it helps in identifying the feature classes when multiple cross sections are created.

Default values, based on the borehole data, are set for the minimum and maximum elevations of the panel dividers. The default values can be kept or modified.

14. Leave the default minimum and maximum elevations for drawing panel dividers.

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

15. Select **Next** to move to the next step in the wizard.

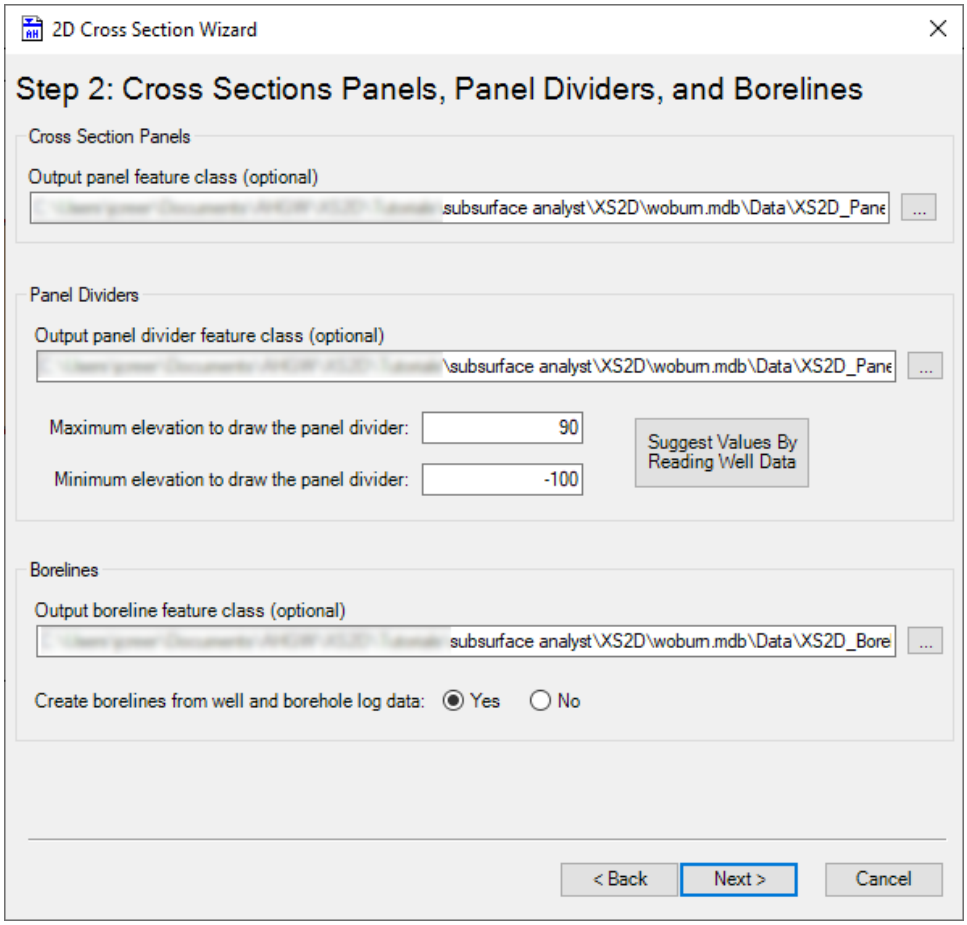


Figure 10 Settings for step 2 in the XS2D Wizard.

Step 3 in the wizard is used to create major and minor grid lines. The grid extent and spacing can be automatically specified based on the length of the selected SectionLine and borehole data, or they can be set manually.

Default values are set for the left, right, minimum and maximum elevations, and spacing of the grid features. The default values can be kept or modified.

16. Leave the default values for the grid extent and spacing.

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

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

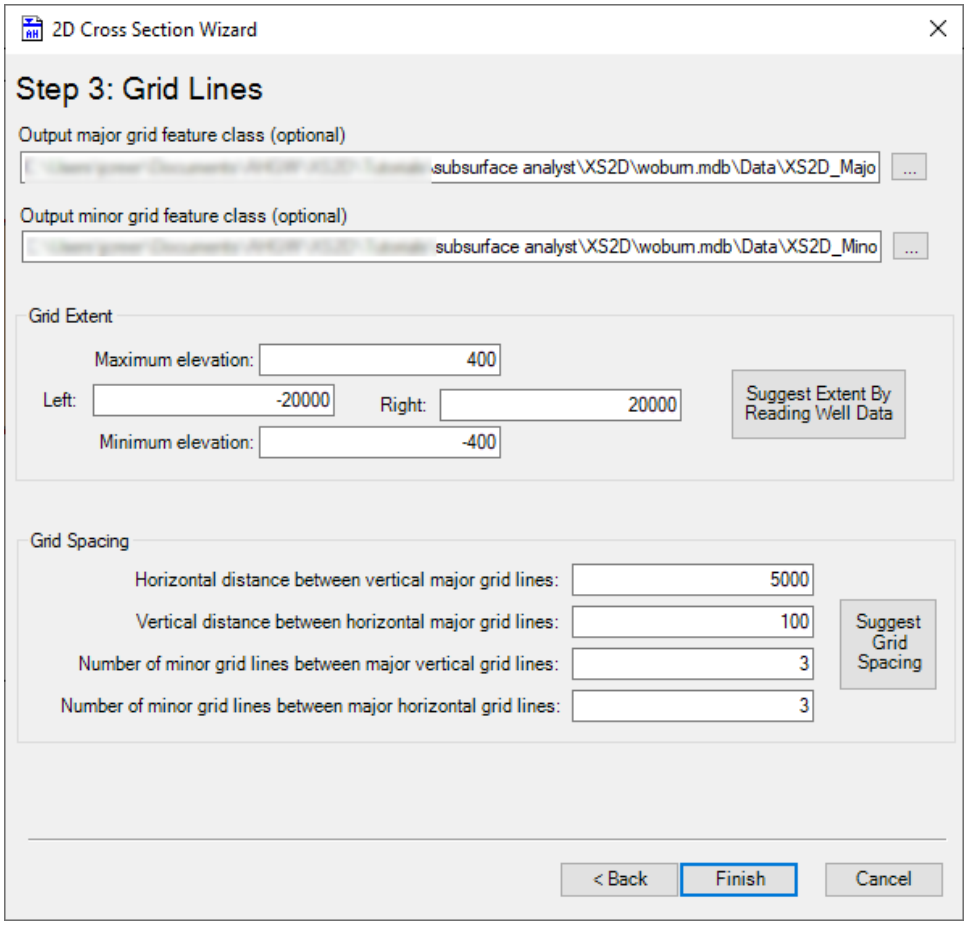


Figure 11 Settings for step 3 in the XS2D Wizard.

A new Data Frame (Section A-A') should be added to the map (be sure to be in layout view to be able to view both data frames). Notice the grid lines, the panel dividers, and the boreline features. Boreline features are automatically symbolized by the *HGUID* to differentiate between the hydrogeologic units. In addition, the borelines are symbolized by the *Offset* field such that borelines from wells closer to the cross section are wider. Also, notice that grid lines showing the vertical and horizontal dimensions were added to the data frame.

Resize the A-A' data frame and move it within the map layout such in order to see both data frames. To better view the XS2D feature created:

- If necessary, change the map to Layout View by selecting *View* | **Layout View**.
- Using the **Select Elements** tool, move the Section A-A' data frame within the map layout and resize it.
- Use the zoom tools ( ) to focus on the data within the cross section.

- Control the grid properties (text size, color, etc.) by right-clicking on the data frame and selecting **Properties** to open the *Data Frame Properties* dialog. In the dialog, select the *Grids* tab, and specify which grid lines you want to display and modify the labels, ticks, color, etc.

Use the *HGU Color Manager* to manage colors within the cross section data frames:

18. In the *Table of Contents*, switch to **List By Source** .
19. In the *Table of Contents*, right-click on "Section A-A'" and select **Activate**.

Now to load the hydrogeologic unit table to the A-A' data frame.

20. Select **Add Data** to open the *Add Data* dialog.
21. Browse to and open the "Woburn.mdb" geodatabase.
22. Select the "HydrogeologicUnit" file and click **Add** to import the table and close the *Add Data* dialog.
23. In the *Arc Hydro Groundwater Toolbar*, select **HGU Color Manager** in the *Subsurface* menu to open the *HGU Color Manager* dialog.
24. Click **Setup** to open the *HGU Setup* dialog.
25. Change the settings to be as follows:
    - *HGU Table* to "HydrogeologicUnit".
    - *HGU ID Field* to "HydroID".
    - *HGU Name Field* to "HGUName".
26. Click **OK** to close the *HGU Setup* dialog.

If desired, modify the colors by using the color picker buttons in the *Symbology* column to pick a color for each of the HGUID values (listed in the *HGU ID* column).

27. Click **Apply Symbology** to apply the changes.

Note that the selected color scheme has been applied to all of the selected scene layers.

28. Click **Save and Exit** to close the *HGU Color Manager* dialog.

Increase the width of the XS2D_BoreLine features by:

29. Right-click on the "XS2D_BoreLine_1" layer and select **Properties…** to open the *Layer Properties* dialog.
30. Select the *Symbology* tab.

31. Click the *Symbol* header above the line symbols and select **Properties for All Symbols...** to open the *Symbol Selector* dialog.

32. Adjust the symbol *Width* to a value of "5.0".

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

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

At the end of this process, there should be an XS2D data frame that is similar to the one shown in Figure 12.

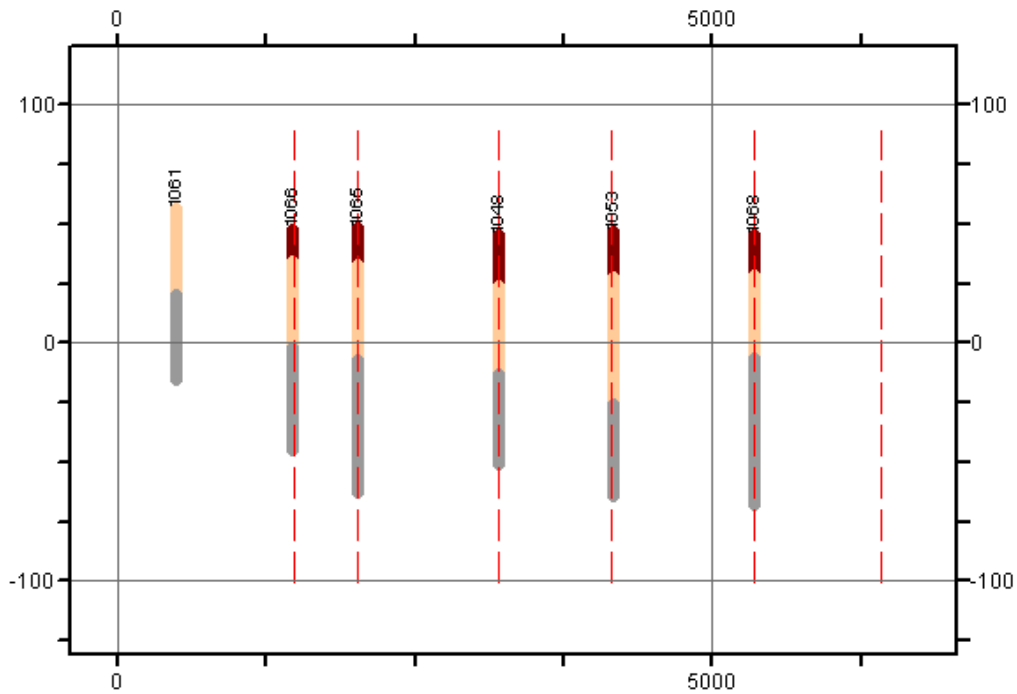


Figure 12 Initial XS2D data frame with XS2D features created by the XS2D Wizard.

Before continuing, create an additional cross section data frame for section line B-B'.

35. Repeat steps 1–32 to create an additional XS2D data frame for section B-B'. Note that the buffer distance may need to be changed to enable the selection of 4–5 wells adjacent to section line B-B'.

If desired, add text boxes to define sections A-A' and B-B' within the map layout. At the end of this process the map layout should be similar to the one shown in Figure 13.

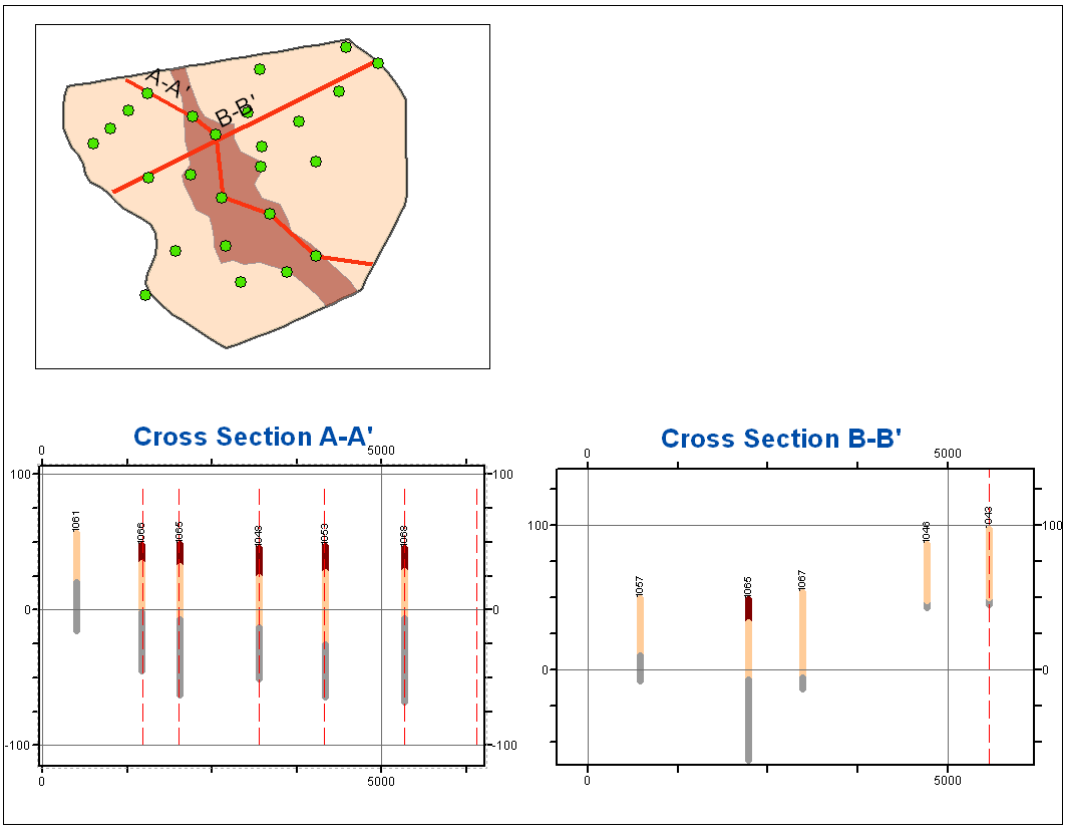


Figure 13 Map layout containing cross sections A-A' and B-B'.

This is a good starting point for digitizing cross sections by connecting borehole data. But before sketching cross sections, add additional data that will guide the process for creating cross sections.

7 Adding Data from Geologic Maps

An important source of data to use while sketching cross sections is outcrop information from geologic maps. Geologic maps describe the outcropping of rock units (the coverage of a rock unit over the land surface). When combined with a digital elevation model, the geologic map data provides additional information to include in a cross section. The map includes a set of polygon features that represent outcrops of the peat and alluvium formations defined within the model.

Before continuing, create a new line feature class to which the output XS2D Lines will be written.

1. In the *Table of Contents*, right-click on "Layers" and select **Activate**.

This is important as the section lines and additional datasets such as the DEM and outcrops are only loaded in the "Layers" data frame.

2. Click the **Clear Selected Features** icon to unselect all features in the data frame.

3. Expand the " XS2D Editor" toolset under the " Subsurface Analyst" toolset.

4. Double-click on the " Create XS2D Line Feature Class" tool to open the *Create XS2D Line Feature Class* dialog.

This tool will create a new XS2D line feature class for each of the selected SectionLine features. If no section line is selected it will create feature classes for all section lines in the SectionLine feature class.

5. For *Input Section Line Features* select "SectionLine".

6. For *XS2D_Catalog Table* select "XS2S_Catelog".

7. For *XS2DType value* enter "Outcrop".

8. For *Feature Class Name Prefix* enter "Outcrop".

The feature classes created will include the prefix specified and the HydroID of the section line feature (e.g. Outcrop_1).

9. Click **OK** exit the *Create XS2D Line Feature Class* dialog and run the tool.

Two new feature classes named "Outcrop_1" and "Outcrop_2" should be added to the Table of Contents.

Next, add XS2DLine features to the feature class just created. Each line in the feature class represents the intersection of the section line with a surface (raster). The values from the raster are usually scaled in the Z dimension, so they can be better visualized.

To add geologic map data along the cross sections:

10. In the " XS2D Editor" toolset, double-click on " Transform Polygons to XS2D Lines" tool to open the *Transform Polygons to XS2D Lines* dialog.

11. For *Input Polygon Features* select "Outcrops".

12. For *Input Section Line Features* select "SectionLine".

13. For *Input XS2D_Catalog Table* select "XS2D_Catelog".

14. For *XS2DType* select "Outcrop".

15. For *Ground Surface DEM* select "dem100ft".

The *Discretization Spacing* should be automatically populated after selecting the raster. The default spacing is equal to the raster cell size.

16. Specify a *Discretization Spacing* of "100".

17. For *FType* enter “Outcrop. This is an optional value that enables classifying the XS2DLine feature created.

The *Overwrite* parameter should be enabled automatically, such that before writing new features, the tool clears the target feature class. If it is disabled, then new features will be appended to the feature class.

18. Click **OK** to close the *Transform Polygons to XS2D Lines* dialog and launch the tool.

When the tool is done a new set of lines is added to the Outcrop_1 and Outcrop_2 feature classes. To view the lines within the cross section data frames:

19. In the *Table of Contents*, right-click on “ Section A-A’” and select **Activate**.

20. Select **Add Data** to open the *Add Data* dialog.

21. Browse to and open the “Woburn.mdb” geodatabase and open the “Data” directory.

22. Select the “Outcrop_1” file and click **Add** to import the table and close the *Add Data* dialog.

Next, use the HGU Color Manager to modify the symbology of the outcrop lines:

23. In the Arc Hydro Groundwater Toolbar, select **HGU Color Manager** in the *Subsurface* menu to open the *HGU Color Manager* dialog.

24. Click **Setup** to open the *HGU Setup* dialog.

25. Change the settings to be as follows:

    - *HGU Table* to “HydrogeologicUnit”.
    - *HGU ID Field* to “HydroID”.
    - *HGU Name Field* to “HGUName”.

26. Click **OK** to close the *HGU Setup* dialog.

27. Click **Apply Symbology** to apply the changes.

Note that the selected color scheme has been applied to the outcrop lines.

28. Click **Save and Exit** to close the *HGU Color Manager* dialog.

29. Repeat steps 19–28 for the B-B’ cross section data frame.

At this point the XS2D data frames (A-A’ and B-B’) should be similar to the one shown in Figure 14.

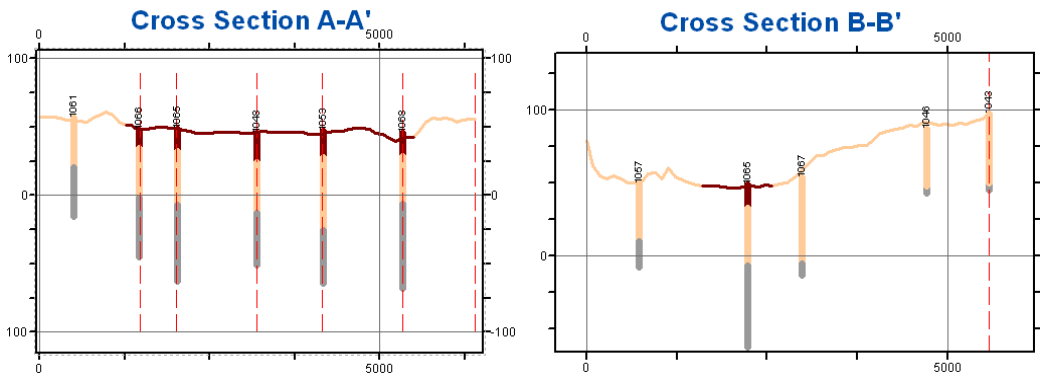


Figure 14 Cross section data frames with borelines and outcrops.

The borelines and outcrops will be used while digitizing new cross sections.

8 Sketching Cross Section Panels

In this section, new cross section panels will be sketched. Use the boreline data and outcrops as guides while utilizing the advanced editing capabilities available in ArcMap.

8.1 Creating a New Template for Editing XS2D Panel Features

First create a template for the XS2D Panel feature class:

1. In the *Table of Contents*, right-click on "Section A-A'" and select **Activate**.

Before creating a template, make sure that the symbology of the panels is setup correctly. The XS2D_Panel symbology should have already been set using the *HGU Color Manager* in previous steps of this tutorial. The symbology of the XS2D_Panel layer should be similar to the one shown in Figure 15. If the symbology is not set correctly, set it using the *HGU Color Manager* as shown in steps 23–28 of section 6.

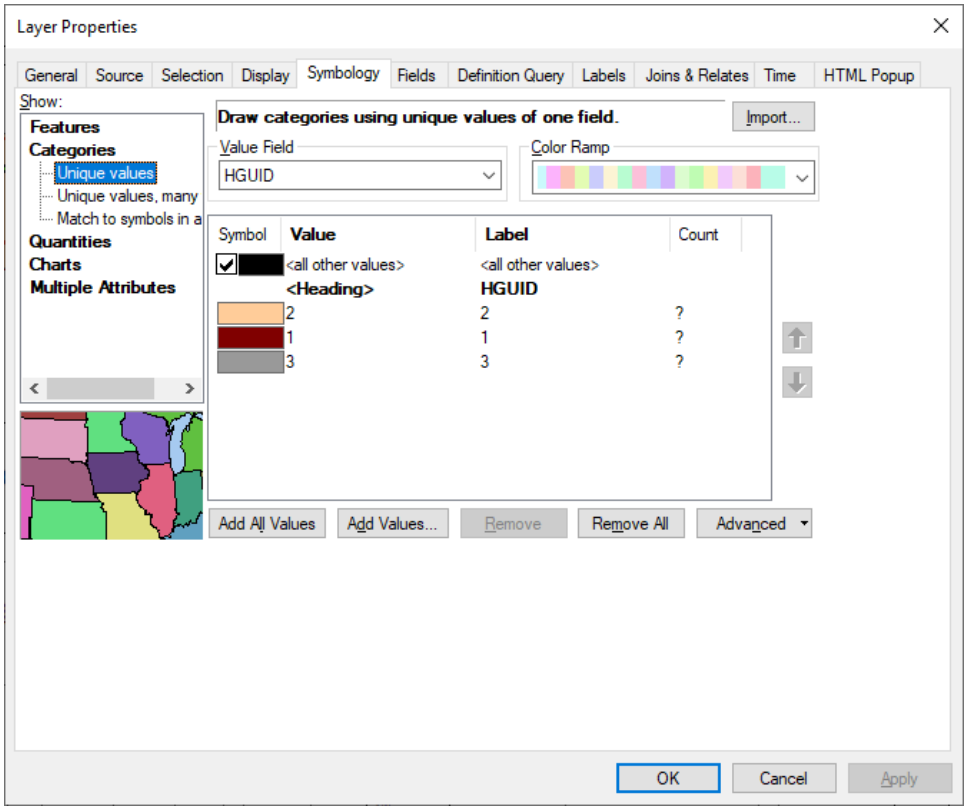


Figure 15 Symbology for the XS2D_Panel layer

Next, define a new feature template:

2. Select **Start Editing** in the *Editor* menu of the *Editor Toolbar* to open the *Create Features* dialog.

The *Create Features* window should include a template for the XS2D_Panel_1 layer, as shown in Figure 16.

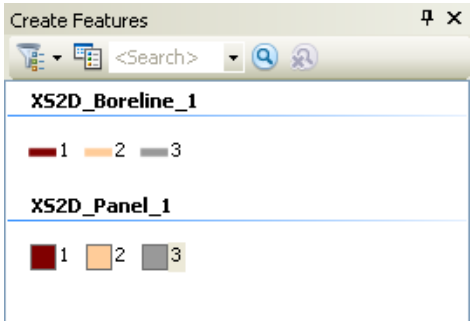


Figure 16 The Create Feature window after adding a template for XS2D Panel features.

3. If the template does not appear as shown in Figure 16 then proceed with steps 4 through 9. If the template does appear skip to Section 8.2.

4. Select **Organize Templates** located at the top of the *Create Features* window to open the *Organize Feature Templates* dialog.

5. In the *Layers* section, select "XS2D_Panel_1". Notice that no template is associated with this layer.

6. Select **New Template** to open the *Create New Template Wizard*.

7. Make sure "XS2D_Panel_1" is the only layer selected.

8. Select **Next** to view the symbology of the features in the template.

9. Select **Finish** to create the template

The *Create Features* window should include a template for the XS2D_Panel_1 feature class, as shown above in Figure 16.

Next, set the snapping environment.

8.2 Setting the Snapping Environment Options

Make sure the Section A-A' data frame is activated.

1. In the *Table of Contents*, right-click on "Section A-A'" and select **Activate**.

2. Select **Start Editing** in the *Editor* menu of the *Editor Toolbar* to open the *Create Features* dialog.

For this tutorial activate the classic snapping option. To enable this option:

3. Select *Editor* | **Options** to bring up the *Editing Option* dialog.

4. In the *General* tab, turn on *Use Classic Snapping*. This allows controling settings of the snapping environment, such as how our edits will be snapped (vertex, edge, end) and the priority of snapping between the layers.

5. Click **OK** to close the *Editing Options* dialog.

6. Select *Editor* |*Snapping* | **Snapping Window** to open the *Snapping Environment* window.

7. Move the layers by selecting them and moving them up or down so that they are in the following order:
    - XS2D_Panel_1
    - Outcrop_1
    - XS2D_Boreline_1
    - XS2D_PanelDivider_1

- XS2D_MinorGrid_1
- XS2D_MajorGrid_1

The order of the layers within the snapping environment interface determines the snapping priority.

8. For "XS2D_Panel_1" turn on *Vertex* and *Edge*.
9. For "Outcrop_1" turn on *End*.
10. For "XS2D_Boreline_1" turn on *End*.
11. For "XS2D_PanelDivider_1" turn on *Edge*.

While editing, enable Snap Tips to show the features to which the new features are being snapped.

1. Select *Editor* |*Snapping* | **Options** to open the *Classic Snapping Options* dialog.
2. Change the *Snapping tolerance* to "7".
3. Click **OK** to close the *Classic Snapping Options* dialog.

8.3 Sketching Panels

1. Select *View* | **Data View**. It is generally easier to sketch in Data View.
2. **Zoom** to the right end of the cross section and zoom in on the outcrop representing HGUID = 2 (Alluvium).
3. In the *Create Features* window, under "XS2D_Panel_1 template", select the feature symbology for HGUID = 2.

Notice that the *Construction Tools* window contains a list of the available tools for creating new panels.

4. Make sure the *Polygon* tool is selected.

The *Trace* editing tool will be used to trace the outcrop as part of the cross section creation.

Tip: while sketching, use the zoom and pan tools to focus on certain elements of the cross section.

5. In the *Editor* menu, select the **Trace** tool.
6. Trace the outcrop defining HGUID = 2. Start tracing from the right side by clicking on the edge of the line, then drag the mouse over the outcrop line. A new

line when creating while moving the mouse to the left side of the outcrop. When the end of the outcrop line is reached, click on the edge to create a vertex.

The sketch should be similar to the one shown in Step 1 of Figure 17.

7. Using the **Straight Segment** tool, and continue sketching a cross section panel. Use the boreline edges as a guiding point. The sketch tool should automatically snap to the end of the boreline features while digitizing. Make sure to also snap to the panel dividers defining the start and end of the cross section.

8. Change between the **Straight Segment** and **Trace** tools to follow the borelines and outcrops.

The sketch should be similar to the one shown in Step 2 of Figure 17.

9. Make sure to reach the right side panel divider as shown in Step 3 of Figure 17.

10. Double-click on the starting point to close the panel.

The sketch should be similar to the one shown in Step 4 of Figure 17.

Tip: To better visualize the borelines on top of the panels, set a transparency of 70% on the panel features (select the layer, right-click, and select Display tab to set the transparency for the layer).

Next, assign some basic attributes to the panel.

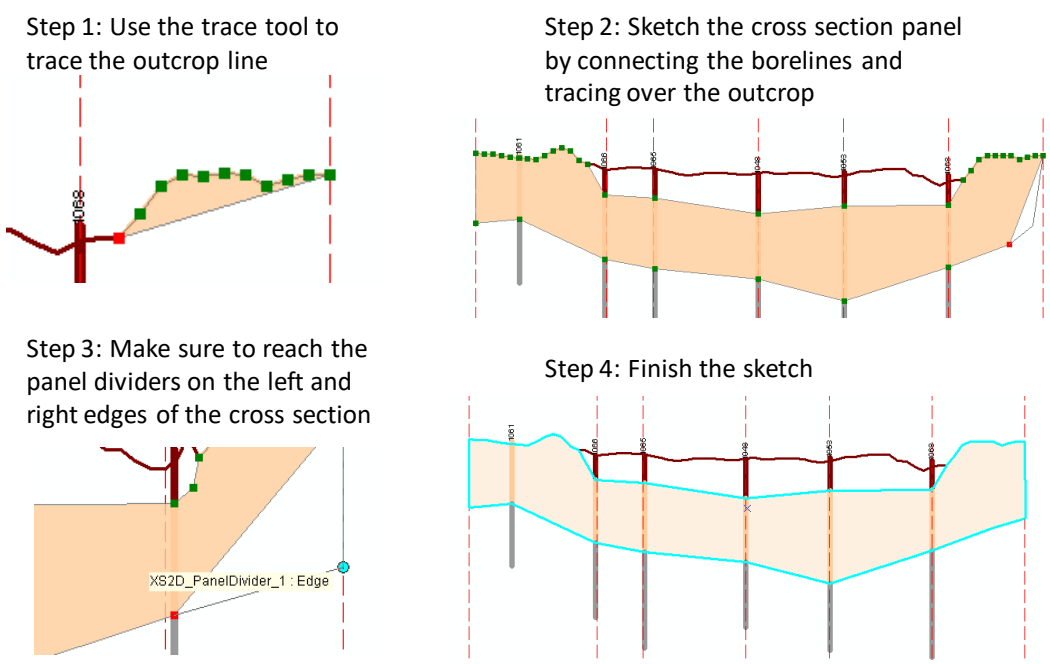


Figure 17 Steps in sketching a cross section panel.

11. Using the **Edit** tool in the *Editor* toolbar, select the feature which was just created.

12. Right-click and select **Attributes** to open the *Attributes* window.

13. In the *Attributes* window edit the following attributes:

    - Make sure a value of "2" is in the *HGUID* field so it matches the HGUID of the borelines and outcrops used in the sketching process. This value should be created automatically.

    - Set the *SectionID* attribute to be equal to the HydroID of the section line (either "1" or "2" depending on the cross section being sketched).

14. When done editing the attributes, close the *Attributes* window.

15. In the *Editor* menu, select **Save Edits**.

Next, digitize the panel for the peat layer represented by HGUID = 1:

16. **Zoom** in to the outcrop line representing HGUID = 1.

17. In the *Create Features* window, under "XS2D_Panel_1 template", select the feature symbology for HGUID = 1.

18. In the *Construction Tools* window select *Auto Complete Polygon*.

19. Using the **Trace** tool, sketch a line following the outcrop representing HGUID = 1.

20. Make sure that the line snaps to the end of the panel representing unit 2, as shown in Figure 18.

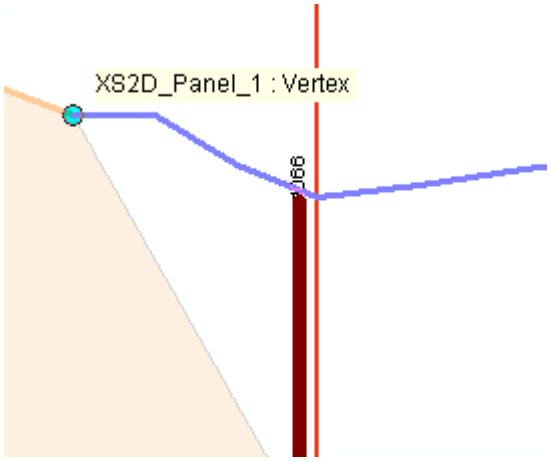


Figure 18 The new polygon should snap to the vertex located at the intersection of the cross section panel and outcrop.

21. Double-click on the starting point to close the panel.

A new polygon representing HGUID = 1 should be created. The polygon's boundary should match the boundary of the polygon representing HGUID = 2.

Thesketch should be similar to the one shown in Figure 19.

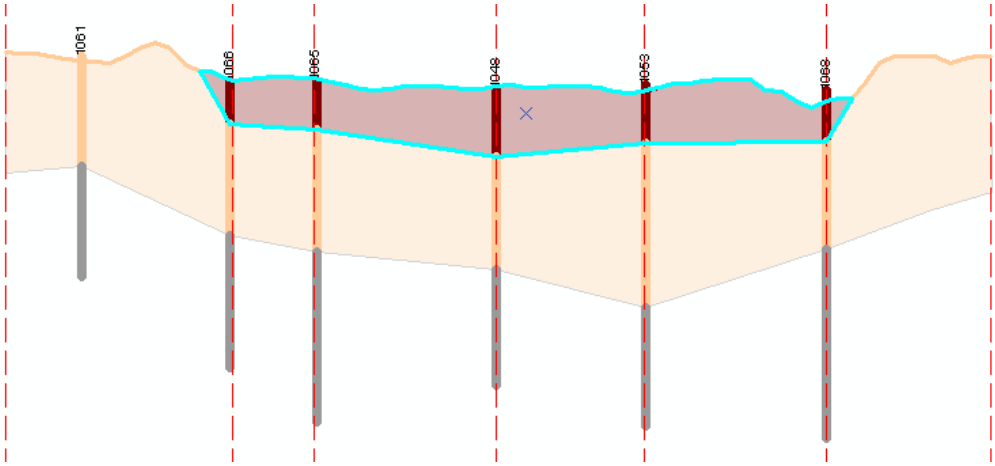


Figure 19 Cross section panel created using the Auto Complete Polygon task.

22. Using the **Edit** tool in the *Editor* toolbar, select the feature which was just created.

23. Right-click and select **Attributes** to open the *Attributes* window.

24. In the *Attributes* window edit the following attributes:

    - Make sure HGUID is set to "1", so it matches the HGUID of the borelines and outcrops used in the sketching process.

    - Set the *SectionID* attribute to be equal to the HydroID of the section line (either "1" or "2" depending on the cross section being sketched).

25. When done editing the attributes, close the *Attributes* window

26. In the *Editor* menu, select **Save Edits**.

Next, sketch the panel for the gravel unit HGUID = 3.

27. In the *Create Features* window, under "XS2D_Panel_1 template", select the feature symbology for HGUID = 3.

28. In the *Construction Tools* window select *Auto Complete Polygon*.

29. Using the **Trace** tool, start sketching from the upper left or right corner of the unit and make sure to snap to the panel representing unit 2, as shown in Figure 20.

30. Using the **Straight Segment** tool, sketch downward along the panel divider, and then across following the borelines representing the bottom of unit 3. At the edge of the cross section, snap to the panel dividers and sketch upwards. Make sure to snap to the panel representing unit 2, as shown in Figure 20.

31. Double-click on the starting point to close the panel.

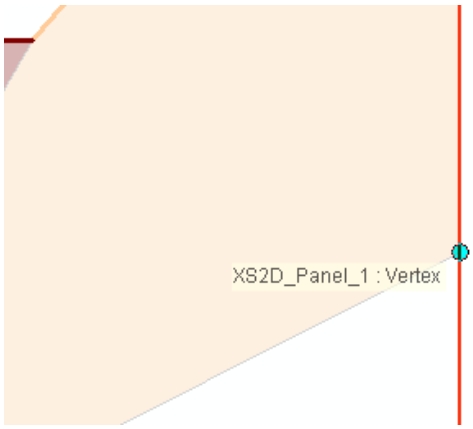


Figure 20 Sketching cross section panel for HGUID = 3.

After finishing the sketch of the gravel unit the cross section should be similar to the one shown in Figure 21.

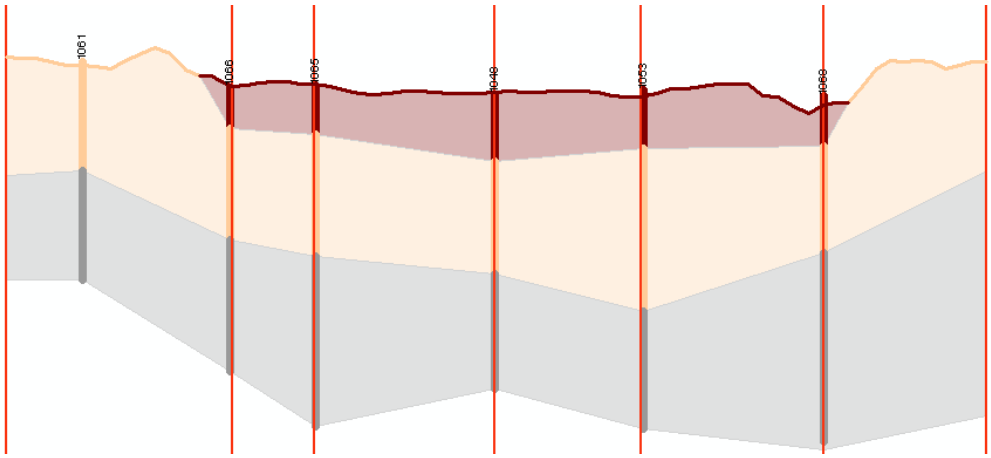


Figure 21 Cross section after sketching the panel representing the gravel unit.

Next, assign some basic attributes to the panel.

32. Using the **Edit** tool in the *Editor* toolbar, select the feature which was just created.

33. Right-click and select **Attributes** to open the *Attributes* window.

34. In the *Attributes* window edit the following attributes:

- Make sure HGUID is set to "3" so it matches the HGUID of the borelines and outcrops used in the sketching process.
- Set the *SectionID* attribute to be equal to the HydroID of the section line (either "1" or "2" depending on the cross section being sketched).

35. When done editing the attributes, close the *Attributes* window
36. In the *Editor* menu, select **Save Edits**.
37. In the *Editor* menu, select **Stop Editing.**
38. Repeat steps 1–37 to sketch cross section panels for cross section B-B' (make sure to activate the B-B' data frame before you start a new edit session).

At the end of this process there should be two completed cross sections, similar to the ones shown in Figure 22.

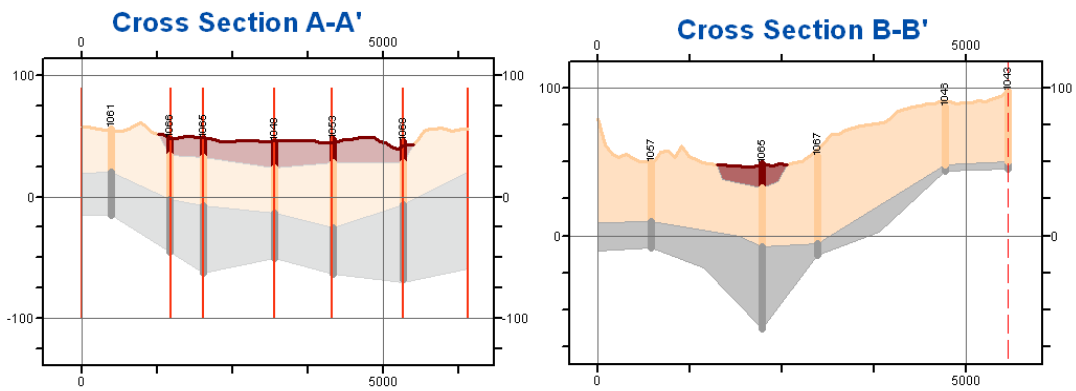


Figure 22 completed cross sections with borelines, outcrops, and panels.

Next, add data from a water level raster into the cross section.

9 Adding Raster Data to the Cross Section

In this section, add a line representing a water table to the cross section. The line is derived from a raster representing the water table surface, values from the raster are transformed into the XS2D coordinate system and a new line is created in the cross section.

1. In the *Table of Contents*, right-click on "Layers" and select **Activate**.
2. Click the **Clear Selected Features** icon to unselect all features in the data frame.
3. In the "XS2D Editor" toolset, double-click on "Create XS2D Line Feature Class" tool to open the *Create XS2D Line Feature Class* dialog.

4. For *Input Section Line Features* select “SectionLine”.

5. For *Input XS2D_Catelog Table* select “XS2D_Catelog”.

6. For *XS2DType Value* enter “Water Table”.

7. For *Feature Class Name Prefix* enter “WaterTable”.

8. Select **OK** to exit the *Create XS2D Line Feature Class* dialog and run the tool.

Two new feature classes WaterTable_1 and WaterTable_2 should be created and added to the map. Now create new line features representing the water table along the section line.

1. In the “ XS2D Editor” toolset, double-click on “ Transform Raster to XS2D Line” tool to open the *Transform Raster to XS2D Line* dialog.

2. For *Input Section Line Features* select “SectionLine”.

3. For *Input Raster* select “watertable”.

4. For *Input XS2D_Catalog Table* select “XS2D_Catelog”.

5. For *XS2DType value* select “Water Table”.

6. The *Discretization Spacing* should be automatically updated to “50”.

7. For *FType* enter “water table”.

8. The *Append to Erxisting XS2D_Line Features* option should be enabled to append the new feature to existing features.

9. Select **OK** to exit the *Transform Raster to XS2D Line* dialog and run the tool.

10. To view the water table lines on the cross sections, drag the WaterTable_1 and WaterTable_2 layers into the appropriate data frames (A-A’ and B-B’).

11. If desired, adjust the symbol properties of the water table layers in the A-A’ and B-B’ cross section data frames.

At the end of this process a line representing the water table should be added to the cross sections, similar to the blue lines shown in Figure 23.

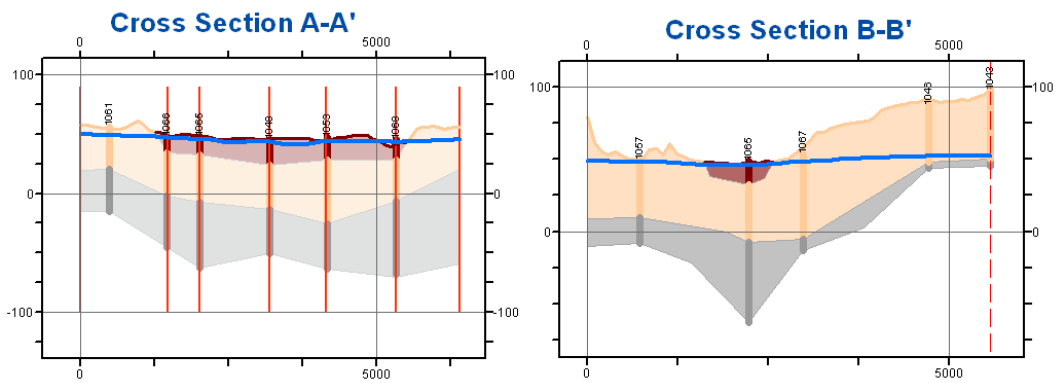


Figure 23 Water table lines added to the cross sections.

10 Transforming 2D Cross Section to 3D GeoSections

Once the2D cross sections are created, it is possible to transform them to 3D features (GeoSections) and visualize them in ArcScene. This part of the tutorial requires 3D Analyst.

First, create the GeoSection feature class:

1. In the *Table of Contents*, right-click on "Layers" and select **Activate**.
2. In the "Features" toolset, double-click on "Create GeoSection Feature Class" tool to open the *Create GeoSection Feature Class* dialog.
3. In the *Output GeoSection Features* field, click the Browse button to open the *Output GeoSection Features* dialog.
4. Browse to the *woburn.mdb\Data* directory and enter "GeoSection" as the feature class name.
5. Click **Save** to close the *Output GeoSection Features* dialog.
6. Select **OK** to exit the *Create GeoSection Feature Class* dialog and run the tool.

Next, create the GeoSection features by transforming 2D cross section panel polygons to 3D GeoSections:

1. In the "XS2D Editor" toolset, double-click on "Transform XS2D Panel to GeoSection" tool to open the *Transform XS2D Panel to GeoSection* dialog.
2. For *Input Section Line Features* select "SectionLine".
3. For *Input XS2D_Catalog Table* select "XS2D_Catelog".
4. For *Input GeoSection Features* select "GeoSection".

5. Select **OK** to exit the *Transform XS2D Panel to GeoSection* dialog and run the tool.

Use ArcScene to visualize the 3D GeoSections just created.

6. If necessary, launch *ArcScene*.

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

8. Browse to the *Tutorials\subsurface analyst\XS2D basic* folder.

9. Select "woburn.sxd" and click **Open** to exit the *Open* dialog and import the model file.

A 3D scene that includes the DEM and water table rasters rendered as 3D surfaces should appear.

10. Select **Add Data** to open the *Add Data* dialog.

11. Browse to and open the "Woburn.mdb" geodatabase and open the "Data" directory.

12. Select the "GeoSection" file and click **Add** to import the table and close the *Add Data* dialog.

13. If desired, symbolize the GeoSection layer using the HGU Color Manager.

The scene should be similar to the one shown in Figure 24.

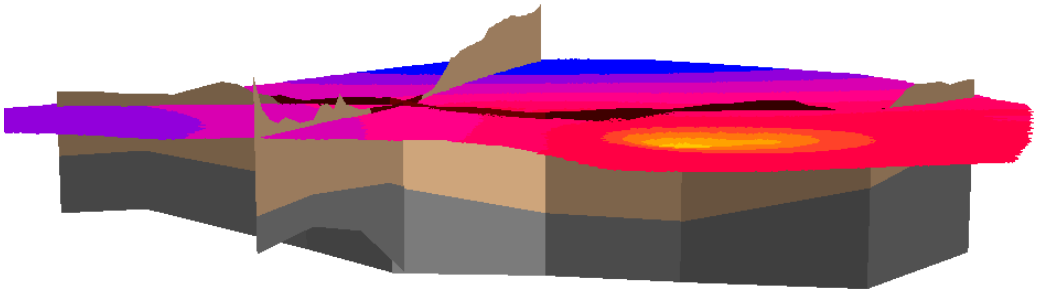


Figure 24 Scene including the GeoSection features transformed from the 2D cross section.

11 Conclusion

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

- The Arc Hydro Groundwater data model includes XS2D feature classes that provide the framework for working with 2D cross sections in ArcMap.
- Sketch cross section lines and use the XS2D Wizard to set up a new data frame and create the basic XS2D feature classes.
- Data from geologic maps in combination with digital elevation models can be transformed to the XS2D data frame, and are used as guides for "sketching" cross sections.
- ArcGIS editing tools are used to help digitize cross sections based on guiding features (e.g. borelines, outcrop lines).
- Additional data can be transformed to the XS2D data frame and added to the cross section.
- 2D cross sections can be transformed to 3D features and visualized in ArcScene.