# Michigan Geological Survey

## *ArcGIS Pro Custom Tools Training*

MGS Mapping Projects

Cross-Section Only (Custom Datasets)

Basic Requirements:

ArcGIS Pro with required extension

- Spatial Analyst

Access to MGS Cross-Section Toolbox

****IMPORTANT NOTE: These tools were tested with ArcGIS Pro 3.3.0. Issues may be present in other versions. ****

Data Input Requirements:

The following is a list of datasets that are used for input into custom tools created by the Michigan Geological Survey for creating cross-section views. ****All files are required for the listed tool unless otherwise noted**:**

| File Input | File Type | Fields/Data Types | Tool | Description |
|---|---|---|---|---|
| **Cross-Section File Geodatabase** | File Geodatabase | NA | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Cross-Section Tool (Segment Profiles);<br>MGS – Cross-Section Tool (Grid Lines) | The file geodatabase to store all the cross-section view files. ***NOTE*: Cannot be the same as default geodatabase.** |
| **Cross-Section Line(s)**<br>- **XSEC Field**<br>- **DIRECTION Field** | Polyline Feature Class | XSEC: Text<br>DIRECTION: Text | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Cross-Section Tool (Segment Profiles);<br>MGS – Cross-Section Tool (Grid Lines) | The line feature that contains the cross-section lines. Needs to contain two fields: XSEC and DIRECTION (See Drawing Cross-Section Lines for more detail) |
| **Elevation Units** | Text List | NA | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Cross-Section Tool (Segment Profiles);<br>MGS – Cross-Section Tool (Grid Lines) | The elevation units of **every feature in the analysis.** This includes:<br>Surface topography<br>Bedrock Surface topography<br>Groundwater Surface topography<br>Borehole elevations & depths<br>Lithology Table & Screen Table depths. Can only be feet or meters. |
| **Surface Topography DEM** | Raster | Stored in File Geodatabase | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Cross-Section Tool (Grid Lines);<br>MGS – Data Formatting;<br>MGS – Project Creation Tool | The surficial topography DEM raster. |
| **Bedrock Surface Topography DEM** (OPTIONAL) | Raster | Stored in File Geodatabase | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Segment Profiles); | The bedrock surface topography DEM raster. Generated from bedrock contacts of wells (Previously generated data by user) |
| **Groundwater Surface Topography** | Raster | Stored in File Geodatabase | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Segment Profiles); | The groundwater surface topography DEM raster(s). Generated from static water level measurements from wells (Previously generated by user) |

| | | | | |
|---|---|---|---|---|
| **DEM(s)** (OPTIONAL) | | | | |
| **Lithology Table** | Table View | Relate ID: Text<br>Depth Top: Double<br>Depth Bottom: Double | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Data Reformatting;<br>MGS – Project Creation Tool | Table containing all the lithology units for a well. Can be either user-generated lithology or MGS formatted table. |
| **Borehole Location Points** | Points Feature Class | Relate ID: Text<br>Total Depth: Double<br>Depth to Bedrock: Double (*Optional*)<br>Construction Date: Date (*Optional*) | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes);<br>MGS – Cross-Section Tool (Segment Profiles);<br>MGS – Data Reformatting;<br>MGS – Project Creation Tool | Points feature class for well locations. Can be either user-generated points or MGS formatted points. |
| **Screens Table** (OPTIONAL) | Table View | Relate ID: Text<br>Depth Top: Double<br>Depth Bottom: Double | MGS – Cross-Section Tool (All Steps);<br>MGS – Cross-Section Tool (Boreholes) | Table containing screen intervals for wells. Can be either user-generated or MGS formatted table. |

Quick Note for Data and Layers:

It is important to consider data quality before data collection. For example, much of the Wellogic well log data that is available for use can be incomplete or incorrect. We don't want to use these data in our calculations because the accuracy of these datasets will be in question and may not yield the correct interpretation. It is also important to review datasets before using them. The same goes for DEM data and any other data that we download.

The processing time for all tools is directly tied to the size of the input datasets. Very large datasets (state-wide or larger) can take days to finish processing. For the quickest results clip your data down to only what you need.

**Note: These tools were designed specifically for MGS mapping projects. Each user's case will vary for their project needs.**

The data produced from the cross-section tools are as follows:

- A dataset for each cross-section line with a custom Cross-Section Projection assigned to it for each subsequent dataset. Each dataset includes the following:

| File Output | Description | File Type |
|---|---|---|
| **Surface Topography Profile** | Profile view of the surface topography DEM.<br>Named as XSEC_{Cross Section Name}_TOPO_{V.E.}x | Polyline Feature Class |
| **Borehole Sticks with Lithology Segmentation** | Profile view of the boreholes with segmented units based on position of lithology along borehole depths.<br>Named as XSEC_{Cross Section Name}_LITH_{V.E.}x | Either Polyline Feature Class or Polygon Feature Class (Depends on user choice) |
| **Screen Sticks** | Profile view of the screened intervals in the wells.<br>Named as XSEC_{Cross Section Name}_SCRNS_{V.E.}x | Either Polyline Feature Class or Polygon Feature Class (Depends on user choice) |

| | | |
|---|---|---|
| **Bedrock Surface Topography Profile (if provided)** | Profile view of the bedrock surface topography DEM.<br>Named as XSEC_{Cross Section Name}_BDRK_{V.E.}x | Polyline Feature Class |
| **Groundwater Surface Topography Profile(s) (if provided)** | Profile view of the groundwater surface topography DEM(s).<br>Named as XSEC_{Cross Section Name}_{Years analyzed}_{V.E.}x | Polyline Feature Class |
| **Cross-Section Grid** | The grid-lines profile view that is built around all viewable datasets.<br>Named as XSEC_{Cross Section Name}_{V.E.}x_Frame_{Elevation Units} | Polyline Feature Class |
| **Cross-Section Labels** | The labels for the grid-lines to display elevation increments and distance markers.<br>Named as XSEC_{Cross Section Name}_{V.E.}x_Labels_{Elevation Units} | Points Feature Class |

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# Cross-Section Only (Custom Datasets)

The following instructions are for creating cross-sections from custom datasets that were not output from either the project creation tool or the data formatting tool.

## *Step 1: Prepare the Workspace*

1. Begin by opening a new map in ArcGIS Pro.
2. Obtain the appropriate elevation data (1-meter-resolution DEMs are recommended for areas less than 10 $mi^2$ in size). Merge DEMs, if necessary, to make a single raster file.
3. Create a geodatabase specifically for storing the cross-section files. ****IMPORTANT NOTE: This must be separate from your default geodatabase or the tool may fail.****
4. Add the *MGS_XSEC_TOOLS_v2.atbx* toolbox to your project by right clicking on *Toolboxes* in the catalog, navigating to where you stored the downloaded tools, and selecting the toolbox.

## *Step 2: Prepare Inputs*

****IMPORTANT NOTE: All files used for tool inputs (other than rasters) must be in geodatabases****

1. Borehole Data
   ****IMPORTANT NOTE: Locations, lithology, and screens must all be separate files or the tool will fail. If the information for one or more of these inputs is in a single file, copy it to use as additional input****
   a. Borehole Locations
      i. This must be a point feature layer in a geodatabase.
      ii. Fields
         1. Relate Field (ID shared between all the tables with well information)
         2. Depth Drilled (Data Type-Double)
         3. Depth to Bedrock (Data Type-Double) *(Optional)*
         4. Completion Date (Data Type-Date) *(Optional)*
   b. Lithology Table
      i. Fields
         1. Relate Field
         2. Depth: Top (Data Type-Double)
         3. Depth: Bottom (Data Type-Double)
   c. Screens Table *(Optional)*
      i. Fields
         1. Relate Field
         2. Depth: Top (Data Type-Double)
         3. Depth: Bottom (Data Type-Double)
2. Surface Rasters *(Optional)*
   a. Bedrock Surface
   b. Groundwater Surface(s)

## *Step 3: Drawing Cross-Section Lines*

1. Before using the cross-section tool, you must create cross-section lines on your map. Start by creating a new Polyline feature class in your default geodatabase.

2. Create two text string fields within the feature class called “XSEC” and “DIRECTION” (case sensitive).
3. Use the “XSEC” to name the cross-section(s).
4. In the “DIRECTION” field, you must specify the quadrant you would like the cross-section to start analyzing (or drawing) from. You must use one of the following codes below in order to define the drawing direction:
    a. If the direction is labeled as W-E, NW-SE, or E-W, the script will be reading the cross-section from the **Northwest quadrant.**
    b. If the direction is labeled SW-NE, S-N, or N-S, the script will be reading the cross-section from the **Southwest quadrant.**
    c. If the direction is labeled as NE-SW, the script will be reading the cross-section from the **Northeast quadrant.**
    d. If the direction is labeled as SE-NW, the script will be reading the cross-section from the **Southeast quadrant.**
5. Draw all necessary cross-section lines and fill out the required information in the attribute table.
6. ***DISCLAIMER*** The number of wells will determine the length of time needed to process the cross-section lines. The length of the line will also increase the processing time.

## *Step 4: Cross-Section Tool (All Steps)*

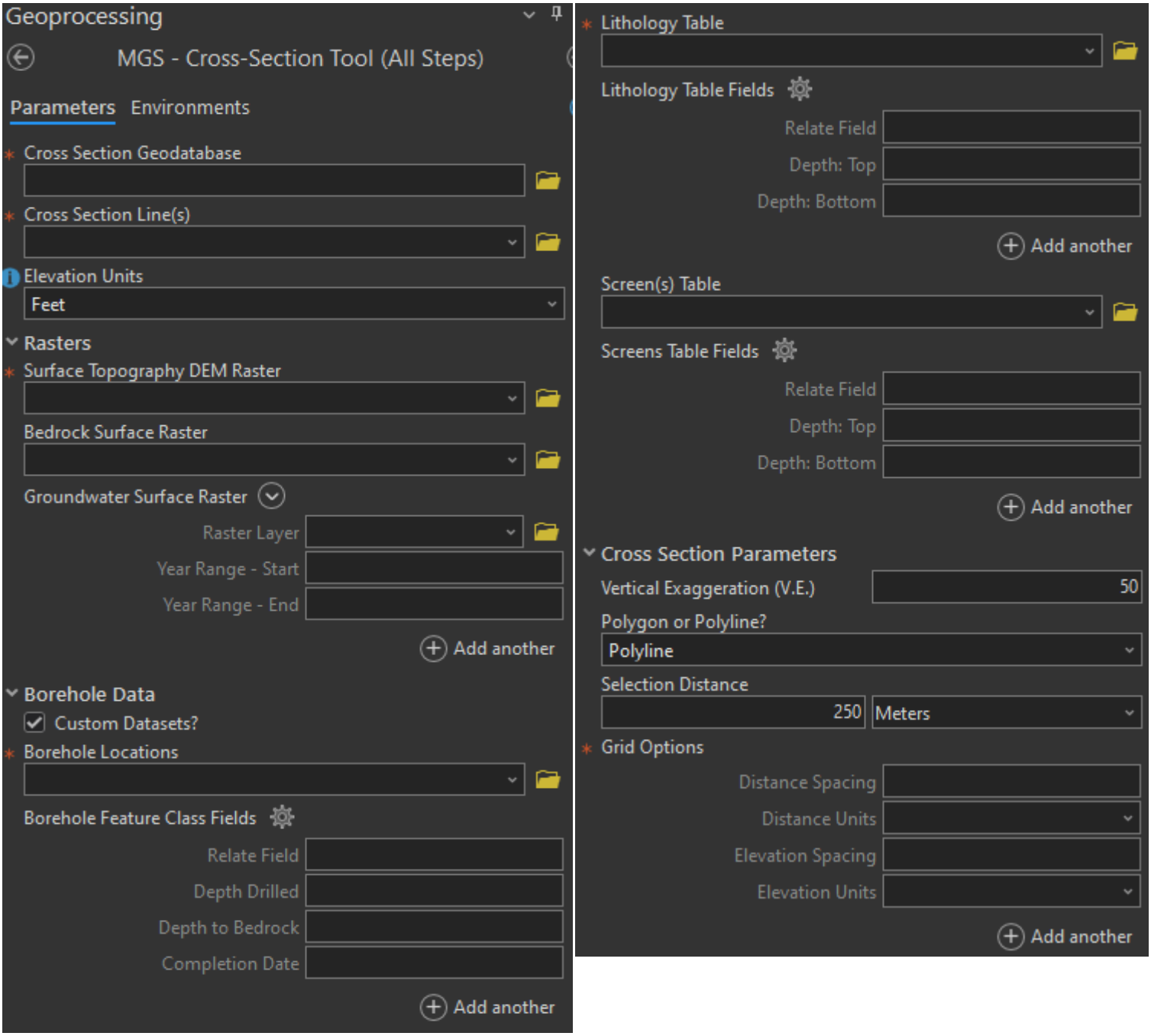


***Figure 1:*** *Screenshot of MGS – Cross-Section Tool (All Steps) custom Python script in the ArcGIS Pro software.*

1. Open the "MGS – Cross-Section Tool (All Steps) under the Cross Section Tools Toolset
    a. Several of the steps have been separated out of the "All Steps" script to be repeated upon changes made to other datasets. These include "Borehole Only", "Segment Profiles Only", and "Grid Line Creation Only". These can be useful for making adjustments to be specific pieces of your cross-sections without having to run the All-Steps tool. Remember, default names will

be overwritten when running these tools. If you wish to keep any of your initial outputs then you must rename them.

2. Select the newly created cross-section geodatabase.
3. Select the cross-section feature class.
4. Select the elevation units for **all your features.** The default is set to feet units.
5. Select the surface DEM used for the project.
6. Select the bedrock surface raster and the groundwater surface raster(s) **(Optional)**
    a. Note for Cross-Sections: These surfaces are generated in sections of confidence (solid line) and inferred (dashed lines). Anomalies in the groundwater levels often come from areas where there are no wells drilled within the selected time interval to support the predicted groundwater level.
    b. For groundwater levels, input the years you would like included in the analysis for the confidence of the surface. These years should match the years of the wells that were selected to create the groundwater raster. If left blank this will include all years.
7. Select the "Custom Datasets" check box.
8. Borehole Data

    ****IMPORTANT NOTE: Borehole Locations, Lithology**

    a. Provide the Borehole Locations for your map area.
        i. Fields
            1. Relate Field (ID shared between all the tables with well information)
            2. Depth Drilled (Data Type-Double)
            3. Depth to Bedrock (Data Type-Double) **(Optional)**
            4. Completion Date (Data Type-Date) **(Optional)**
    b. Select the lithology table.
        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
    c. Select the screen table created by the data formatting tool **(Optional)**
        i. Fields
            1. Relate Field
            2. Depth: Top (Data Type-Double)
            3. Depth: Bottom (Data Type-Double)
9. Cross Section Parameters
    a. Choose your vertical exaggeration (V.E.).
        i. 50 – 100x Recommended. Default is 50.
    b. Choose whether you would like the borehole lithologies to be represented by polylines or polygons.
        i. Note: Polylines are easier to read on dense cross-sections.
    c. Choose how far away wells should be selected to be included in the cross-section.
        i. 120 Meters is the default.
    d. Choose your grid spacing for the cross-section frame.
        i. Recommendation if Elevation Units are in Feet = Distance: 2000 feet and Elevation: 50 feet.
    e. Run the tool.

f. Once the tool is complete a new map will be compiled with all of the layer outputs named XSEC_"Cross-Section Name". An example of this is in **Figure 5.**
g. Complete your layout. All symbologies are fully user customizable. See completed cross-section in **Figure 6.**

## Additional Notes

The *Templates* folder incudes several formatting and symbology files for symbolizing several of the toolboxes outputs which include:

*GWL Colors*

- Function: Folder containing several symbologies for different well types and time periods of groundwater levels

*Cross_Section_CoordinateSystem.prj*

- Function: Custom coordinate system for the cross-sections. This is hard-coded into the scripts and not required to run them but it may be necessary to add additional layers to the cross-section that were not created using the MGS toolbox

*LithologyClasses_YYYYMMDD.xlsx*

- Function: MGS's system for simplyfying Wellogic data into aggregated lithology classes. This file is required for running both the Project Creation tool and the Data Reformatting tool

*LithSticks_UPDATE_YYYYMMDD.lyrx*

- Symbology for borehole lithologies (Polylines)

LithSticks_Polygons_YYYYMMDD.lyrx

- Function: Symbology for borehole lithologies (Polygons)

*NAD_1983_Hotine_Oblique_Mercator_Azimuth_Natural_Origin.prj*

- Function: Custom coordinate system for the project creation tool. This is hard-coded into the scripts and not required to run them but it may be necessary to add additional layers to the project that were not created using the MGS toolbox

ScreensPolygon_YYYYMMDD.lyrx

- Function: Symbology for screen lines (Polygons)

*ScreensSticks_UPDATED_*YYYYMMDD*.lyrx*

- Function: Symbology for screen lines (Polylines)

***Figure 2**: Example of initial output Cross-Section Tool (All Steps) (Credit: Garrett Ringle)*

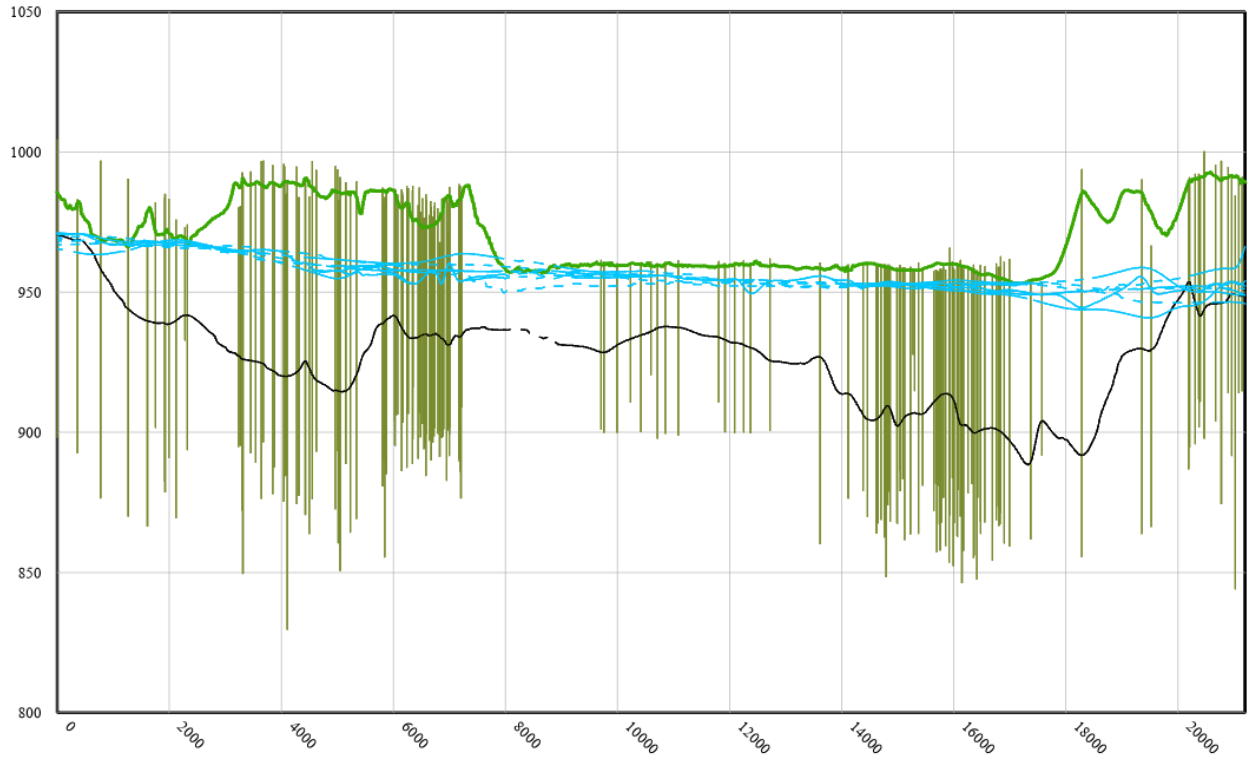

*Figure 3: Example final cross-section layout view (Credit: Garrett Ringle)*