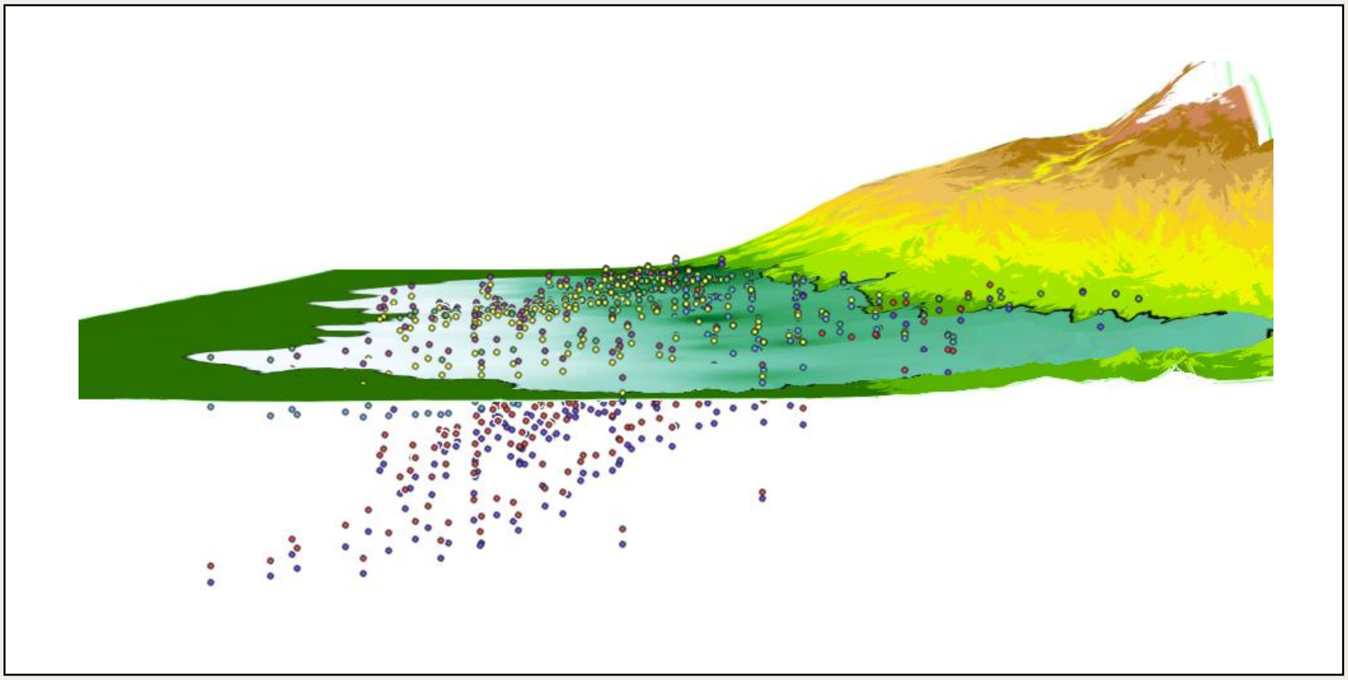
AHGW Pro 1.0 Tutorial

Subsurface Analyst – Creating GeoRasters from Borehole Data

Generating and indexing GeoRasters



Objectives

Learn how to use the Arc Hydro Groundwater Pro tools to create raster surfaces from borehole data and load and index those surfaces in the GeoRasters mosaic dataset.

Prerequisite Tutorials

- None

Required Components

- ArcGIS Pro
- 3D Analyst
- Subsurface Analyst

Time

- 20–40 minutes

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1 Introduction

Arc Hydro Groundwater Pro (AHGW Pro) is a geodatabase design for representing groundwater datasets within ArcGIS Pro. The data model helps to archive, display, and analyze multidimensional groundwater data. It includes several components to represent different types of datasets, such as 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 Pro geodatabase. *Subsurface Analyst* is a subset of the AHGW Pro 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 raster surfaces from borehole data. It will also show how to load and index the surfaces in the GeoRasters mosaic dataset.

1.1 Background

Data used in this tutorial are part of a project for developing a groundwater simulation model: The Sacramento Regional Model, which encompasses an area of approximately 1,360 square miles (871,000 acres) near the city of Roseville in the Sacramento valley, California. The model is bounded by the Bear River and Feather River to the north, the Mokelumne River to the south, the Sacramento River to the west and by bedrock of the Sierra Nevada to the east (Figure 1).

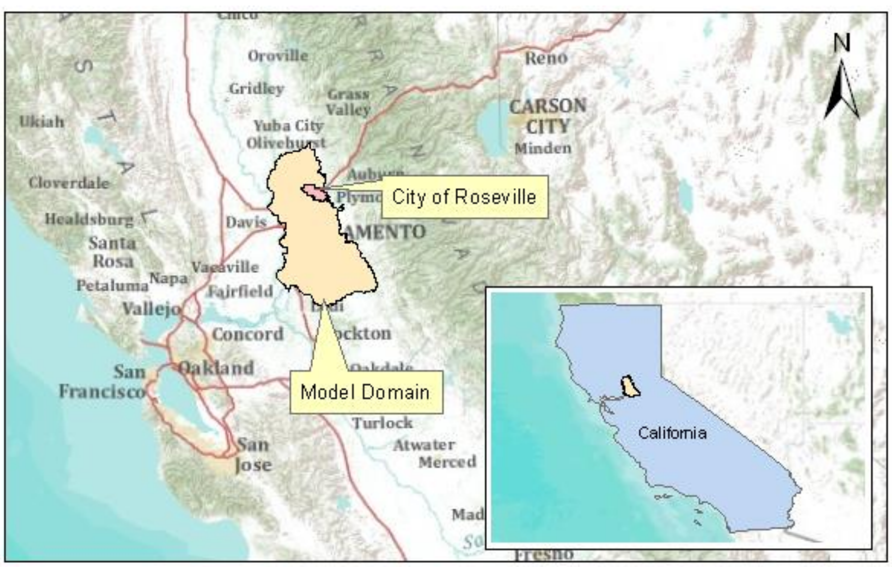


Figure 1 Location of the Roseville Model.

As part of the model development, a set of hydrogeologic units were defined. A simplified set of units was extracted from the original list and is used in this tutorial. Figure 2 shows the sequence of formations used in this tutorial. Each of the units is indexed by a hydrogeologic unit identifier (HGUID). The unit properties are defined in the HydrogeologicUnit table. In addition, each of the units is indexed with a horizon ID.

The term “horizon” refers to the top of each stratigraphic unit that will be represented in the subsurface model. Horizons are numbered consecutively in the order that the strata are “deposited” (from the bottom up). Each contact that you wish to represent in the subsurface model must have a HorizonID. Horizons can be represented as rasters, one for each horizon ID. The rasters will typically be created by interpolating the borehole contact data for each horizon. When organized in a mosaic dataset, the rasters can be used to create 3D GeoSection and GeoVolume features based on an attribute field containing the horizon ID, but this tutorial focuses on creating the GeoRasters.

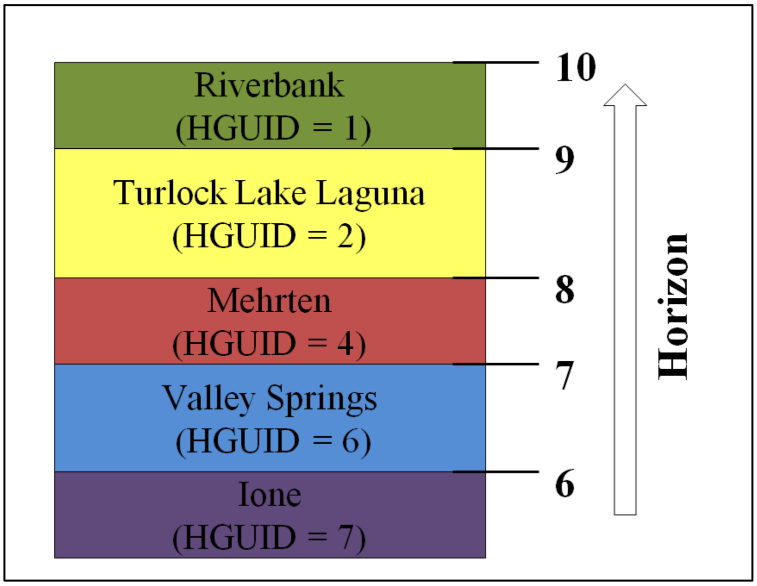


Figure 2 Hydrogeologic units indexed with a HGUID and a HorizonID.

1.2 Outline

The objective of this tutorial is to introduce the basic workflow and tools for creating raster surfaces from borehole data, and loading and indexing the rasters in the GeoRasters mosaic dataset. The tutorial includes the following steps:

1. Create BorePoints representing hydrogeologic units as contacts along boreholes.
2. Interpolate BorePoints to raster surfaces.
3. Load rasters into the GeoRasters mosaic dataset and index the rasters with appropriate attributes.
4. Visualize the resulting points in ArcGIS Pro.

1.3 Required Modules/Interfaces

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

- ArcGIS Pro license
- 3D Analyst

- Arc Hydro Groundwater Pro Tools
- AHGW Pro Tutorial Files

The AHGW Pro Tools require that you have a compatible ArcGIS Pro service pack installed. Check the AHGW Pro Tools documentation to find the appropriate service pack for your version of the tools. The tutorial files should be downloaded and saved on a local drive.

2 Getting Started

To start, open the project file for this tutorial.

1. If necessary, launch *ArcGIS Pro*.
2. If on the *ArcGIS Pro* start page, select **Open another project** in the bottom right corner of the window to open the *Open Project* dialog.
3. If already in the user interface, use the **Open** macro to open the *Open Project* dialog.
4. Browse to the location with tutorial files for this tutorial.
5. Select the file “creating georasters.aprx” located in the *SubsurfaceAnalystPro\creating georasters* folder.
6. Click **OK** to import the project.

A *Map* view and a *Scene* view containing the model boundary, a DEM, and well features located within the model domain (Figure 3) should appear.

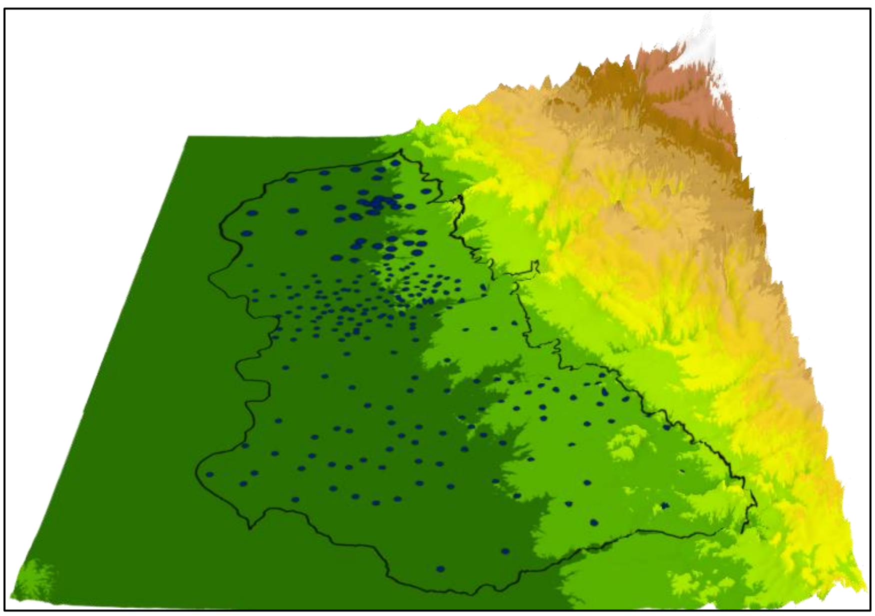


Figure 3 Initial scene containing the model boundary, a DEM, and well features

This entire tutorial is carried out in *Scene* view.

7. Click on the *Scene* tab to switch to the *Scene* view. Remain in this view for the entire tutorial.

Next, ensure that the AHGW Pro tools are correctly configured.

8. Expand the *Toolboxes* list in the *Catalog* pane. Check if "ArcHydroGroundwater.pyt" is there. If it is not there, follow steps 8-10.
9. In the *Catalog* pane, right-click on *Toolboxes* and use the **Add Toolbox** command.
10. In the *Add Toolbox* dialog, browse to the location where the Arc Hydro Groundwater Toolbox files were saved.
11. Select "ArcHydroGroundwater.pyt" and click **OK**.

"ArcHydroGroundwater.pyt" now appears in the *Toolboxes* list. When using geoprocessing tools, it's possible to set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

12. On the ribbon, select the *Project* tab.
13. From the list on the left, select **Options** to open the *Options* dialog.
14. Select *Geoprocessing* from the list under *Application* on the left of the dialog.
15. Ensure that *Allow geoprocessing tools to overwrite existing datasets* and *Add output datasets to an open map* are turned on.

The options should appear similar to Figure 4.

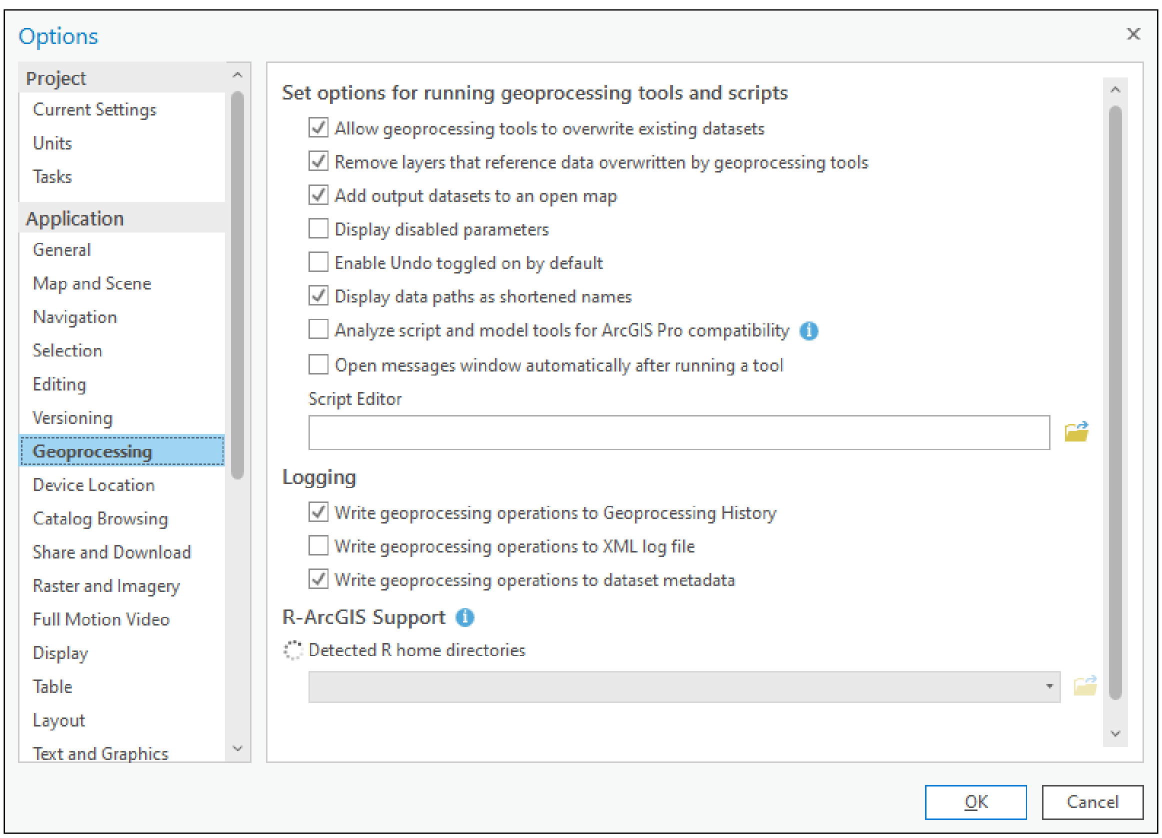
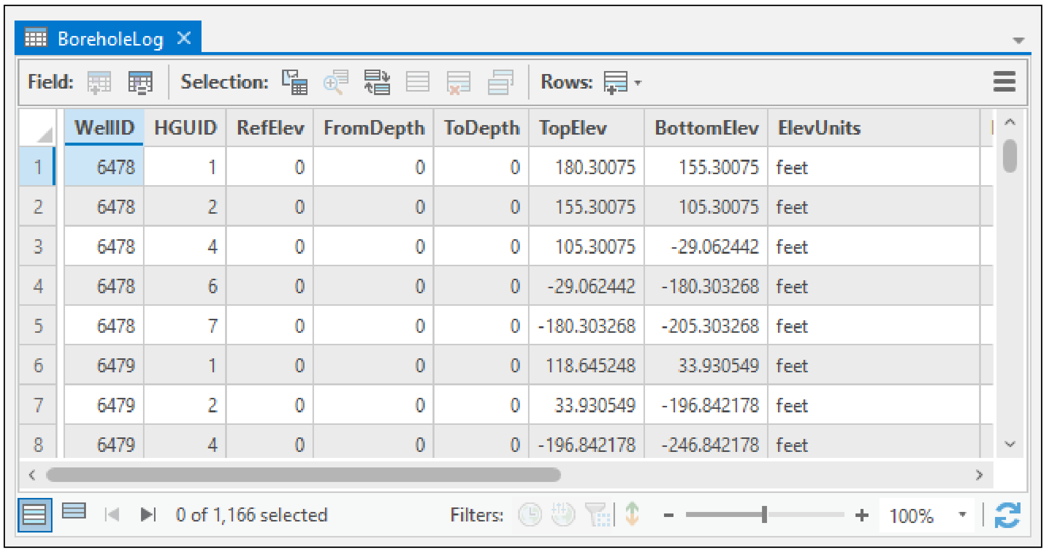


Figure 4 Setting Geoprocessing tools to overwrite outputs by default and to add results of geoprocessing tools to the display

16. Select **OK** to exit the *Options* dialog.
17. Using the arrow in the upper left corner, return to the main user interface.

3 Creating BorePoints from Borehole Data

Borehole information is stored in the BoreholeLog table. Each row in the table represents a hydrogeologic unit observed along the borehole. Data in the BoreholeLog table are referenced to well features. The *WellID* attribute in the BoreholeLog table relates to the *HydroID* of a well feature. Figure 5 shows an example of a BoreholeLog table. Records in the table are indexed with a WellID to relate the vertical information with specific Wells. In addition, top and bottom elevations are defined for the different hydrogeologic units, and each unit is indexed with a hydrogeologic unit identifier (HGUID). Each of the units is also indexed with a HorizonID which defines the ordering of the units from bottom up and is used for indexing rasters.



	WellID	HGUID	RefElev	FromDepth	ToDepth	TopElev	BottomElev	ElevUnits
1	6478	1	0	0	0	180.30075	155.30075	feet
2	6478	2	0	0	0	155.30075	105.30075	feet
3	6478	4	0	0	0	105.30075	-29.062442	feet
4	6478	6	0	0	0	-29.062442	-180.303268	feet
5	6478	7	0	0	0	-180.303268	-205.303268	feet
6	6479	1	0	0	0	118.645248	33.930549	feet
7	6479	2	0	0	0	33.930549	-196.842178	feet
8	6479	4	0	0	0	-196.842178	-246.842178	feet

Figure 5 BoreholeLog table containing information on hydrogeologic units along boreholes. The WellID attribute relates vertical logs to a Well feature.

In order to create a raster that defines a surface across the model domain, first create a set of points from which the raster will be interpolated. This is achieved by joining the Well features with the BoreholeLog table and creating a new set of points with the hydrogeologic information. Use the **BoreholeLog Table To Points** tool to automate this process:

1. In the Catalog pane, expand *ArcHydroGroundwater.pyt*.
2. Under *Subsurface Analyst* in the *Features* toolset, double-click the **BoreholeLog Table to Points** tool to open the *BoreholeLog Table to Points* tool in the *Geoprocessing* pane.
3. Select the “Well” feature class as the *Input Well Features*.
4. Select “HydroID” as the *Well Unique Feature Identifier Field*.
5. Select the “BoreholeLog” table as the *Input BoreholeLog Data Table*.
6. Select “WellID” as the *BoreholeLog Related Identifier Field*.
7. Click the **Browse** button next to *Output Feature Class* to open the *Output Feature Class* dialog.
8. In the data tree to the left, under the *Project* folder, navigate to *Project\Databases\Georasters.gdb\Data.*
9. Double-click on the folder called *Data*.

This is the location where BorePoints will be stored.

10. Next to *Name,* enter “BorePoint”.
11. Click **Save** to save the feature class name and exit the *Output Feature Class* dialog.
12. Click the arrow button next to *Copy Fields* to reveal a list of checkboxes.
13. Click the **Toggle All Checkboxes** button at the bottom of the list to mark all the checkboxes
14. Click **Add** to select them all as copy fields.
15. Turn on the *Create 3D Features* option.
16. Select the “TopElev” field as the *Elevation Field for 3D Features*.
17. Select **Run** to run the tool.

At the end of this process, there should be a new 3D point feature class that contains the BorePoints. Each point represents a horizon in the subsurface model. Next, interpolate a set of rasters based on the point features.

4 Interpolating Rasters from Points Features

To create the rasters, use any of the interpolation tools available in the 3D Analyst and Spatial Analyst extensions.

Before the interpolation, we will specify a query to define a HorizonID. This will ensure that only points representing a certain horizon in the model are included in the interpolation.

1. In the *Contents* pane, select “Well”.

It can be any item besides “BorePoint”.

2. Now select “BorePoint” again.

Use the *Filtering* section available in the AHGW ribbon to define a query for points with a horizon of 6.

3. On the ribbon, select the *Arc Hydro Groundwater* tab.
4. In the *Field* drop-down menu, select the “HorizonID”.
5. In the *Value* drop-down menu select a value of “6” to indicate this is the raster for horizon 6.

For this tutorial, use the IDW interpolation method to interpolate the points to create the rasters.

6. In the *Command Search* box to the left of the ribbon tabs, enter “IDW”.
7. Select **IDW (Spatial Analyst Tools)** from the options that appear to open the *IDW* tool in the *Geoprocessing* pane.
8. Specify the “BorePoint” point feature class as the *Input point features*.
9. Select the “TopElev” field as the *Z value field*.
10. Click the **Browse** button next to *Output raster* to open the *Output raster* dialog.

11. Under the *Project* folder in the data tree, browse to the *Folders\creating georasters\Rasters* folder and enter "idw_horizon06" as the *Name*.
12. Click **Save** to save the name and location of the output raster close the *Output raster* dialog.
13. Specify an *Output cell size* of "1000".

Before running the tool, also set the Environment settings so the raster interpolation covers the whole model domain:

14. Select the *Environments* tab in the *Geoprocessing* pane.
15. In the *Processing Extent* section, select the "Same as layer: ModelBoundary" option from the *Extent* drop-down menu.
16. In the *Raster Analysis* section, from the *Mask* drop-down menu, select the "ModelBoundary" layer.
17. Select **Run** to run the tool.

Now, use the same tool for horizons 7, 8, 9, and 10. To do this, follow these steps:

18. Leave the *Geoprocessing* pane open.

If the *Geoprocessing* pane was already closed, see the tip below. Then return to step 19.

19. Ensure "BorePoint" is selected in the *Contents* pane.
20. In the *Arc Hydro Groundwater* ribbon tab, for the *Field* drop-down menu, select "HorizonID"
21. For the *Value* drop-down menu, select the value of the horizon (7, 8, 9, or 10).
22. Change the number at the end of the *Output raster* name to reflect the current horizon (i.e. idw_horizon07, idw_horizon08, etc.).
23. Make sure that the *Value* drop-down menu value and the number in the *Output raster* field match.
24. Check all other settings in the *Paramaters* and *Environments* tab to make sure they match the settings detailed in steps 8-9 and 13-17.

The settings should have remained exactly the same besides the change for each horizon number.

25. Select **Run** to run the tool.

Tip: It's possible to access the results of a geoprocessing tool and edit the inputs. This can be done with the IDW tool. This might be useful if all the same inputs are needed from a former tool run, but the tool was already closed. This is done from *History* pane. On the ribbon, select the *Analysis* tab. Then, select **History** to open the *History* pane. Right-click on the tool run that is to be reproduced and select **Open**. Then, proceed to adjust the inputs as needed and run the tool again.

At the end of this process there should be five rasters, one for each horizon (6, 7, 8, 9, and 10). They are listed in the *Contents* pane by the name "idw_horizon06"--or 07, etc.).

5 Visualizing the Points

To visualize the BorePoint data in 3D in the *Scene* view, do the following:

1. Select "BorePoint" in the *Contents* pane.
2. On the ribbon, select the *Arc Hydro Groundwater* tab.

3. In the *Filtering* section in the *Field* drop-down menu, select “All”.
4. In the *Value* drop-down menu, select “All”.

This ensures that every BorePoint is included in the visualization as opposed to the BorePoints from just one horizon or with some other identifier.

5. Drag “BorePoint” in the *Contents* pane from *2D Layers* to 3*D Layers*.
6. Right-click on the BorePoint layer and choose the **Properties** command to open the *Layer Properties*: *BorePoint* dialog.
7. Go the *Elevation* property sheet by selecting *Elevation* from the list on the left.
8. In the *Features are* drop-down menu, select “Relative to the ground”.
9. Under *Additional feature elevation using*, select *Geometry z-values*.
10. Set the *Vertical Exaggeration* to “20.00”.

This matches the vertical exaggeration for this feature class to the vertical exaggeration for the whole project. This allows for visualization of BorePoints that clearly shows their position relative to the other vertical data in the project. Furthermore, it makes them more visible over all.

If desired, change the colors of the rasters and points using the *Symbology* tab to better visualize the different horizons.

At the end of this process, the 3D BorePoint features will be visible above and beneath the “surface”. To visualize:

11. In the *Contents* pane, select “Ground” to make the *Elevation Surface* ribbon appear.
12. Under the *Elevation Surface* ribbon, select the *Appearance* tab.
13. Select the **Swipe** tool from the *Effects* section.
14. In *Scene* view, click and drag to temporarily remove the ground layer to be able to visualize more of the BorePoints.

Alternatively, rotate the scene using the regular navigation tools until under the scene is visible. Now, it may be desirable to unselect the **Swipe** tool by selecting another tool. The **Explore** tool, for example:

15. On the ribbon, click on the *Map* tab.
16. Select the **Explore** tool (or any tool desired) to unselect the **Swipe** tool.

If the scene has been manipulated using the navigation tools, the final view should look similar to Figure 6.

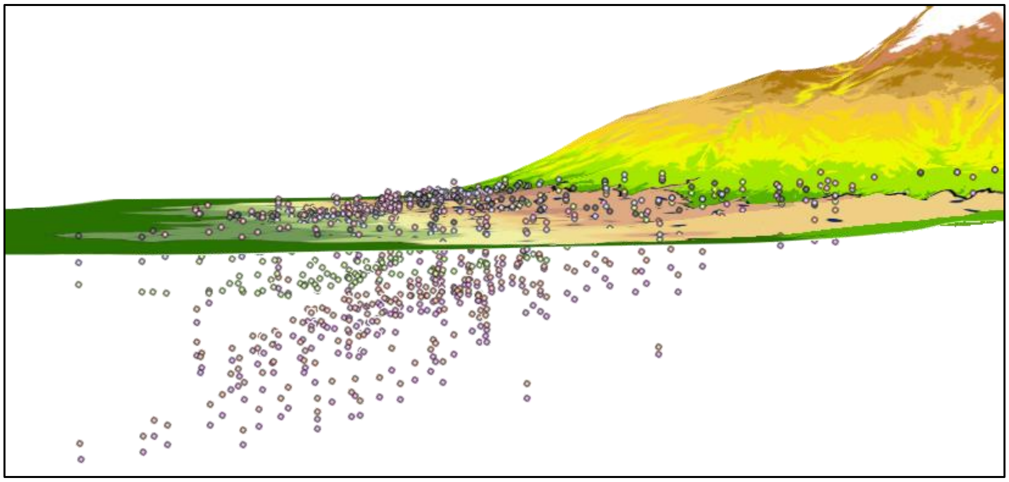


Figure 6 Points being visualized in the Scene view pane

Based on the GeoRasters mosaic dataset, 3D fence diagrams and volume models can be constructed. The creation of the 3D features is demonstrated in a separate tutorial.

6 Loading the Rasters into the GeoRasters Mosaic Dataset

Next, load the rasters into the GeoRasters mosaic dataset, and index them with the appropriate attributes.

1. In the *Command Search* box to the left of the ribbon tabs, enter “Add Rasters to Mosaic Dataset”.
2. Select **Add Rasters to Mosaic Dataset (Data Management Tools)** from the options that appear to open the *Add Rasters To Mosaic Dataset* tool in the *Geoprocessing* pane.
3. Set the options in the tool to be as follows:
    - *Mosaic Dataset* to “GeoRasters”.
    - *Raster Type* to “Raster Dataset”.
    - *Processing Templates* to “Default”.
4. Under *Input Data*, select the **Browse** button to open the *Input Data* dialog.
5. If necessary, change the file types drop-down menu to “All Types”.
6. In the data tree to the left, under *Project*, navigate to *Project\Folders\creating georasters\Rasters*.
7. In the *Rasters* folder, select the “idw_horizon06” raster.
8. Hold down the *Shift* button and select “idw_horizon10” to select all of the previously created rasters.
9. Click the **OK** button to close the *Input Data* dialog and add the selected rasters to the *Input Data* list.

Now to add one more raster:

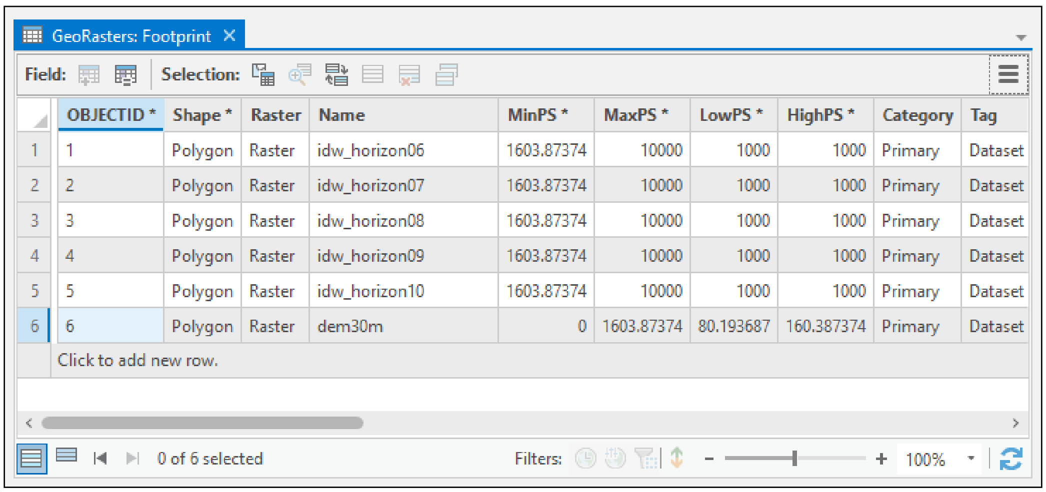
10. Under *Input Data*, select the **Browse** button to open the *Input Data* dialog.
11. If necessary, change the file types drop-down menu to “All Types”.

12. In the data tree to the left, under *Project*, navigate to *Project\Folders\creating georasters*.
13. In the *creating georasters* folder, select the “dem30m” raster.
14. Click the **OK** button to close the *Input Data* dialog and add the selected raster to the *Input Data* list.

Leave the rest of the data as is.

15. Select **Run** to run the *Add Rasters to Mosaic Dataset* tool.
16. Once the tool has finished, in the *Contents* pane, right-click on the “GeoRasters” item and select *Open Table* | **Attribute Table** to open the *GeoRasters: Footprint* table view.

Notice that the rasters were added to the mosaic dataset. The table view should be similar to the one shown in Figure 7. Keep the *GeoRasters: Footprint* table view open to complete the rest of the tutorial.



	OBJECTID *	Shape *	Raster	Name	MinPS *	MaxPS *	LowPS *	HighPS *	Category	Tag
1	1	Polygon	Raster	idw_horizon06	1603.87374	10000	1000	1000	Primary	Dataset
2	2	Polygon	Raster	idw_horizon07	1603.87374	10000	1000	1000	Primary	Dataset
3	3	Polygon	Raster	idw_horizon08	1603.87374	10000	1000	1000	Primary	Dataset
4	4	Polygon	Raster	idw_horizon09	1603.87374	10000	1000	1000	Primary	Dataset
5	5	Polygon	Raster	idw_horizon10	1603.87374	10000	1000	1000	Primary	Dataset
6	6	Polygon	Raster	dem30m	0	1603.87374	80.193687	160.387374	Primary	Dataset

Figure 7 Example of a populated GeoRasters mosaic dataset

Next, edit the attributes of the dataset to add the appropriate indexes. First, the *Name* column will be frozen, so the *Name* of the raster will always be visible.

17. In the *GeoRasters*: *Footprint* table view, right-click on the column labeled *Name*, and select the **Freeze/Unfreeze Field** command.

Now, fields will be edited to add the appropriate indexes. This will likely require scrolling to the right.

18. If necessary, on the *Edit* ribbon tab, click **Edit** to enable editing.

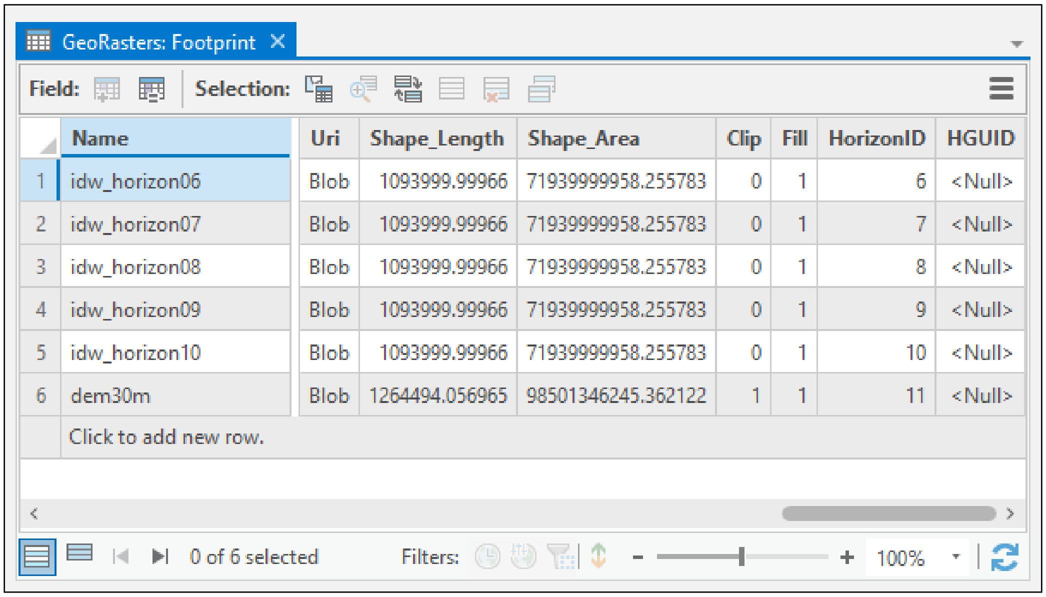
The necessity of step 18 depends on the settings for ArcGIS Pro on the machine being used for the tutorial.

19. In the table view, edit the *HorizonID* attribute such that each raster is indexed with the corresponding horizon ID (e.g., idw_horizon06 should have “6” in the *HorizonID* column, idw_horizon07 should have “7” in the *HorizonID* column, etc.)
20. Put “11” as the *HorizonID* in the row labeled “dem30m”.
21. Set the *Clip* attribute to “0” and the *Fill* attribute to “1”.
22. For “dem30m”, set the *Clip* attribute to 1.

23. On the *Edit* ribbon tab, click **Save** to save the changes to the GeoRasters mosaic dataset.

A value of 1 means that when creating 3D fence diagrams and volumes features extending above the DEM, they will be clipped at the DEM elevation (for more details see a separate tutorial – Building 3D Models with the Horizons Method).

At this point the catalog attributes should be similar to those shown in Figure 8.



	Name	Uri	Shape_Length	Shape_Area	Clip	Fill	HorizonID	HGUID
1	idw_horizon06	Blob	1093999.99966	71939999958.255783	0	1	6	<Null>
2	idw_horizon07	Blob	1093999.99966	71939999958.255783	0	1	7	<Null>
3	idw_horizon08	Blob	1093999.99966	71939999958.255783	0	1	8	<Null>
4	idw_horizon09	Blob	1093999.99966	71939999958.255783	0	1	9	<Null>
5	idw_horizon10	Blob	1093999.99966	71939999958.255783	0	1	10	<Null>
6	dem30m	Blob	1264494.056965	98501346245.362122	1	1	11	<Null>
	Click to add new row.							

Figure 8 GeoRaster mosaic dataset table view after editing the HorizonID, Clip, and Fill attributes

At the end of this process, a set of rasters has been interpolated from borehole data, and the rasters have been loaded and indexed in a GeoRasters mosaic dataset. The GeoRasters mosaic dataset can be used to create 3D GeoSection and GeoVolume features for representing the hydrogeologic units as fence diagrams and volume objects. This process is illustrated in a separate tutorial.

7 Conclusion

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

- 3D BorePoint features can be created from tabular bore log data associated with well features.
- The *BoreholeLog Table To Points* tool is used to create 3D point features from tabular bore log data – a set of points can be created for each horizon in the subsurface model.
- The *Filtering* section of the *Arc Hydro Groundwater* ribbon tab is used to query for specific sets of points based on a HorizonID.
- Rasters representing top/bottom of units can be interpolated from the BorePoints.
- The rasters are loaded into the GeoRasters mosaic dataset and indexed with the appropriate HorizonID, Clip, and Fill attributes.
- The points created can be visualized in *Scene* view in ArcGIS Pro.

