Geoscience Australia's Semi-automated Morphological Mapping Tools for Seabed Characterisation (GA-SaMMT v1.2)

Tutorials and User Guide

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Contents

1. Background

Seabed characterisation requires the measurement, description and classification of physical features on the seabed. A key first step in this process is the identification of morphological forms, as derived from bathymetric data. To facilitate rapid and consistent morphological mapping, Geoscience Australia has developed several semi-automated ArcGIS toolboxes that:

- generate polygons from bathymetry surfaces that represent ‘bathymetric high’ and ‘bathymetric low’ seabed features;
- calculate metrics/attributes to describe the characteristics of the polygons; and
- classify individual polygons into one of the bathymetric high or low seabed morphology features.

The toolboxes adopt the suite of terms as presented in the glossary of seabed morphology features defined by Dove et al. (2020).

Dove, D., Nanson, R., Bjarnadóttir, L., Guinan, J., Gafeira, J., Post, A., Dolan, M.; Stewart, H.; Arosio, R, Scott, G. (October, 2020). A two-part seabed geomorphology classification scheme (v.2); Part 1: morphology features glossary. Zenodo. http://doi.org/10.5281/zenodo.4075248

This document provides a user guide and step-by-step tutorial for the use of the tool kit, including worked examples. Note that these tutorials assume that the user is experienced with ArcGIS Desktop and ArcGIS Pro. Otherwise, the user should consult manuals and user-guides of these ArcGIS software for further guidance.

2. System and Data Requirements

These semi-automatic morphological mapping tools are developed as ArcGIS Python tools using Python 3+. As a result, the tools can only be used in ArcGIS Pro. In addition, please note that the tools only accept raster and vector data stored in File Geodatabase. Therefore if the input bathymetry grid is not already in a File Geodatabase, the users need to create a File Geodatabase and import the bathymetry grid into the File Geodatabase. The subsequent output vector and raster data should also be stored in a File Geodatabase. Also note that all the input raster and vector data must have projected coordinate system.

The semi-automatic morphological tools and sample data are in GA-SaMMT_v1p2 folder. The Tools sub-folder contains six Python toolboxes:

- BathymetricHigh.pyt: Mapping Bathymetric High features

- BathymetricLow.pyt: Mapping Bathymetric Low features
- AddAttributes.pyt: Generate attributes for Bathymetric High (Low) features
- ClassificationFeature.pyt: Classify Bathymetric High (Low) features
- Accessory_Tools.pyt: Accessory Tools
- Surface.pyt: Mapping three-class morphological surface

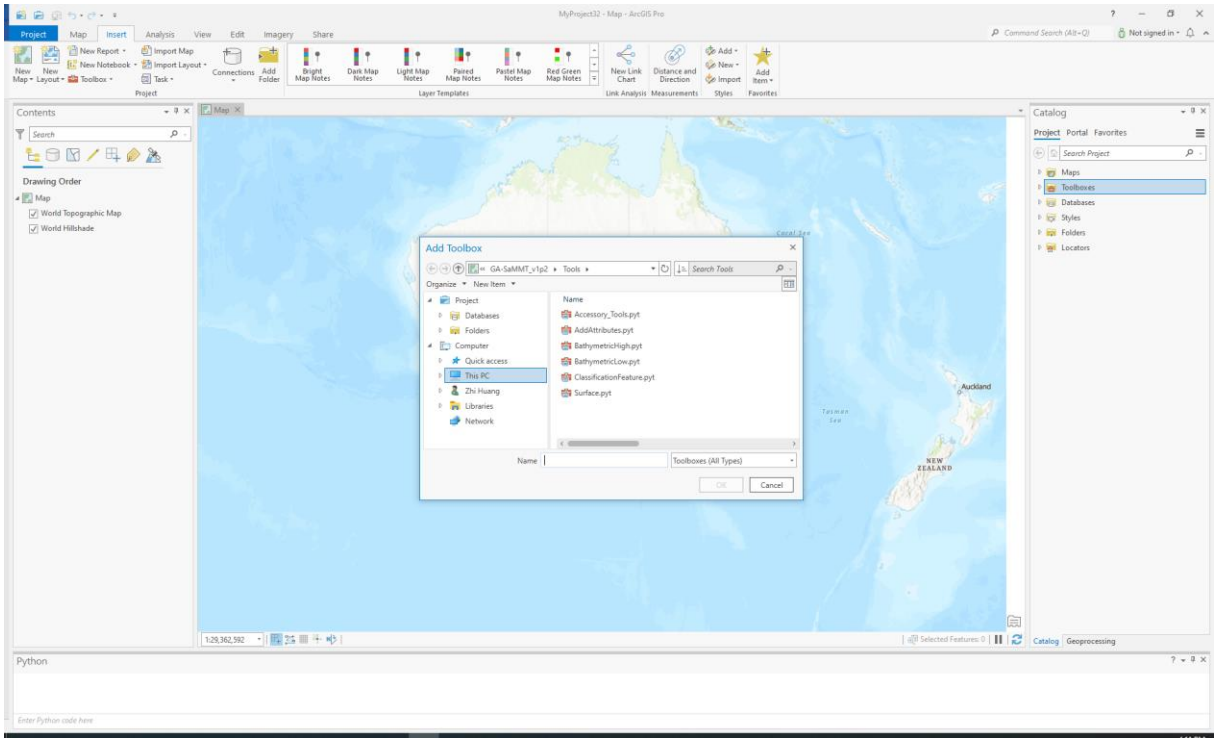
The sample data are contained in four File Geodatabase:

- Gifford.gdb
- Gifford1.dgb
- Oceanic_Shoals.gdb
- Points_Cloates.gdb

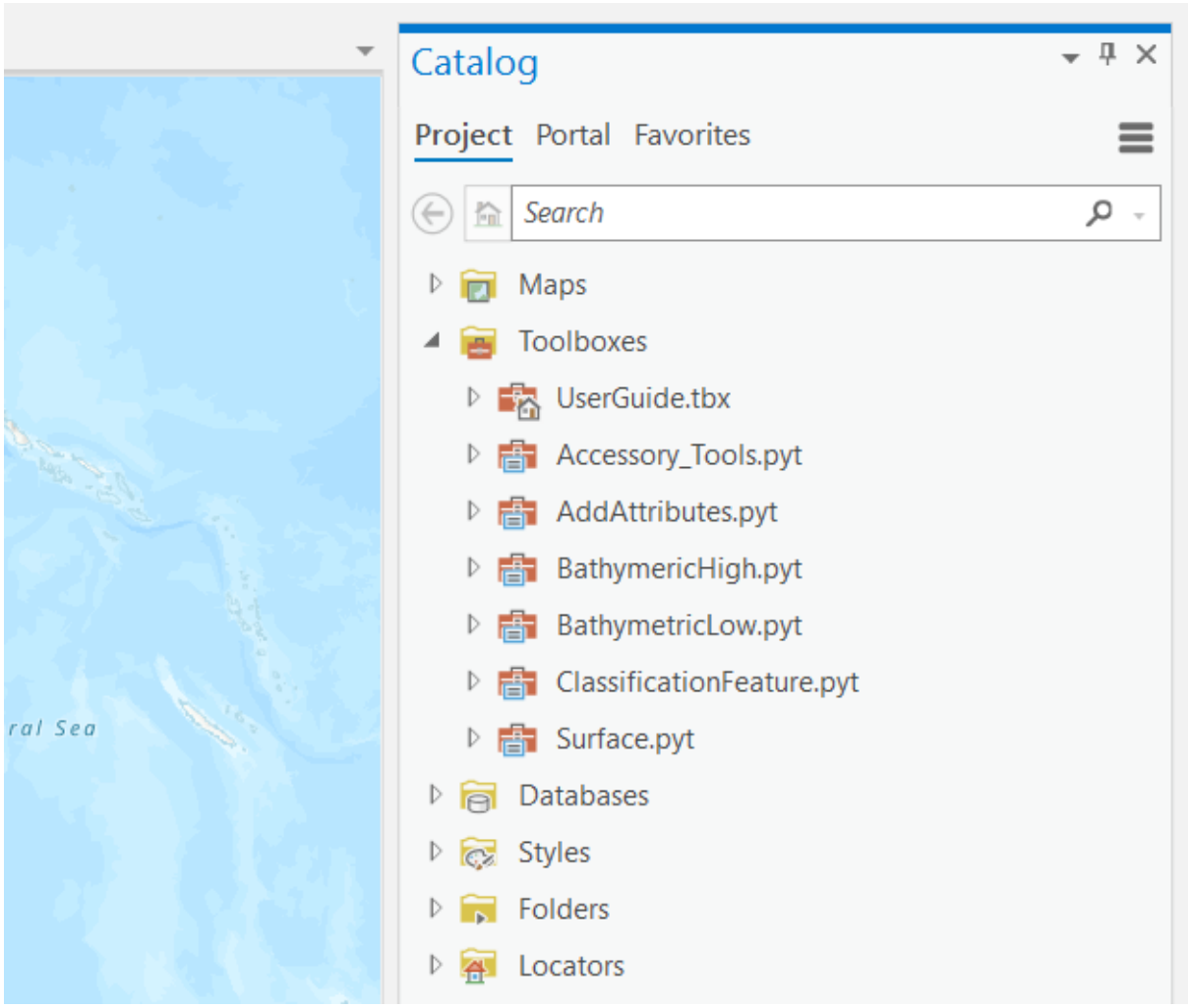
These semi-automatic morphological mapping tools are tested in ArcGIS Pro 2.6.4 and ArcGIS Pro 2.9.2. Earlier versions of ArcGIS Pro are likely to generate errors. Please use ArcGIS Pro 2.6.4 and higher versions for these tutorials. The tools also require Advanced ArcGIS Pro license and Spatial Analyst extension.

3. Add Tools and Data

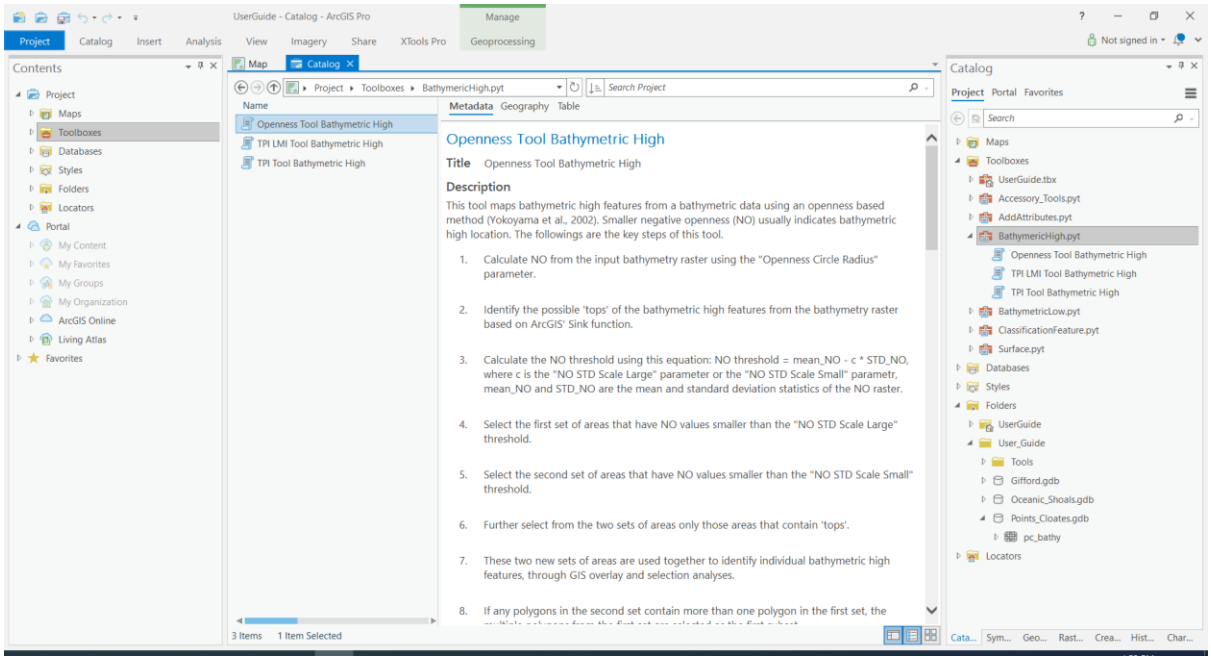
1. Open an existing or create a new project in ArcGIS Pro
2. Under the Catalog Pane, Right-Click Toolboxes, Click Add Toolbox



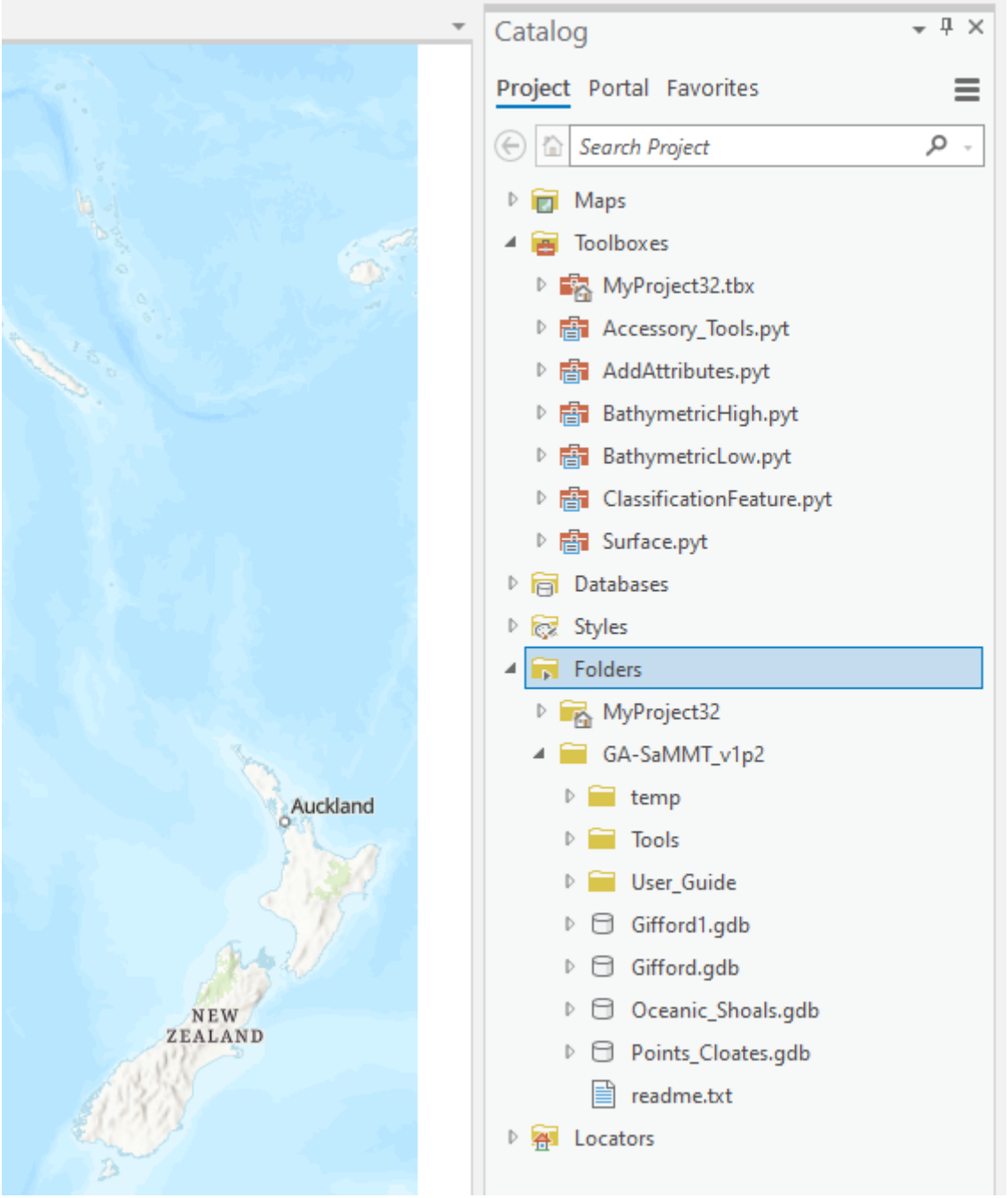
3. Navigate to …\GA-SaMMT_v1p2\Tools folder, Add all six Python toolboxes



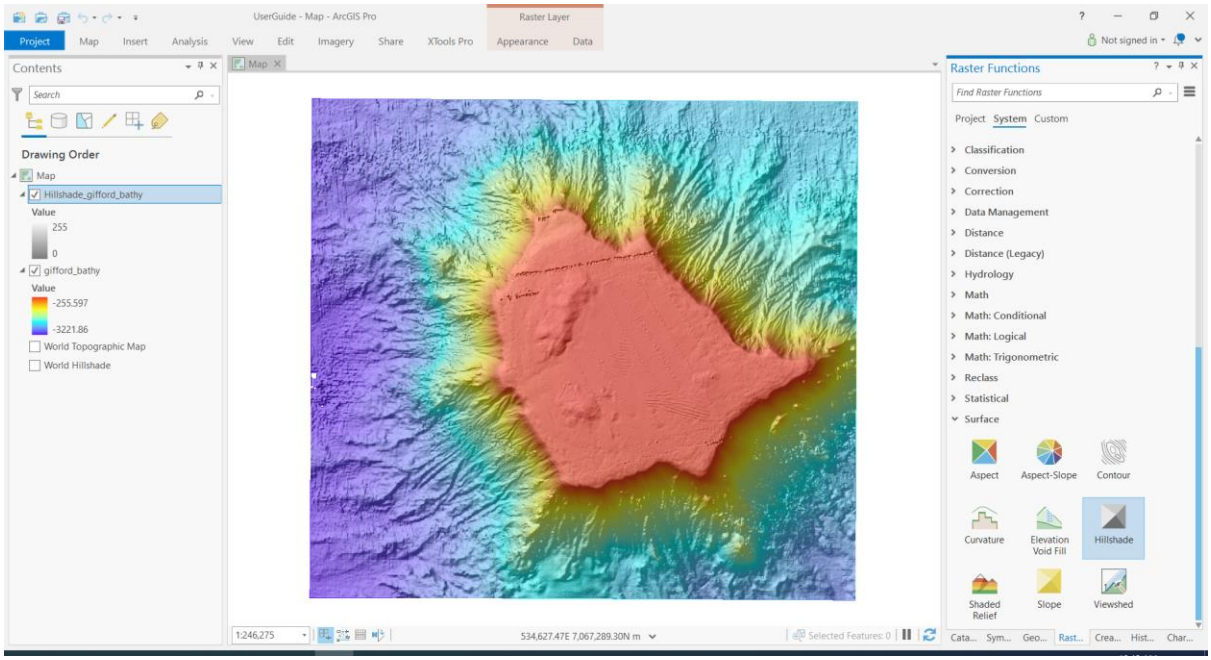
4. Right-Click the individual tools, Click View Metadata menu to examine the metadata of these tools. Note that these metadata provide detailed descriptions, graphic illustrations, usages and python code examples of these tools.



5. Go to Catalog Pane, Right-Click Folders, Click Add Folder Connection, Navigate and Add GA-SaMMT_v1p2 folder, the four File Geodatabases appear under the folder.



6. Open Gifford.gdb and add the bathymetry grid named gifford_bathy to the map, change the displaying symbology if necessary, generate a hill-shade layer using Raster Functions -> Surface -> HillShade (you can change the Z-factor for vertical exaggeration) , change the hill-shade layer to 50% transparency, explore the bathymetry data.



7. Explore the other two bathymetry grids under Oceanic_Shoals.gdb and Point_Cloates.gdb, respectively. Note that you may need to create new maps for exploring these bathymetry grids.

4. Use Bathymetric High tools

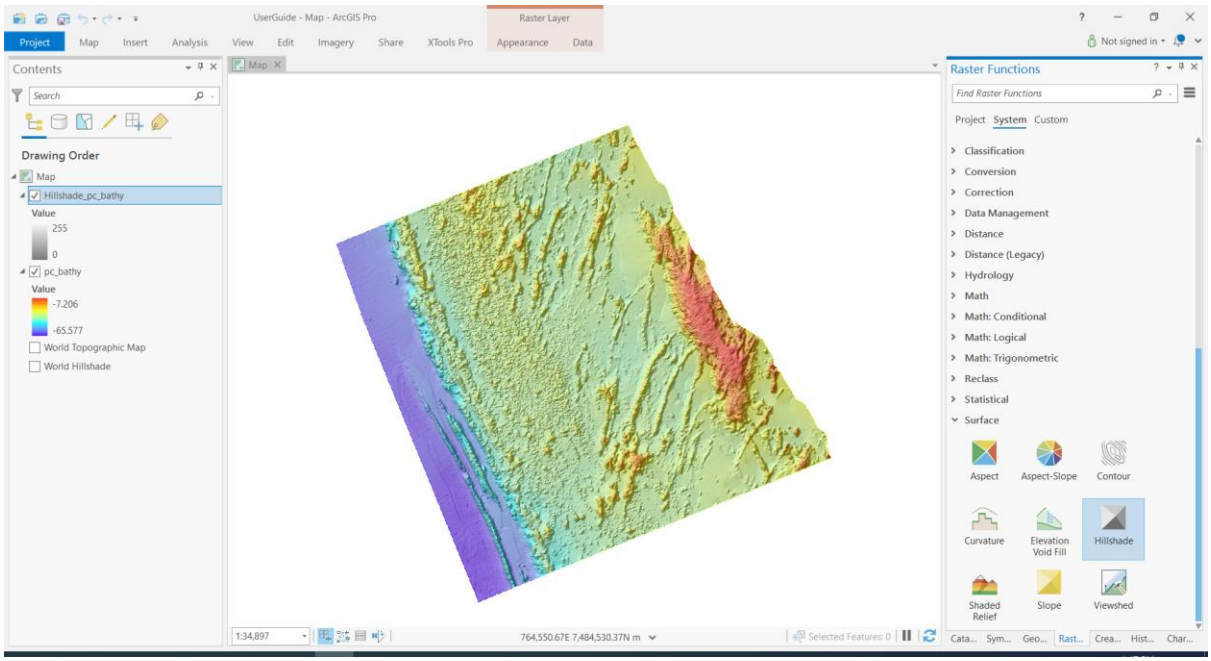
There are three tools under the BathymetricHigh toolbox:

1. TPI Tool Bathymetric High: This tool maps bathymetric high features from a bathymetric data using a Topographic Position Index (TPI) based method.
2. TPI LMI Tool Bathymetric High: This tool maps bathymetric high features from a bathymetric data using a combination of Topographic Position Index (TPI) and Local Moran's I (LMI) method.
3. Openness Tool Bathymetric High: This tool maps bathymetric high features from a bathymetric data using an openness based method.

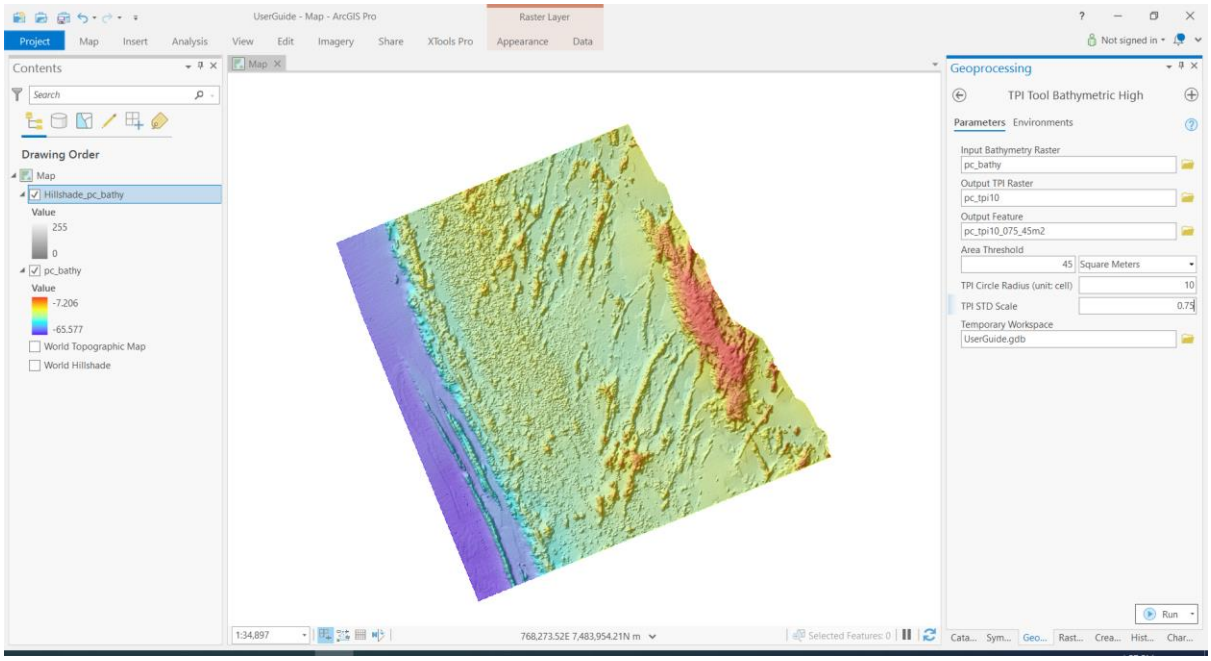
All of these three BathymetricHigh tools are able to map bathymetric high features. However, they are based on different methodologies and thus could be suitable for different applications. Please familiar yourself with the metadata of these tools before attempting to use them. When applying to real-world applications, the users are advised to evaluate which tool(s) are most suitable for their applications.

4.1. TPI Tool Bathymetric High

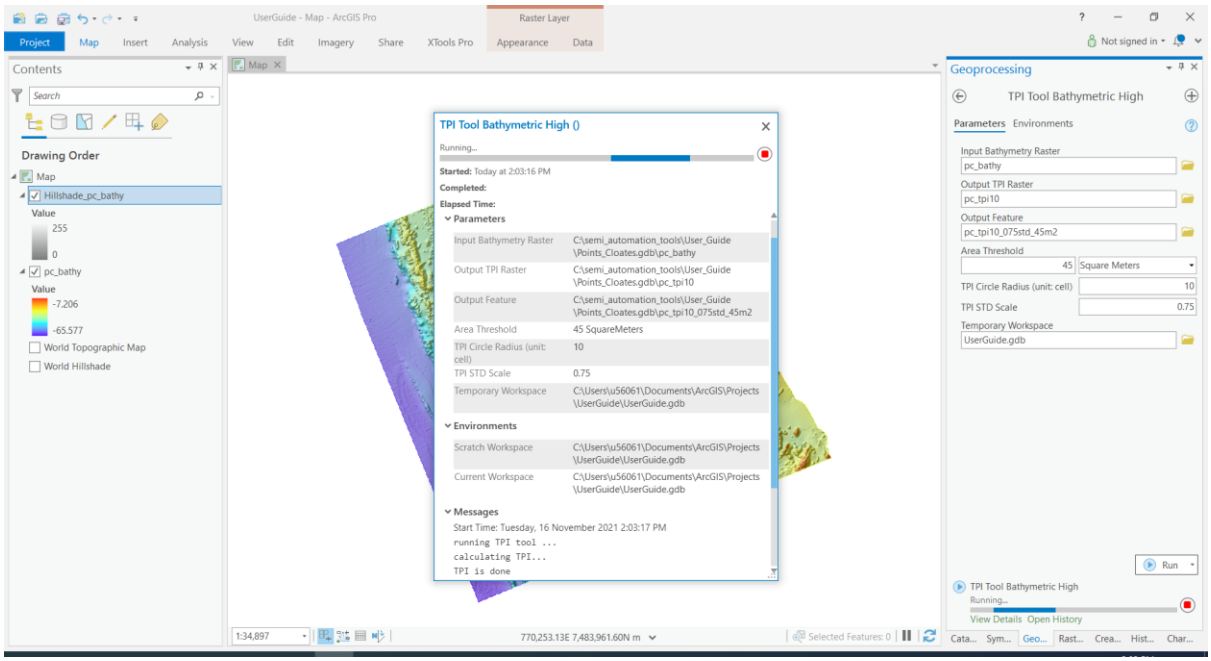
1. If not already loaded, add the pc_bathy bathymetry grid from the Point_Cloates.gdb into the map. Explore the bathymetry data which contains many bathymetric high features.



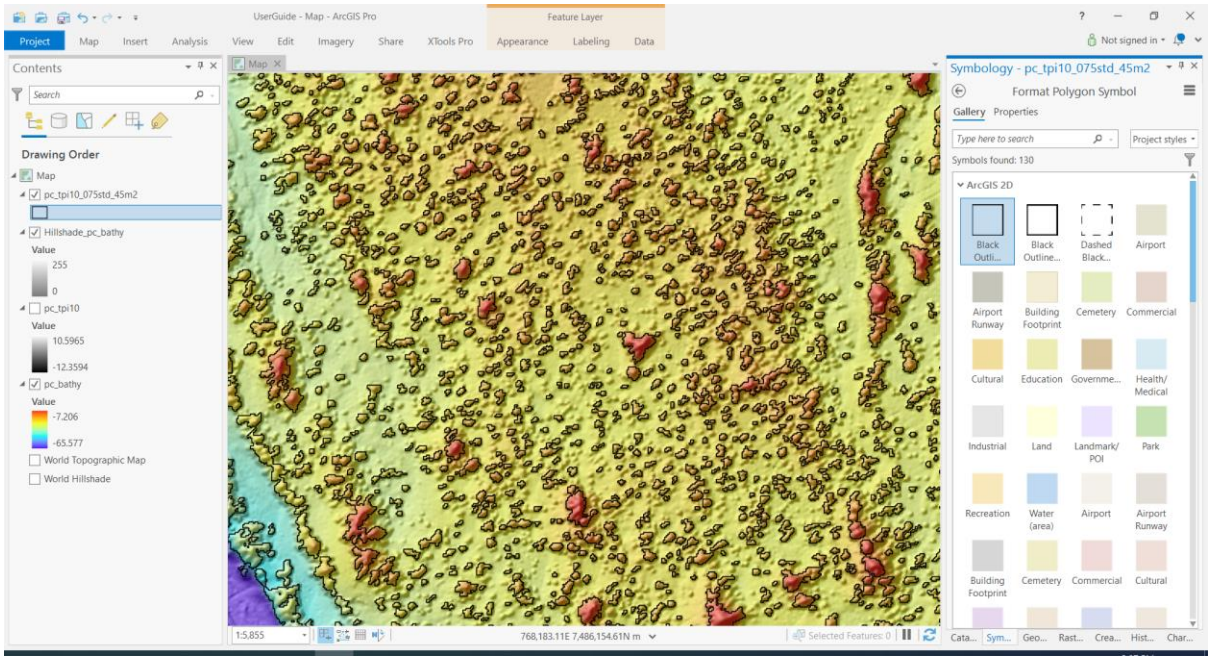
2. Select the TPI Tool Bathymetric High tool, Double-Click to open the tool in Geoprocessing tab. For the Input Bathymetry Raster, select the pc_bathy grid from the drop-down list or navigate to Point_Cloates.gdb and select the pc_bathy grid. For the Output TPI Raster, navigate to Point_Cloates.gdb and enter a name like “pc_tpi10”. For the Output Feature, navigate to Point_cloates.gdb and enter a name like “pc_tpi10_075std_45m2”. For the Area Threshold, enter 45 Square Meters. For the TPI Circle Radius, enter 10. For the TPI STD Scale, enter 0.75. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



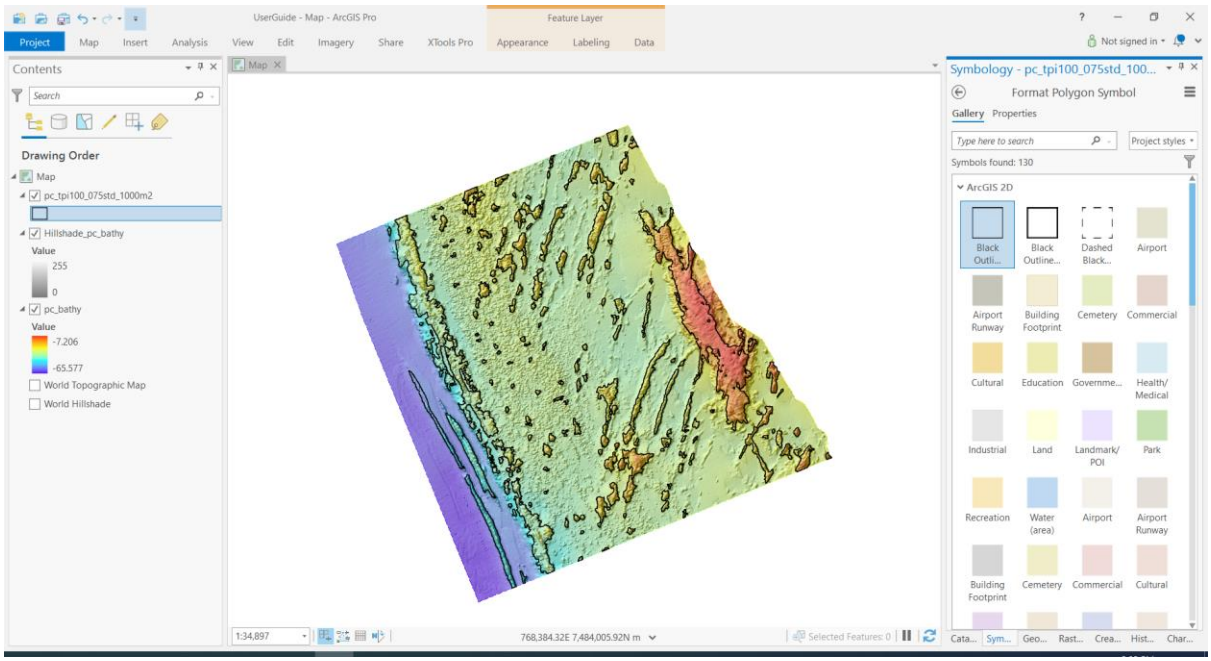
3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, the pc_tpi10 TPI grid and the pc_tpi10_075std_45m2 output bathymetric high features have been generated and added to the current map. Explore the output TPI grid and the bathymetric high features which map a large number of fine-scale bathymetric high features including hummocks and ridges.



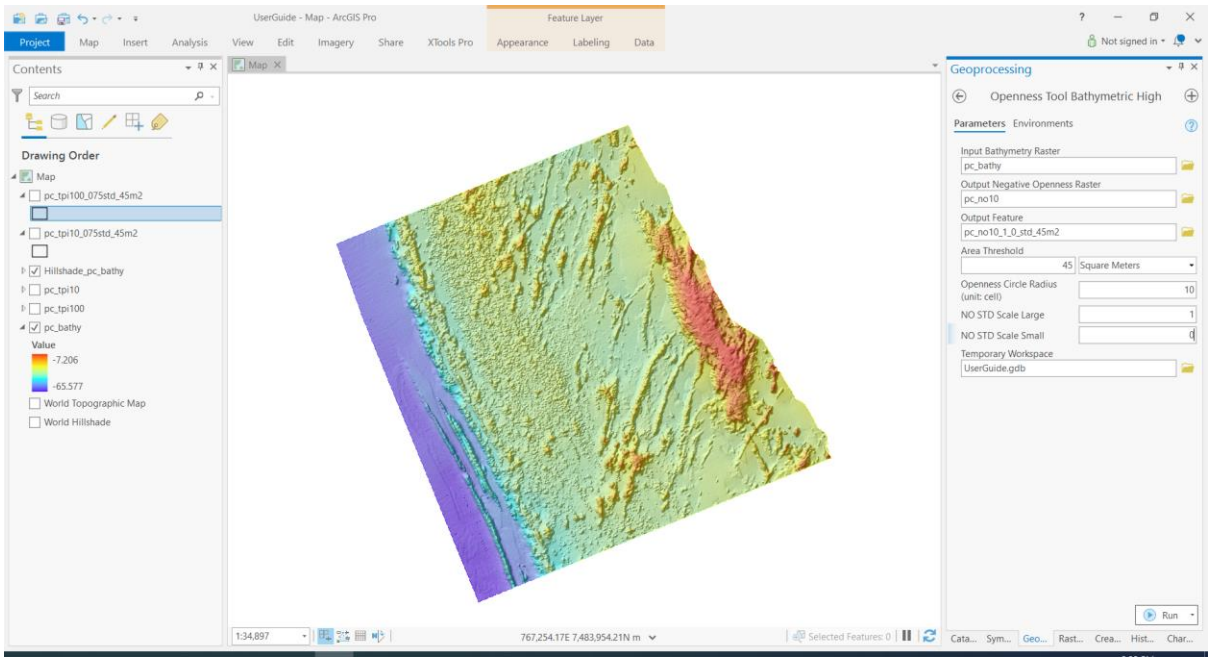
5. Now change the Area Threshold to 1000 m^2 and the TPI radius to 100, and re-run the tool. Remember to change the names of the ouput TPI grid and the bathymetric high features accordingly.
6. Explore the new outputs. This time, you have mapped broader-scale bathymetric high features.



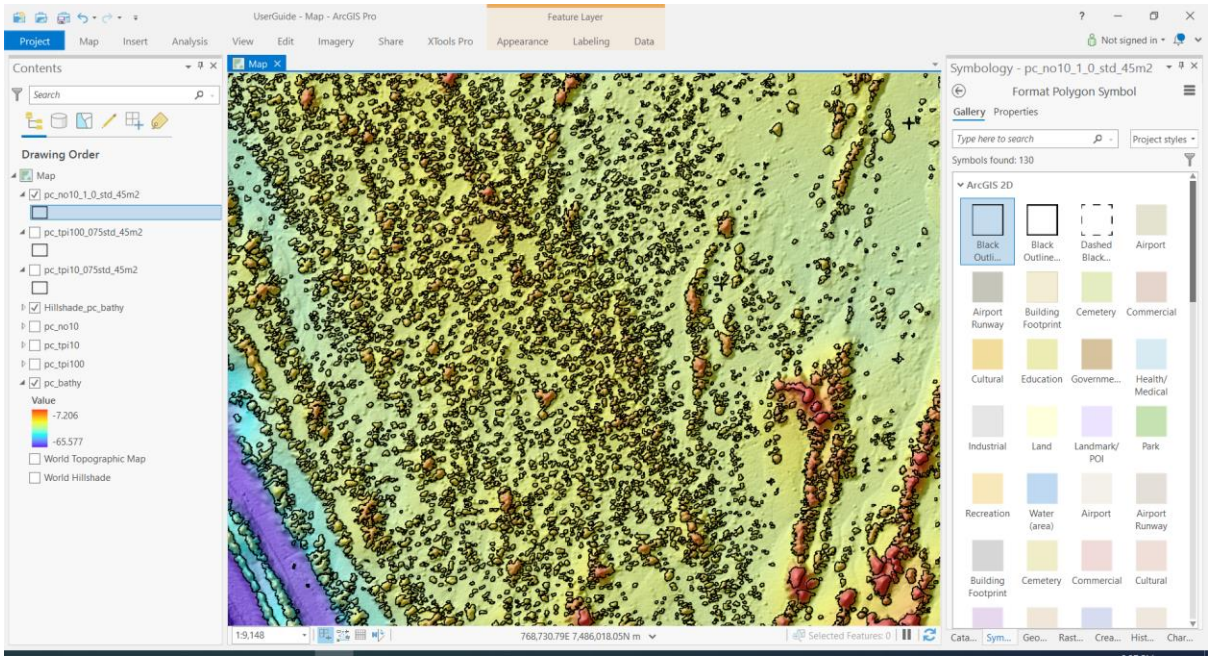
7. Additional Tasks
    a. Explore other values for the input parameters: TPI Radius, TPI STD scale, Area Threshold, etc.
    b. Try different GIS tools in ArcGIS toolboxes to combine the fine-scale and broad-scale bathymetric high features into one single output of bathymetric high features.

4.2. Openness Tool Bathymetric High

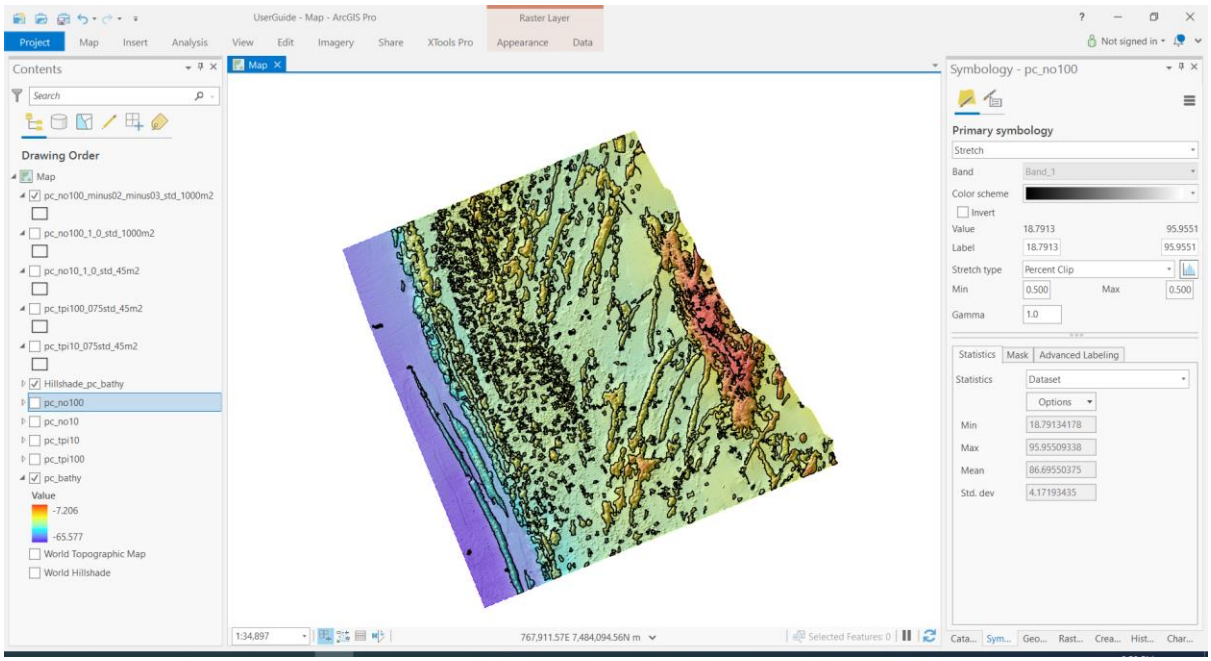
1. If not already loaded, add the pc_bathy bathymetry grid from Point_Cloates.gdb into the map. Explore the bathymetry data which contains many bathymetric high features.
2. Select the Openness Tool Bathymetric High tool, Double-Click to open the tool in the Geoprocessing tab. For the Input Bathymetry Raster, select the pc_bathy grid from the drop-down list or navigate to Point_Cloates.gdb and select the pc_bathy grid. For the Output Negative Openness Raster, navigate to Point_Cloates.gdb and enter a name like “pc_no10”. For the Output Feature, navigate to Point_cloates.gdb and enter a name like “pc_no10_1_0_std_45m2”. For the Area Threshold, enter 45 Square Meters. For the Openness Circle Radius, enter 10. For the NO STD Scale Large, enter 1. For the NO STD Scale Small, enter 0. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.
4. After the geoprocessing is completed, the pc_no10 Negative Openness grid and the pc_no10_1_0_std_45m2 output bathymetric high features have been generated and added to the current map. Explore the output NO grid and the bathymetric high features which map a large number of fine-scale bathymetric high features including hummocks and ridges.



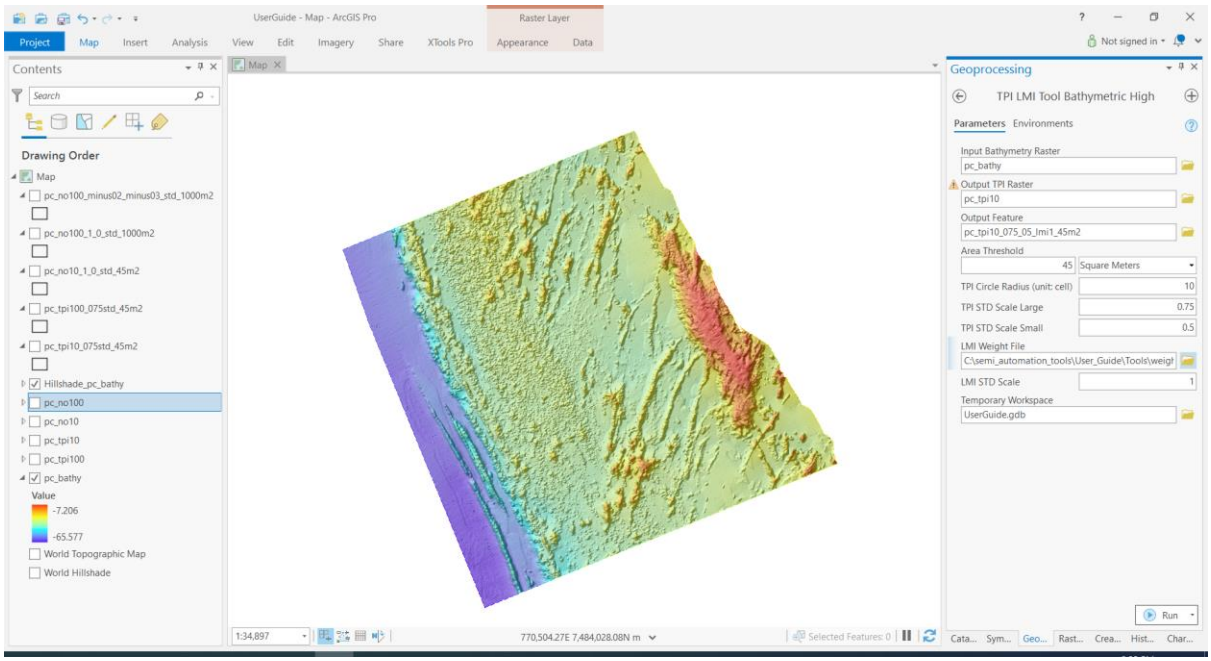
5. Now change the Area Threshold to 1000 m^2, the NO radius to 100,, the NO STD Scale Large to -0.2 and the NO STD Scale Small to -0.3, and re-run the tool. Remember to change the names of the ouput NO grid and the bathymetric high features accordingly.
6. Explore the new outputs. This time, you have mapped broader-scale bathymetric high features.



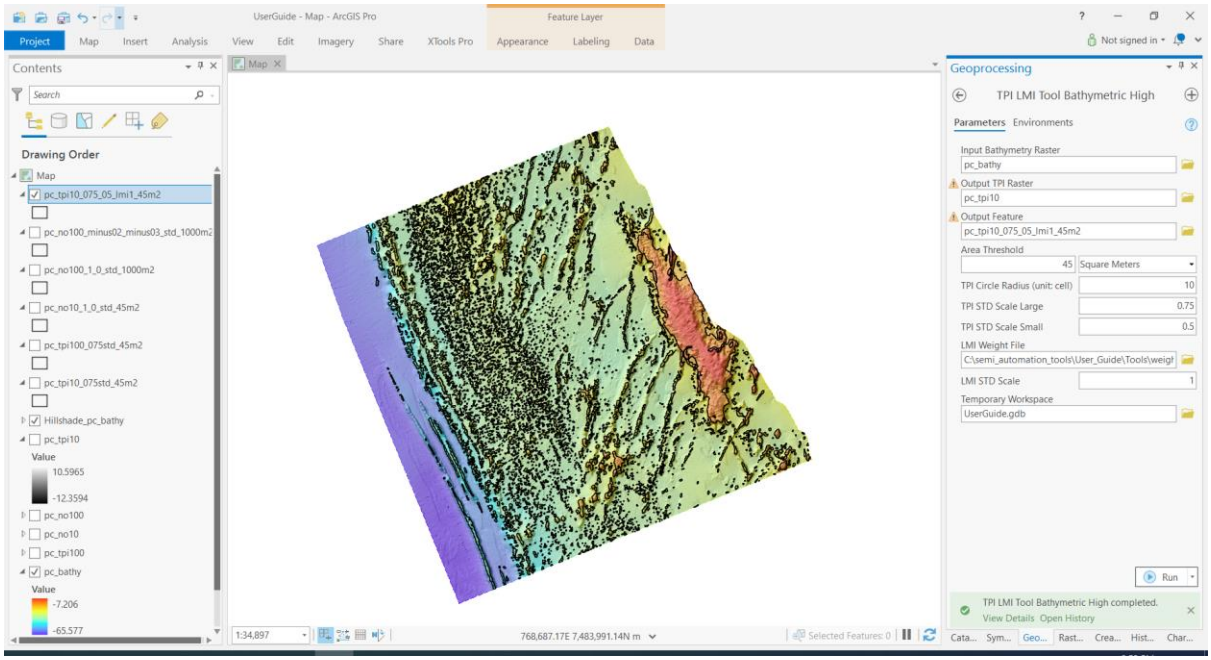
7. Additional Tasks
    a. Explore other values for the input parameters: NO Radius, NO STD scales, Area Threshold, etc.
    b. Try different GIS tools in ArcGIS toolboxes to combine the fine-scale and broad-scale bathymetric high features into one single output of bathymetric high features.

4.3. TPI LMI Tool Bathymetric High

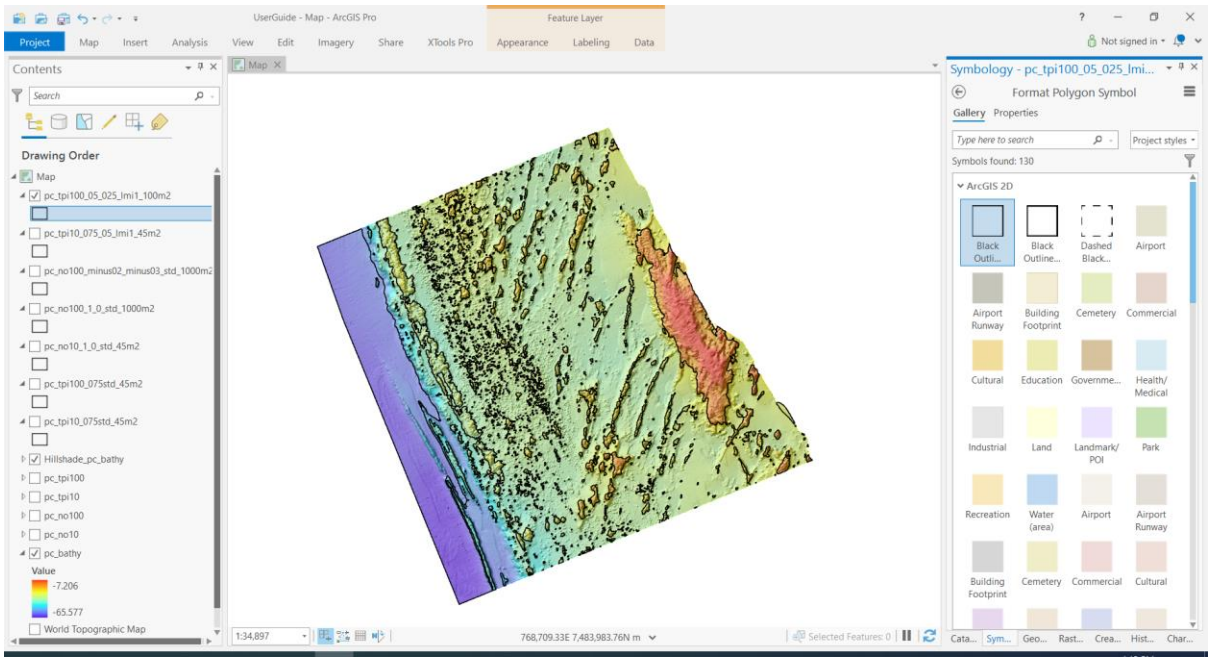
1. If not already loaded, add the pc_bathy bathymetry grid from Point_Cloates.gdb into the map. Explore the bathymetry data which contains many bathymetric high features.
2. Select the TPI LMI Tool Bathymetric High tool, Double-Click to open the tool in the Geoprocessing tab. For the Input Bathymetry Raster, select the pc_bathy grid from the drop-down list or navigate to Point_Cloates.gdb and select the pc_bathy grid. For the Output TPI Raster, navigate to Point_Cloates.gdb and enter a name like “pc_tpi10”. For the Output Feature, navigate to Point_cloates.gdb and enter a name like “pc_tpi10_075_05_lmi1_45m2”. For the Area Threshold, enter 45 Square Meters. For the TPI Circle Radius, enter 10. For the TPI STD Scale Large, enter 0.75. For the TPI STD Scale Small, enter 0.5. For the LMI Weight File, navigate to GA-SaMMT_v1p2\Tools\weight_3.txt. For the LMI STD Scale, enter 1.0. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.
4. After the geoprocessing is completed, the pc_tpi10 TPI grid and the pc_tpi10_075_05_lmi1_45m2 output bathymetric high features have been generated and added to the current map. Explore the output TPI grid and the bathymetric high features which map a large number of fine-scale bathymetric high features including hummocks and ridges.



5. Now change the Area Threshold to 1000 m^2, the TPI radius to 100 and, the TPI STD Scale Large to 0.5, and the TPI STD Scale Small to 0.25, and re-run the tool. Remember to change the names of the output TPI grid and the bathymetric high features accordingly.
6. Explore the new outputs. This time, you have mapped broader-scale bathymetric high features.



7. Additional Tasks
    a. Explore other values for the input parameters: TPI Radius, TPI STD scales, LMI STD scale, Area Threshold, etc.
    b. Try different GIS tools in ArcGIS toolboxes to combine the fine-scale and broad-scale bathymetric high features into one single output of bathymetric high features.

5. Use Bathymetric Low tools

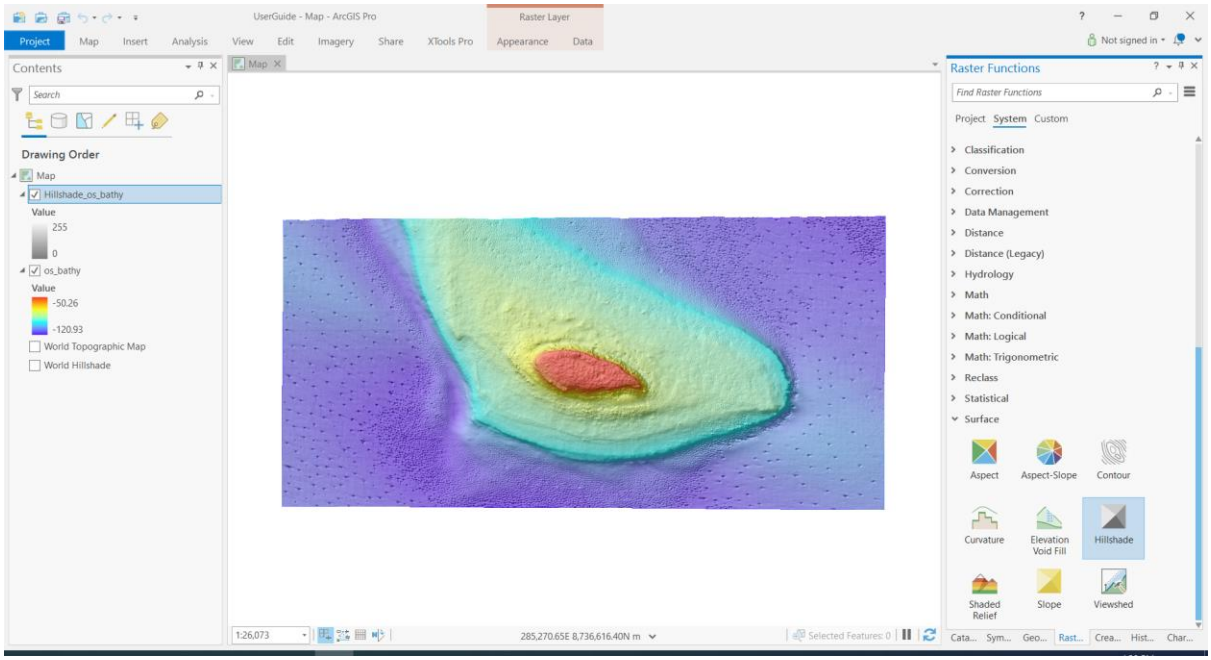
There are three tools in the BathymetricLow toolbox:

1. TPI Tool Bathymetric Low: This tool maps bathymetric low features from a bathymetric data using a Topographic Position Index (TPI) based method.
2. TPI CI Tool Bathymetric Low: This tool maps bathymetric low features from a bathymetric data using a combination of Topographic Position Index (TPI) and Convergence Index (CI) method.
3. Openness Tool Bathymetric Low: This tool maps bathymetric low features from a bathymetric data using an openness based method.

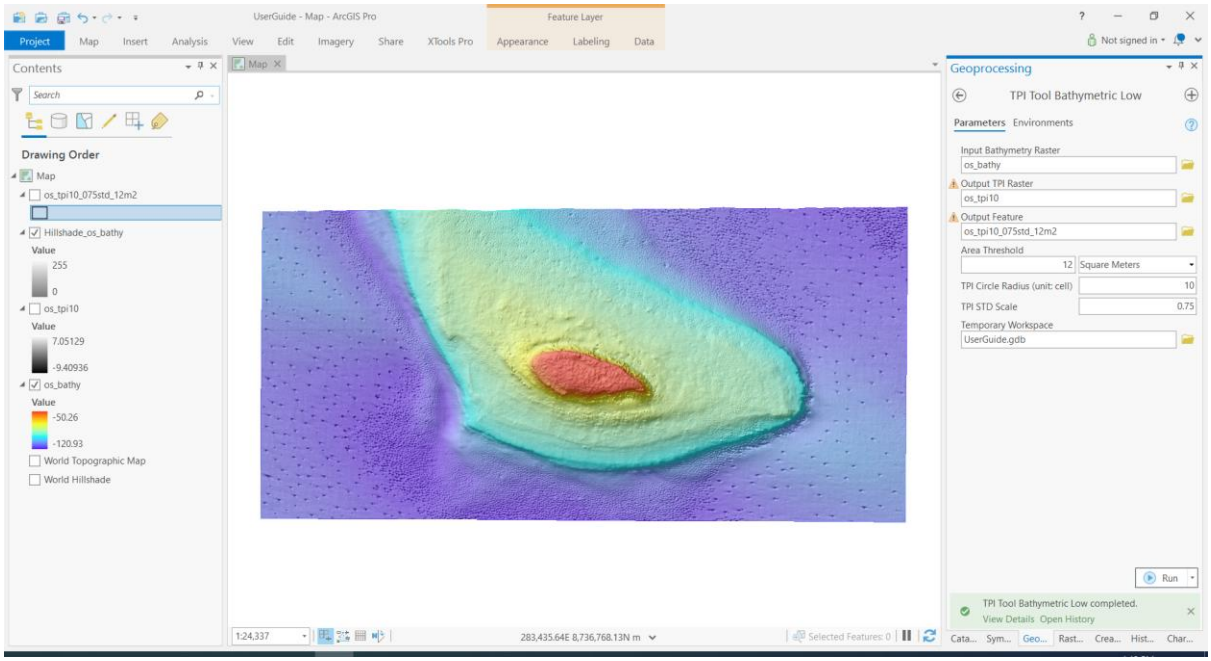
All of these three BathymetricLow tools are able to map bathymetric low features. However, they are based on different methodologies and thus could be suitable for different applications. Please familiar yourself with the metadata of these tools before attempting to use them. When applying to real-world applications, the users are advised to evaluate which tool(s) are most suitable for their applications.

5.1. TPI Tool Bathymetric Low

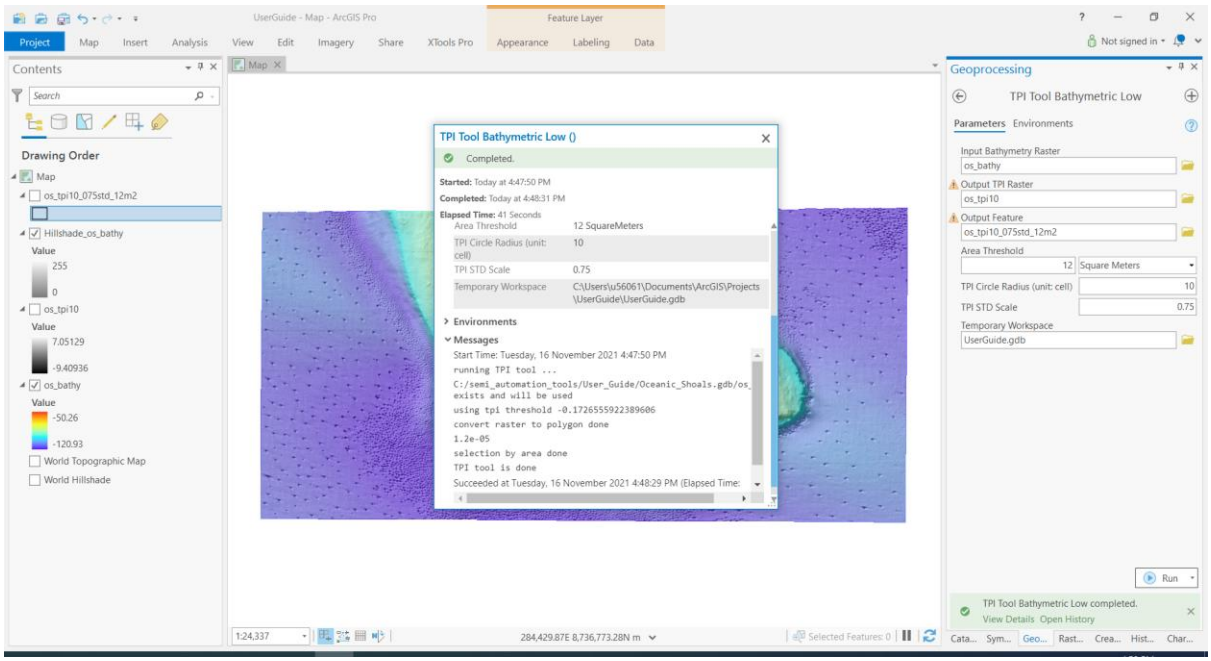
1. Create a new map (e.g., using Insert New Map menu), add the os_bathy bathymetry grid from Oceanic_Shoals.gdb into the map. Explore the bathymetry data which contains a large number of pockmarks as bathymetric low features.



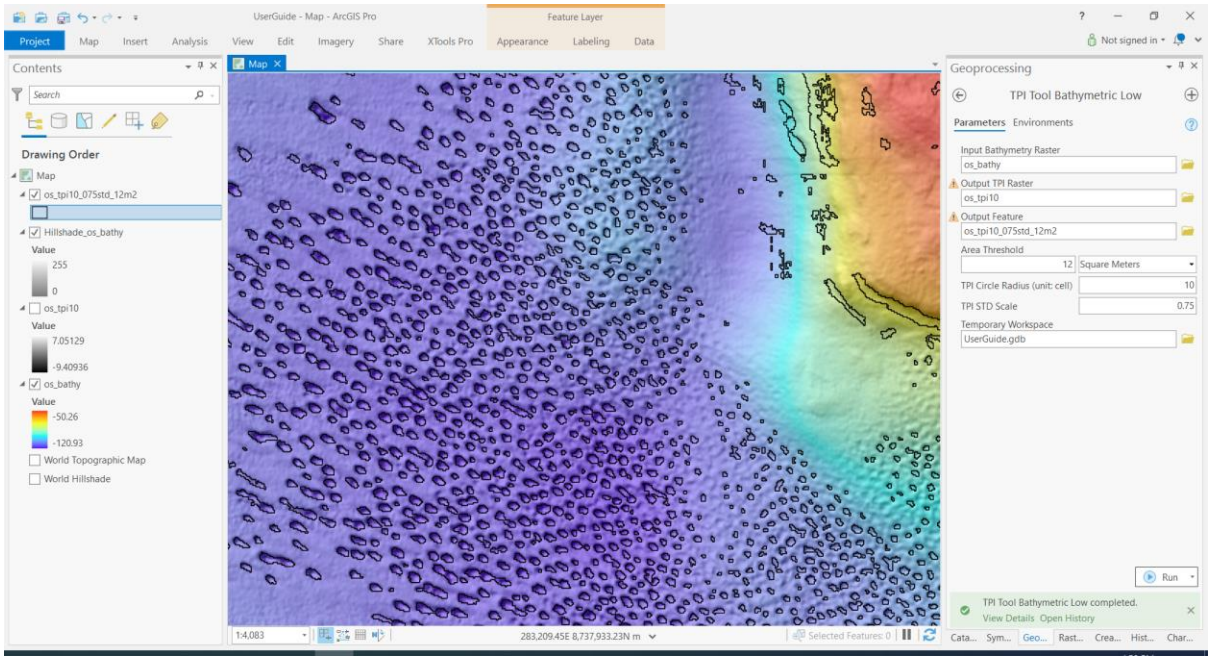
2. Select the TPI Tool Bathymetric Low tool, Double-Click to open the tool in the Geoprocessing tab. For the Input Bathymetry Raster, select the os_bathy grid from the drop-down list or navigate to Oceanic_Shoals.gdb and select the os_bathy grid. For the Output TPI Raster, navigate to Oceanic_Shoals.gdb and enter a name like “os_tpi10”. For the Output Feature, navigate to Oceanic_Shoals.gdb and enter a name like “os_tpi10_075std_12m2”. For the Area Threshold, enter 12 Square Meters. For the TPI Circle Radius, enter 10. For the TPI STD Scale, enter 0.75. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, the os_tpi10 TPI grid and the os_tpi10_075std_12m2 output bathymetric high features have been generated and added to the current map. Explore the output TPI grid and the bathymetric low features which map a large number of pockmarks.

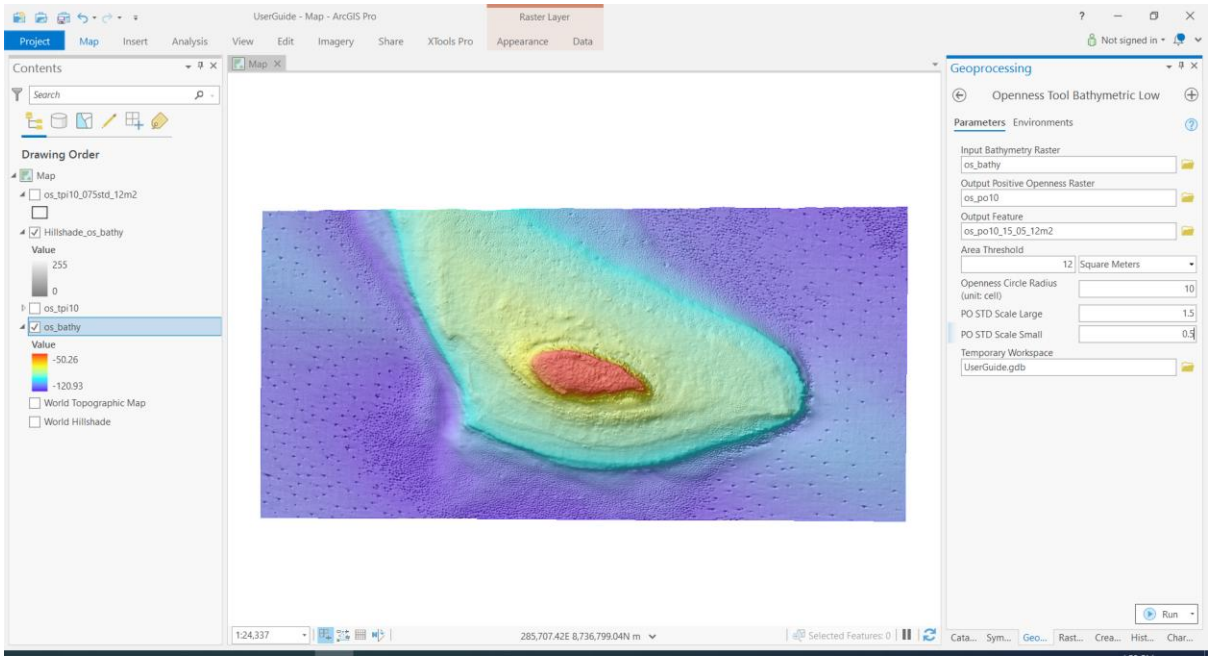


5. Explore other values for the input parameters: TPI Radius, TPI STD scale, Area Threshold, etc.

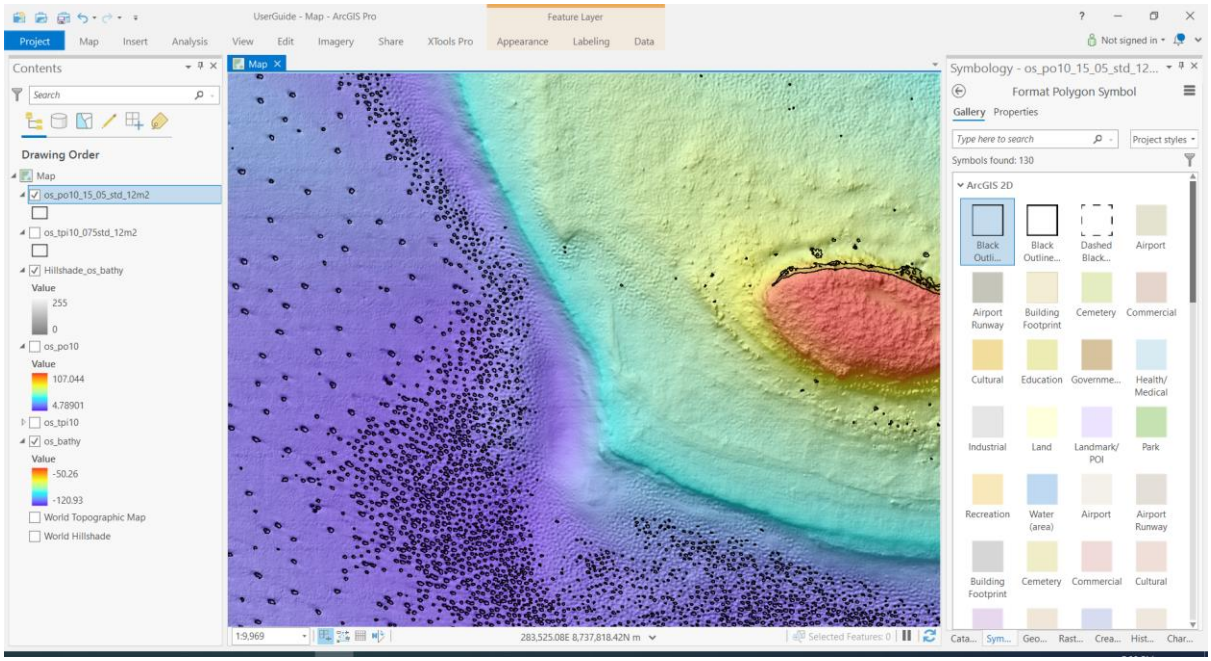
5.2. Openness Tool Bathymetric Low

1. If not already loaded, add the os_bathy bathymetry grid from the Oceanic_Shoals.gdb into the map. Explore the bathymetry data which contains a large number of pockmarks as bathymetric low features.
2. Select the Openness Tool Bathymetric Low tool, Double-Click to open the tool in the Geoprocessing tab. For the Input Bathymetry Raster, select the os_bathy grid from the drop-down list or navigate to Oceanic_Shoals.gdb and select the os_bathy grid. For the Output

Positive Openness Raster, navigate to Oceanic_Shoals.gdb and enter a name like “os_po10”. For the Output Feature, navigate to Oceanic_Shoals.gdb and enter a name like “os_po10_15_05_std_12m2”. For the Area Threshold, enter 12 Square Meters. For the Openness Circle Radius, enter 10. For the PO STD Scale Large, enter 1.5. For the PO STD Scale Small, enter 0.5. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



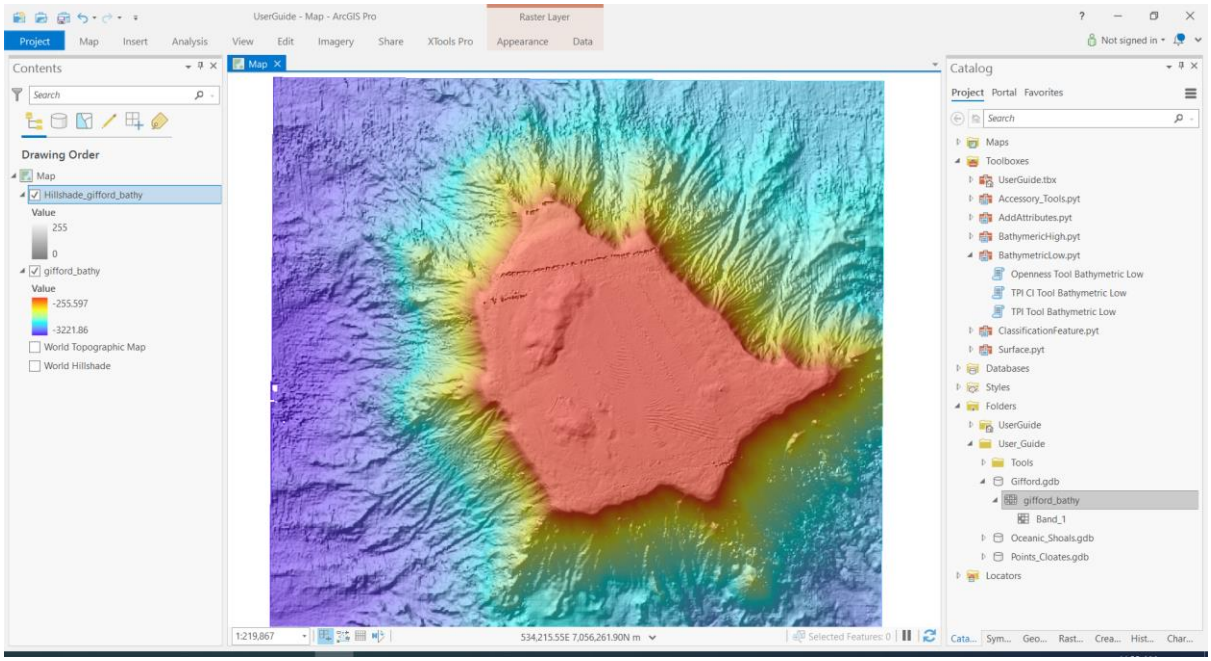
3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.
4. After the geoprocessing is completed, the os_po10 Positive Openness grid and the os_po10_15_05_std_12m2 output bathymetric high features have been generated and added to the current map. Explore the output PO grid and the bathymetric low features which map a large number of pockmarks.



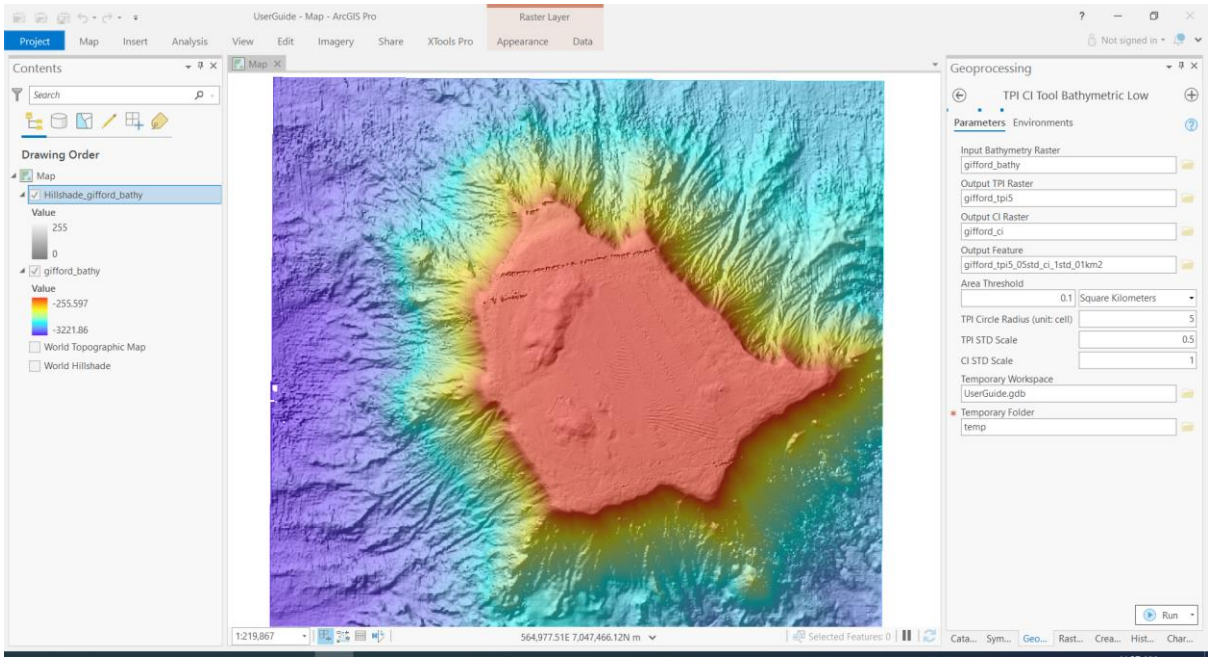
5. Explore other values for the input parameters: Openness Radius, PO STD scales, Area Threshold, etc.

5.3. TPI CI Tool Bathymetric Low

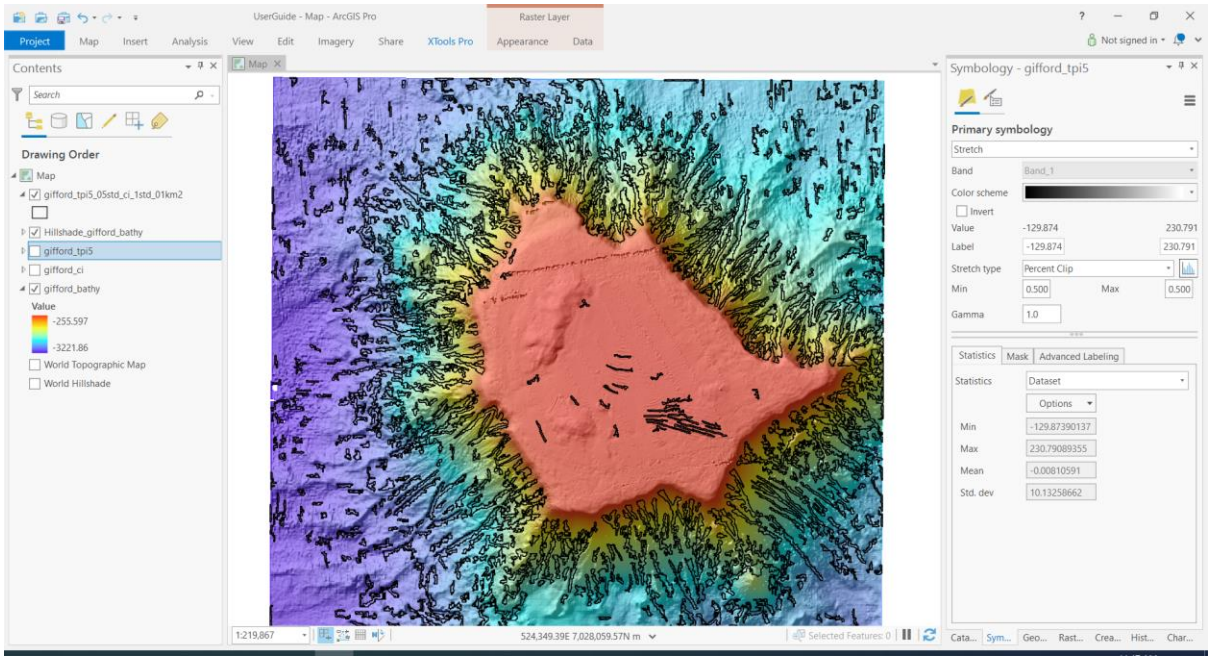
1. Create a new map (e.g., using Insert New Map menu), add the gifford_bathy bathymetry grid from Gifford.gdb into the map. Explore the bathymetry data which contains bathymetric low features on the flank of the seamount.



2. Select the TPI CI Tool Bathymetric Low tool, Double-Click to open the tool in the Geoprocessing tab. For the Input Bathymetry Raster, select the Gifford_bathy grid from the drop-down list or navigate to Gifford.gdb and select the gifford_bathy grid. For the Output TPI Raster, navigate to Gifford.gdb and enter a name like “gifford_tpi5”. For the Output CI Raster, navigate to Gifford.gdb and enter a name like “gifford_ci”. For the Output Feature, navigate to Gifford.gdb and enter a name like “gifford_tpi5_05std_ci_1std_01km2”. For the Area Threshold, enter 0.1 Square Kilometers. For the TPI Circle Radius, enter 5. For the TPI STD Scale, enter 0.5. For the CI STD Scale, enter 1.0. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s). For the Temporary Folder, nominate a folder.



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.
4. After the geoprocessing is completed, the gifford_tpi5 TPI grid, the gifford_ci grid and the gifford_tpi5_05std_ci_1std_01km2 output bathymetric low features have been generated and added to the current map. Explore the output grids and the bathymetric low features.



5. Explore other values for the input parameters: TPI Radius, TPI STD scale, CI STD scale, Area Threshold, etc.

6. Use Add Attributes tools

The AddAttributes toolbox contains the following six tools:

1. Add Shape Attributes High Tool: This tool generates shape attributes for each bathymetric high feature.
2. Add Shape Attributes Low Tool: This tool generates shape attributes for each bathymetric low feature.
3. Add Topographic Attributes High Tool: This tool generates topographic attributes for each bathymetric high feature.
4. Add Topographic Attributes Low Tool: This tool generates topographic attributes for each bathymetric low feature.
5. Add Profile Attributes High Tool: This tool generates profile attributes for each bathymetric high feature.
6. Add Profile Attributes Low Tool: This tool generates profile attributes for each bathymetric low feature.

For both bathymetric high and bathymetric low features, there are three groups of attributes to be calculated: Shape, Topographic and Profile, using three individual tools. These three

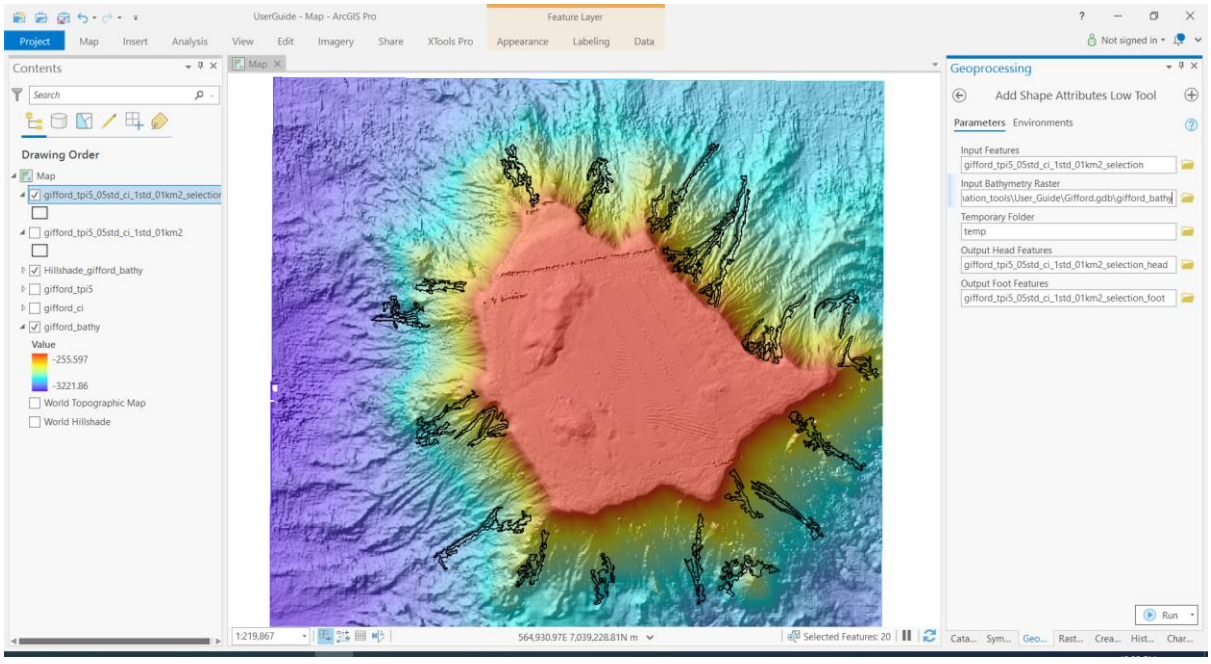
groups of attributes need to be calculated in the order of Shape, Topographic and Profile attributes due to the inter-dependency.

This user guide illustrates the usage of these *add attributes* tools using two examples. The first example is to generate the attributes for a subset of the output bathymetric low features: gifford_tpi5_05std_ci_1std_01km2. The other example is to generate the attributes for a subset of the output bathymetric high features: pc_tpi100_075std_45m2.

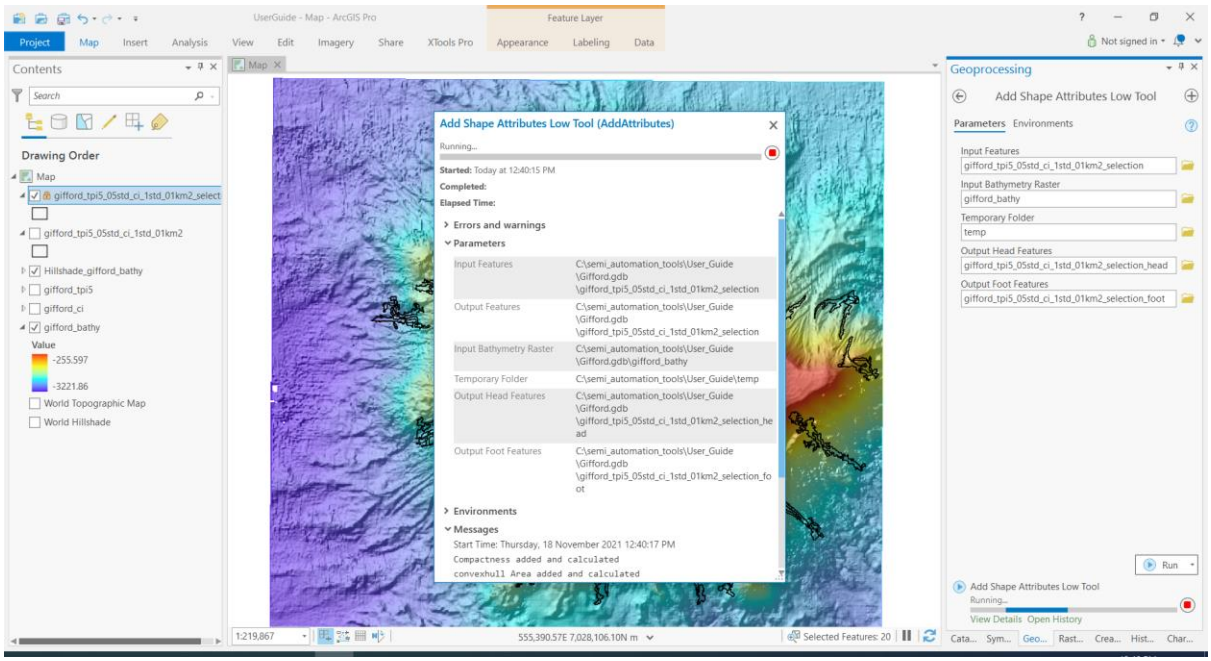
6.1. Add Shape Attributes Low Tool

The Add Shape Attributes Low Tool is time-consuming. For the purpose of simplification, we just calculate the attributes for the largest 20 features (polygons).

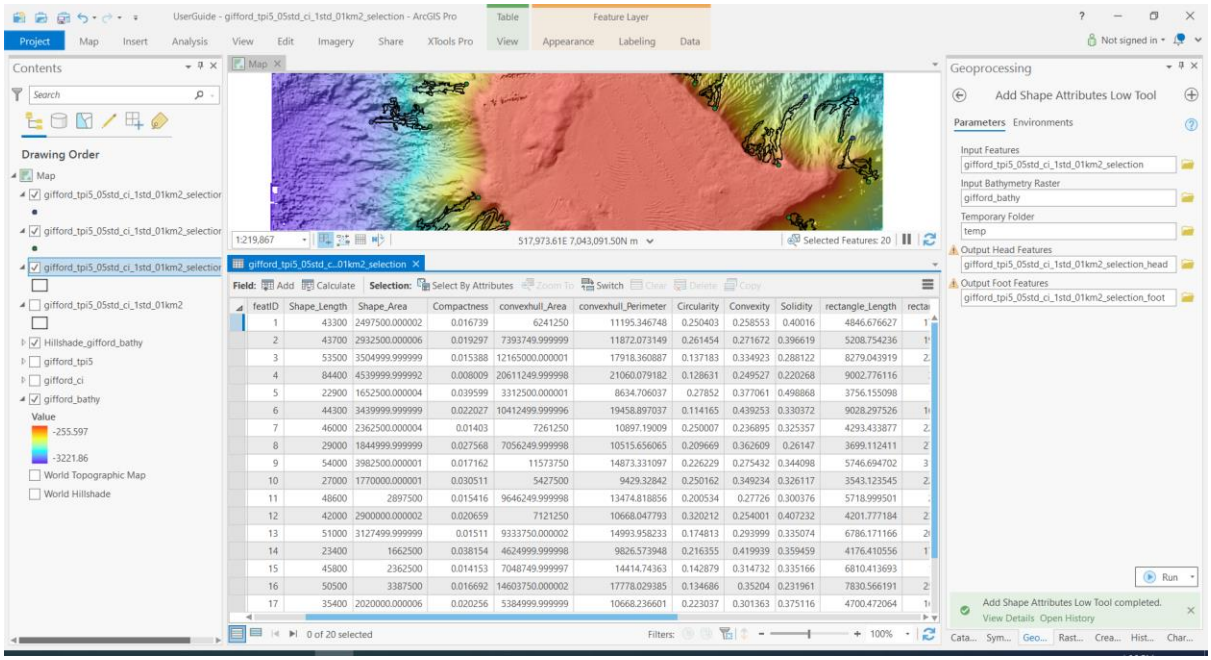
1. Select the largest 20 features (polygons) from gifford_tpi5_05std_ci_1std_01km2 and export the selected features as a new feature class: gifford_tpi5_05std_ci_1std_01km2_selection.
2. Select the Add Shape Attributes Low Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select gifford_tpi5_05std_ci_1std_01km2_selection from the drop-down list or navigate to Gifford.gdb and add gifford_tpi5_05std_ci_1std_01km2_selection. For the Input Bathymetry Raster, select gifford_bathy from the drop-down list or navigate to Gifford.gdb and add gifford_bathy. For the Temporary Folder, nominate a folder. For the Output Head Features, navigate to Gifford.gdb, enter a name like “gifford_tpi5_05std_ci_1std_01km2_selection_head”. For the Output Foot Features, navigate to Gifford.gdb, enter a name like “gifford_tpi5_05std_ci_1std_01km2_selection_foot”.



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, check that the shape attributes have been generated.

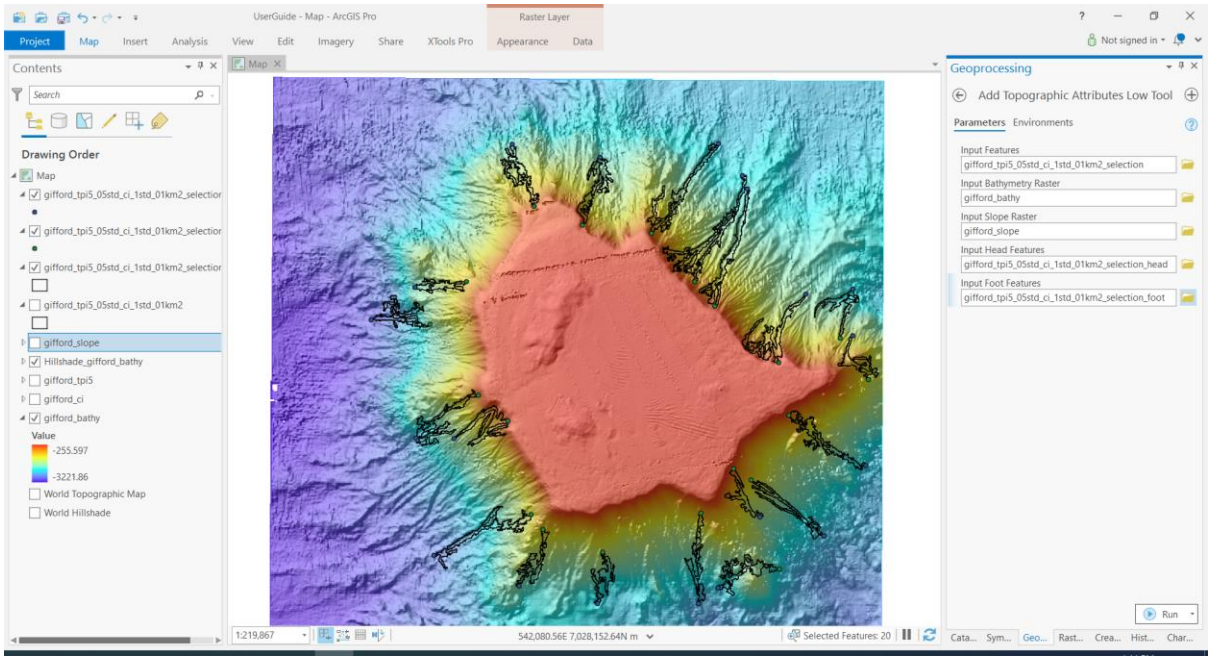


5. Explore the shape attributes of the bathymetric low features if you wish. Otherwise, continue next step.

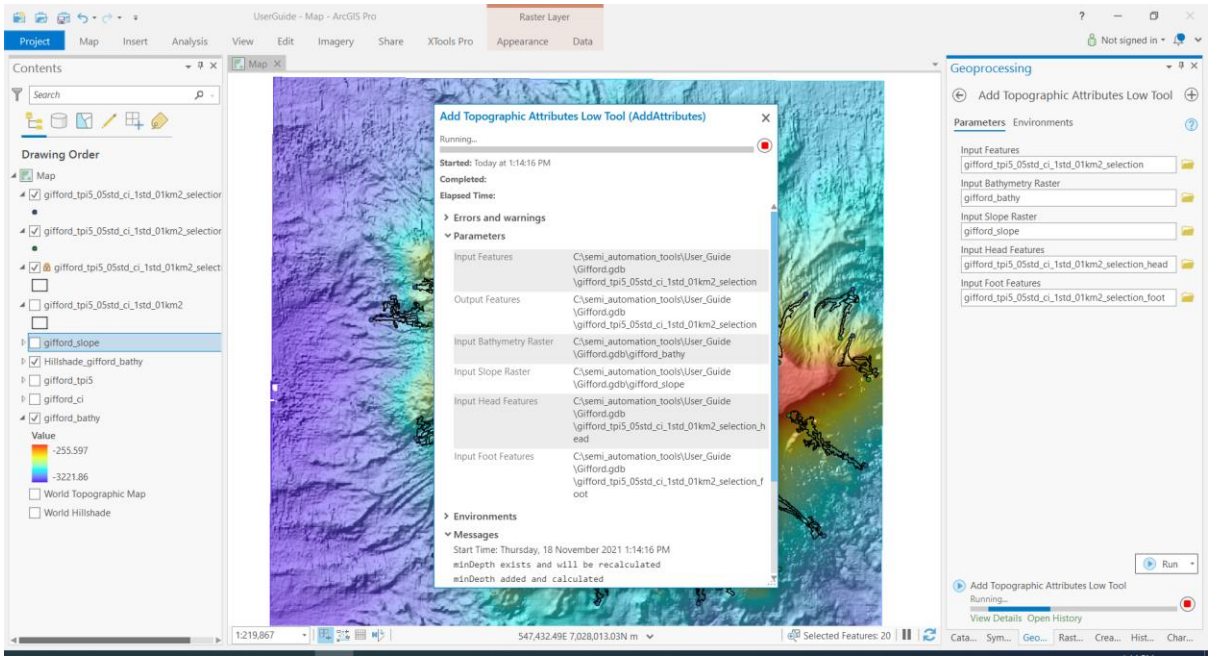
6.2. Add Topographic Attributes Low Tool

1. The Add Topographic Attributes Low Tool requires slope gradient grid as input. First, generate the slope grid from the gifford_bathy.
2. Select the Add Topographic Attributes Low Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select gifford_tpi5_05std_ci_1std_01km2_selection from the drop-down list or navigate to Gifford.gdb and add gifford_tpi5_05std_ci_1std_01km2_selection. For the Input Bathymetry Raster, select gifford_bathy from the drop-down list or navigate to Gifford.gdb and add gifford_bathy. For the Input Slope Raster, select the slope grid generated in the previous step from the drop-down

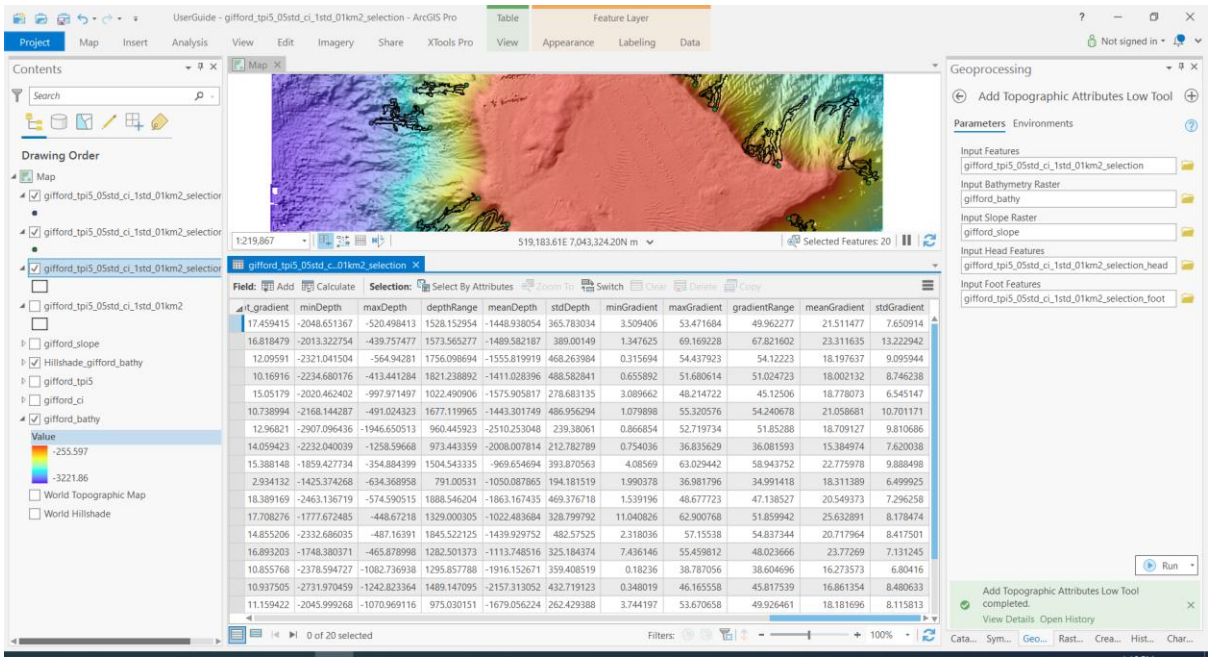
list or navigate and add the slope grid. For the Input Head Features, select the head features generated in the Add Shape Attributes Low Tool or navigate to Gifford.gdb and select the head features. For the Input Foot Features, select the foot features generated in the Add Shape Attributes Low Tool or navigate to Gifford.gdb and select the foot features.



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



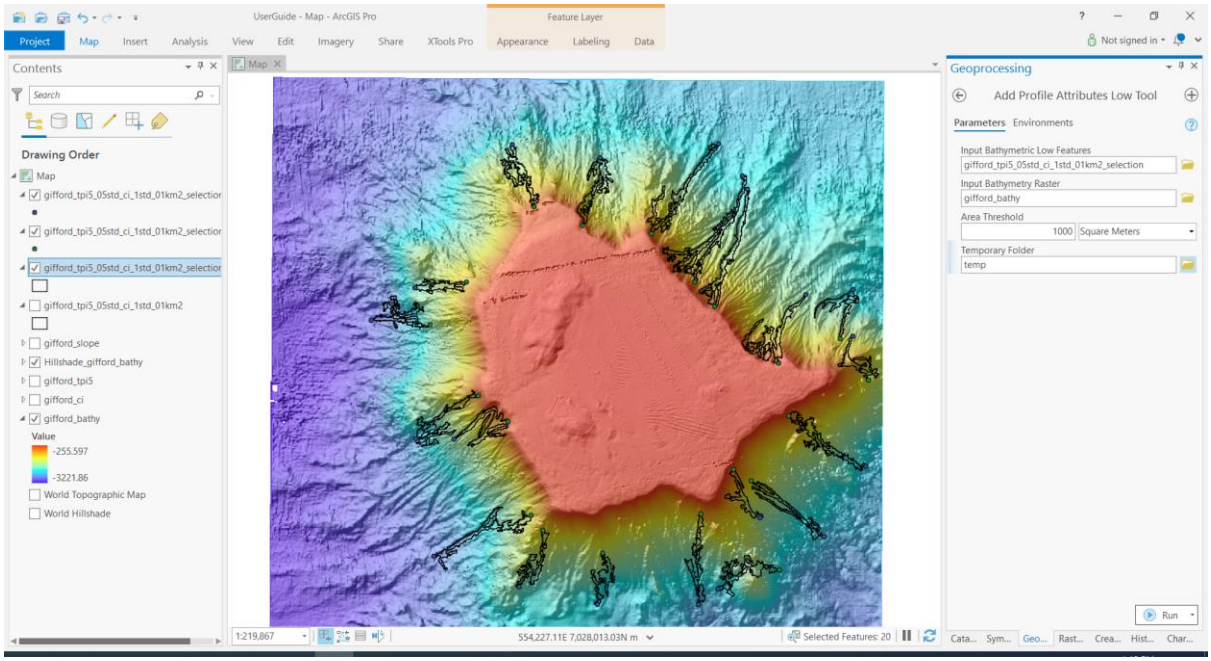
4. After the geoprocessing is completed, check that the topographic attributes have been generated.



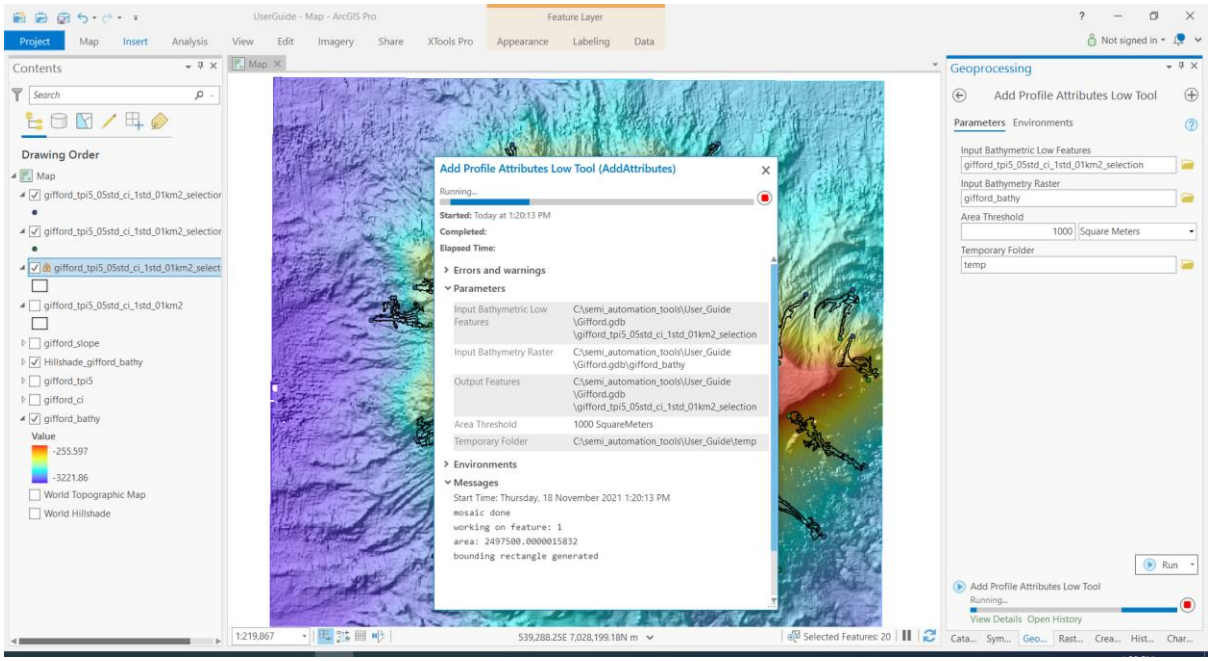
5. Explore the topographic attributes of the bathymetric low features if you wish. Otherwise, continue next step.

6.3. Add Profile Attributes Low Tool

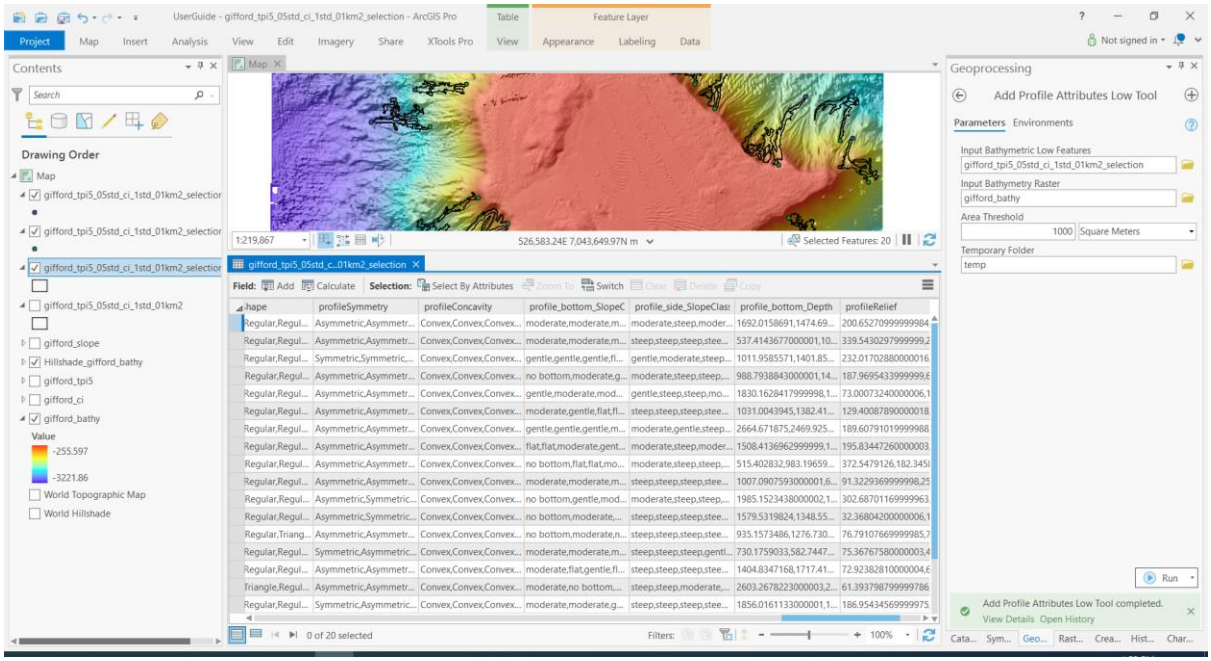
1. Select the Add Profile Attributes Low Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select gifford_tpi5_05std_ci_1std_01km2_selection from the drop-down list or navigate to Gifford.gdb and add gifford_tpi5_05std_ci_1std_01km2_selection. For the Input Bathymetry Raster, select gifford_bathy from the drop-down list or navigate to Gifford.gdb and add gifford_bathy. For the Area Threshold, enter 1000 Square Meters. For the Temporary Folder, nominate a folder.



2. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



3. After the geoprocessing is completed, check that the profile attributes have been generated.



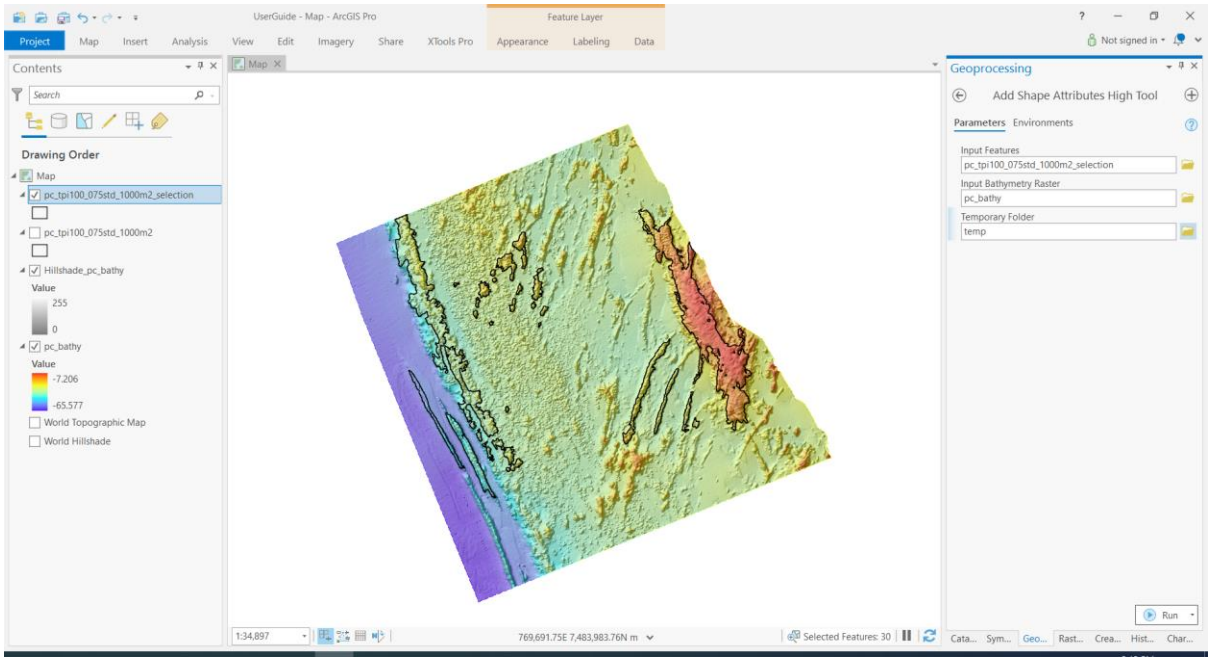
4. Explore the profile attributes of the bathymetric low features if you wish.

6.4. Add Shape Attributes High Tool

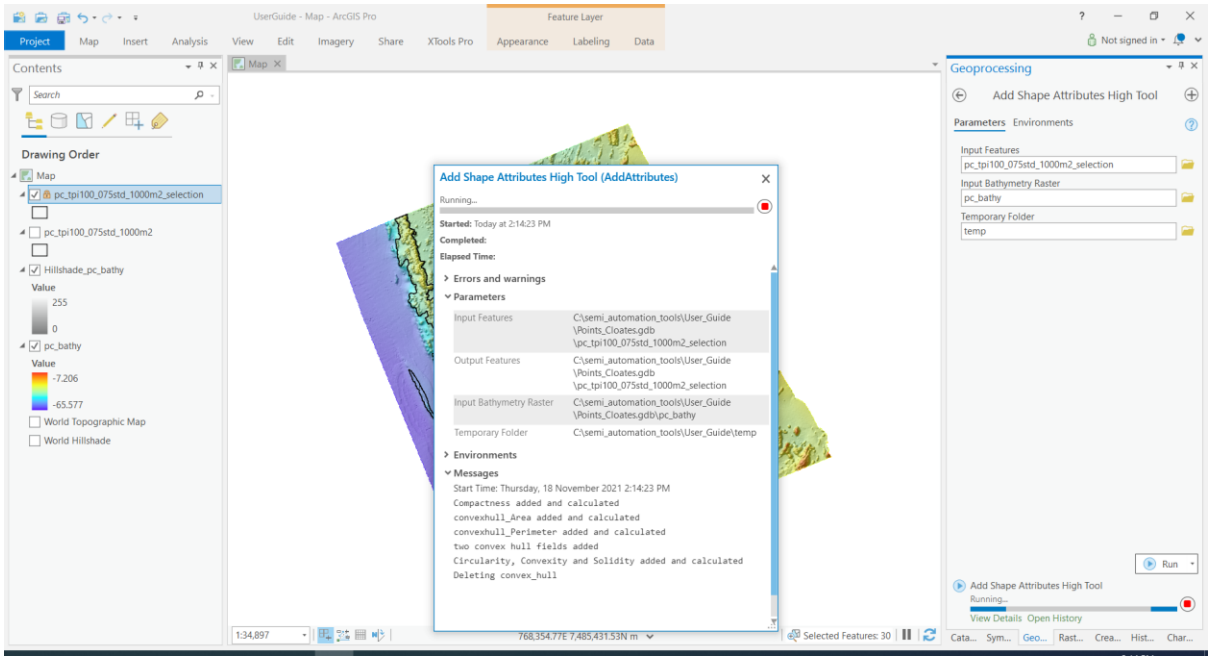
The Add Shape Attributes High Tool is time-consuming. For the purpose of simplification, we just randomly select a number of large and small bathymetric features and calculate the attributes for these features.

1. If not already open, create a new map and add pc_bathy from Points_Cloates.gdb to the map, create a hill-shade layer.

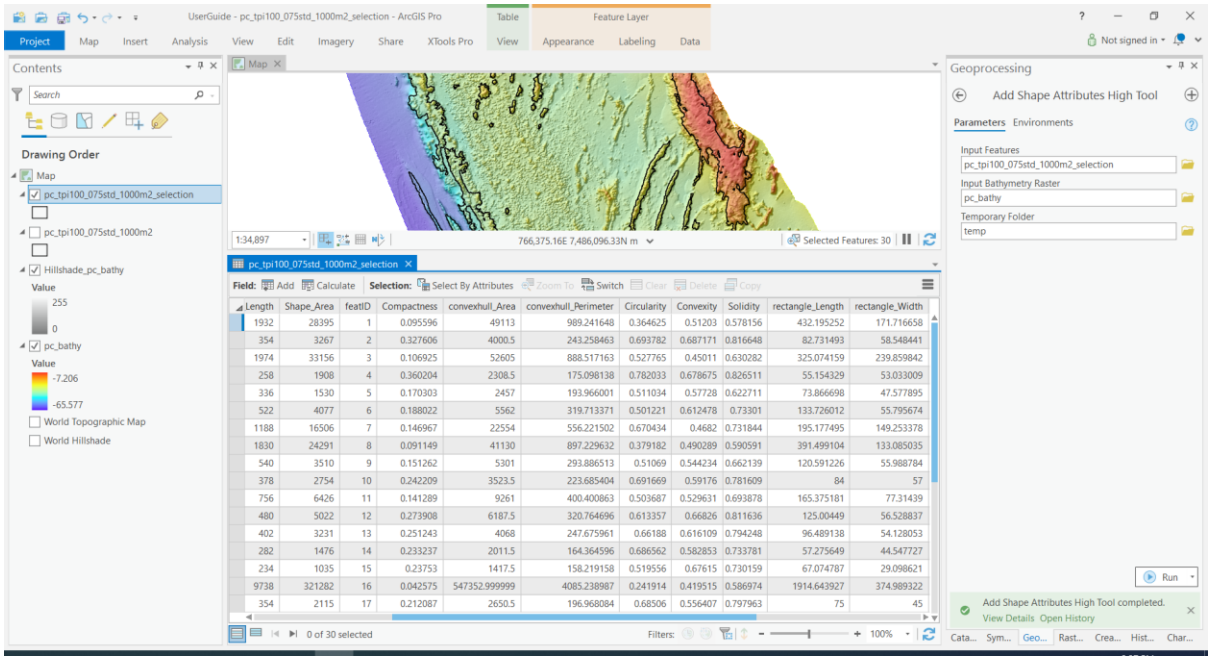
2. Add pc_tpi100_075std_1000m2 bathymetric high features from Points_Cloates.gdb to the map.
3. Randomly select a number of features and export the selection to a new feature class: pc_tpi100_075std_1000m2_selection.
4. Select the Add Shape Attributes High Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select pc_tpi100_075std_1000m2_selection from the drop-down list or navigate to Points_Cloates.gdb and add pc_tpi100_075std_1000m2_selection. For the Input Bathymetry Raster, select pc_bathy from the drop-down list or navigate to Points_Cloates.gdb and add pc_bathy. For the Temporary Folder, nominate a folder.



5. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



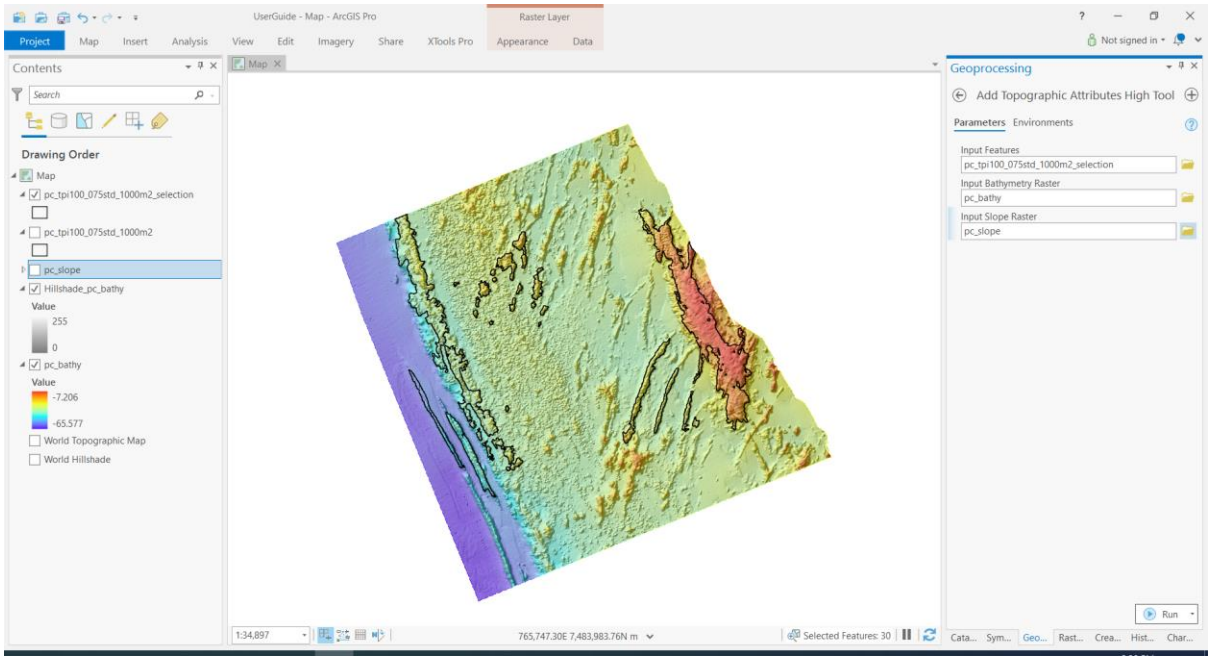
6. After the geoprocessing is completed, check that the shape attributes have been generated.



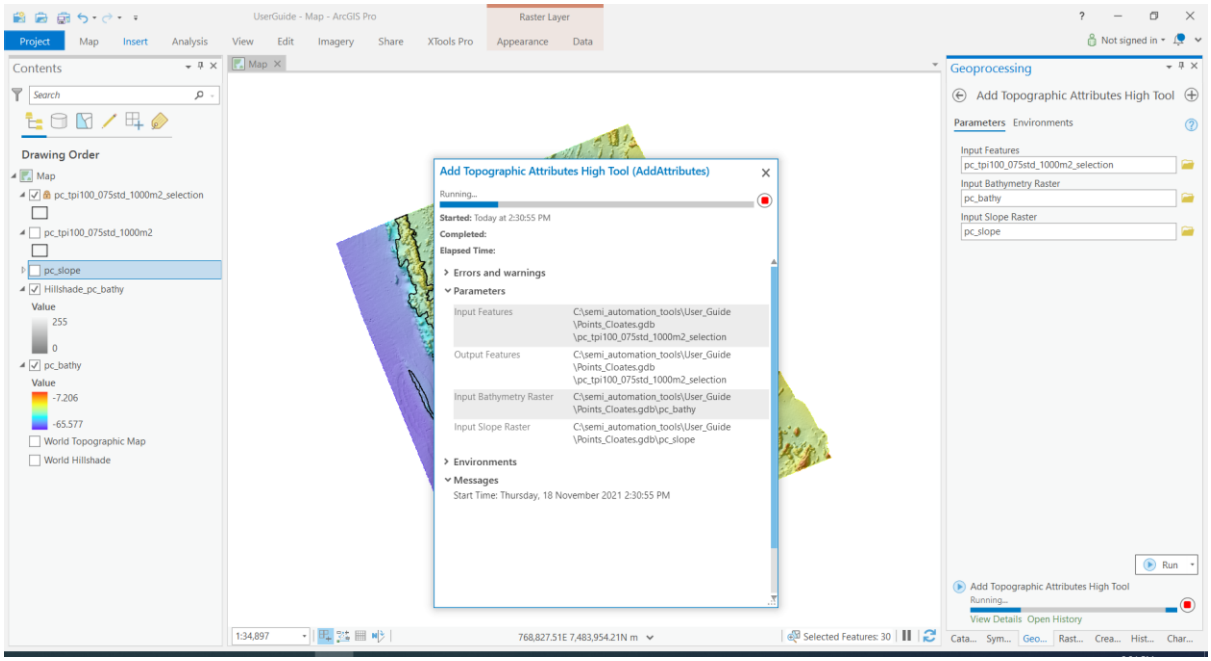
7. Explore the shape attributes of the bathymetric high features if you wish. Otherwise, continue next step.

6.5. Add Topographic Attributes High Tool

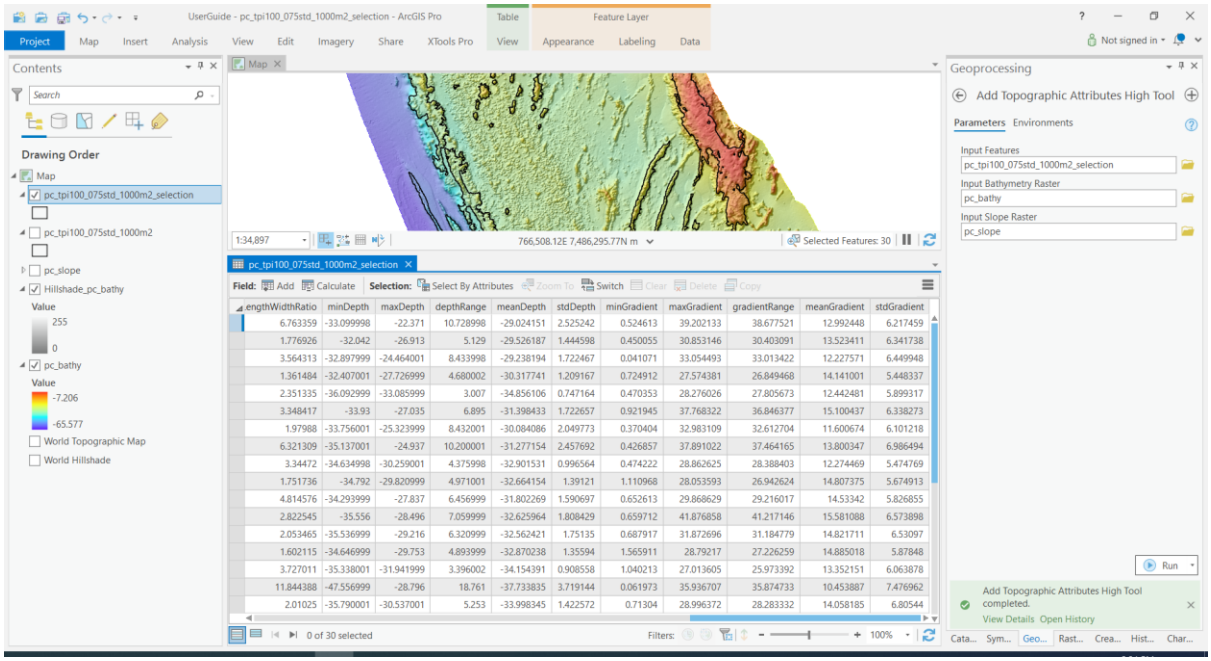
1. The Add Topographic Attributes High Tool requires slope gradient grid as input. First, generate the slope grid from pc_bathy.
2. Select the Add Topographic Attributes High Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select pc_tpi100_075std_1000m2_selection from the drop-down list or navigate to Points_Cloates.gdb and add pc_tpi100_075std_1000m2_selection. For the Input Bathymetry Raster, select pc_bathy from the drop-down list or navigate to Points_Cloates.gdb and add pc_bathy. For the Input Slope Raster, select the slope grid generated in the previous step from the drop-down list or navigate and add the slope grid.



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, check that the topographic attributes have been generated.

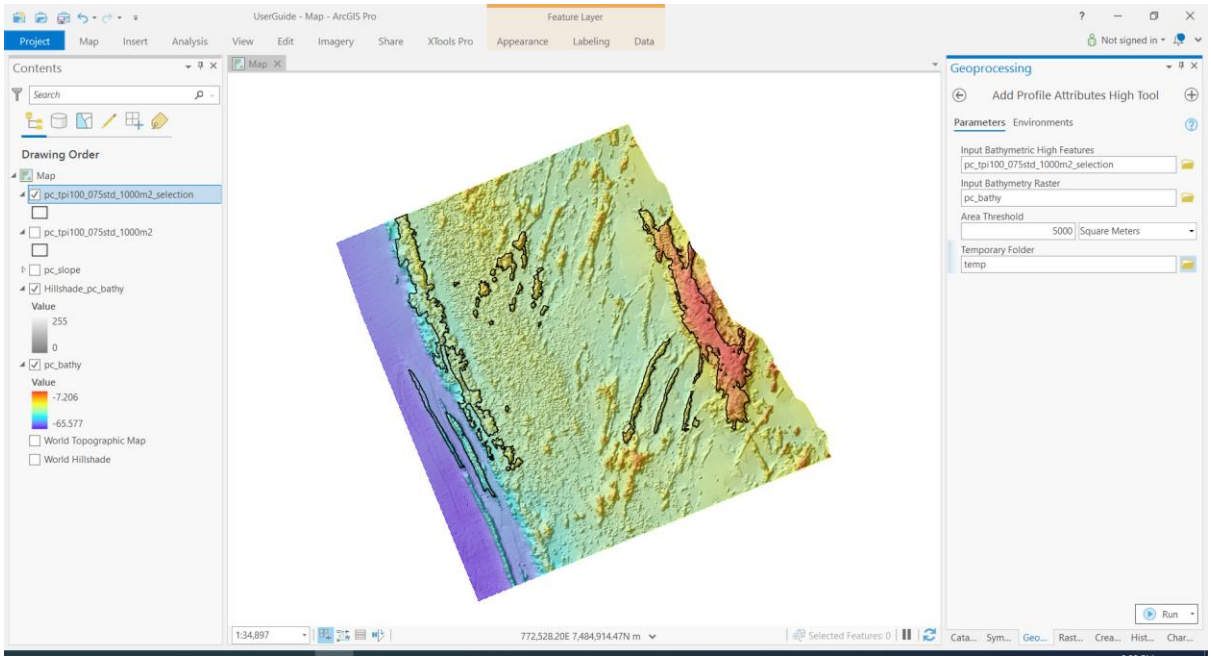


5. Explore the topographic attributes of the bathymetric high features if you wish. Otherwise, continue next step.

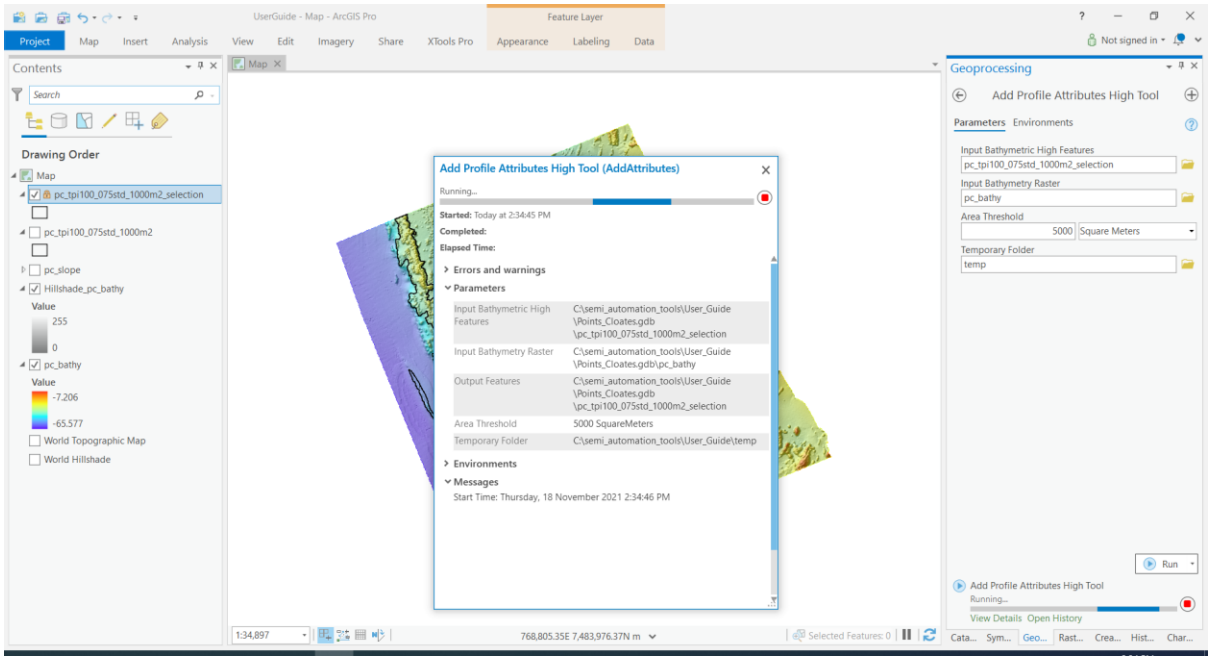
6.6. Add Profile Attributes High Tool

1. Select the Add Profile Attributes High Tool from the AddAttributes toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Features, select pc_tpi100_075std_1000m2_selection from the drop-down list or navigate to Points_Cloates.gdb and add pc_tpi100_075std_1000m2_selection. For the Input Bathymetry

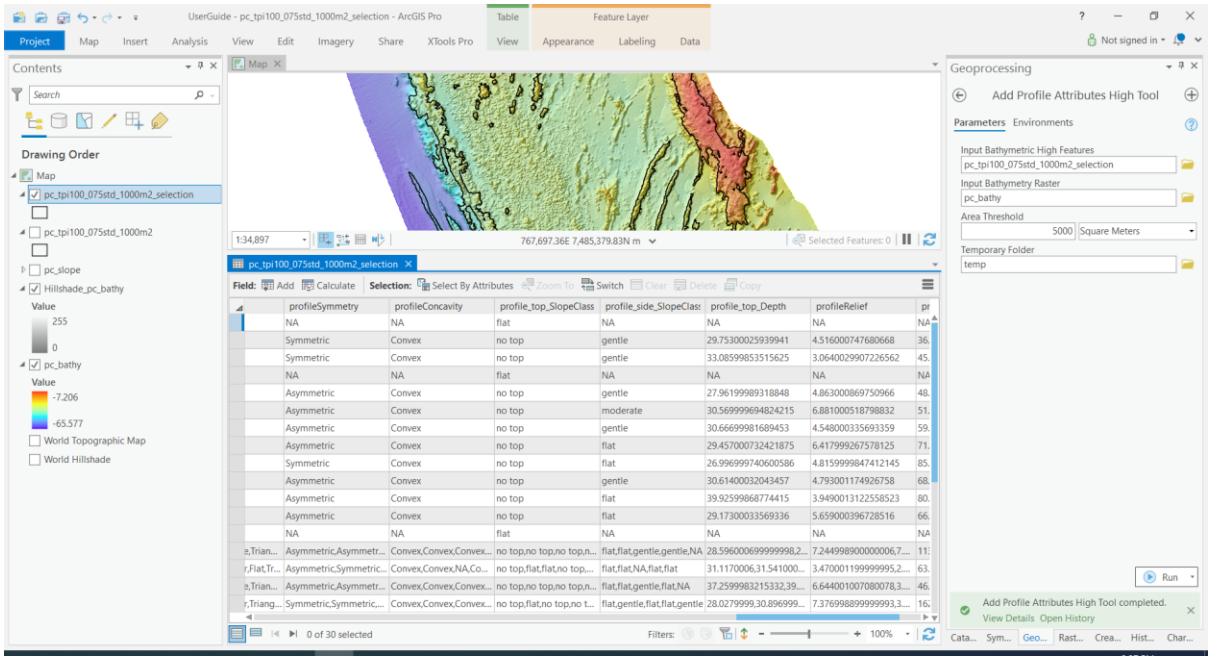
Raster, select pc_bathy from the drop-down list or navigate to Points_Cloates.gdb and add pc_bathy. For the Area Threshold, enter 5000 Square Meters. For the Temporary Folder, nominate a folder.



2. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



3. After the geoprocessing is completed, check that the profile attributes have been generated.



4. Explore the profile attributes of the bathymetric high features if you wish.

7. Use Classification Feature tools

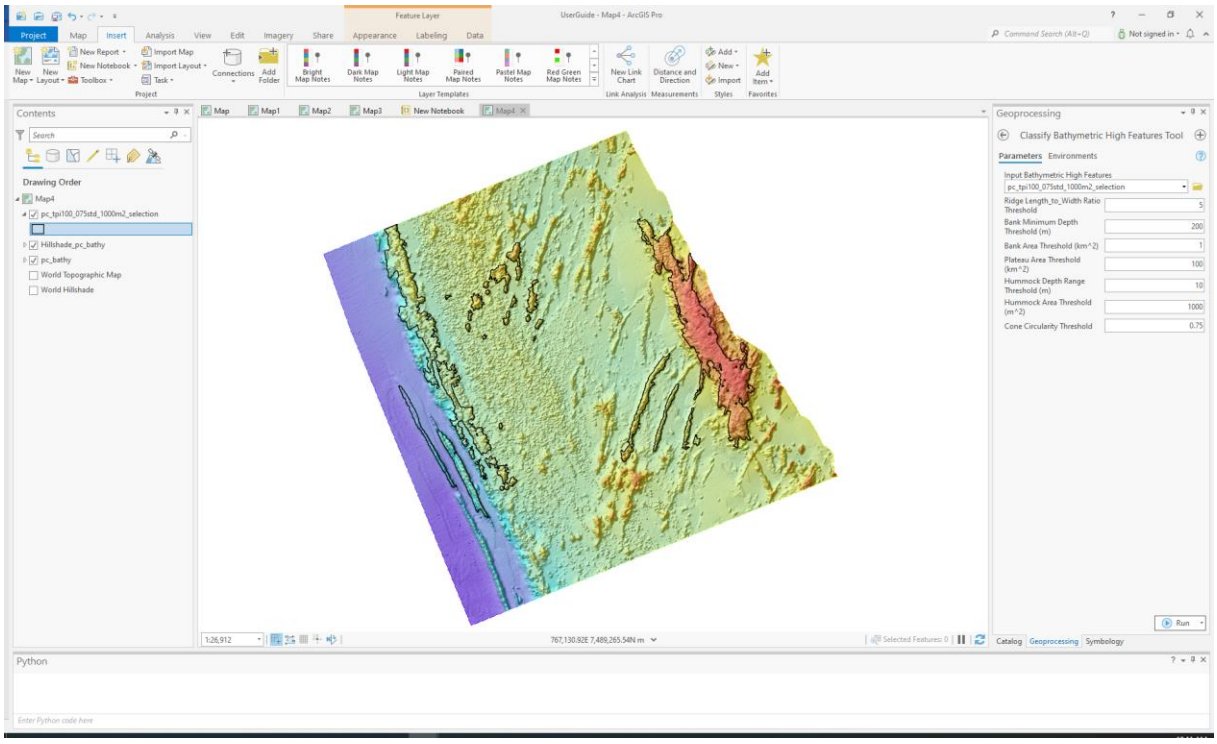
The ClassificationFeature toolbox contains two tools. Please see detailed metadata of these tools.

- Classify Bathymetric High Features: This tool classifies each bathymetric high feature into one of several feature types.
- Classify Bathymetric Low Features: This tool classifies each bathymetric low feature into one of several feature types.

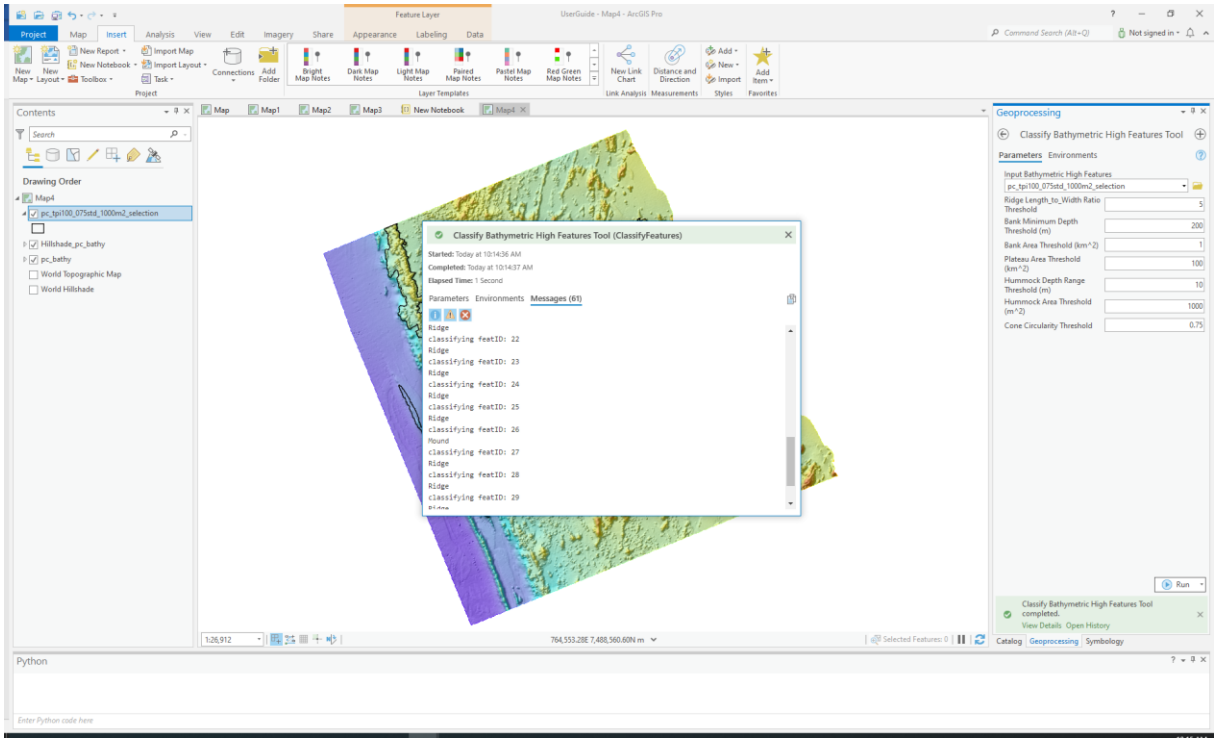
7.1. Classify Bathymetric High Features Tool

This tool classifies each bathymetric high feature into one morphological feature type based on the attributes calculated from the Add Attributes tools.

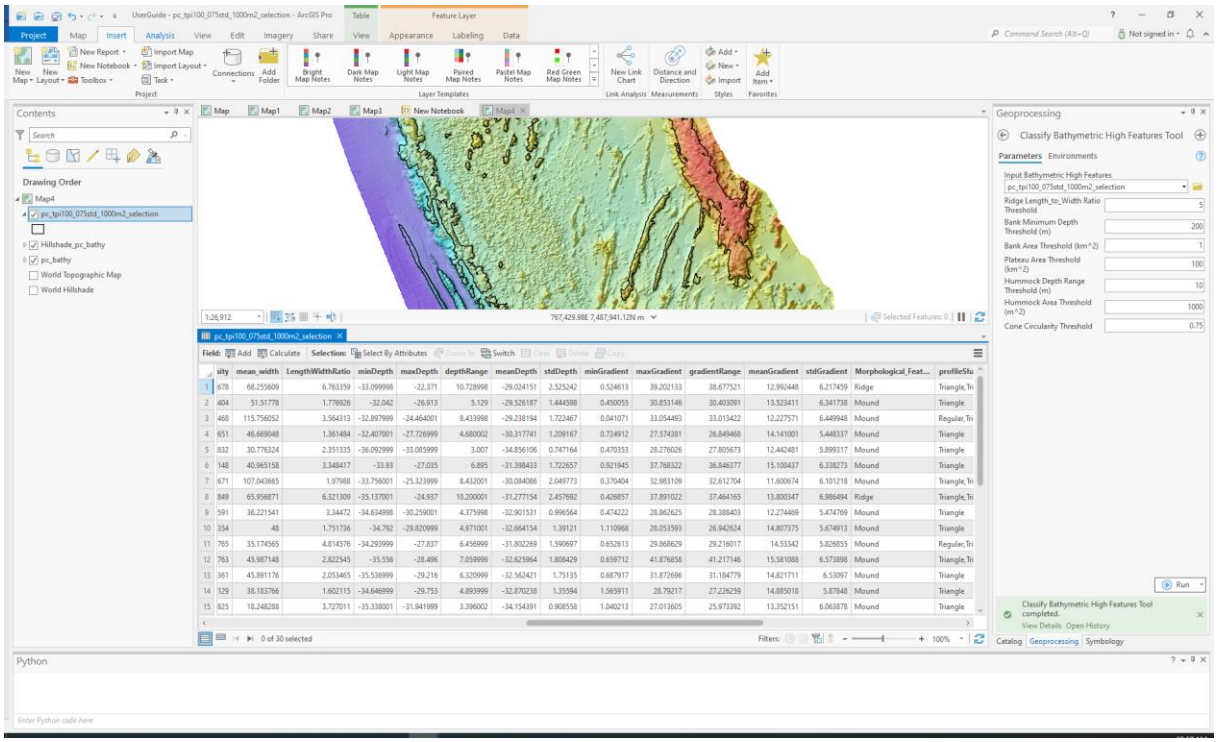
1. If not already loaded, create a new map and open pc_tpi100_075std_1000m2_selection bathymetric high features and associated data from Points_Cloates.gdb in the map.
2. Select the Classify Bathymetric High Features Tool from the ClassificationFeature toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Bathymetric High Features, select pc_tpi100_075std_1000m2_selection from the drop-down list or navigate to Points_Cloates.gdb and select pc_tpi100_075std_1000m2_selection. For all other parameters, keep the default values.



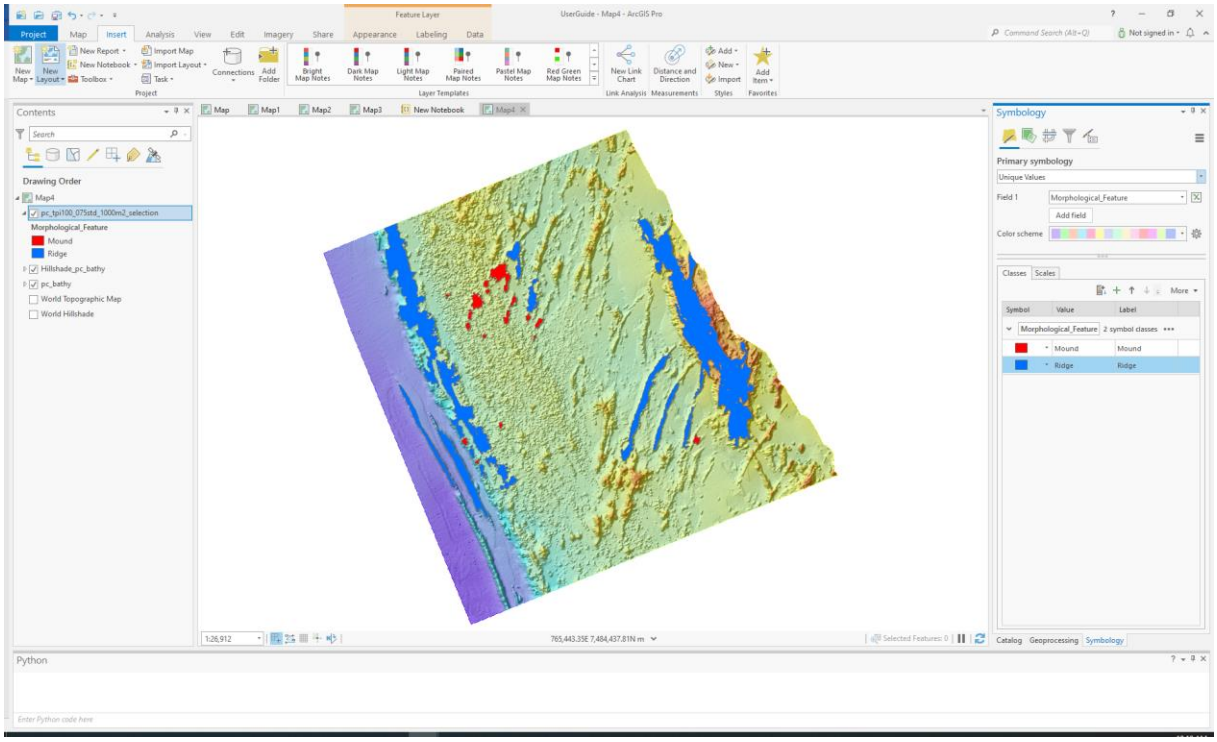
3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, check that the Morphological_Feature attribute has been generated. This attribute lists the morphological feature resulted from the classification.



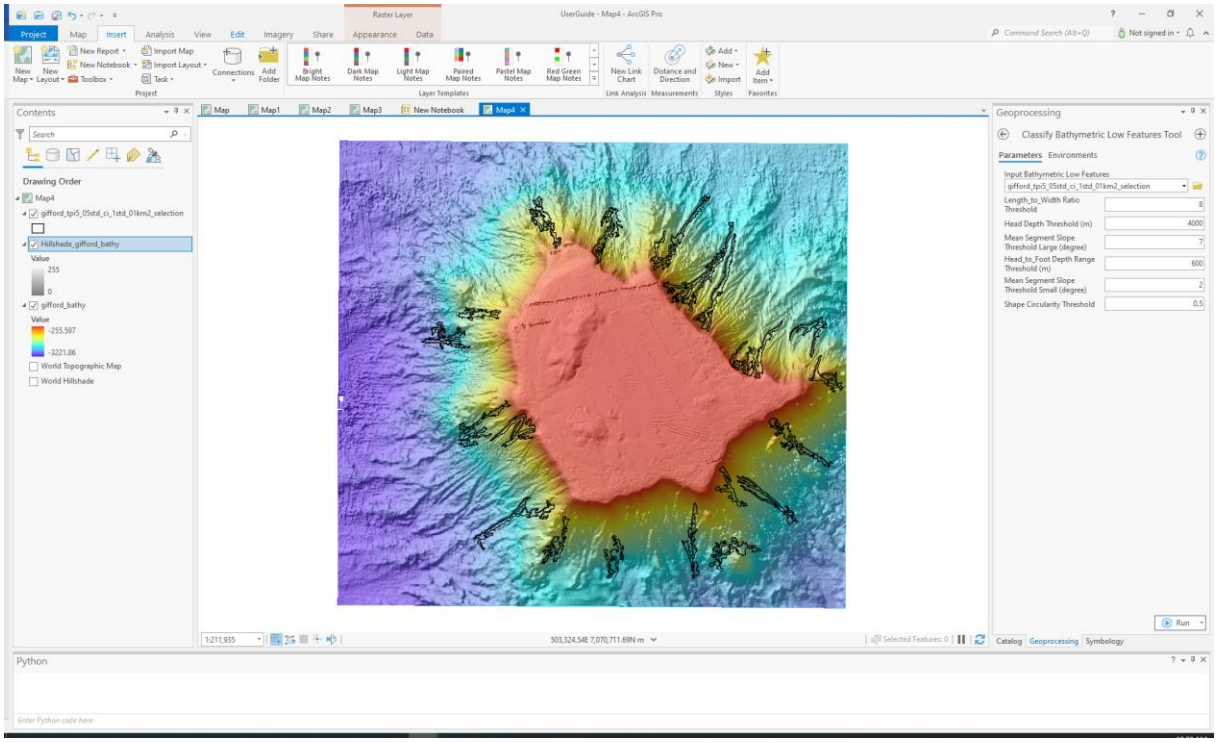
5. To display the classification results, change the symbology as Unique Values, select Morphological_Feature field, select an appropriate colour scheme, and apply the new symbology. The individual morphological feature types are now displayed as distinctive colours.



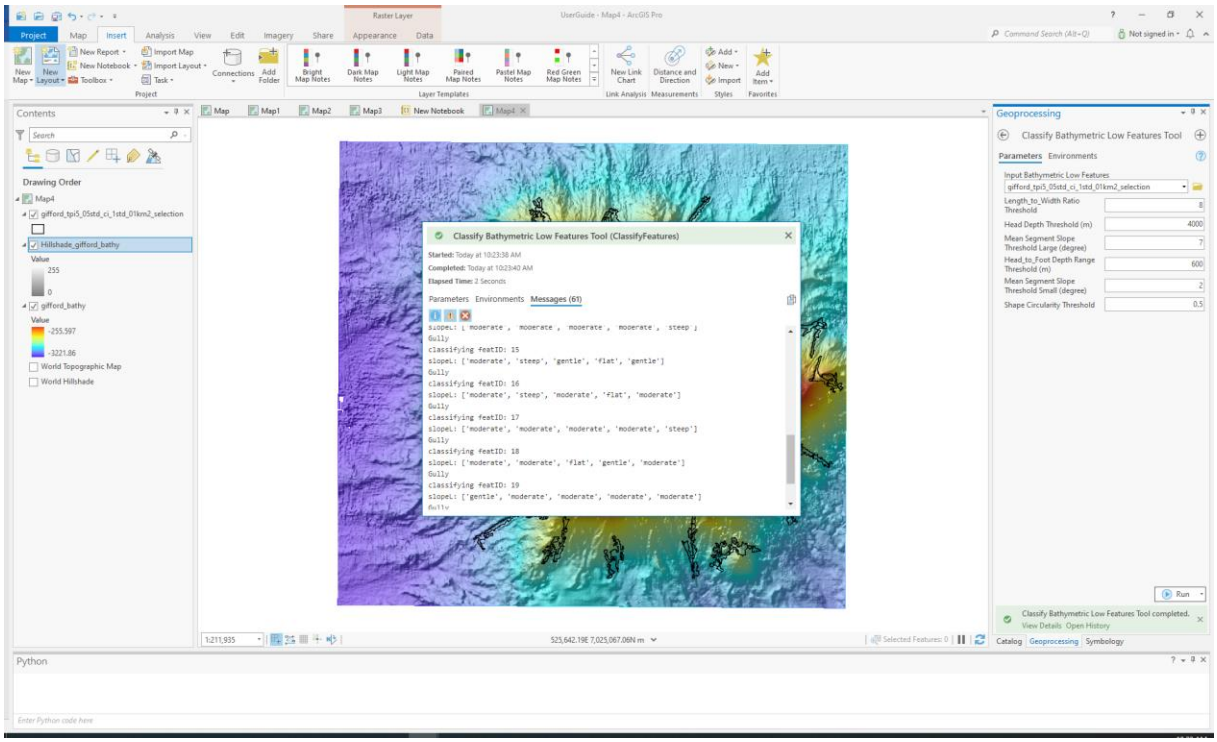
7.2. Classify Bathymetric Low Features Tool

This tool classifies each bathymetric low feature into one morphological feature type based on the attributes calculated from the Add Attributes tools.

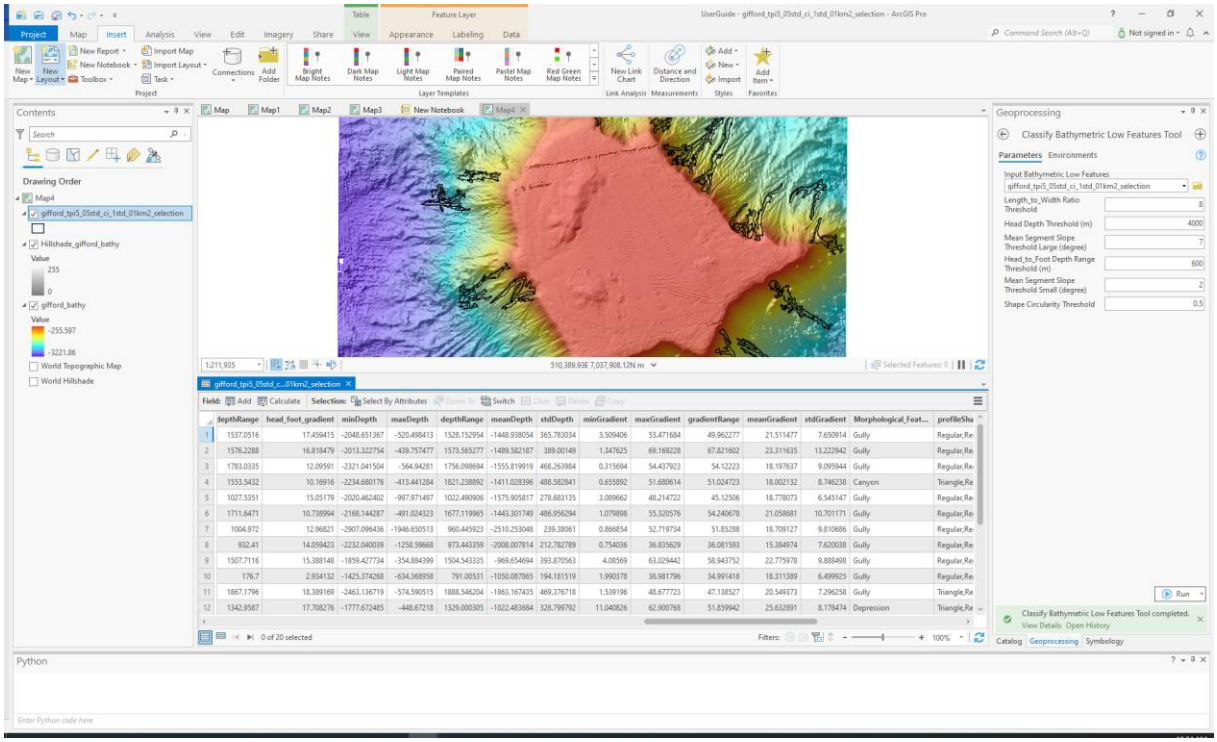
1. If not already loaded, create a new map and open gifford_tpi5_05std_ci_1std_01km2_selection bathymetric low features and associated data from Gifford.gdb in the map.
2. Select the Classify Bathymetric Low Features Tool from the ClassificationFeature toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Bathymetric Low Features, select gifford_tpi5_05std_ci_1std_01km2_selection from the drop-down list or navigate to Gifford.gdb and select gifford_tpi5_05std_ci_1std_01km2_selection. For all other parameters, keep the default values.



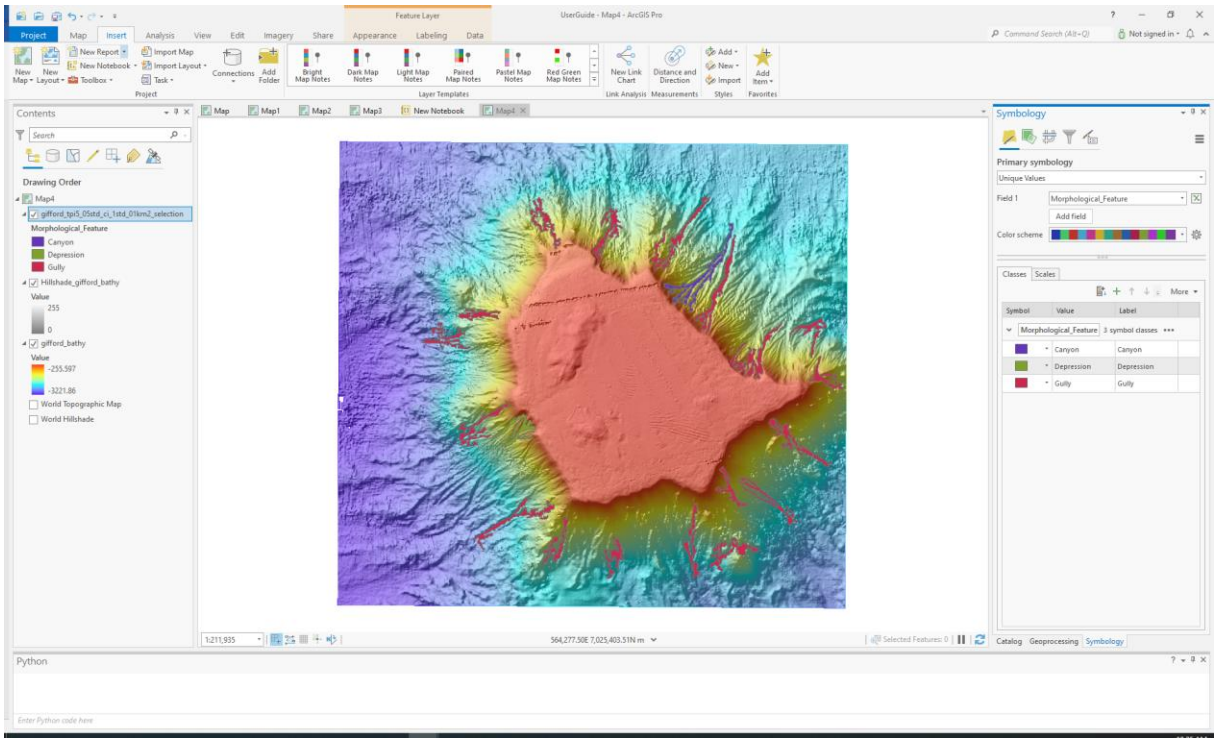
3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. After the geoprocessing is completed, check that the Morphological_Feature attribute has been generated. This attribute lists the morphological feature resulted from the classification.



5. To display the classification results, change the symbology as Unique Values, select Morphological_Feature field, select an appropriate colour scheme, and apply the new symbology. The individual morphological feature types are now displayed as distinctive colours.



8. Use Accessory Tools

The Accessory_Tools toolbox currently contains two tools. Please see the detailed metadata from each tool.

- Merge Connected Features Tool: This tool merges polygon features that are connected through shared points or borders.
- Connect Nearby Linear Features Tool: This tool connects nearby linear bathymetric low features.

Two or multiple polygons that are connected through a shared point or border may be considered as a single feature. The Merge Connected Features Tool is used to merge (or dissolve) these connected polygons into larger polygons. A linear bathymetric low feature such as canyon, channel, valley and gully is sometimes broken into multiple smaller and disconnected features due to several possible reasons:

- deficiency in the bathymetric data,
- deficiency in the mapping method, and
- natural local processes such as erosion and disposition.

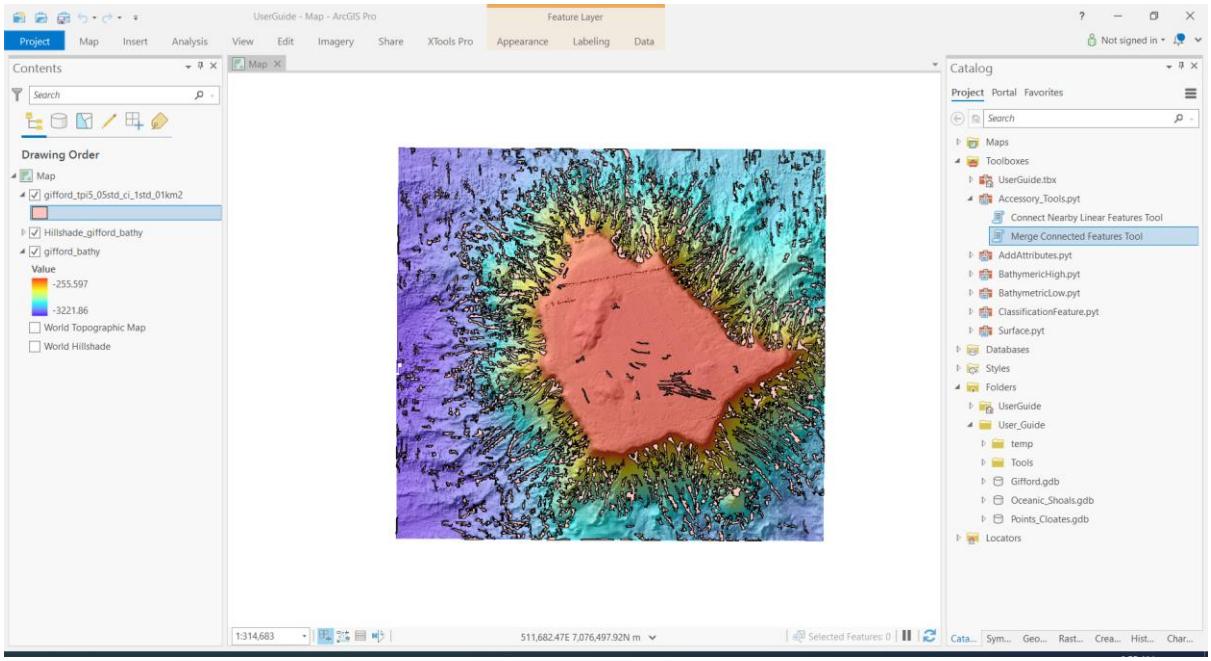
Ideally, these disconnected features should be merged to form a single integrated linear feature to facilitate the subsequent attribute generation and classification. However, the users are advised to make their own judgement on whether to apply one or both of these two accessory tools before the subsequent attribute generation and classification steps.

This Connect Nearby Linear Features Tool is used to connect (or merge) two or multiple bathymetric low features that satisfying the following conditions:

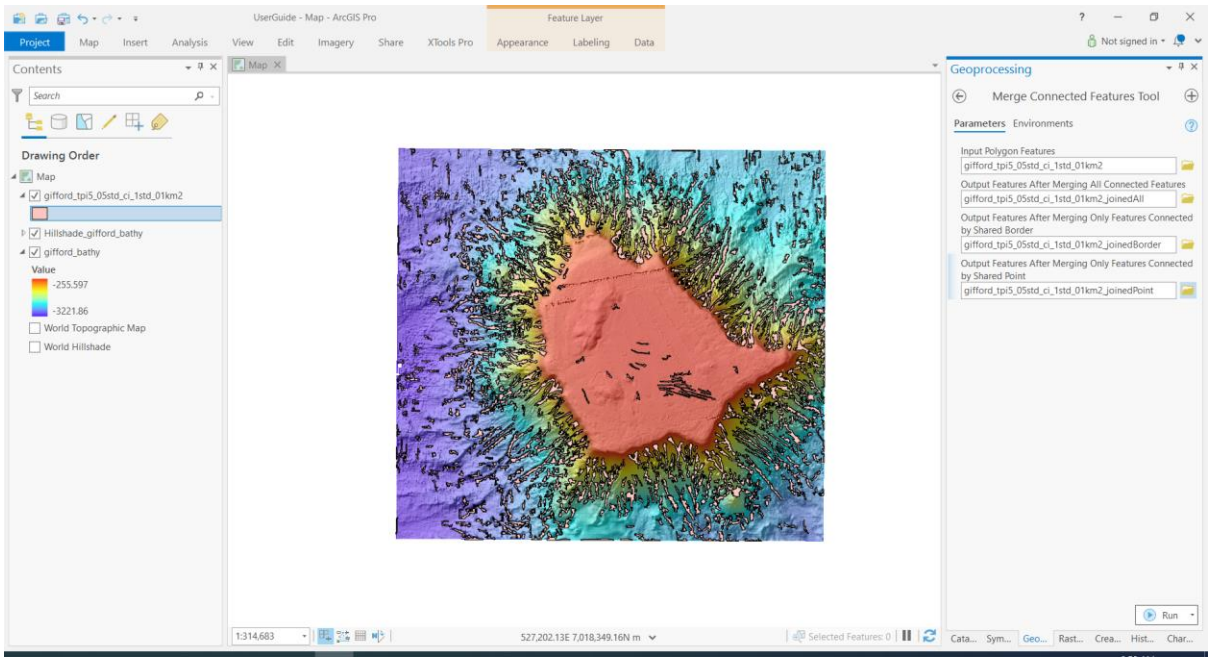
- the distance between the head of one feature and the foot of another feature is less than a user-defined threshold, and
- the two nearby features align in orientation with the intersecting angle < 45 degree.

8.1. Merge Connected Features Tool

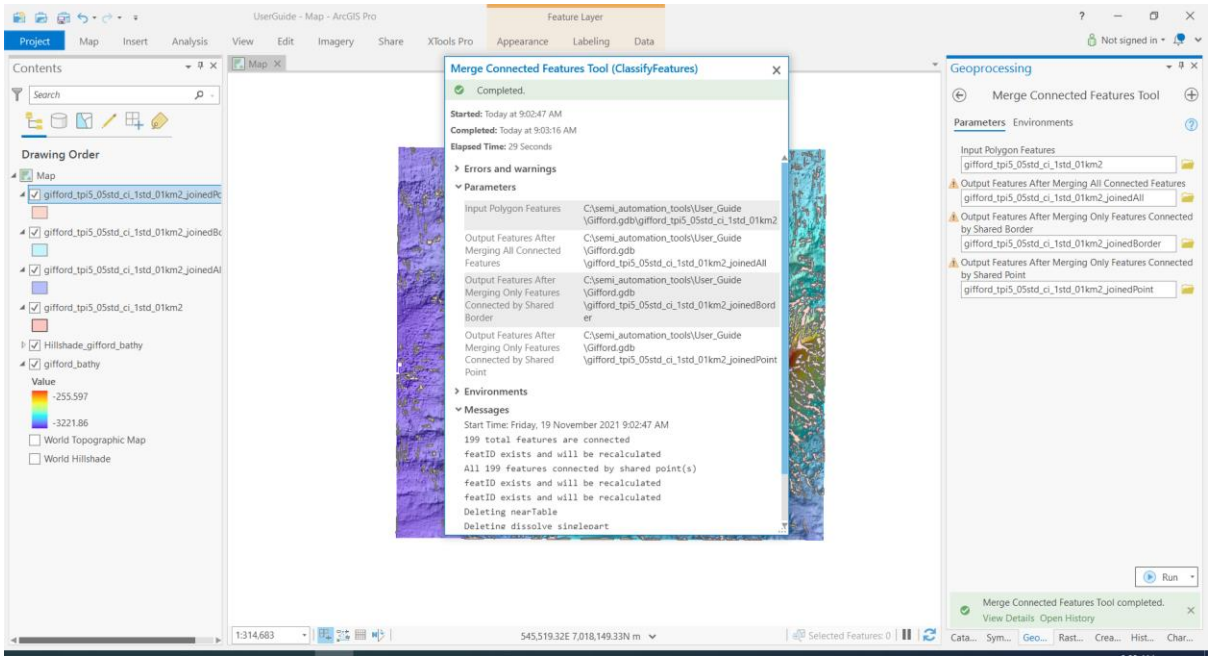
1. If not already loaded, create a new map and open gifford_tpi5_05std_ci_1std_01km2 bathymetric low features and associated data from Gifford.gdb in the map.



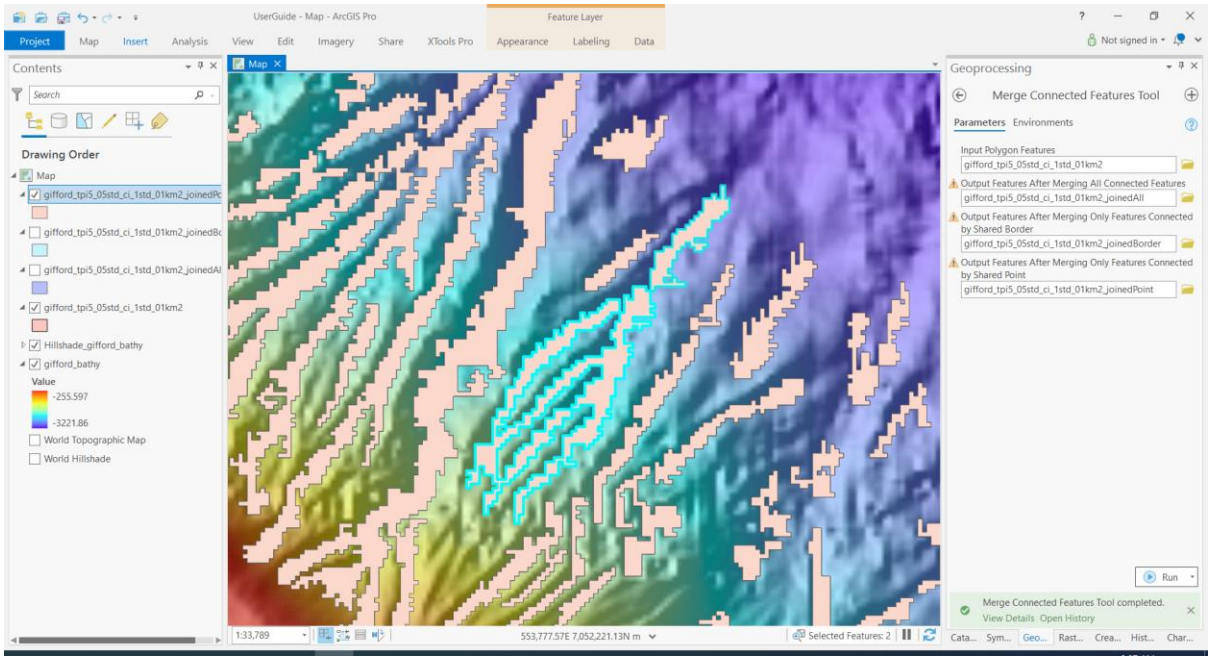
2. Select the Merge Connected Features Tool from the Accessory_Tools toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Polygon Features, select gifford_tpi5_05std_ci_1std_01km2 from the drop-down list or navigate to Gifford.gdb and select gifford_tpi5_05std_ci_1std_01km2. For the Output Features After Merging All Connected Features, navigate to Gifford.gdb and enter a name like "gifford_tpi5_05std_ci_1std_01km2_joinedAll". For the Output Features After Merging Only Features Connected by Shared Border, navigate to Gifford.gdb and enter a name like "gifford_tpi5_05std_ci_1std_01km2_joinedBorder". For the Output Features After Merging Only Features Connected by Shared Point, navigate to Gifford.gdb and enter a name like "gifford_tpi5_05std_ci_1std_01km2_joinedPoint".



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages. From the messages, we know that there are 199 features spatially connected. All these features are connected by shared points.



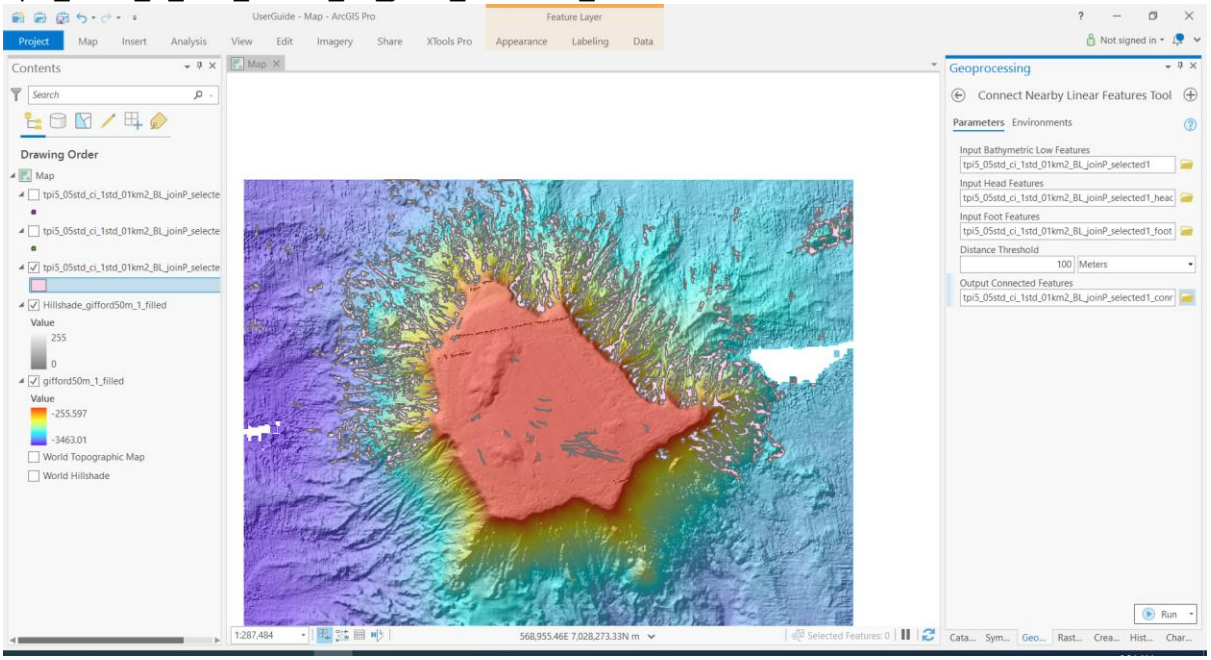
4. Examine the output features after merging the connected features. For example, the highlighted feature shown below is the result of merging two features connecting through a point.



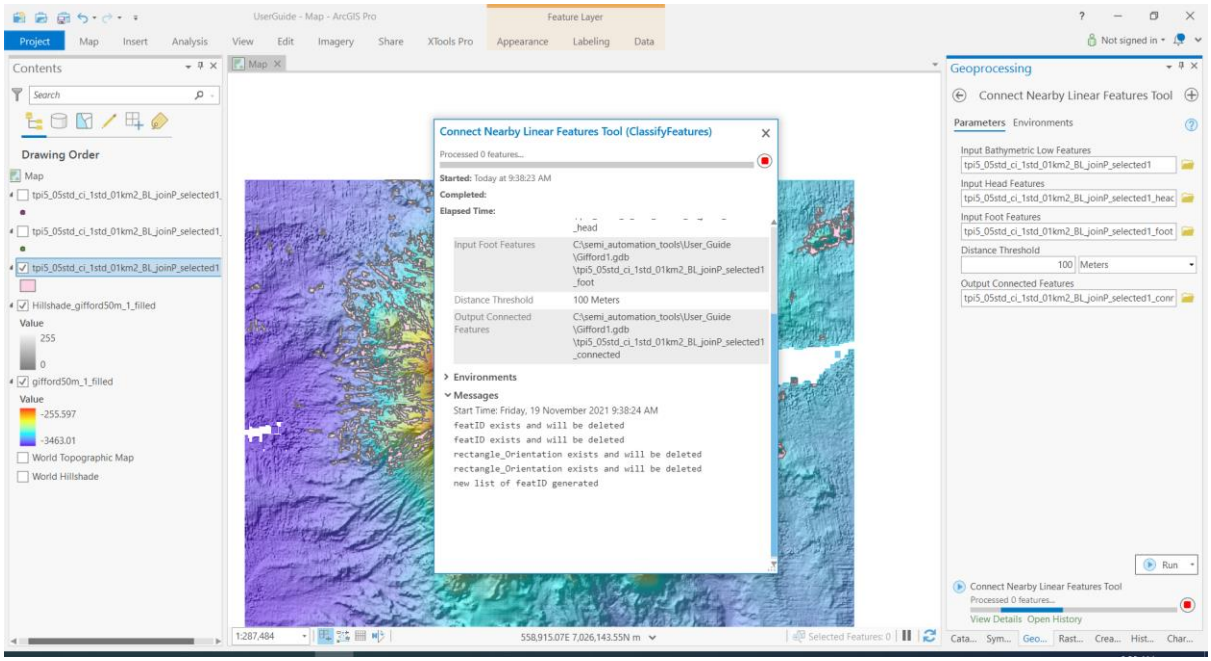
8.2. Connect Nearby Linear Features Tool

1. If not already loaded, create a new map and open tpi5_05std_ci_1std_01km2_BL_joinP_selected1 bathymetric low features, tpi5_05std_ci_1std_01km2_BL_joinP_selected1_head head features, tpi5_05std_ci_1std_01km2_BL_joinP_selected1_foot foot features, and associated data from Gifford1.gdb in the map.
2. Select the Connect Nearby Linear Features Tool from the Accessory Tools toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Polygon Features, select tpi5_05std_ci_1std_01km2_BL_joinP_selected1 from the drop-down list or navigate to Gifford1.gdb and select tpi5_05std_ci_1std_01km2_BL_joinP_selected1. For the Input Head Features, select tpi5_05std_ci_1std_01km2_BL_joinP_selected1_head from the drop-down list or navigate to the Gifford1.gdb and select tpi5_05std_ci_1std_01km2_BL_joinP_selected1_head. For the Input Foot Features, select tpi5_05std_ci_1std_01km2_BL_joinP_selected1_foot from the drop-down list or navigate to the Gifford1.gdb and select tpi5_05std_ci_1std_01km2_BL_joinP_selected1_foot. For the Distance Threshold, enter 100 Meters. For the Output Connected Features, navigate to the Gifford1.gdb and enter a name like

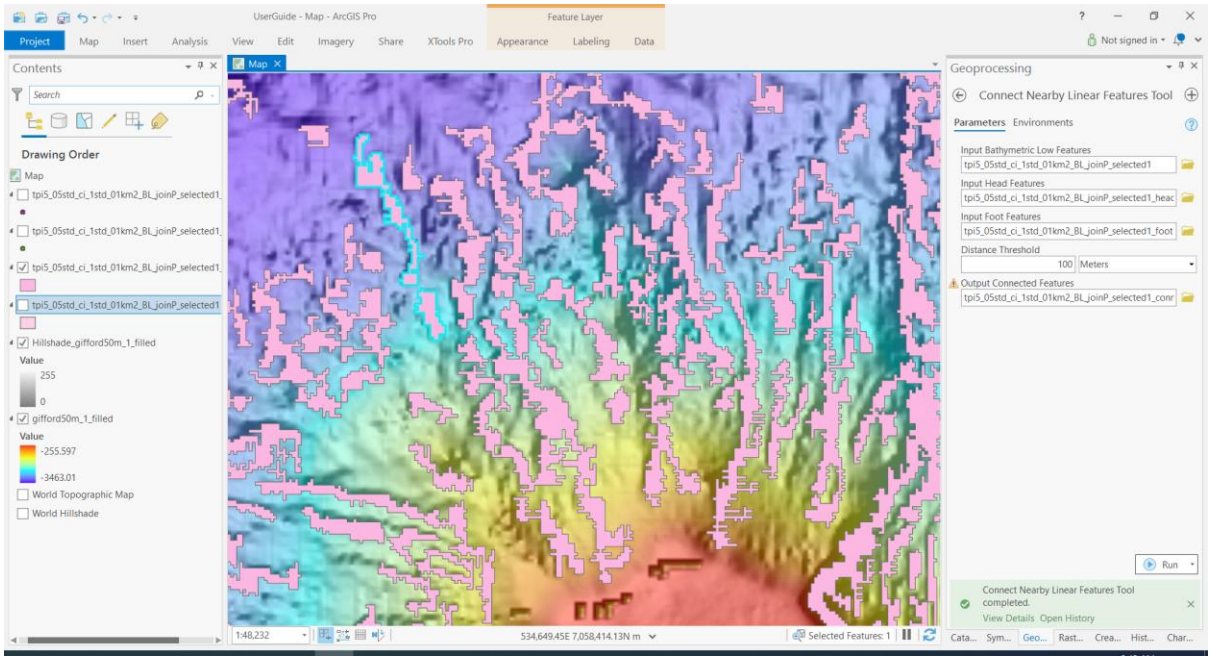
“tpi5_05std_ci_1std_01km2_BL_joinP_selected1_connected”.



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. Examine the output features after connecting the linear nearby features. For example, the highlighted feature shown below is the result of merging two features that are spatially separated but satisfying the connecting criteria.



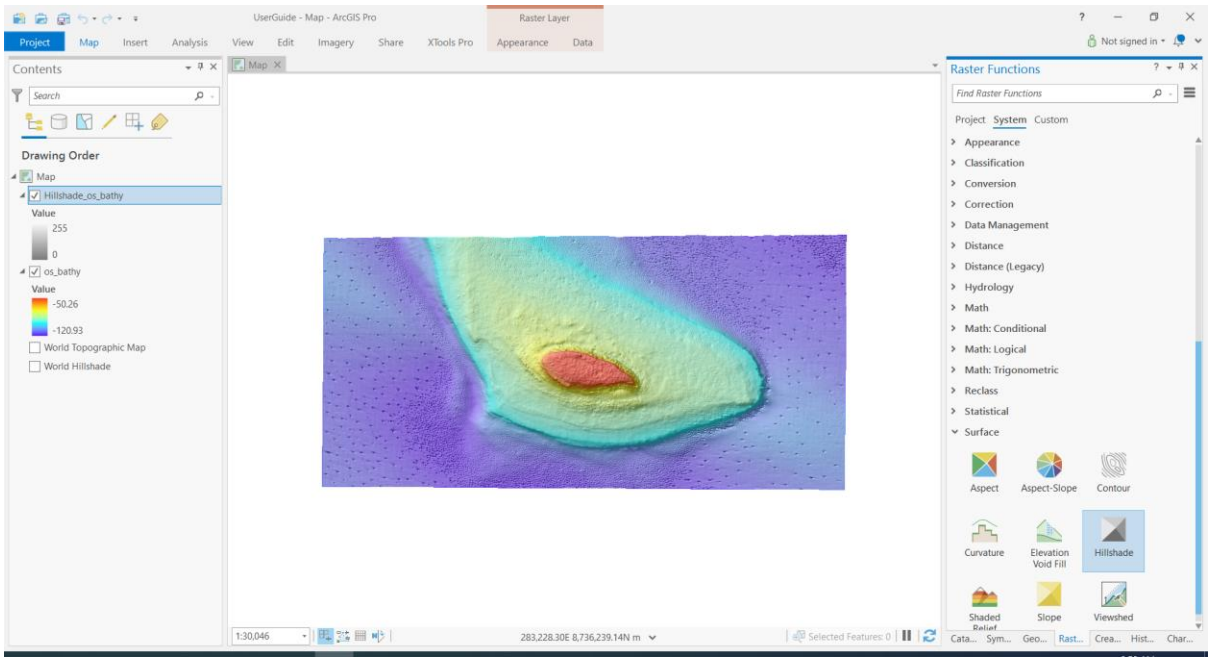
9. Use Surface Tools

The Surface toolbox contains two tools. Please see detailed metadata of each tool.

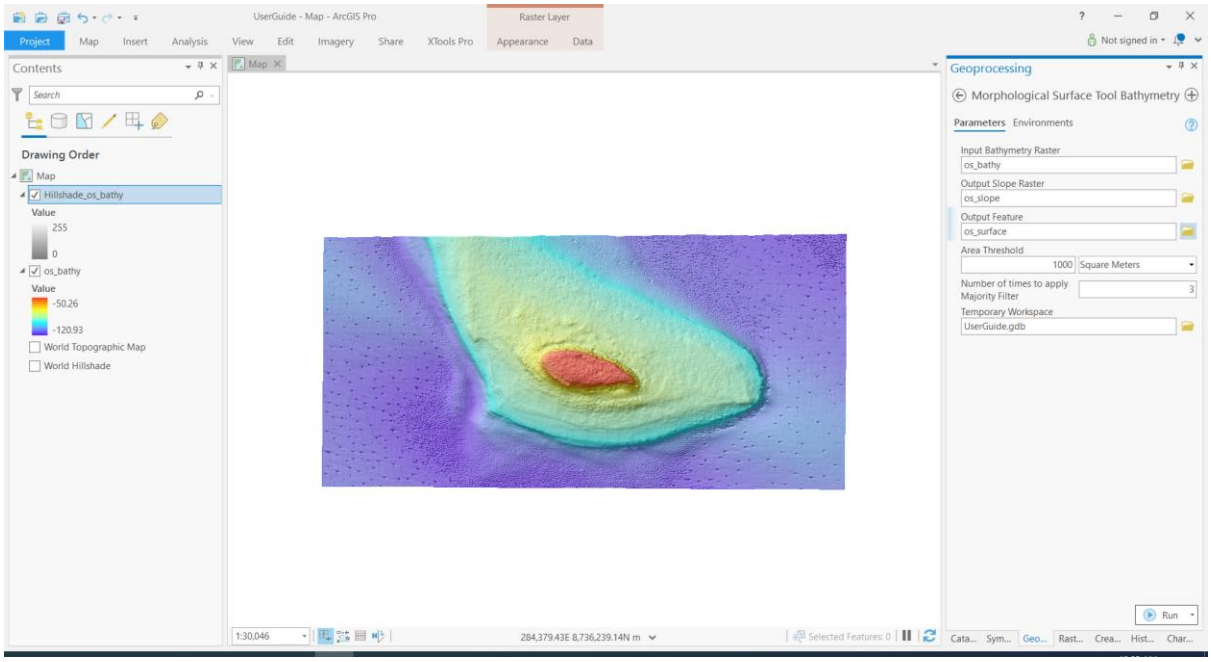
- Morphological Surface Tool Bathymetry: This tool classifies an area into three "surface" categories: Plane, Slope and Escarpment from a bathymetric data.
- Morphological Surface Tool Slope: This tool classifies an area into three "surface" categories: Plane, Slope and Escarpment from a slope gradient grid.

9.1. Morphological Surface Tool Bathymetry

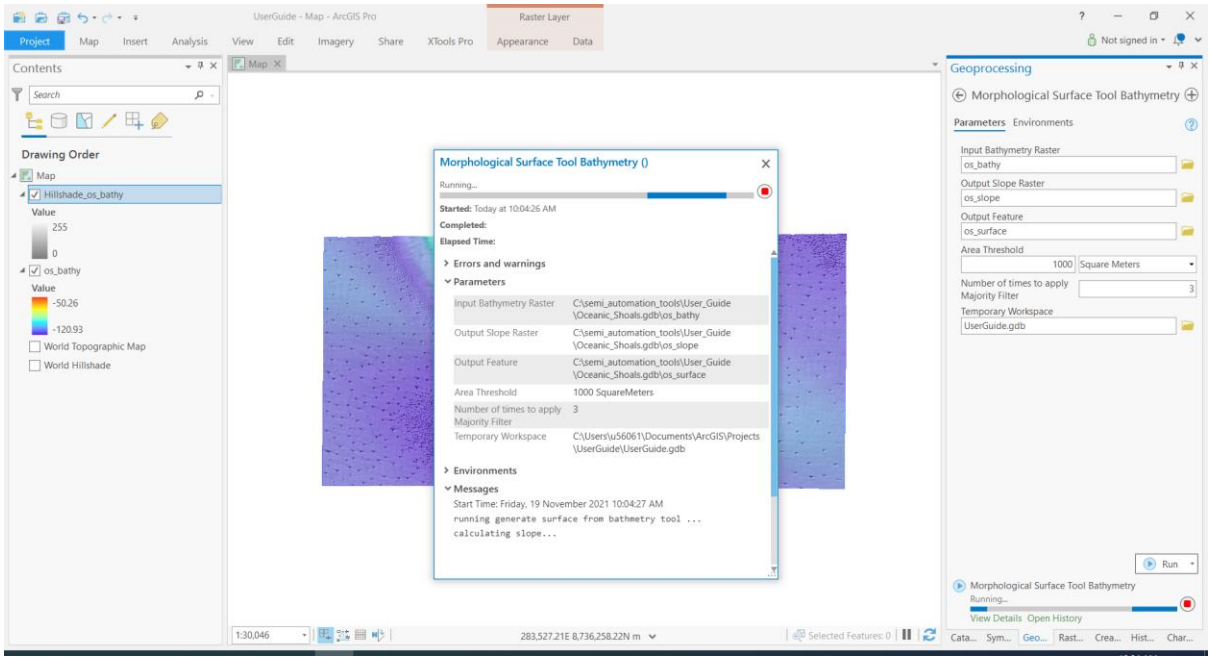
1. If not already loaded, create a new map and open os_bathy grid from Oceanic_Shoals.gdb in the map.



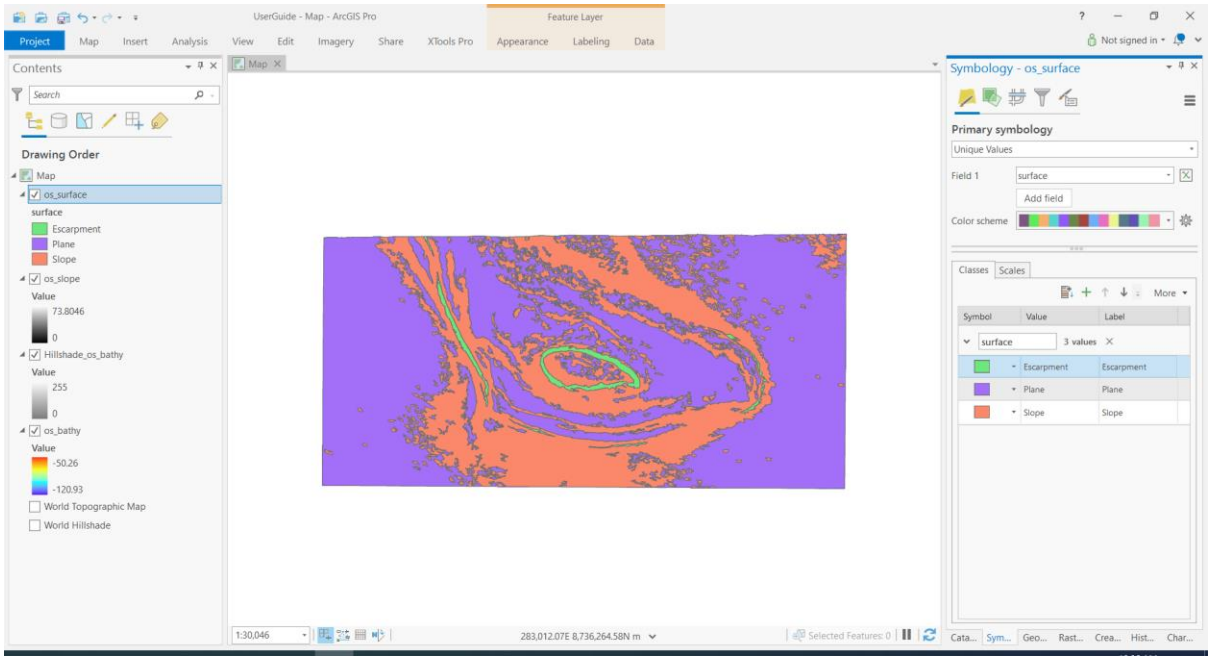
2. Select the Morphological Surface Tool Bathymetry from the Surface toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Bathymetry Raster, select os_bathy from the drop-down list or navigate to the Oceanic_Shoals.gdb and select os_bathy grid. For the Output Slope Raster, navigate to the Oceanic_Shoals.gdb and enter a name like “os_slope”. For the Output Feature, navigate to the Oceanic_Shoals.gdb and enter a name like “os_surface”. For the Area Threshold, enter 1000 Square Meters. For the Number of times to apply Majority Filter, keep the default value. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.

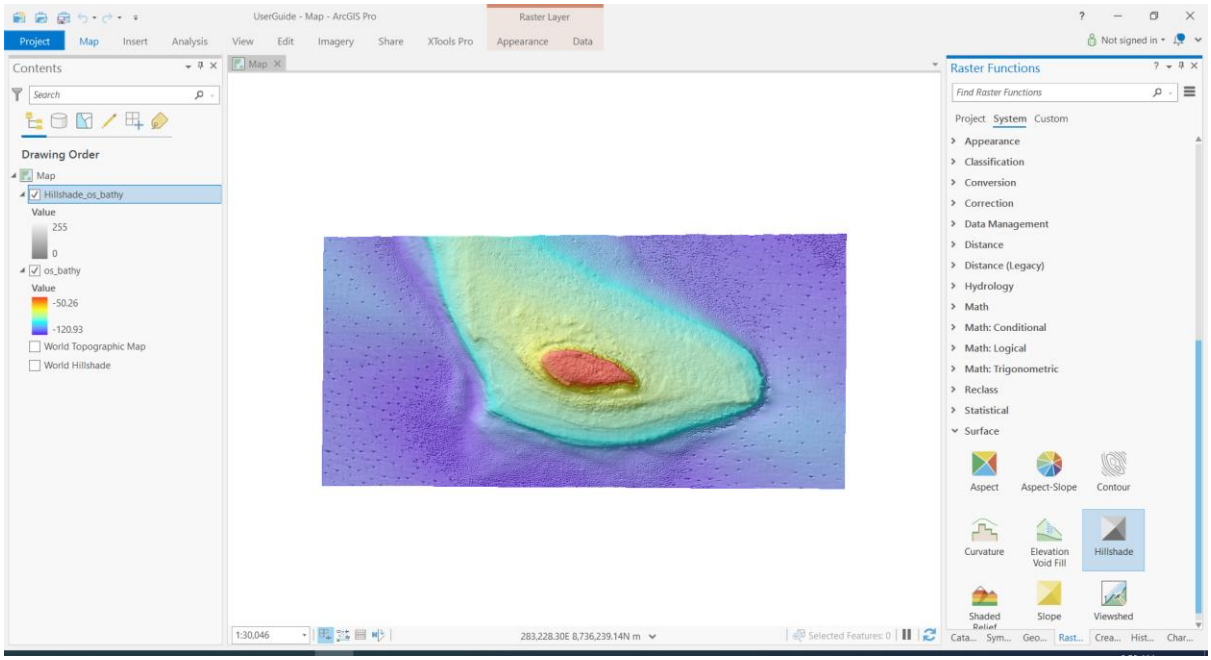


4. Examine the output surface features after the geoprocessing is completed. Symbolise the output features to display the three surface classes as distinct colors.

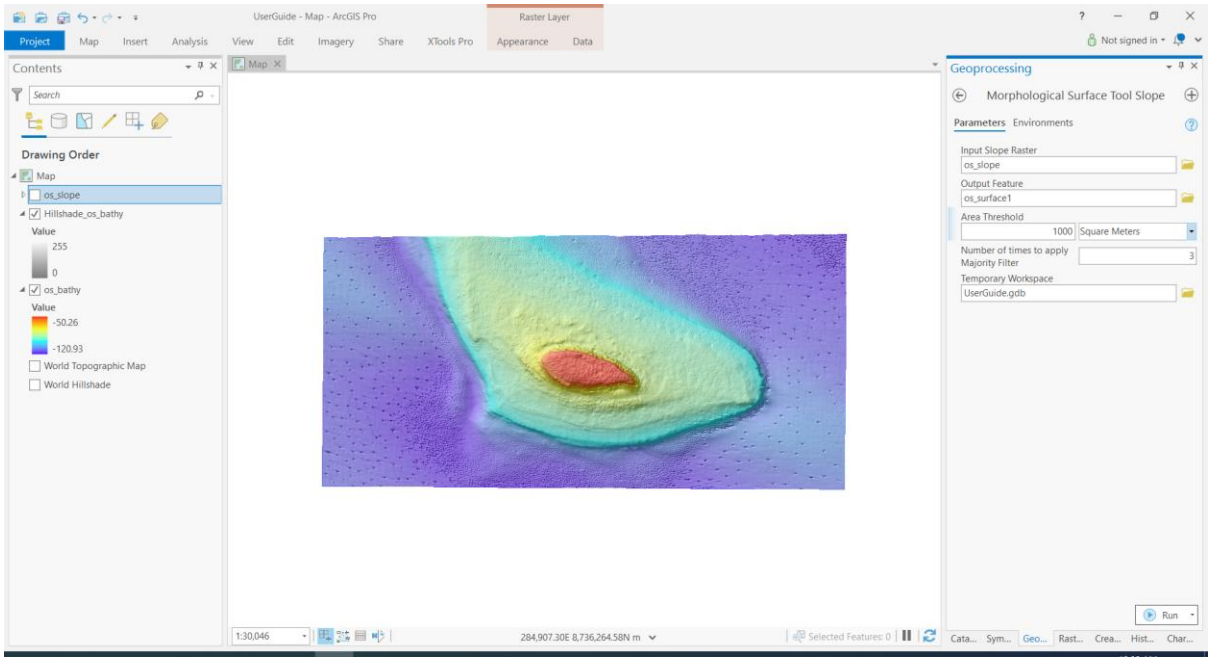


9.2. Morphological Surface Tool Slope

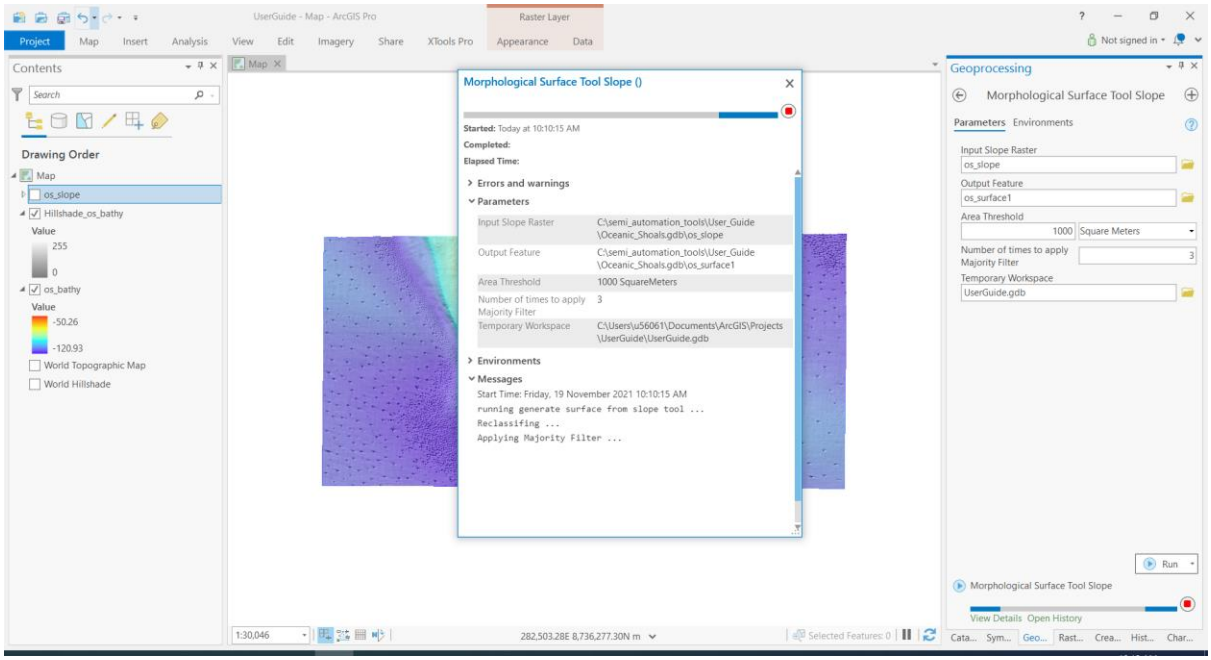
1. If not already loaded, create a new map and open os_bathy grid from Oceanic_Shoals.gdb in the map.



2. Select the Morphological Surface Tool Slope from the Surface toolbox. Double-Click to open it on the Geoprocessing tab. For the Input Slope Raster, select os_slope grid from the drop-down list or navigate to the Oceanic_Shoals.gdb and select os_slope grid. For the Output Feature, navigate to the Oceanic_Shoals.gdb and enter a name like “os_surface1”. For the Area Threshold, enter 1000 Square Meters. For the Number of times to apply Majority Filter, keep the default value. For the Temporary Workspace, nominate a File Geodatabase that is different from the input/output workspace(s).



3. Click the Run button to start the tool. Open the View Details tab to display the geoprocessing messages.



4. Examine the output surface features after the geoprocessing is completed. Symbolise the output features to display the three surface classes as distinct colors.