ArcGIS Pro Spatial Analyst Extension

Surface Tools:

Contour, Topo to Raster, Slope, Hillshade

Technical Innovation and Professional Services (TIPS)

TIPS Tools in service to the SMCRA professional

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Table of Contents

Quick Guide and Tutorial Overview

The ArcGIS Pro Spatial Analyst extension provides a broad range of powerful spatial modeling and analysis capabilities. You can create, query, map, and analyze cell-based raster data; perform integrated raster/vector analysis; derive new information from existing data; query information across multiple data layers; and fully integrate cell-based raster data with traditional vector data sources.

An overview of the ArcGIS Spatial Analyst and its capabilities can be found here.

By the end of this tutorial, you'll be able to:

1. Set up and create a project in ArcGIS Pro,
2. Instructions on how to keep your project and data organized,
3. Access the Spatial Analyst Toolbox,
4. Add external data to your geodatabase,
5. Create a contour feature class from a raster or through the editing tools,
6. Clip an area of interest,
7. Create a raster surface from a contour feature class for analysis,
8. Perform Slope and Hillshade analysis from a raster.

GIS Terms and Definitions

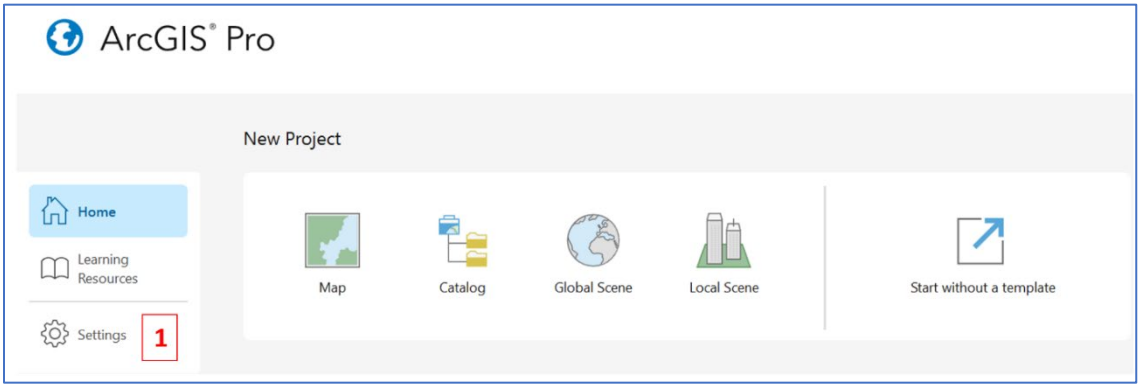
For a comprehensive list of GIS terms and definitions, please refer to this GIS dictionary hosted by Esri: GIS Dictionary (esri.com)

Project setup

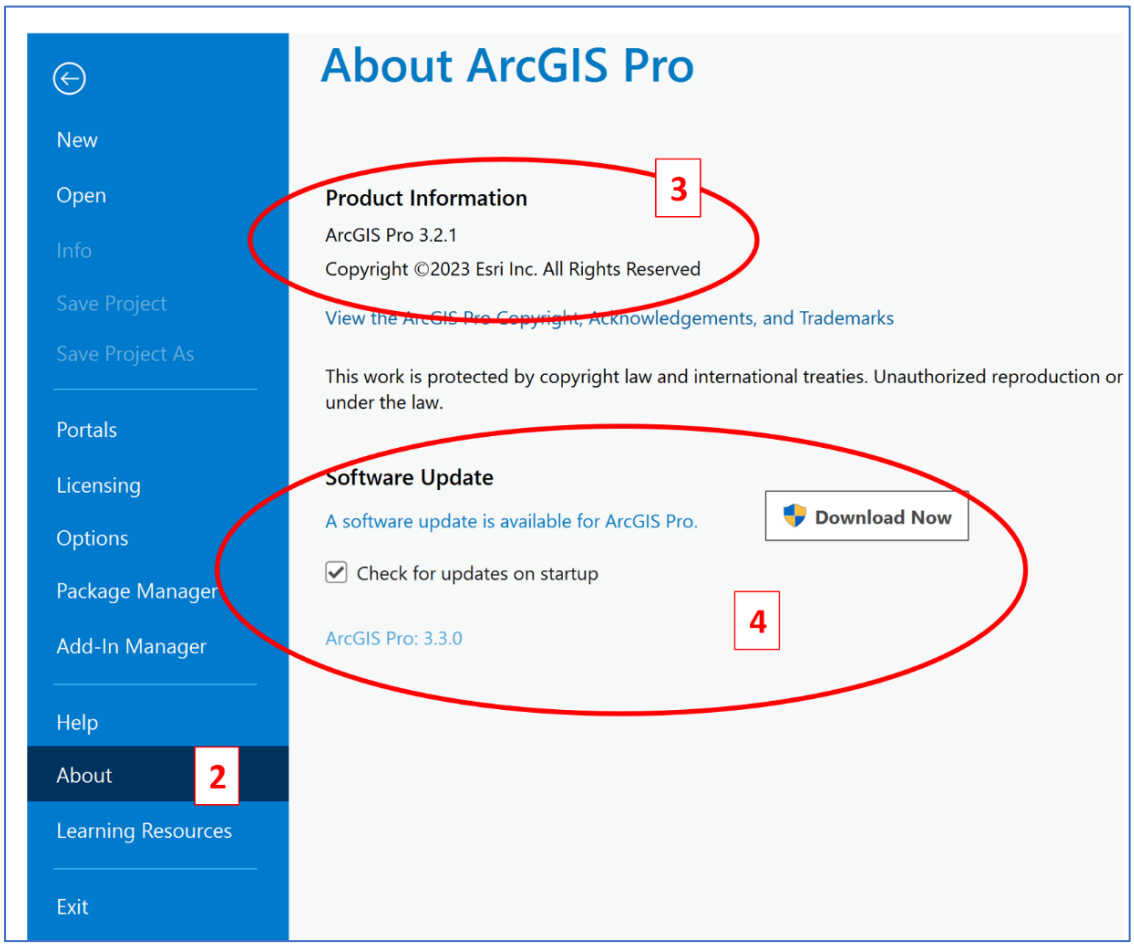
Verify: ArcGIS Pro Software Version and Spatial Analyst Extension License

It is important to have the latest update for the ArcGIS Pro Software since many small steps change from update to update. The most current version to-date (6/26/2024) is 3.3.0. To check what version you have, follow these steps:

1. Open ArcGIS Pro 



2. On the initial screen, on the top left menu, click **Settings (1, above)** and then **About (2, below)** if it is not already selected.

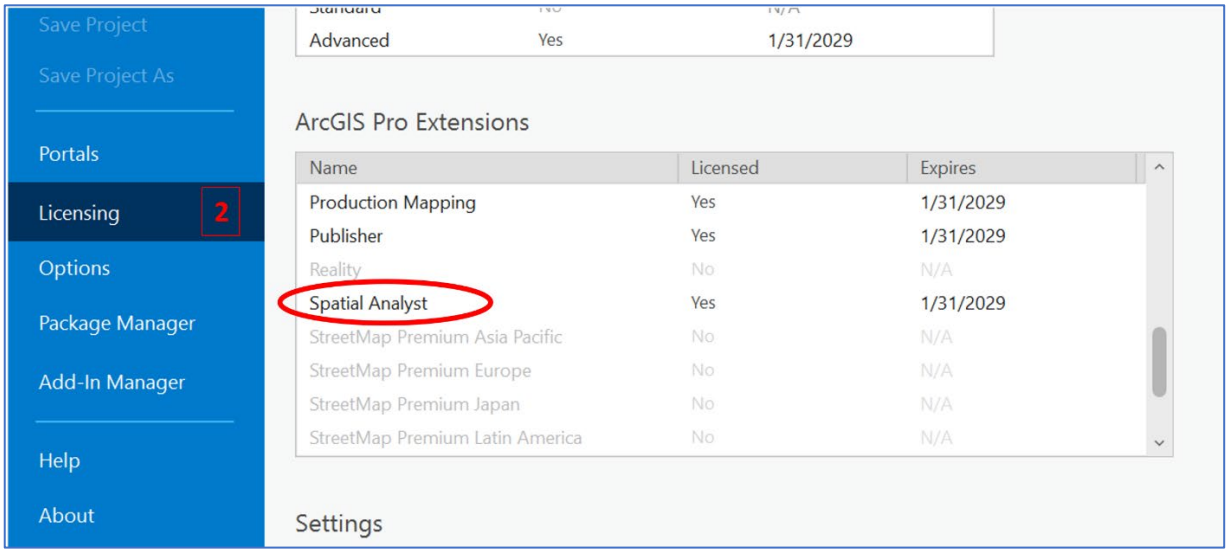


3. To the right of the menu, you should see the version that you have installed **(3, above)** and if you need to install any new updates **(4, above).**

To check your Spatial Analyst Extension License, follow these steps:

4. On the same screen, click on **Licensing (2, see below)** on the left side of the screen.

5. Scroll down to the **ArcGIS Pro Extensions** list until you find **Spatial Analyst.** If you're licensed, you'll see the name in the list and when the license expires. If you have Spatial Analyst, there's nothing more you need to do. If not, contact your OSMRE AGOL admin to activate the extension.



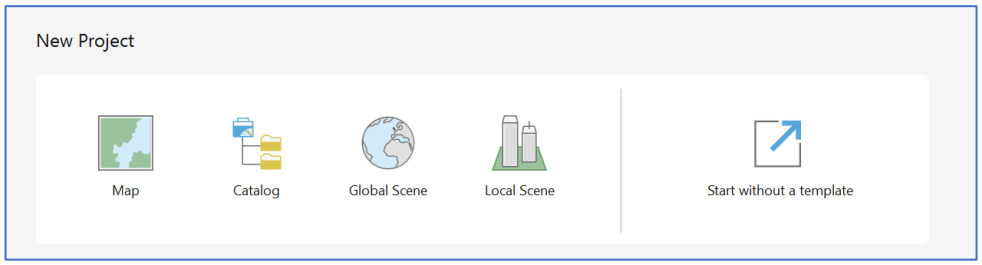
Create a Project in ArcGIS Pro

1. If your ArcGIS Pro is not already open, double click on the ArcGIS Pro icon to open the application. If your ArcGIS Pro is already open from the previous step, click on the white arrow located at the top left to get you back to the main screen.

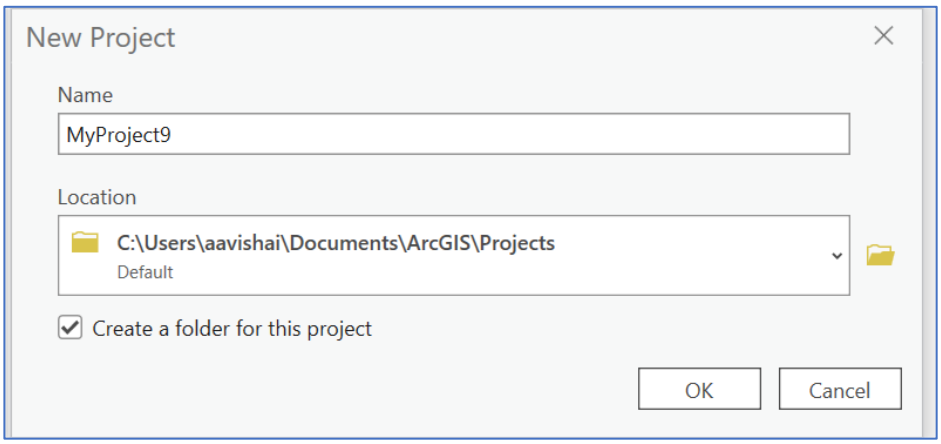
2. There are two ways to start a project:

   <u>Start a new project:</u>

   a. You can choose from any of the options across the top to begin a new project. For a simple map, choose **Map**. This will start your project with a map already loaded.



b. When you choose **Map**, a **New Project** window will appear with a default name and location (shown below):



c. If you prefer to save your project in a different location and/or with a unique name, rename your project, and save it in a place that is convenient for you. Leave the **Create a folder for this project** checked. This option will put all your files for this project into one folder and will keep it organized for you.

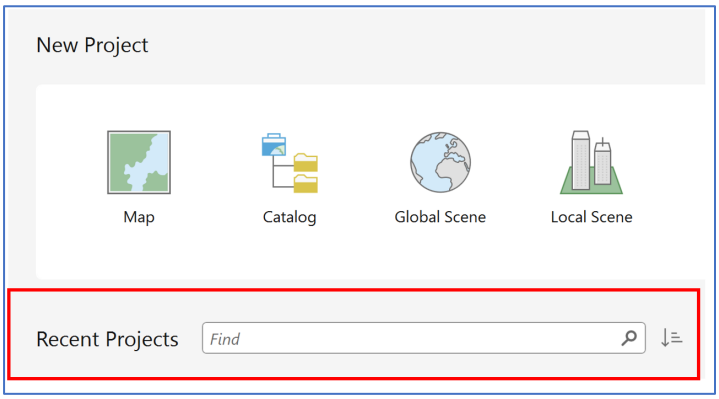
NOTE: The name you choose for your project is applied to the project file and can't be changed after the project is created. If you keep your project name as *MyProject9*, as shown above, it will be created with the default settings keeping the name of your geodatabase as *MyProject9*.

It's important to stay organized when setting up a project. See the **Keeping Your ArcGIS Pro Project Organized** section below for some tips. This will ensure you'll be able to easily find your documents later. This becomes extremely helpful and important for larger projects.

d. When all the names and options are as you like them, Click **OK** to create your project. Your map will open, and you are ready to begin.

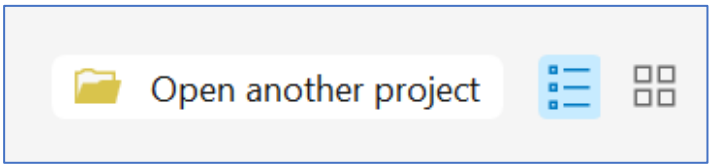
Open an existing project: There are several different options if you wish to open a recent project.

a. You can search for projects using the **Recent Projects** search box. This can be found directly below the **New Project** area.

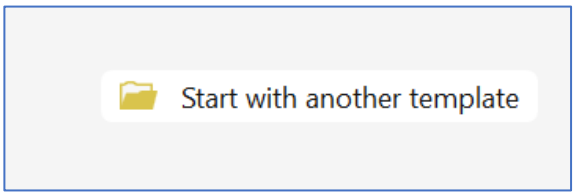


b. You can open a recent project from the list of **Recent Projects** shown below the **New Project** area and the search box. Just find the one you want to work on, click on it, and it will open.

c. If you don't see the project you want, you can browse to the project file by clicking on the **Open another project** option. You can find this to the right of the **Recent Projects** list, next to the yellow folder.



d. You can also use an existing template if you have one set up. This option can be found on the very right of your screen.



Change Settings for a Project

To set up or change the settings for a project, check out this link.

Keeping Your ArcGIS Pro Project Organized

It's important to keep your project organized from the beginning even if the project is small and involves only a small number of features classes and analyses. The better you plan, the easier it'll be to find your data later.

When starting a project, it's important to understand its scope to better plan and organize as you go. A project might include:

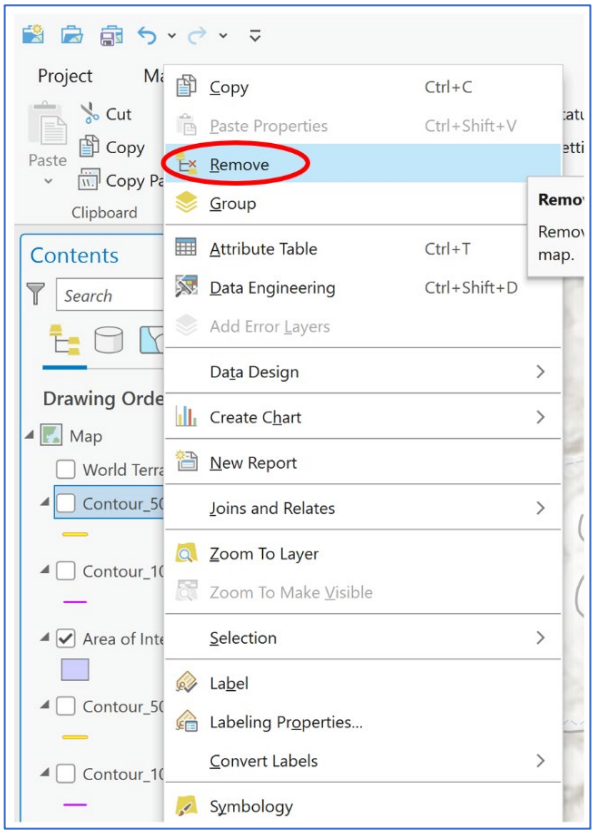
- Multiple mine maps from multiple seams,
- Various feature classes connected to each seam,
- A large project with an undetermined time frame or deadline,
- Working with more than one other person, some who might not be GIS experts.

All these components can lead to a very unruly pile if you don't stay organized. Here are some tips to keep everything under control:

1. **Deleting feature classes and/or raster datasets from your Contents Pane.** If you are using shapefiles, feature classes, and/or raster dataset/s and performing analyses on them, many times you won't need the original file/s as you get deeper into the project. If that's the case, these files can simply be removed from your **Contents Pane**.

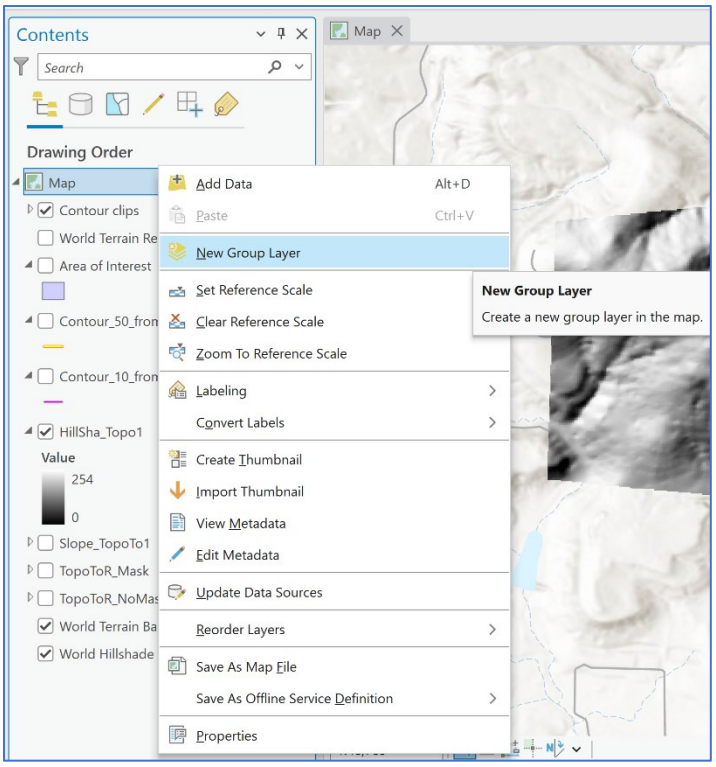
   This will NOT delete them, merely get them out of the way. You'll still have access to them if you wish to add them back to your project later.

   In the **Contents Pane,** right click on the feature layer you wish to remove and choose **Remove** from the menu.

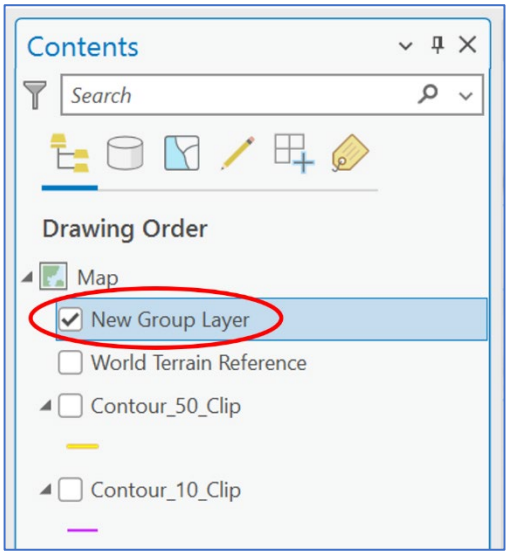


2. **Creating Group Layers.** You might be working with a lot of feature classes, but you want to keep them within the project so you can use them later in the process. For example, if you're performing analyses and you want to compare the different steps or end products, the best organizational path is to create **Group Layers**.

   To do this, right click on **Map** in the **Contents Pane** and select **New Group Layer** from the menu that pops up.

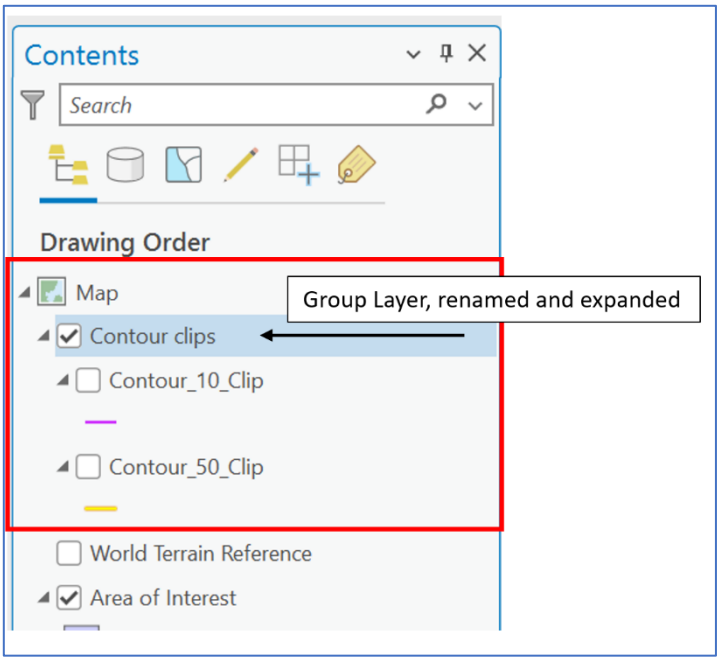


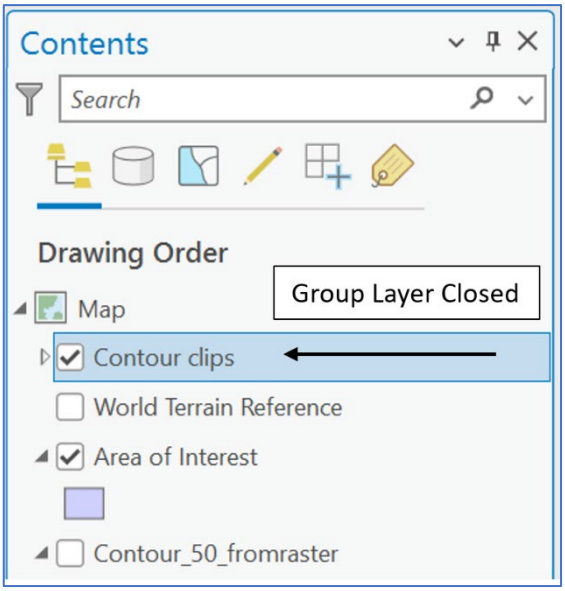
   A **New Group Layer** will be added to your **Contents Pane**.



Rename it to something that makes sense to you and the project you're working on.

3. The next step is to drag the appropriate files into that group layer. Highlight the layers and feature classes you want and drag them into the **Group Layer**, like dragging files into a folder. The software will place all the layers into the group. What's nice about the **Group Layers** is, you can expand the group or close it to help keep your project less cluttered (see below).





4. **Giving your data unique and descriptive names.** As you're creating feature classes, organizing them, and performing analyses, it's important to remember to give them unique and descriptive names. This will help you remember what the feature classes are, and how they're different from other similarly named feature classes.

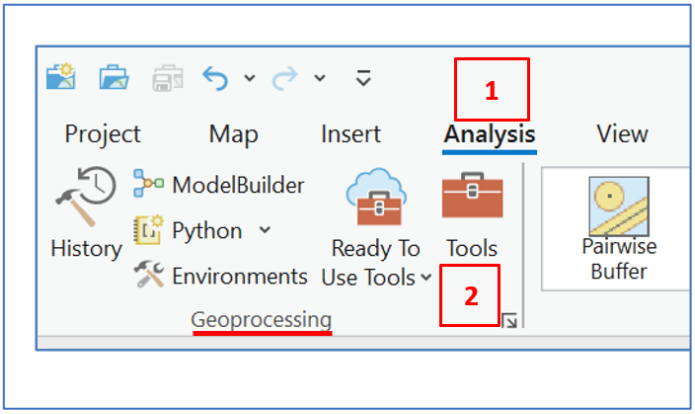
   For example, suppose you have a contour feature class named *Contour_10*. This indicates that the contours are in 10-foot intervals. If you want to clip that feature class, you might want to rename it to *Contour_10_clip*. However, if you are creating 10-foot contours from a raster, maybe you'll want to name the feature class *Contour_10_raster* and, with a clip function, *Contour_10_raster_clip*. This way, you'll be able to remember what type of feature class it is and how it was created.

   If the contours are attached to a certain coal seam, you might want to add that seam name to the feature class name. All these little steps will help keep everything organized.

Accessing Spatial Analyst Toolbox

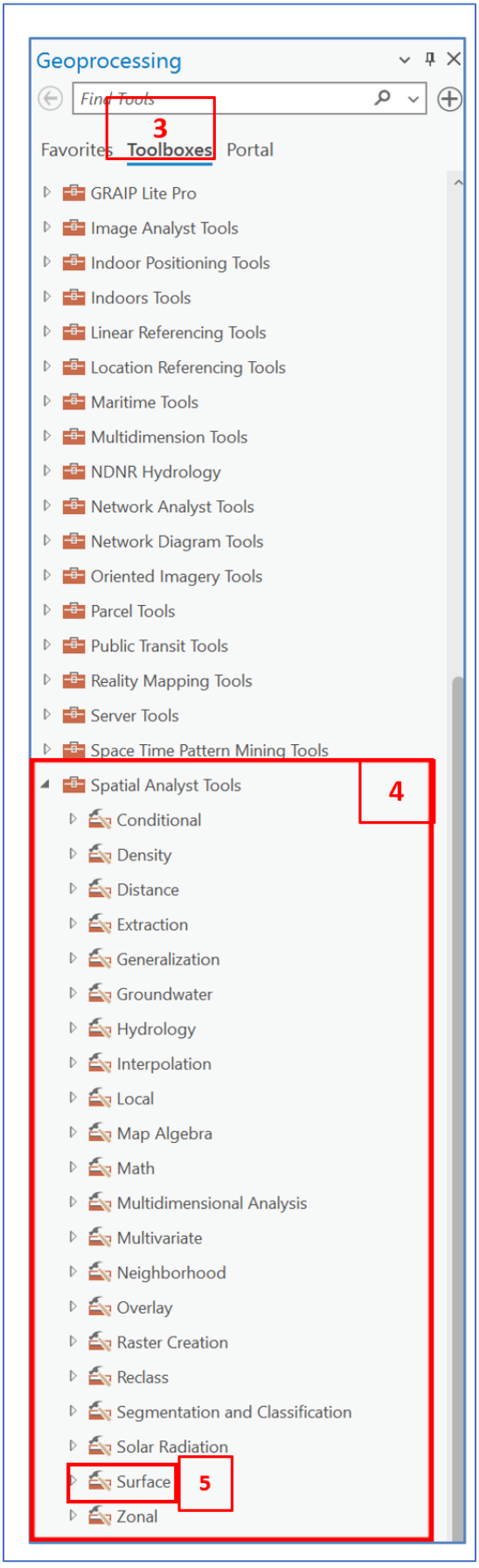
Spatial Analyst provides many geoprocessing tools to perform spatial analysis operations. In addition to the purely analytic tools, general categories of these tools include those that perform basic mathematical and logical operations, as well as raster dataset creation and processing. The tools are organized by groups of related functionalities into toolsets. A common way to access the Spatial Analyst tools is through the geoprocessing tools. This rich environment allows you to organize and run the tools necessary to complete your analytic tasks, and it provides a mechanism to automate, document, and share your workflows.

1. After you set up your project, go to the **Analysis Tab (1)** then click on **Tools (2)** under the **Geoprocessing** group.



2. Within the **Geoprocessing Window** that appears, click on the **Toolboxes Tab (3, below)** and there you will find the **Spatial Analyst Tools (4, below).** You will be using some of the **Surface Tools (5, below)** for this training.

3. If you don't want to explore the toolsets, you can search for a specific tool in the search box at the top of the **Geoprocessing Window**, right above where you found **Toolboxes (3, below)**.


Geoprocessing
Find Tools
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Favorites
Toolboxes
Portal
GRAIP Lite Pro
Image Analyst Tools
Indoor Positioning Tools
Indoors Tools
Linear Referencing Tools
Location Referencing Tools
Maritime Tools
Multidimension Tools
NDNR Hydrology
Network Analyst Tools
Network Diagram Tools
Oriented Imagery Tools
Parcel Tools
Public Transit Tools
Reality Mapping Tools
Server Tools
Space Time Pattern Mining Tools
Spatial Analyst Tools
4
Conditional
Density
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Generalization
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Hydrology
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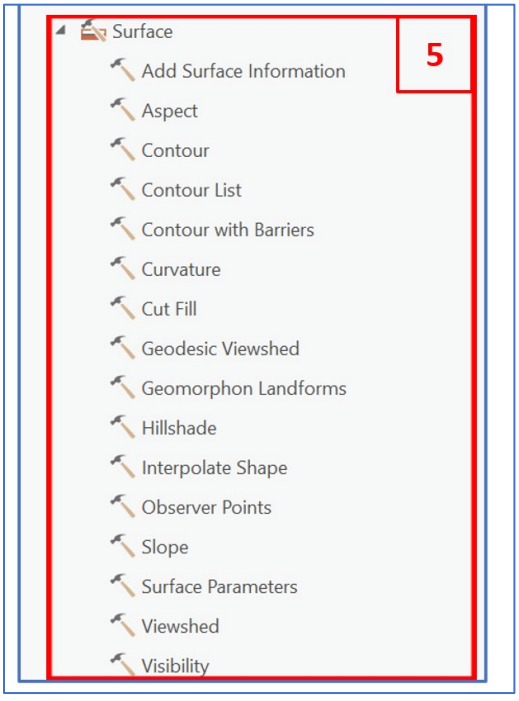
Surface
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Add Surface Information
Aspect
Contour
Contour List
Contour with Barriers
Curvature
Cut Fill
Geodesic Viewshed
Geomorphon Landforms
Hillshade
Interpolate Shape
Observer Points
Slope
Surface Parameters
Viewshed
Visibility

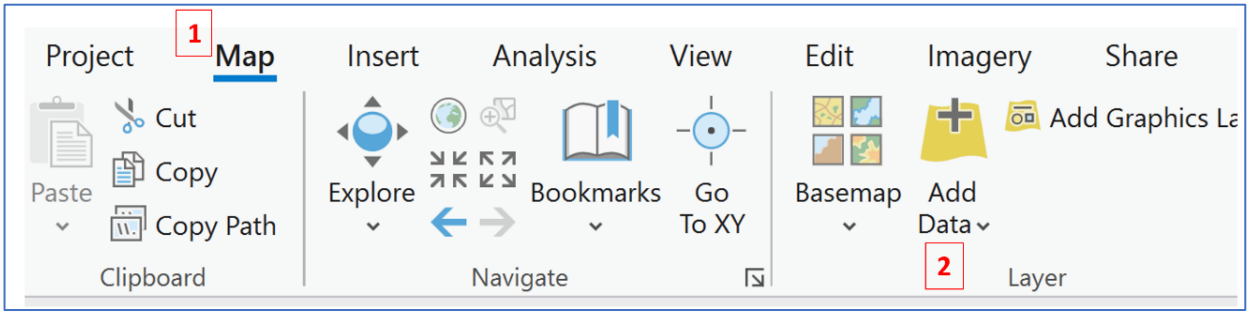
Creating Contours

A contour is a line that connects points of equal surface value. Contour lines reveal the rate of change in values across an area for a spatially continuous phenomena. Where the lines are closer together, the change in values over an area is more rapid than when they're farther apart. Contours are commonly used to map elevation, but they can also be used to map any surface with continuous values, such as barometric pressure or precipitation. By following the line of a particular contour, you can identify which locations have the same value. Contours are also a useful surface representation because they allow you to simultaneously visualize flat and steep areas (distance between contours) and ridges and valleys (converging and diverging lines).

Add an Existing Contour Shapefile to your Map

If you have a shapefile you received from someone else or downloaded from a website, you can add the data to your ArcGIS Pro project by following these steps:

1. Within the **Map Tab (1)** at the top of your ArcGIS Pro screen, click on the **Add Data (2)** button under the **Layer** group.



2. Within the **Add Data Window** that pops up, navigate to the location of your contour shapefile (the file will end with *.shp*). Click on the file and then click **OK** at the bottom.

3. Your contour shapefile is now added to the map.

Create a Contour Feature Class from a Raster

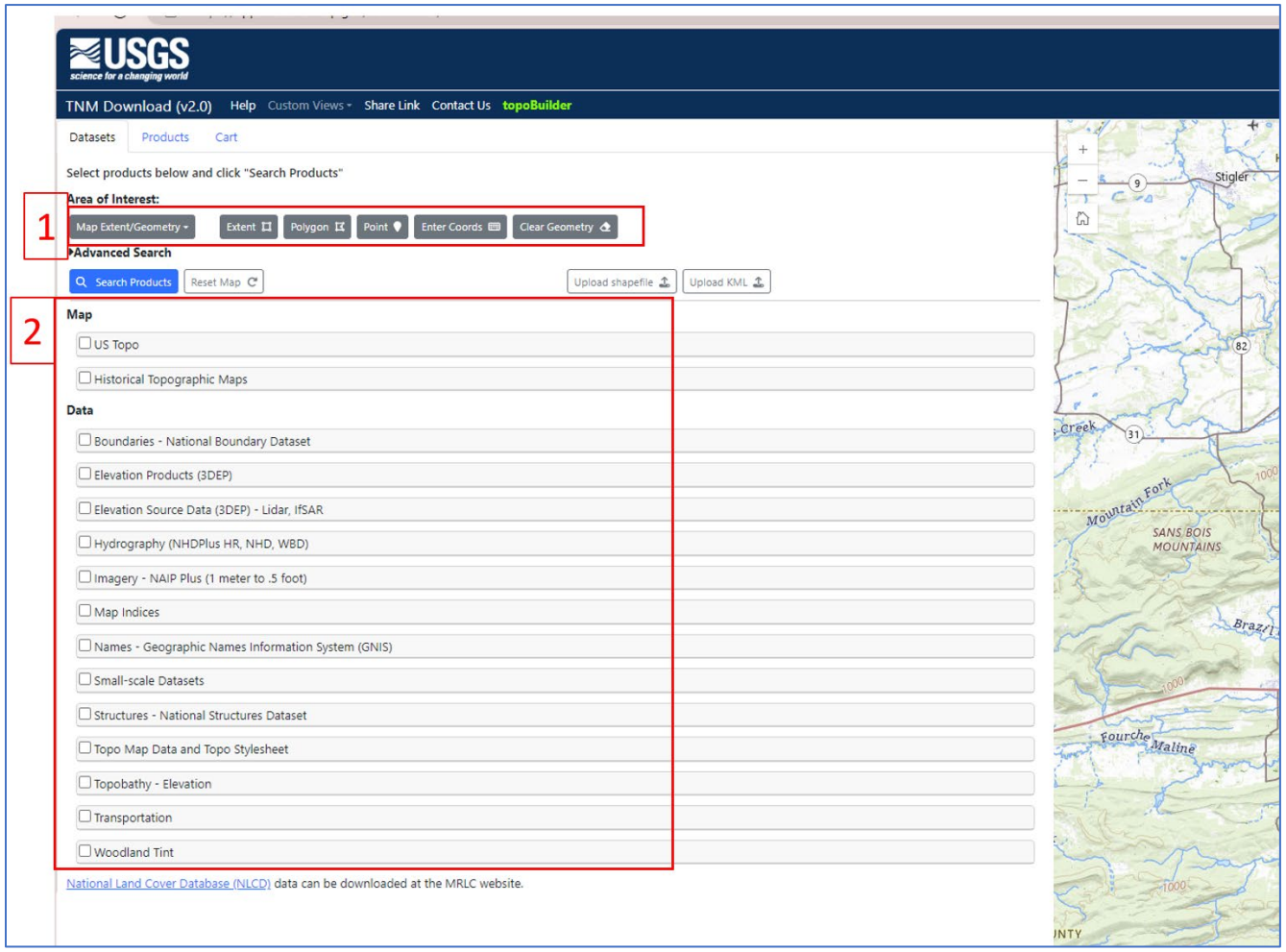
You can also create a contour feature class from a raster. In this example, we're going to create two sets of contour lines, one that will show 10-foot contours and one that will show 50-foot contours. You will create them from a one-meter resolution digital elevation model (DEM) produced through the 3D Elevation Program (3DEP). The DEM can be downloaded from TNM Download v2 (nationalmap.gov).

For detailed instruction on how to use the National Map Download application please refer to this video: Using The National Map Download Application.

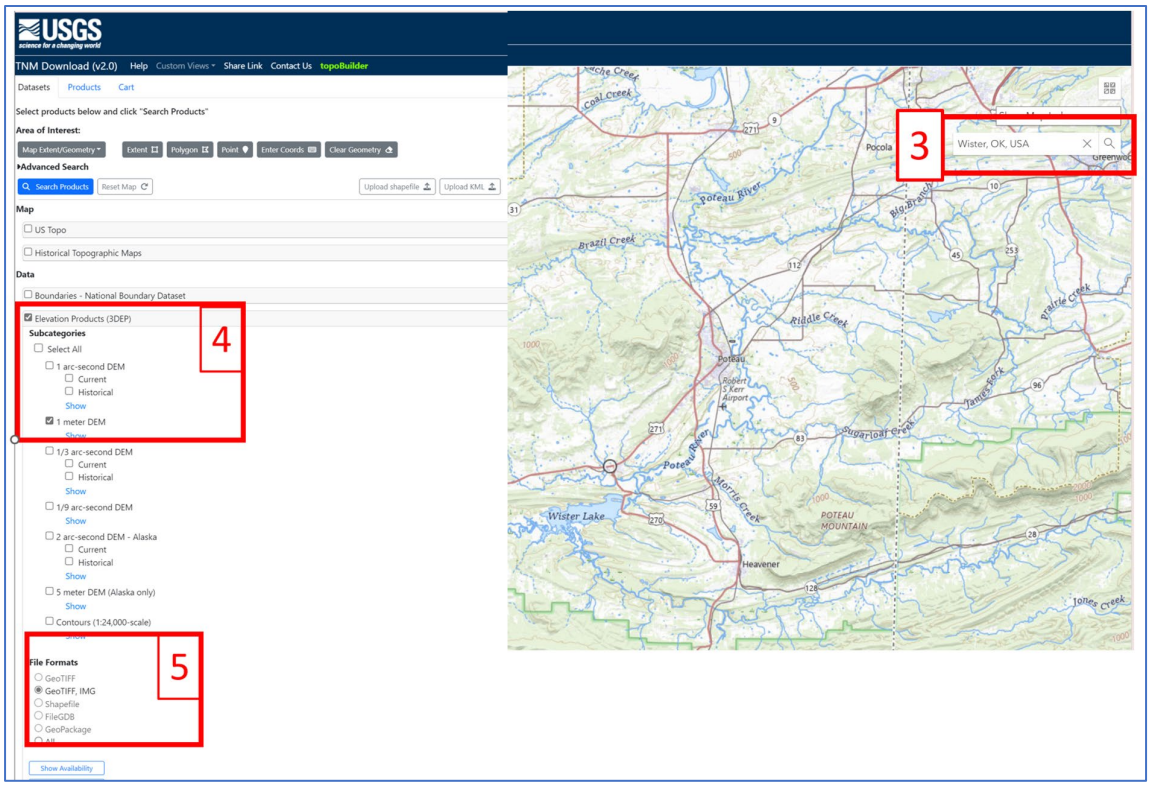
To download the DEM, follow these steps:

1) Go to [TNM Download v2 (nationalmap.gov)](). There are several steps involved to download the DEM.

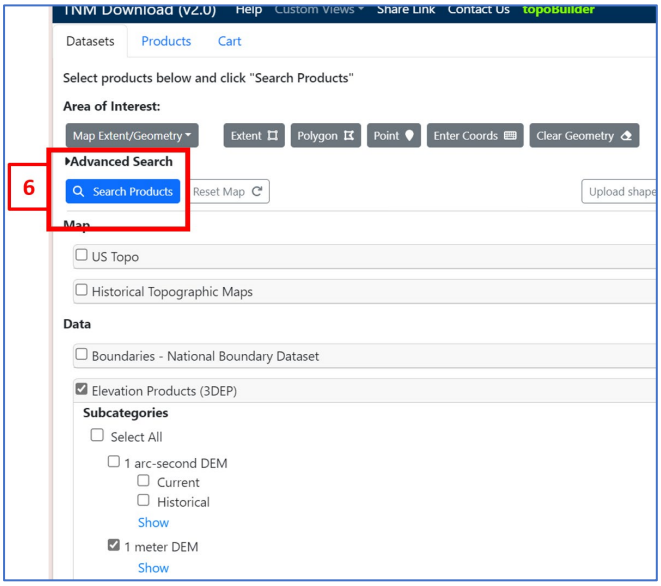
2) One way is to define your **Area of Interest (1)** by using a variety of map tools, and then selecting the product you wish to download under the **Map** and **Data** sections **(2)**.



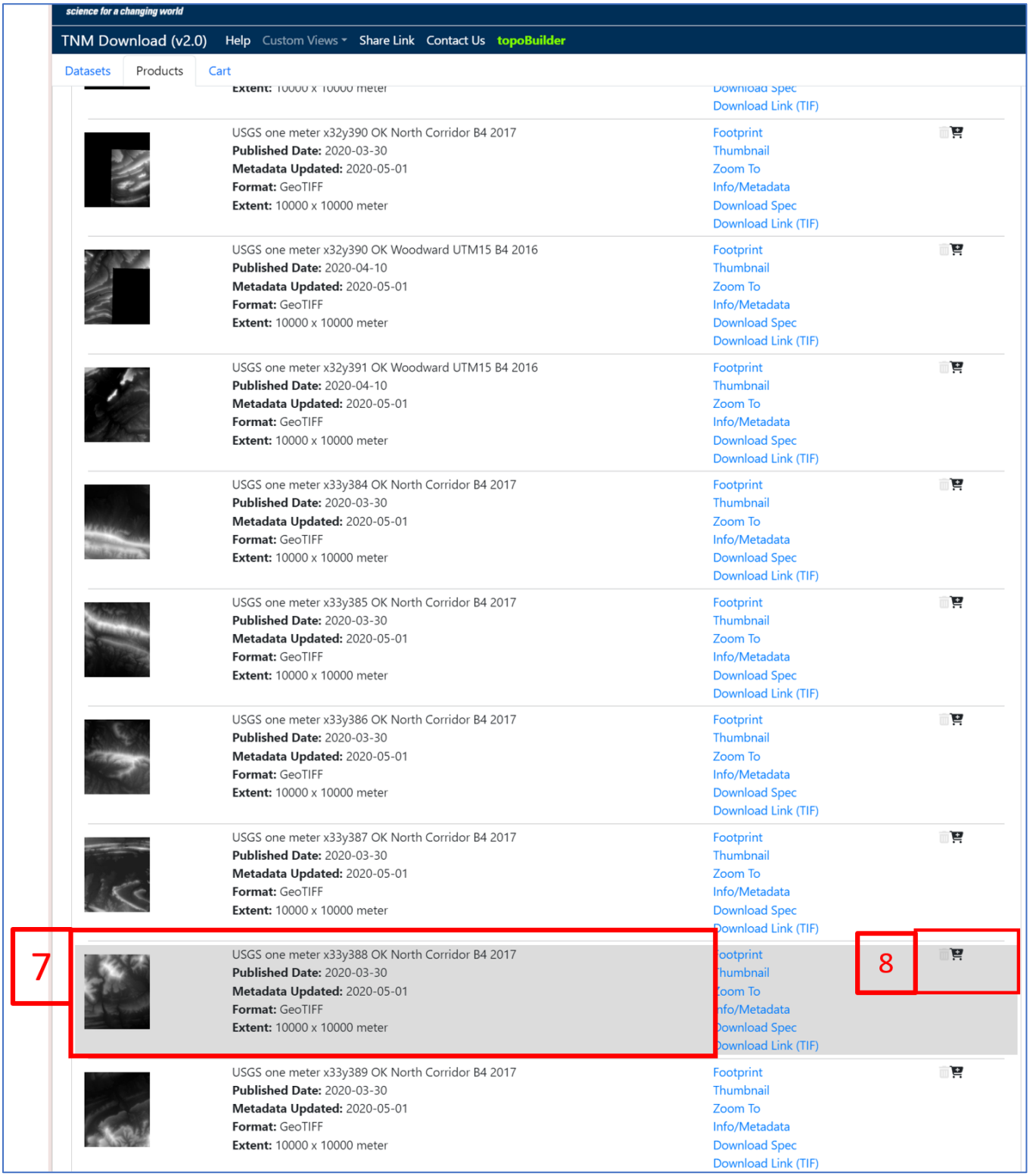
3) For this training, we're going to define our Area of Interest by using the **Search Box** at the top right corner of the page **(3).** In the **Search Box**, search for Wister, OK **(3),** select *1 meter DEM* under **Elevation Products (3DEP) (4),** and then select *GeoTIFF, IMG* under **File Formats (5).**



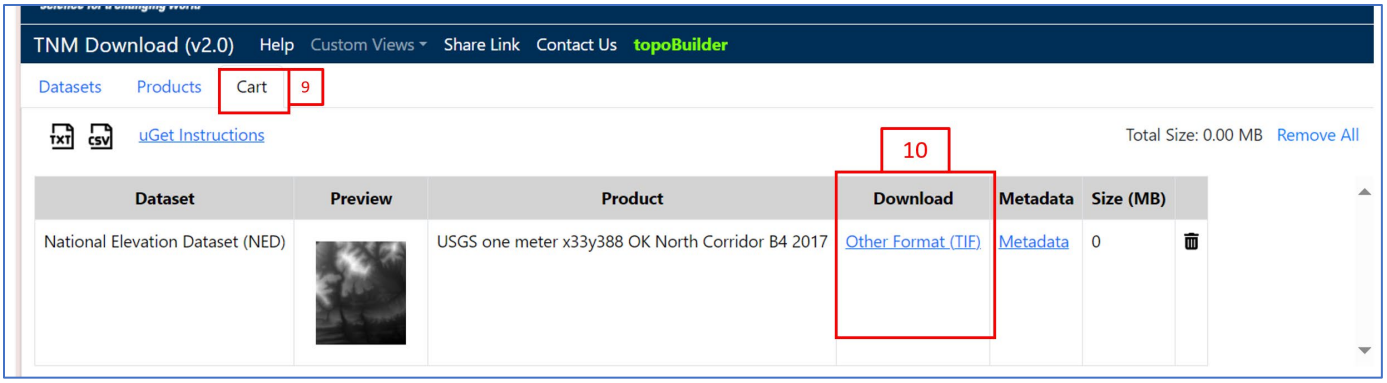
4) When everything is selected, click on the **Search Products** button under **Advanced Search (6)** located at the top left corner.



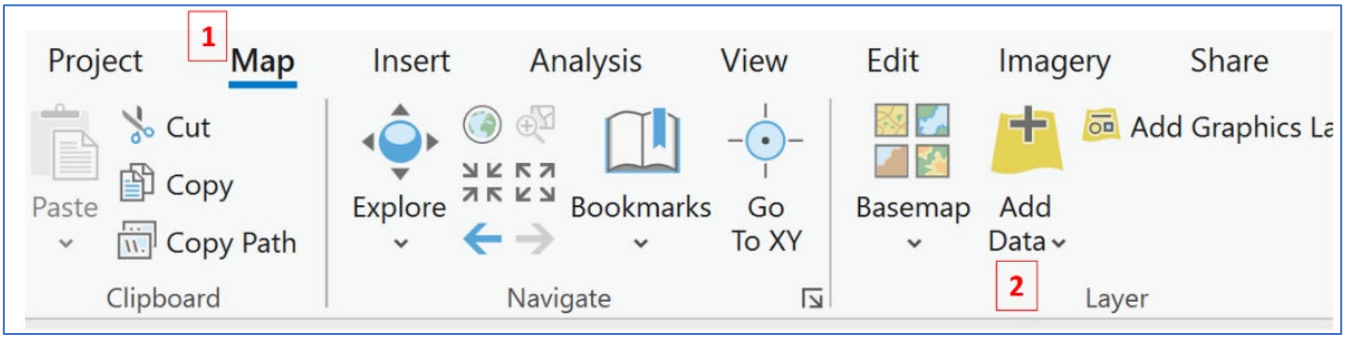
5) You will see a list of 1-meter DEMs for Wister, OK on the left side of the screen. Add the *USGS one meter x33y388 OK North Corridor B4 2017* **(7)** raster to the cart **(8)** for download.



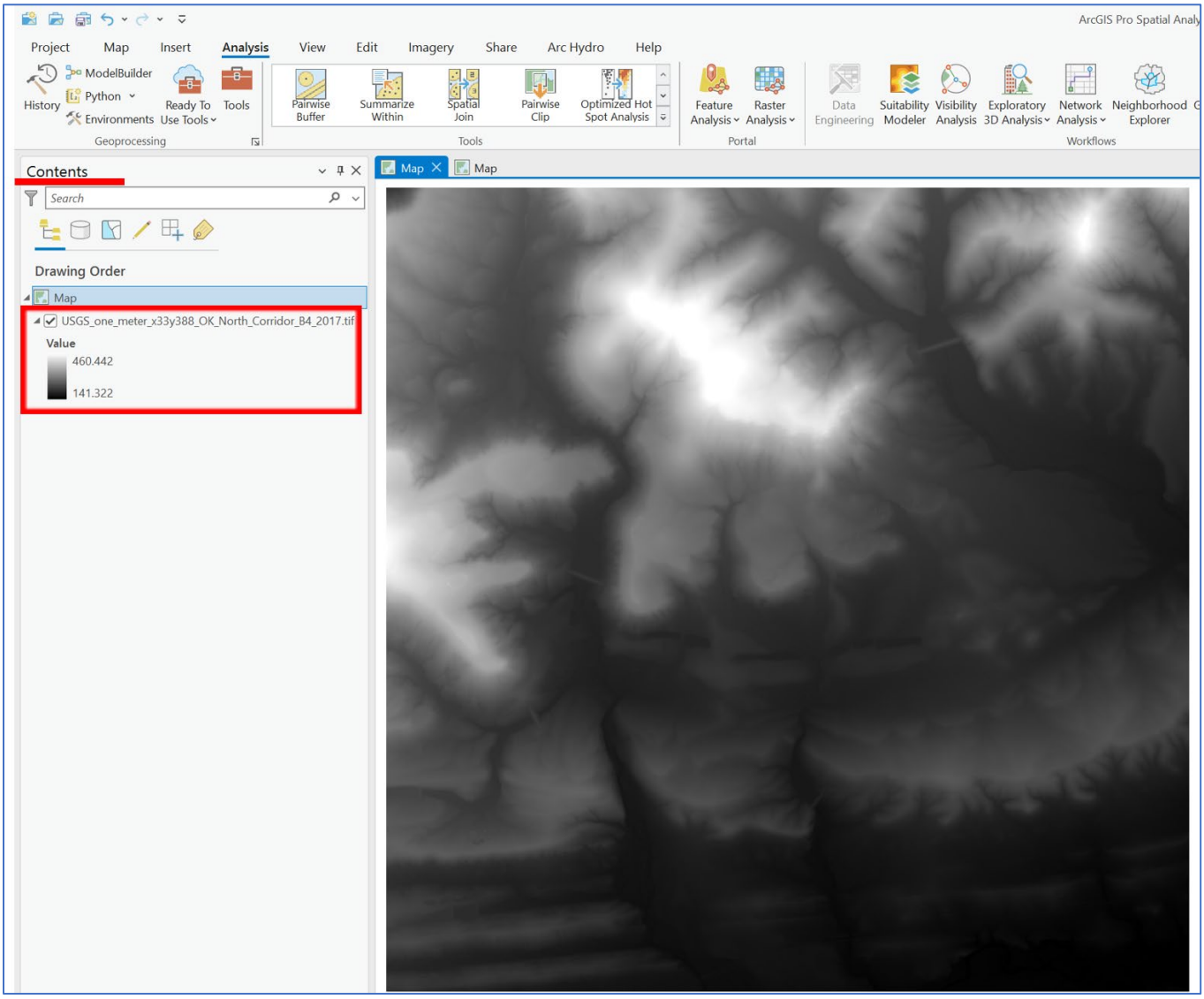
6) Click on **Cart (9)** at the top of the screen and, under **Download,** select Other Format (TIF) **(10),** and save the file to whichever folder you choose.



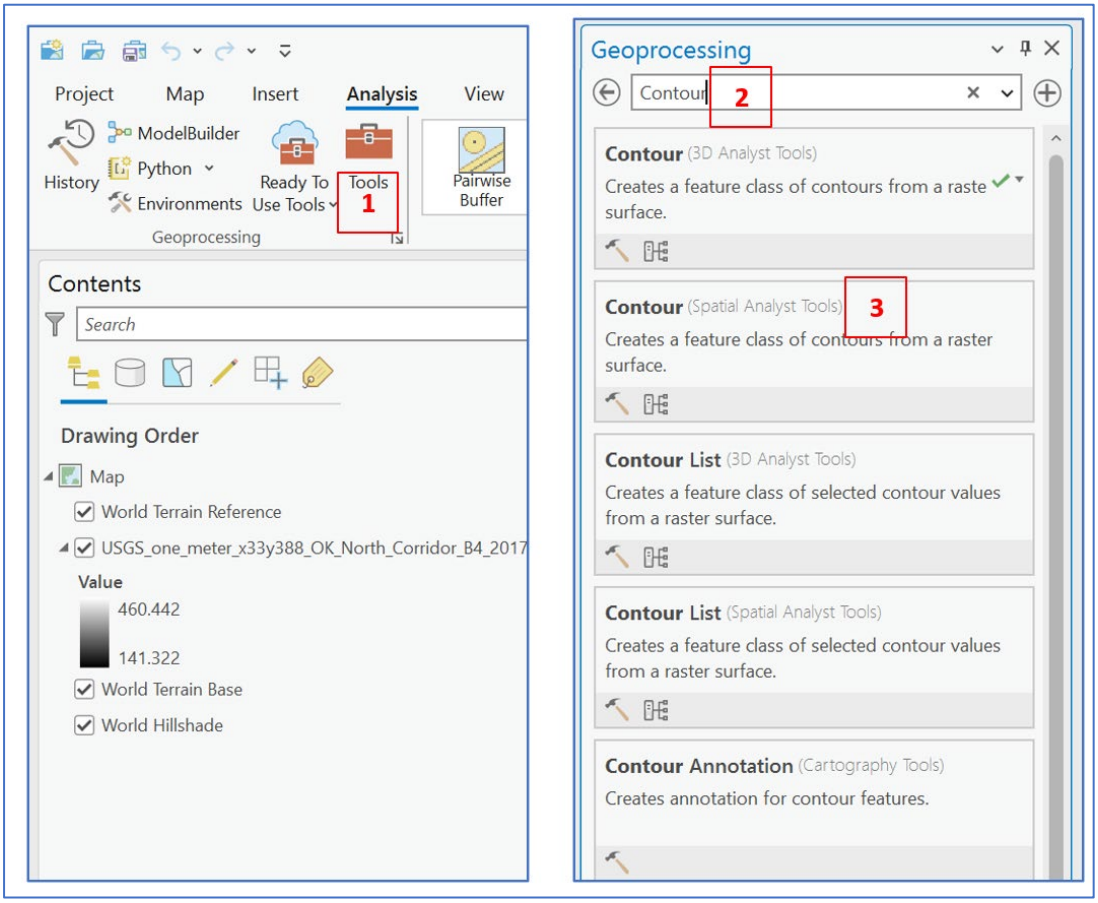
7) Once you downloaded your DEM (Wister, OK for this training), you will need to add it to your ArcGIS Pro project. From the **Map Tab (1)** in ArcGIS Pro, click on **Add Data (2)** within the **Layer** group. In the **Add Data Window**, you will navigate to where you saved the DEM, highlight the file, and add it to the map, as you did with the shapefile in the previous section.



Your map should look something like this. The image on your screen may vary depending on the DEM you're using.



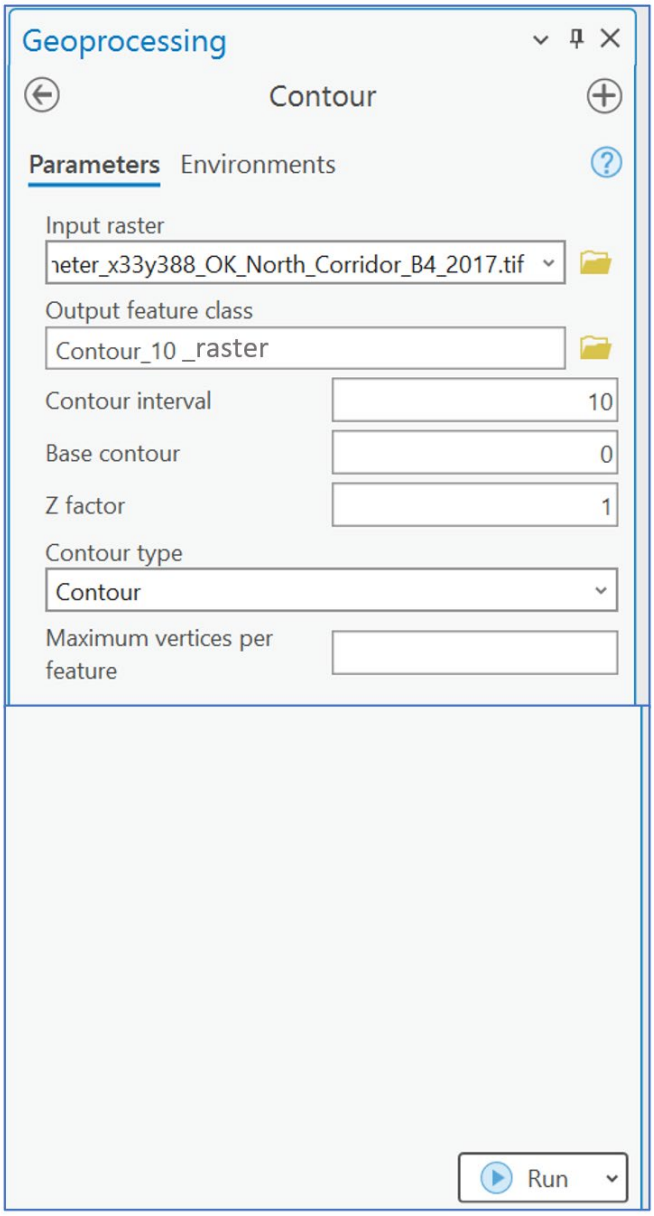
8) Now it's time to create contours from this raster. Click on **Tools (1)** from the **Analysis Tab** within the **Geoprocessing** group and, within the **Geoprocessing Window Search Area (2)** in the Geoprocessing window, type in Contour, and select the tool labeled **Contour** (**Spatial Analyst Tools) (3).**



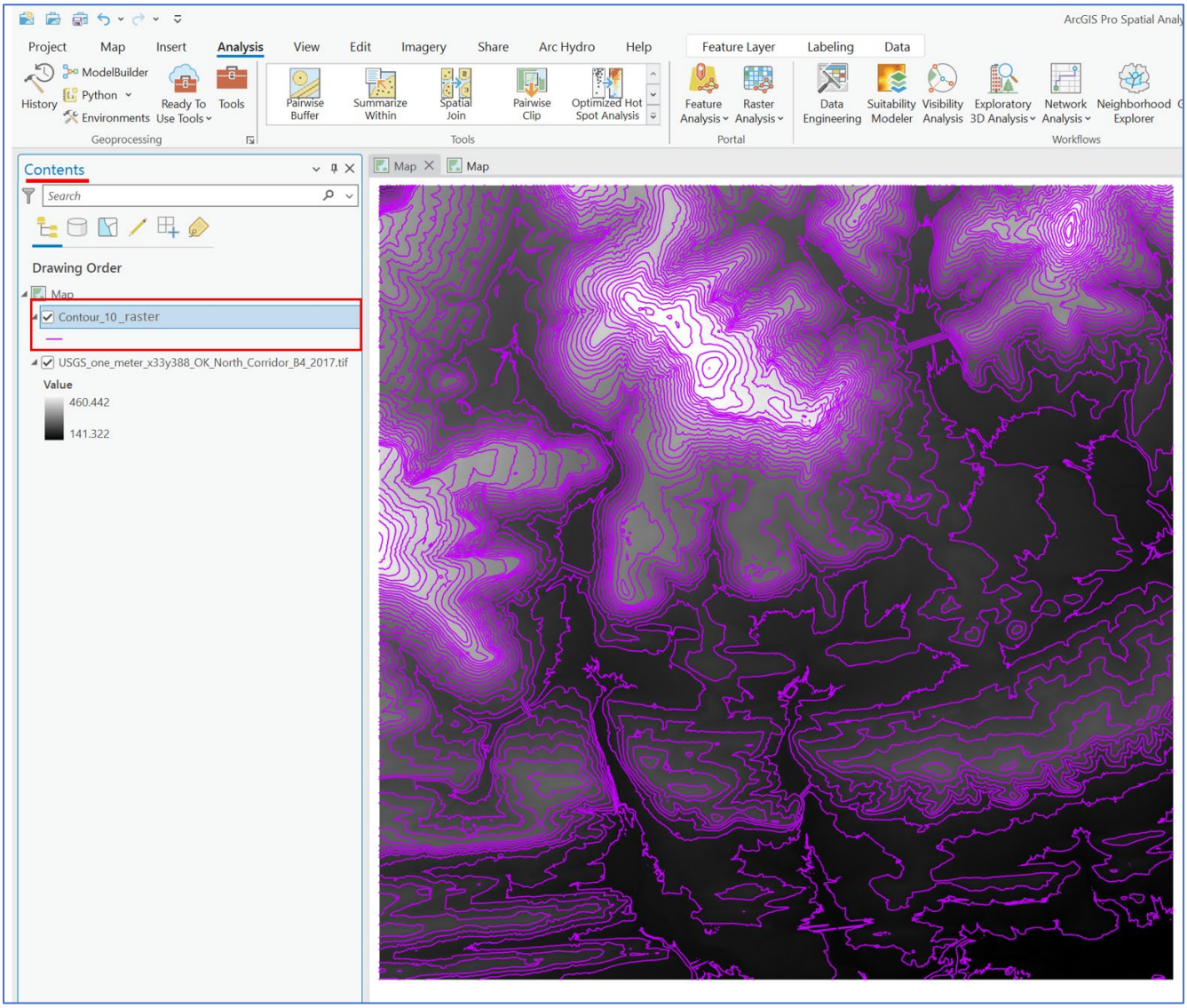
9) In the **Contour Geoprocessing Window**, complete the fields as follows for the 10-foot contour feature class:

- **Input raster:** choose the *DEM* you added to your map.
- **Output Feature Class:** Change the name to *Contour_your interval number_datasource* (In this case, it will be *Contour_10_raster* because we want to indicate that this output feature class contains 10-foot contours, and it was created from a raster).
- **Contour Interval:** *10* (for 10-foot contours).
- **Base Contour:** Leave as default.
- **Z Factor:** Leave as default.

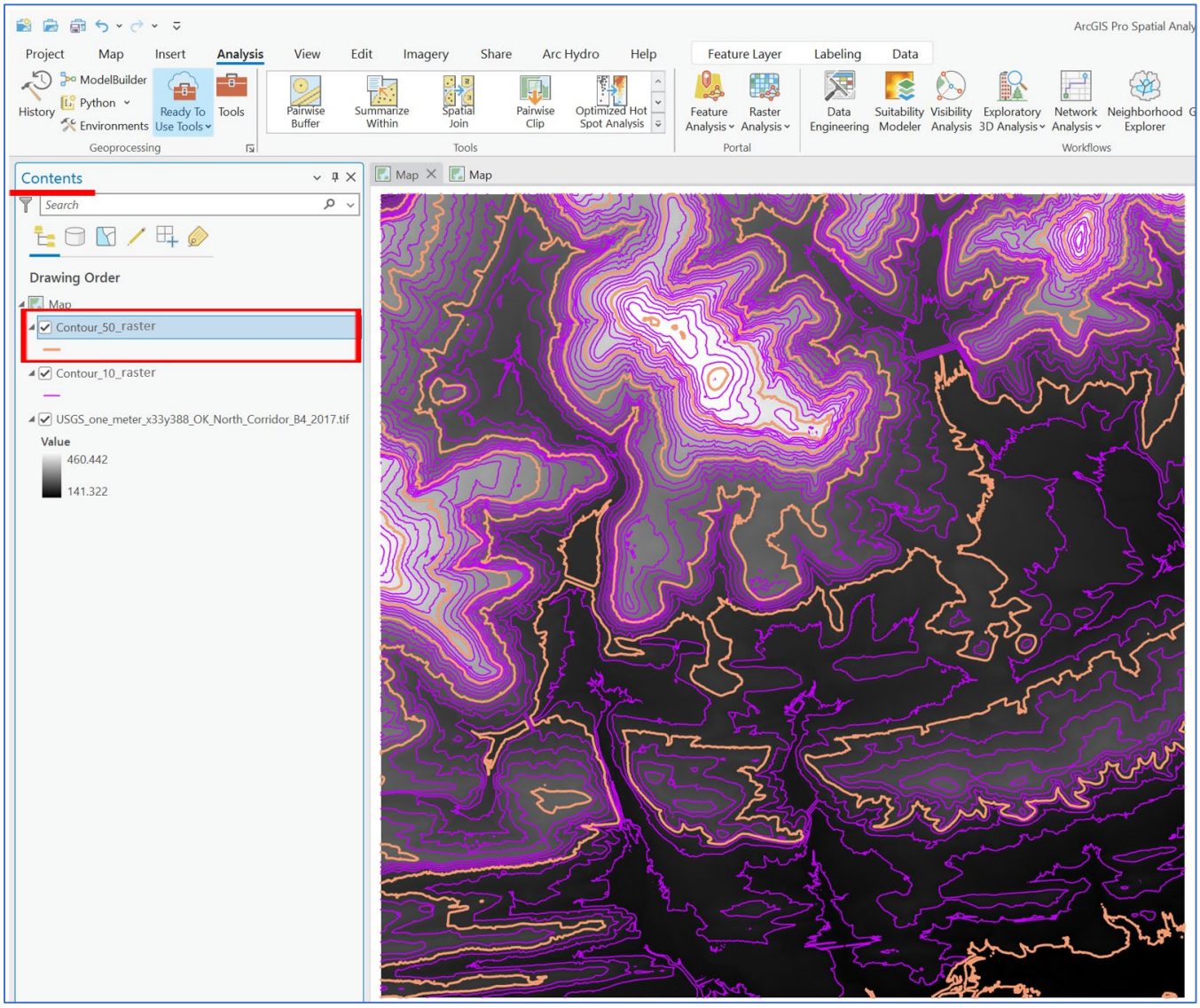
- **Contour Type:** *Contour*
- Click **Run**, at the bottom.



10) Note that the 10-foot contour line feature class, named *Contour_10_raster,* has been added to your **Contents Pane** on the left.



11) Repeat the same process to create a contour line feature class with 50-foot contour intervals. Below, the second contour feature class has been created and added to the map.



******Make sure to save your project! ******

Editing in ArcGIS Pro

Editing geographic data is the process of creating, modifying, or deleting features and related data from layers in a map. Each layer is connected to a data source that defines and stores the features; this is typically a geodatabase feature class or a feature service. By default, ArcGIS Pro starts an edit session automatically for the workspace of a selected layer when you create or modify data and stops the session when you save or discard edits. Any subsequent edits resume the edit session until the edits are saved or discarded.

NOTE: Editing tools remain enabled, and there are no buttons to start or stop an edit session.

The Edit button is available when ArcGIS Pro is configured to enable editing tools manually within the Edit tab and allows ArcGIS Pro to manage workspace edit sessions.

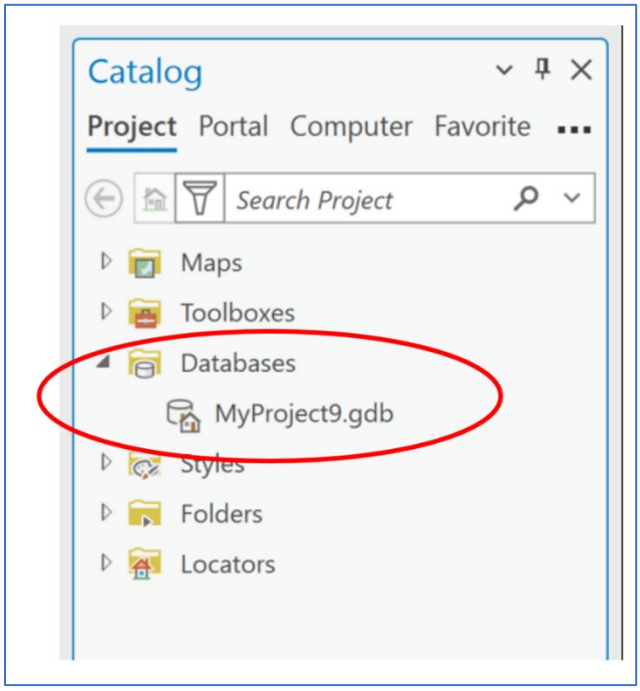
Create a Contour Feature Class Through the Editing Toolbar

If you're working with a mine map (or a topo map), either surface or underground, and you want to record the lines of elevation shown on your map/s, you can create a new feature class in your geodatabase and digitize those contour lines.

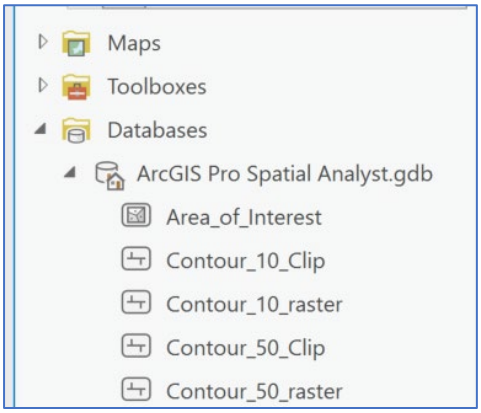
NOTE: This section will require a georeferenced mine map. Follow the instructions in step 3 of Create a Contour Feature Class from a Raster above to add a map to your project.

When setting up your project, ArcGIS Pro created a geodatabase where all your project data is stored. You'll now go to that geodatabase to create a new feature class.

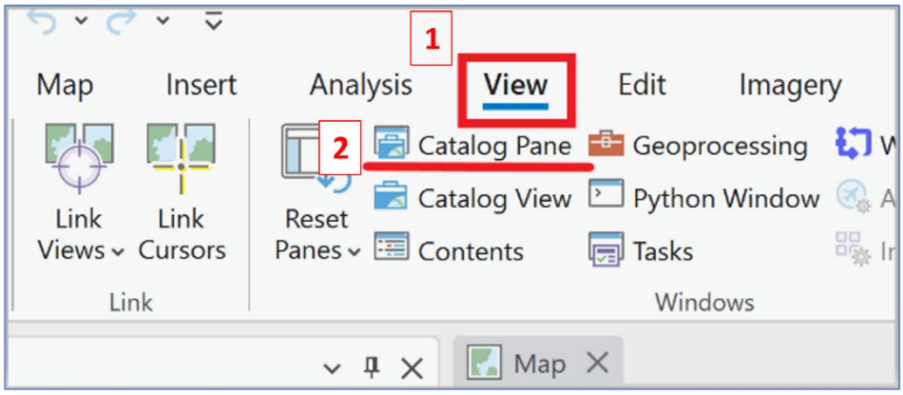
1. In the **Catalog Pane,** under **Databases**, expand the database for your project by clicking on the arrow to the left of the **Databases** folder, as shown below. If you chose not to give your project a specific name, the geodatabase will be named whatever the software assigned it when you were setting up your project. In the example below, the Geodatabase has the default name, "*MyProject9*".



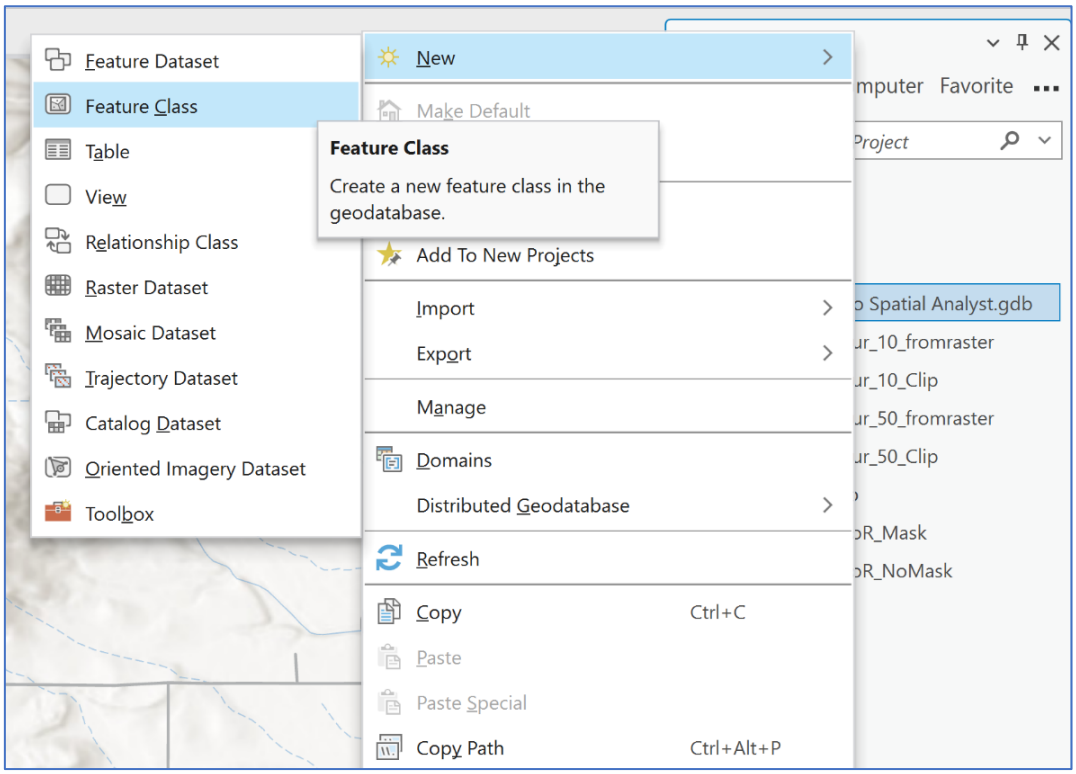
This what your geodatabase will look like with a specified name and saved features classes within in it.



2. Many times, the pane is open and docked on the right side of your ArcGIS Pro screen. If your **Catalog Pane** is not open, you can find it under the **View Tab (1)** within the **Windows** group at the top of your ArcGIS Pro screen. Click on **Catalog Pane (2)** to open the Catalog Pane. You can leave it floating or choose to dock it.



3. Right click on your database within the **Catalog Pane**, hover over **New** at the top of the first menu, and then click on **Feature Class** in the second menu. This will bring up the **Create Feature Class window**. This will take you through the steps to create a new feature class, in this case, your contour feature class.



4. You will choose the following options within the **Create Feature Class window** for your new contour feature class.

   a. First screen:
   Insert Name and Alias- The name you pick for this contour feature class should be descriptive and tell you what part of the project it's connected with. For example, if the contours are for a specific coal seam, add that coal seam name into the feature class name.

   In this case, we will start with the 10-foot contour feature class and name the line feature class *Contour_10_edit*. We add the descriptive "edit" at the end to differentiate it from the 10-foot contour lines we created above with the raster, *Contour_10_raster*.

   Feature class type- line (contours will always be lines).

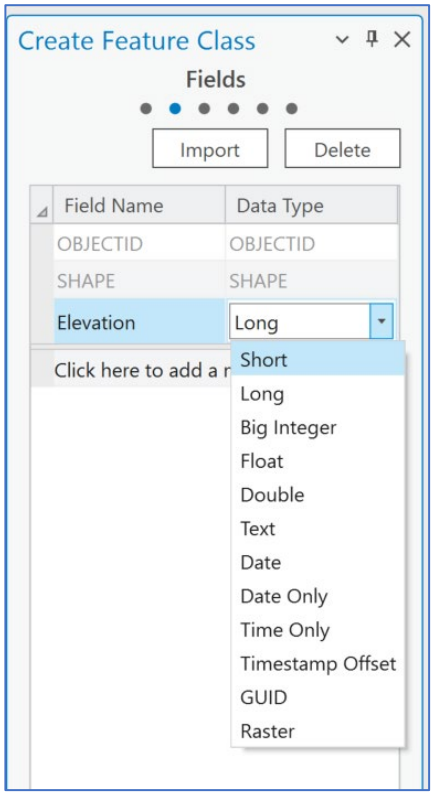
   Leave everything else as the default values and click **Next**.

   b. Second screen:
   Field Name-Add the attributes you wish to collect under the "Field Name" column as

you create this feature class (see below). This could include elevation, seam name, geologic information, flooded/not flooded, etc. These attributes will vary from one feature class to the next and from one project to the next. You can always add additional attribute fields after the feature class is created.

Data Type- Not all feature classes are collected and recorded in the same way. Some data is collected numerically (e.g., elevation or temperature) while other data is collected as text (e.g., notes or property names).

To change the data type, click in the section under "Data Type" and choose the appropriate category for your data from the drop-down list.



For more information about the different data types and the best one to choose, check out this link. Overview of the different field data types.

When done inputting the attributes you wish to record, click **Next**.

c. Third screen:
Spatial Reference-Set the spatial reference for the feature class. The coordinate system you choose will vary based on the location of your data and the type of data you're dealing with, for example local vs national.

Click **Next**.

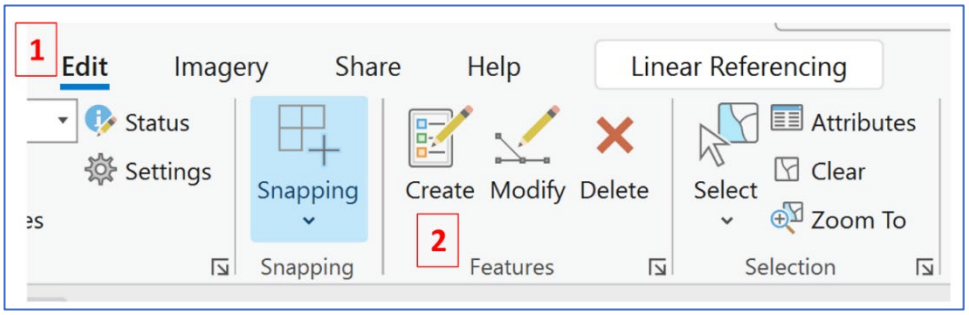
d. Remaining screens:

Leave everything else as the default and then click **Finish** on the last screen.

Your feature class is added to the **Contents Pane.** You're now ready to start creating your contours and adding features to your new feature class.

******Make sure to save your project! ******

5. Click on the **Edit Tab (1)** on the top ribbon and click on **Create (2)** in the **Features** group, as shown below. A **Create Feature Window** will show up and there you'll see all the layers that you can edit. The shapefile or feature class you want to edit will need to be turned on (checked) in the **Contents Pane**.



*****NOTE:** The editing screen shot examples in the next few steps are from a different project so they'll look different from the previous images used above and what you might see on your screen. You'll notice all the names are different, but the process is the same no matter what files you're working with.

6. Click on the feature class you want to edit. A dropdown menu of icons will appear (see image to the right) and, to start editing, click on the first icon in the row, the one that looks like a diagonal line.

   Your cursor will turn into a crosshair indicating you are ready to edit. The crosshair will appear no matter what vector data type you are editing, point, line, or polygon.

7. Place your crosshair where you want to start drawing your feature and click to create the first vertex. Then move to the next spot along the line and click to create the next vertex (Image 1). Keep moving along the feature and creating vertexes and drawing the line (Image 2). When you reach the end of the line/contour, double click to complete the feature (Image 3).

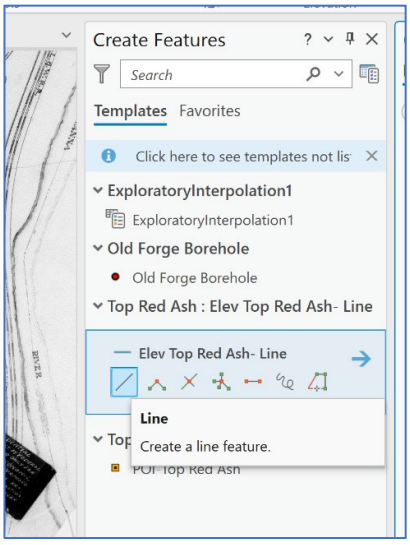


Image 1: Start editing a line feature class.

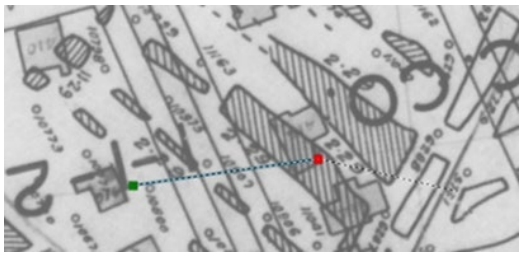
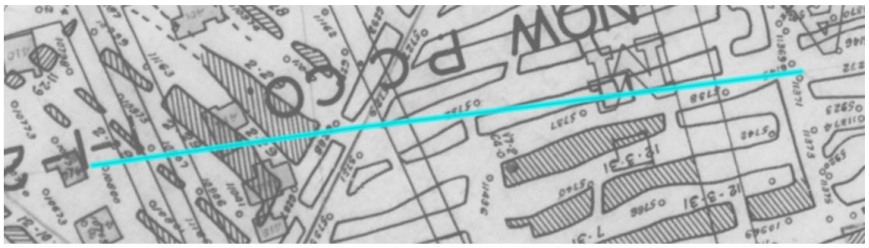


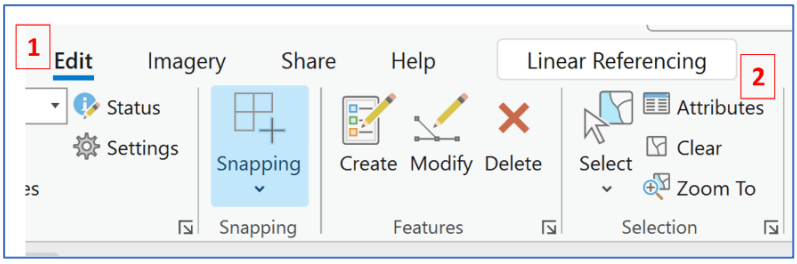
Image 2: Continue creating the line feature class.

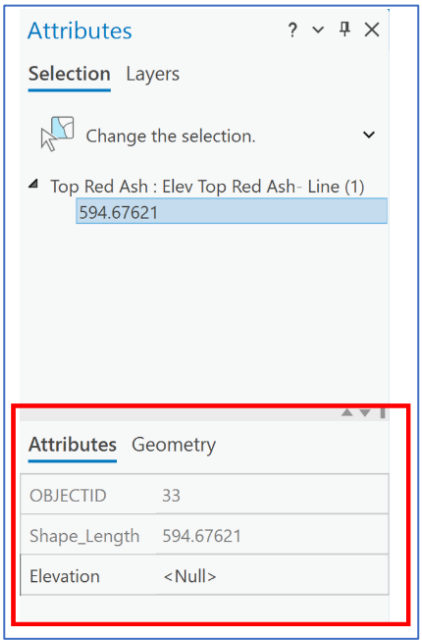
Image 3: Completed contour line.



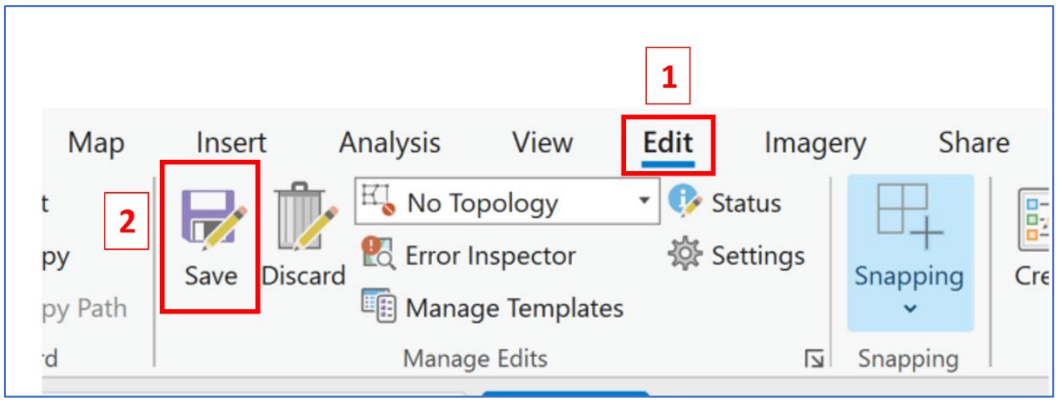
8. You'll now add attributes to this new contour segment you created. Go to the **Edit Tab (1)** at the top ribbon and click on **Attributes (2)** from the **Selection** group.

   An **Attribute Window** will appear (below, right). In the bottom section, input whatever attributes you want to track or record for this feature. In this example, we're only collecting elevation values.





9. Once all the information is recorded, remember to save your edits. To do this, go to the **Edit Tab (1)** at the top ribbon and click on the **Save Button (2)** within the **Manage Edits** group**.** If there are edits to save, it will look like the image below. If there're no new edits to save, that **Save Button (1)** will be grayed out.



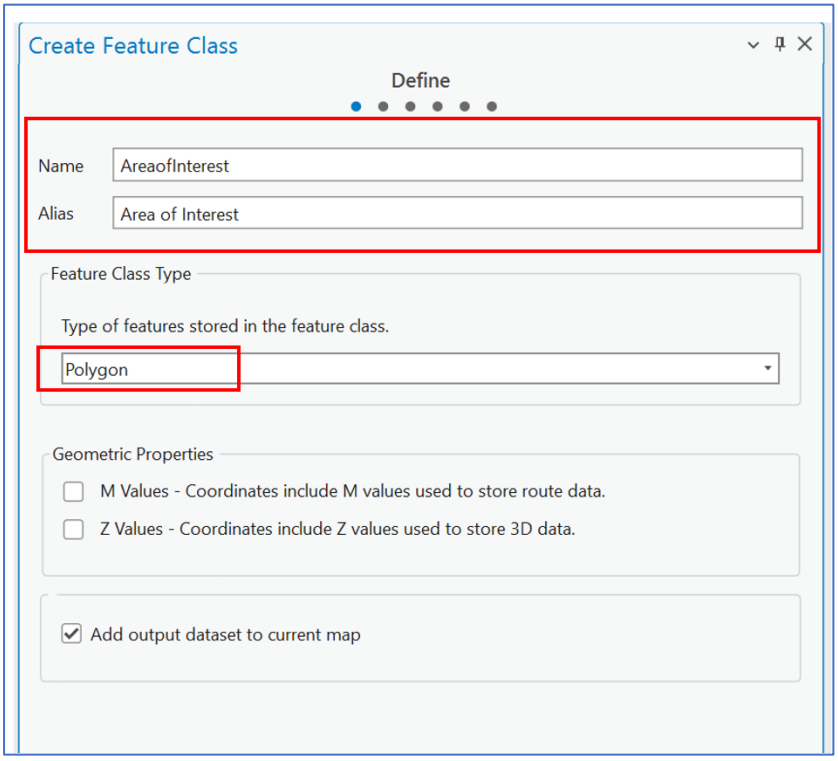
10. Now you're ready to create the next contour line. Find the next contour and follow the same process until all the contours are digitized.

****REMEMBER to save your edits and your project often!**

Create a New Polygon Feature Class

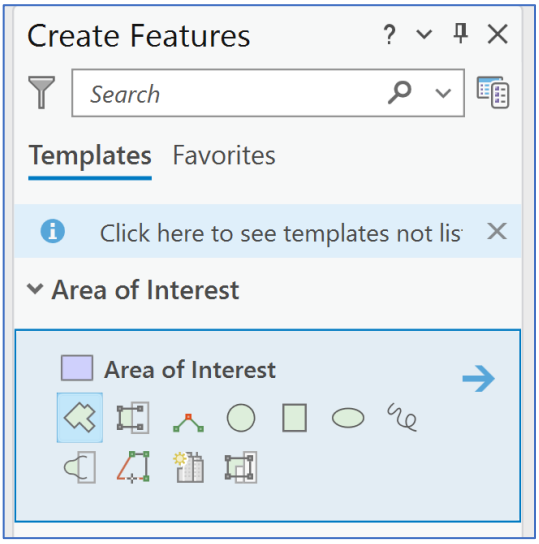
Sometimes you need to create a polygon feature class or denote an area of interest for further analysis. You will do this by first creating a polygon feature class. This process follows steps 1-3 above in the **Create a Contour Feature Class Through The Editing Toolbar** section above. The only differences will be the feature class name and the feature class type.

In step 3a, the first screen should look like the image below (in this case, we are creating an *Area of Interest* for further analysis):



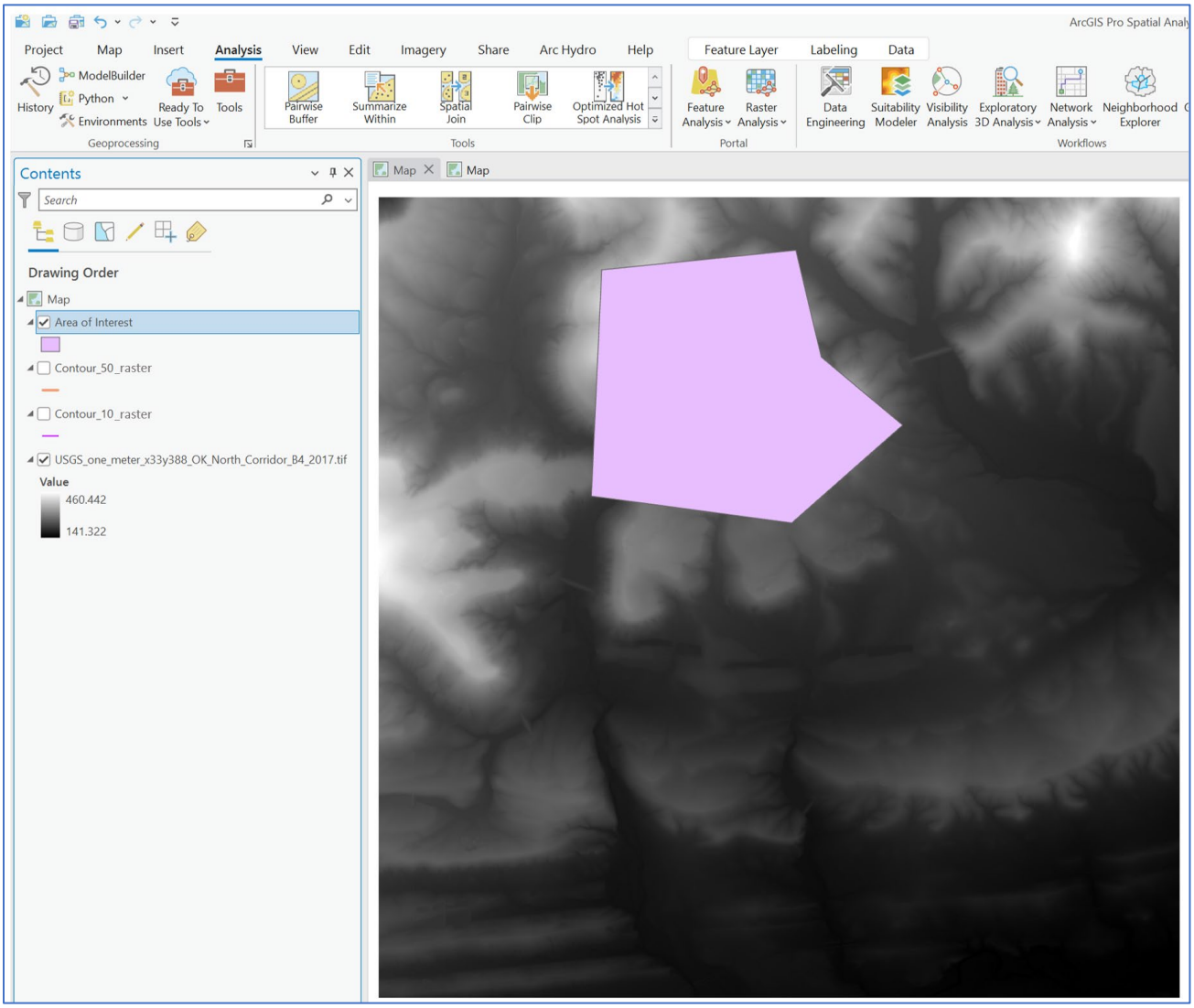
After creating your *Area of Interest* feature class, you can see that it's added to your map in the **Contents Pane**, but no features appear on the map. Just like the contour lines, you'll need to create them or digitize them.

To do this, follow steps 4-7 in the **Create a Contour Feature Class Through the Editing Toolbar** section above. Keep in mind that you'll be creating a polygon, not a line, as the instructions above discuss. The one difference is, in step 5 above, when you click on *Area of Interest* within the **Create Features** Window, the icons that appear below the feature class will look a bit different (shown below). To start editing, you will still click on the first icon in the row, only this one will look like a polygon and not a line.



When your polygon is complete, your map should look like this**.**

What if my polygon looks different? See NOTE below image.



NOTES:

Don't worry if your polygon looks different than the image above. For this tutorial, this is the area of interest we chose, and it will differ from project to project.

The color and shape of your feature classes may be different than shown here. To change their appearance, right click on the feature in the **Contents Pane,** select **Symbology** and from **Symbology Window** you can make any changes you want.

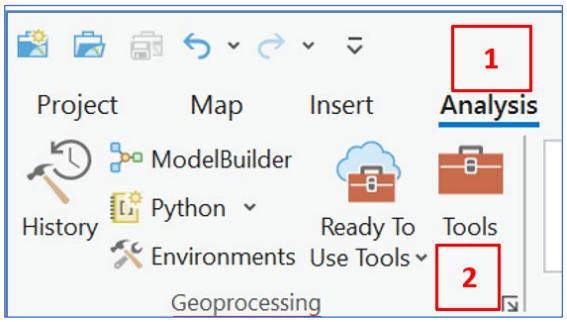
******Make sure to save your project! ******

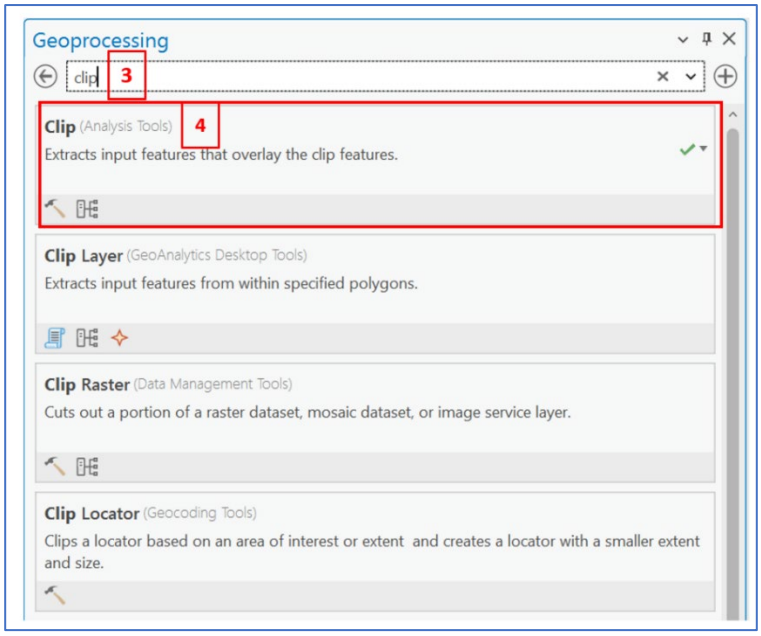
Clip an Area of Interest

Now that you created your *Area of Interest* polygon, you will use the **Clip** function to separate your area of interest from the rest of the data. This analysis will help get rid of the noise, the data that might influence or skew the results.

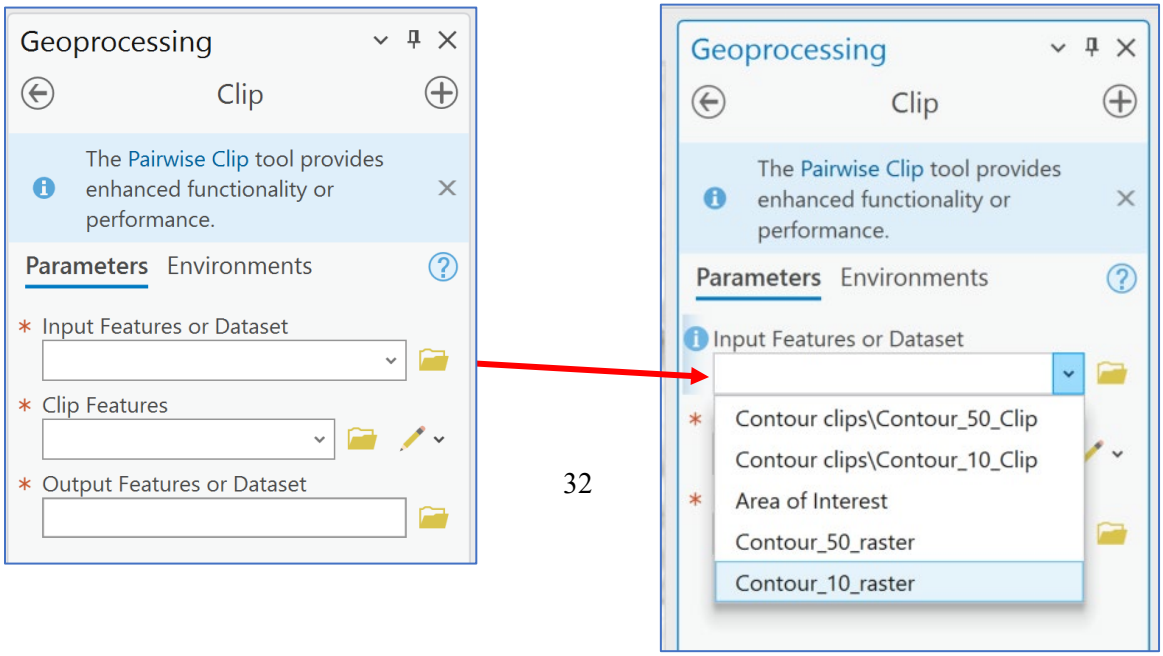
Follow these steps to clip your area of interest:

1. Navigate to the **Analysis Tab (1),** click on **Tools (2),** type **Clip** into the **search box** at the top of the **Geoprocessing window** that pops up **(3)**, and then Select **Clip** (**Analysis Tools) (4)** from the list of tools.





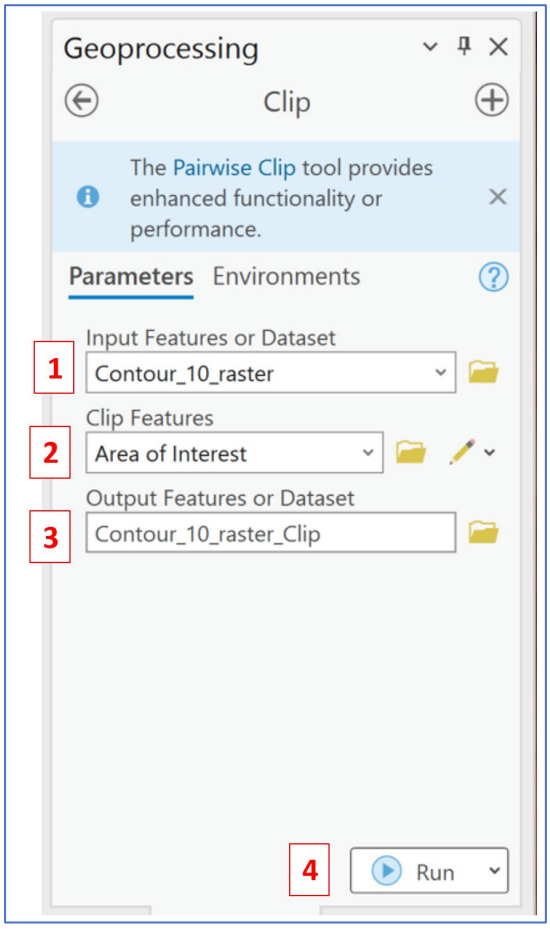
2. In the **Clip Geoprocessing Window**, for the **Input Features or Dataset (below and (1) on next page),** click the drop-down arrow and choose one of the contour feature datasets (in this example, we're going to choose *Contour_10_raster*). These are the features that will be clipped.



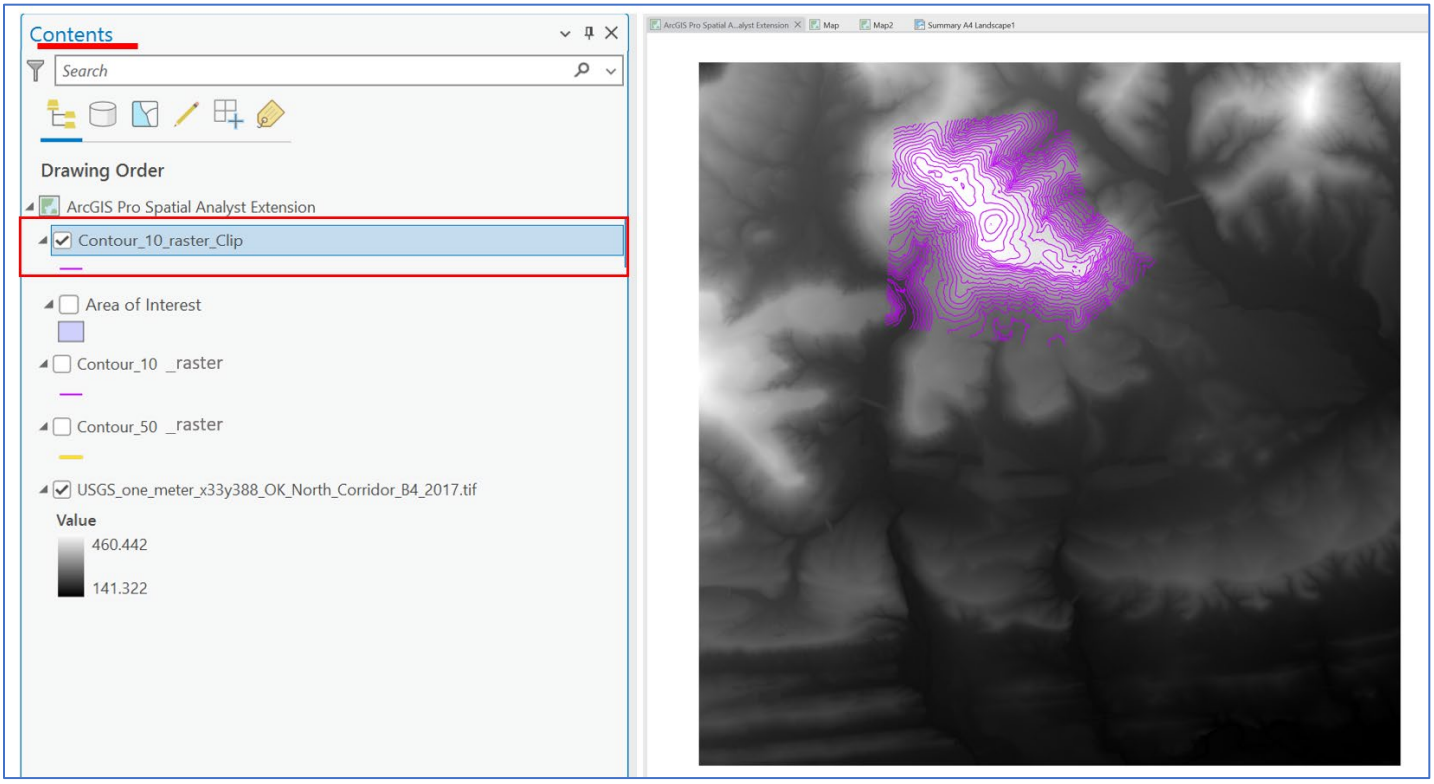
3. For **Clip Features (2),** click the drop-down arrow and choose *Area of Interest.* This is what we'll use to clip the data.

4. In **Output Features or Dataset (3)**, name the file something that will make sense to you in the context of this project. In this example, we're calling our clipped file, *Contour_10_raster_Clip.*

5. Leave the rest as the default. Now your **Clip Geoprocessing Window** should look like this. Click **Run (4)** at the bottom.

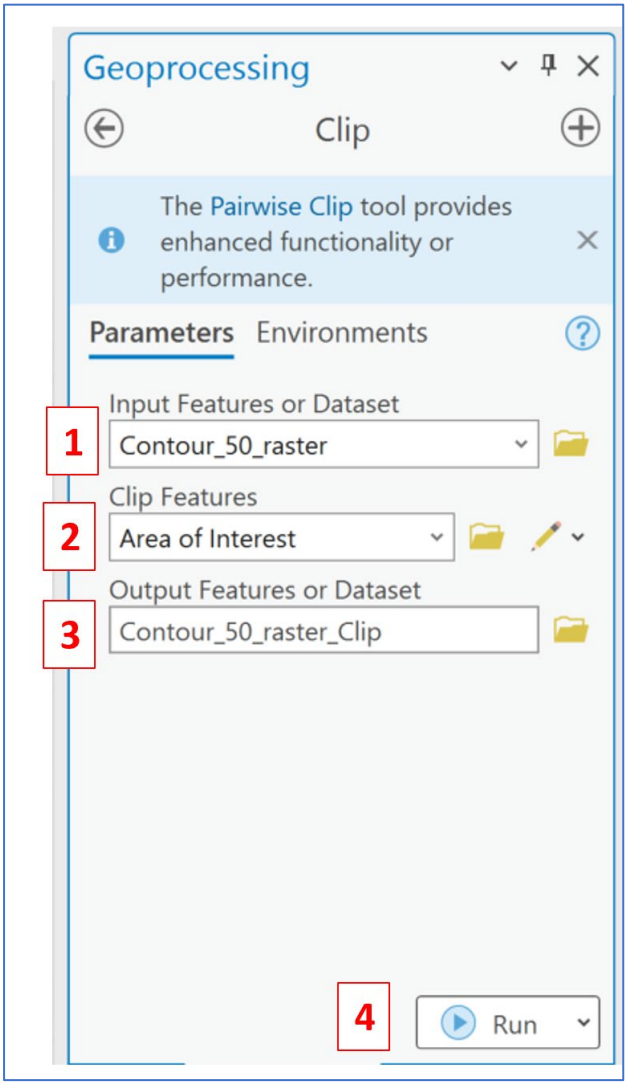


The new clipped feature class, *Contour_10_raster_Clip,* is added to the **Contents Pane**. To better visualize the result, turn off all the layers in the **Contents Pane** by unchecking them, leaving just the clipped contour layer *Contour_10_raster_Clip* on.

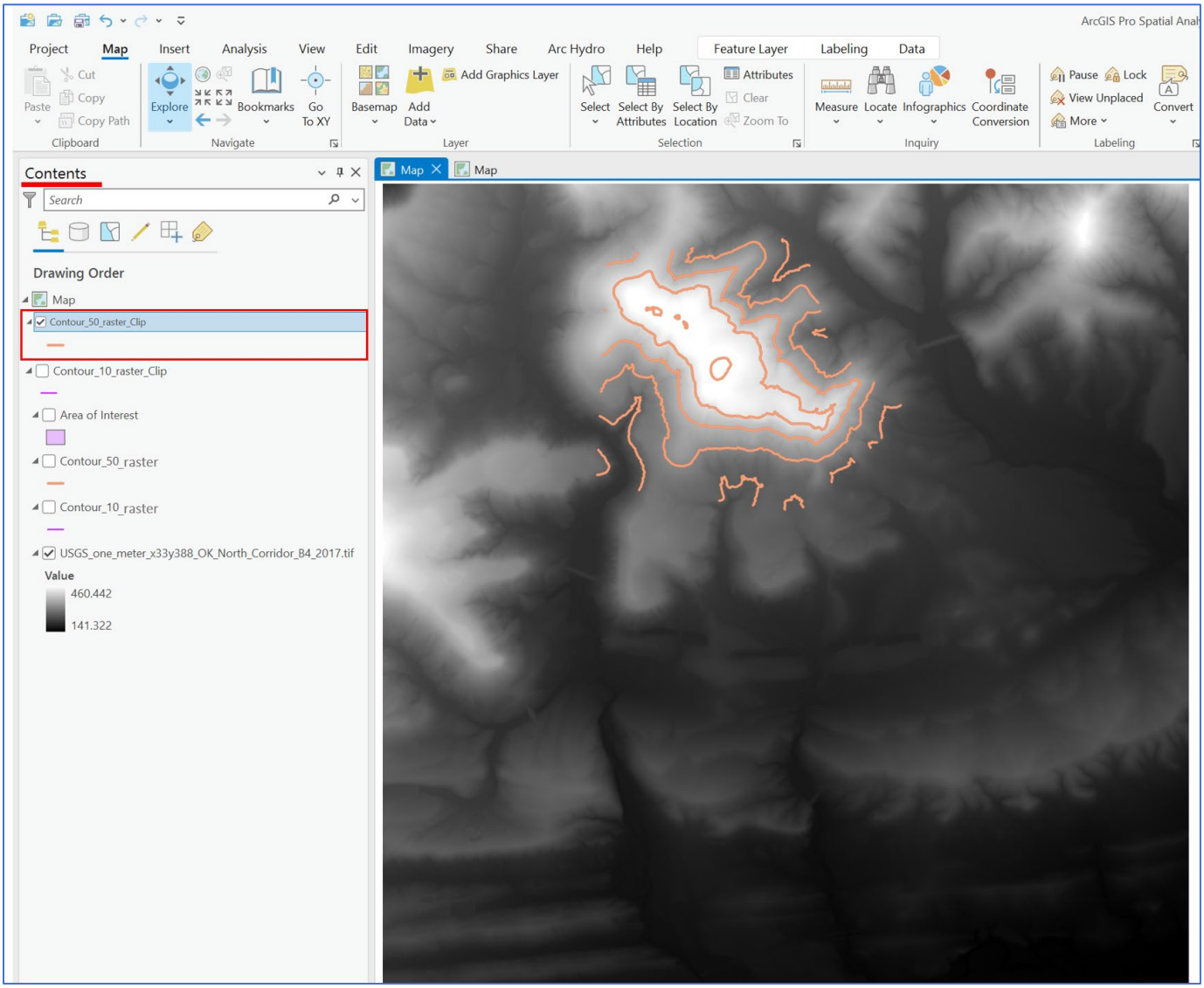


Repeat steps 1 – 4 above for the *Contour_50_raster* feature class.

The **Clip Geoprocessing Window** for the *Contour_50_raster* feature class should look like this.


Geoprocessing
Clip
The Pairwise Clip tool provides enhanced functionality or performance.
Parameters
Environments
Input Features or Dataset
1
Contour_50_raster
Clip Features
2
Area of Interest
Output Features or Dataset
3
Contour_50_raster_Clip
4
Run

The clipped *Contour_50_raster_Clip* feature class in your map should look like this. The colors may be different, but they do not affect the data.



******Make sure to save your project! ******

Creating a Surface (Raster) for Analysis

Now that you've everything set up, you'll move into the analysis portion of the project. When working with contours, many times you want to work with a surface (a raster) instead of a vector (in this case, a line feature class, but polygons and points are also vector data) to better visualize patterns and perform analyses. To create a raster surface from contour lines, we'll use the Topo to Raster Interpolation method.

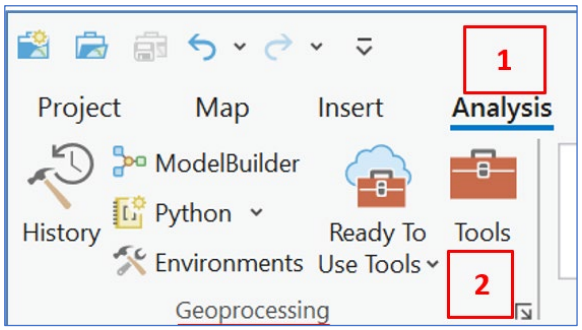
To learn more about Topo to Raster, check out these links:

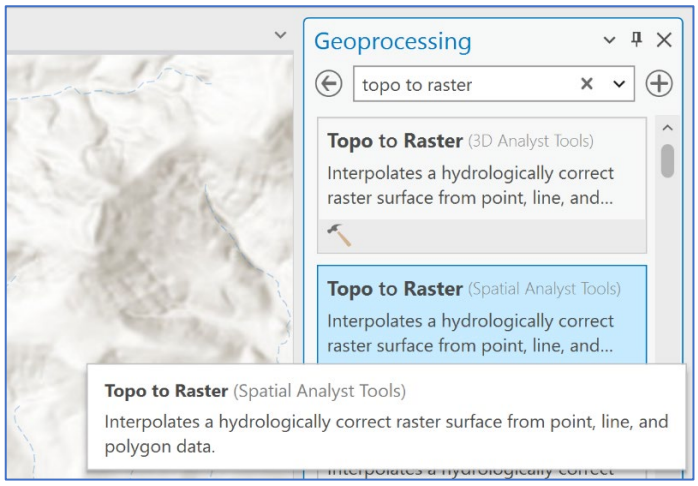
Topo to Raster (Spatial Analyst)—ArcGIS Pro | Documentation

Comparing interpolation methods—ArcGIS Pro | Documentation

We'll be running this analysis on the two clipped contour feature classes we created above: *Contour_10_raster_clip* and *Contour_50_raster_clip*.

1. To run **Topo to Raster**, you'll need to bring up the **Geoprocessing Window**. Navigate to the **Analysis Tab (1)** and click on **Tools (2)** within the **Geoprocessing** group**,** just as you have in previous steps.





2. When the **Geoprocessing Window** appears (above, right), search for **Topo to Raster** in the top **search box** and click on **Topo to Raster (Spatial Analyst Tools)** from the tools list.

3. In the **Topo to Raster Geoprocessing Window**, complete the fields as follows:

   Input Feature data- you will be adding both contour layers into this section one at a time.
   Feature layer: *Contour_10_raster_Clip*
   Field: Contour (or whatever field holds your elevation data)
   Type: Contour

   Click on **Add Another** just underneath the three fields you filled in and input the information for *Contour_50_raster_Clip* feature class.

Feature layer: *Contour_50_raster_Clip*
Field: Contour (or whatever field holds your elevation data)
Type: Contour

Output Surface Raster- Choose the name for the output raster you'll create from this process. For this project, name the output raster *TopoToR_NoMask*. (Masks will be explained below)

Drainage Enforcement- this information is optional and what you fill in here depends on the data you are working with. **Enforce** is the default.

The drainage enforcement option can be set to attempt to remove all sinks or depressions so a hydrologically correct DEM can be created. If sink points have been explicitly identified in the input feature data, these depressions will not be filled.

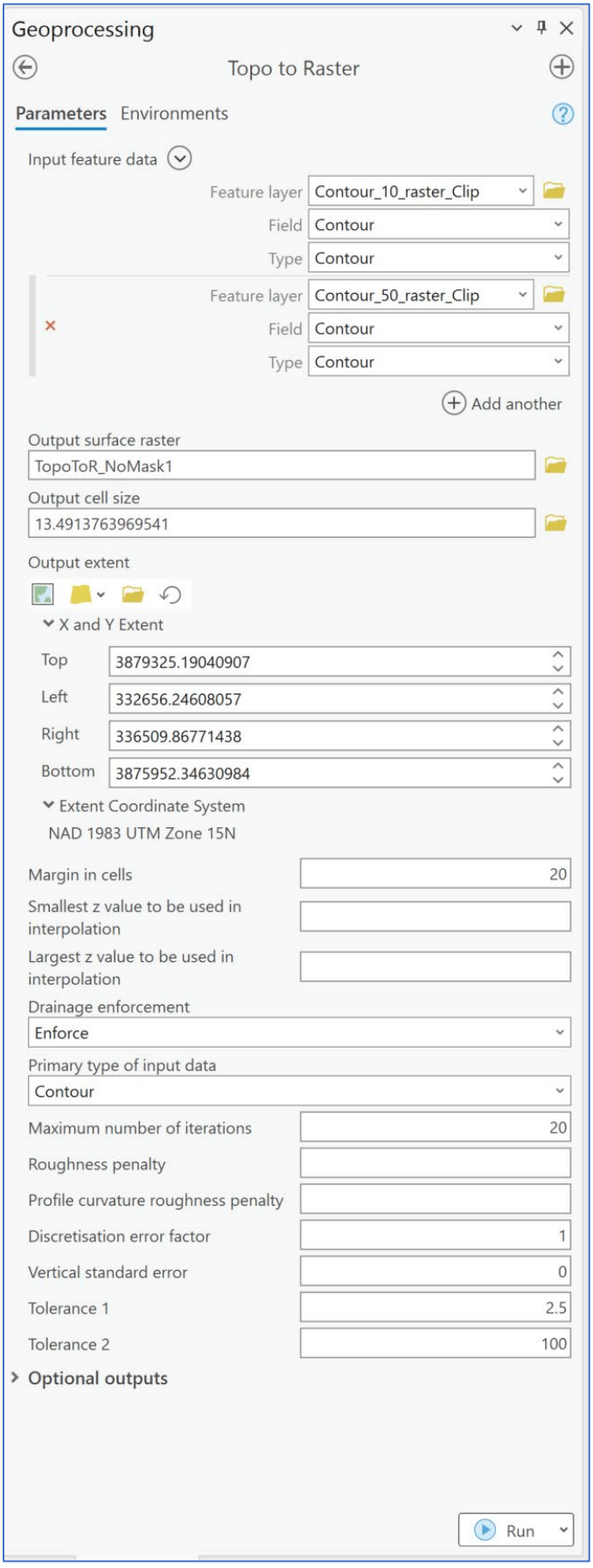
Enforce—The algorithm will attempt to remove all sinks it encounters, whether they are real or spurious. This is the default.

Do not enforce—No sinks will be filled.

Enforce with sink—Points identified as sinks in Input feature data represent known topographic depressions and will not be altered. Any sink not identified in input feature data is considered spurious, and the algorithm will attempt to fill it. Having more than 8,000 spurious sinks causes the tool to fail.

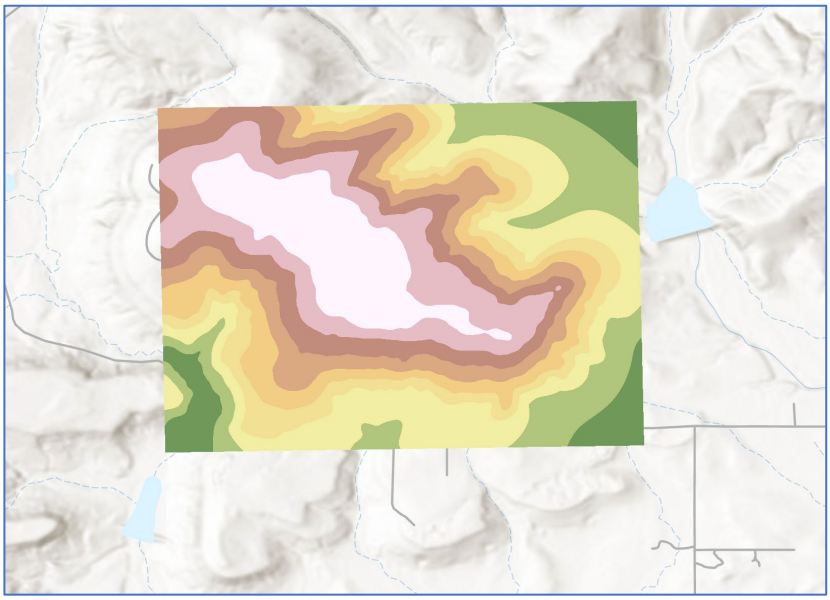
Primary type of input data – *Contour*. You're working with lines of elevation, not points.

Leave the rest as the default. The **Topo to Raster Geoprocessing window** should look like the image below.

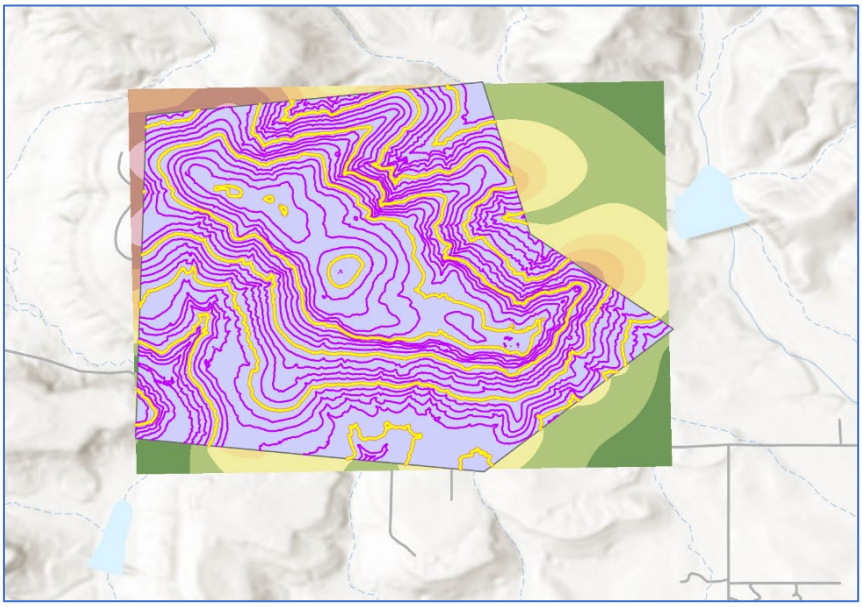

Geoprocessing
Topo to Raster
Parameters
Environments
Input feature data
Feature layer
Contour_10_raster_Clip
Field
Contour
Type
Contour
Feature layer
Contour_50_raster_Clip
Field
Contour
Type
Contour
Add another
Output surface raster
TopoToR_NoMask1
Output cell size
13.4913763969541
Output extent
X and Y Extent
Top
3879325.19040907
Left
332656.24608057
Right
336509.86771438
Bottom
3875952.34630984
Extent Coordinate System
NAD 1983 UTM Zone 15N
Margin in cells
20
Smallest z value to be used in interpolation
Largest z value to be used in interpolation
Drainage enforcement
Enforce
Primary type of input data
Contour
Maximum number of iterations
20
Roughness penalty
Profile curvature roughness penalty
Discretisation error factor
1
Vertical standard error
0
Tolerance 1
2.5
Tolerance 2
100
Optional outputs
Run

4. Click **Run**

The result will look something like below picture:



If you look at the raster you created from your data (*Area of Interest* and contours), you'll notice that the interpolation surface goes beyond the extent of the data you inputted into the **Topo to Raster Geoprocessing Tool**, as shown below.



This happens because the software picks an extent, usually the orthogonal extent of the input data, and it interpolates the surface to that extent. You'll see, from the raster you just created, that the elevation

information on the raster surface beyond the clipped contour lines doesn't seem to be as precise. That's because it's not. There is no real data there, so the software is making a best guess as to the values at those locations. For an analysis, this is not going to be helpful. You're going to fix this by setting a mask.

******Make sure to save your project! ******

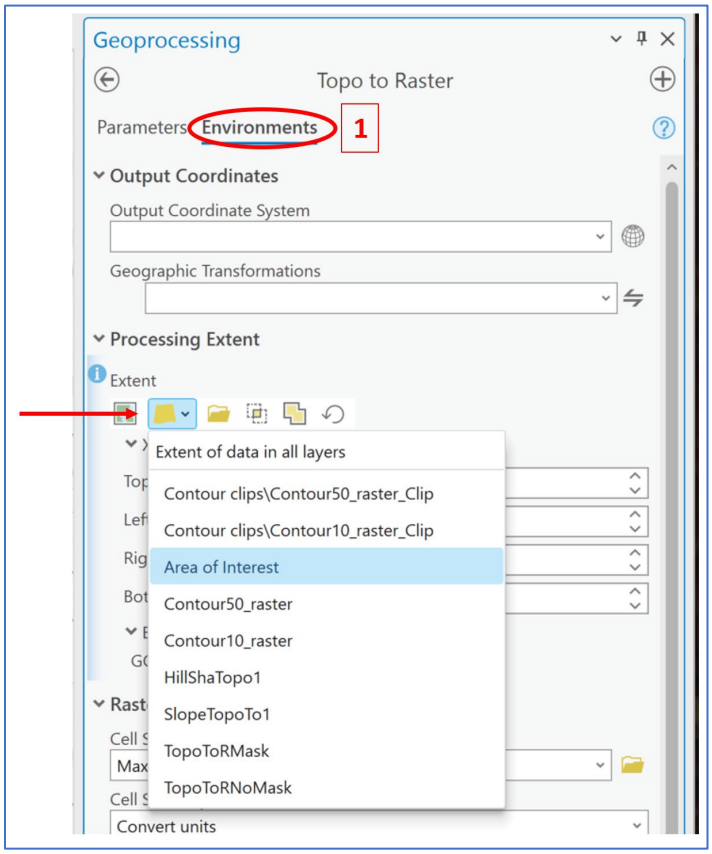
Setting a Mask When Creating a Surface from Contours

Go through steps 1-3 above. **BEFORE you click Run in step 3, follow these extra steps:**

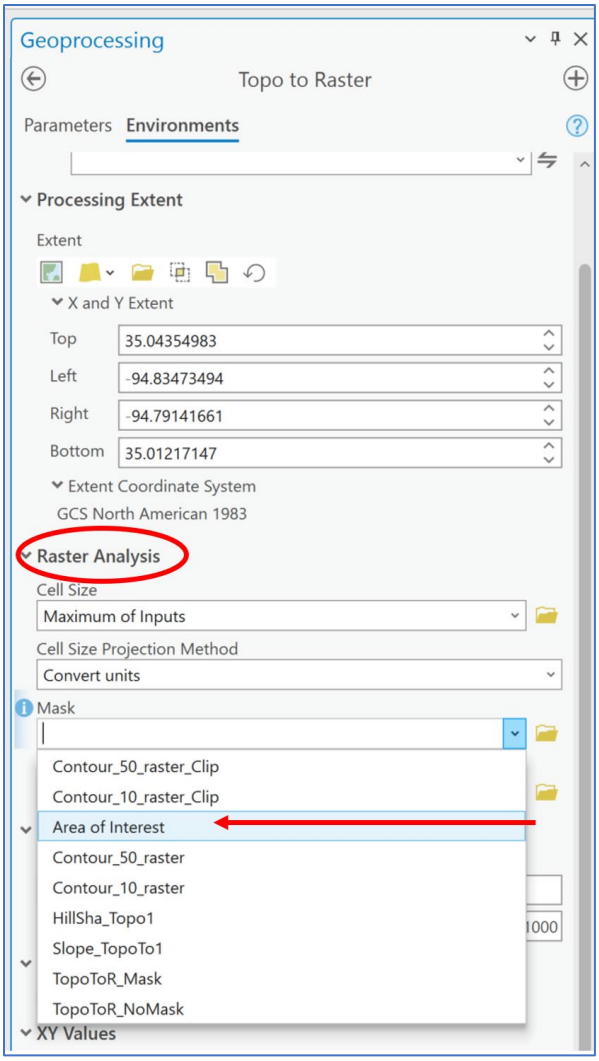
1. Click on the **Environments (1)** tab at the top of the **Topo to Raster** Geoprocessing window.

2. In **Processing Extent**, click on the yellow folder drop down menu (shown below) and pick *Area of Interest*. This will set your processing extent to the *Area of Interest* Polygon feature class only.

   NOTE: If your window does not look like this, double check your ArcGIS Pro version.



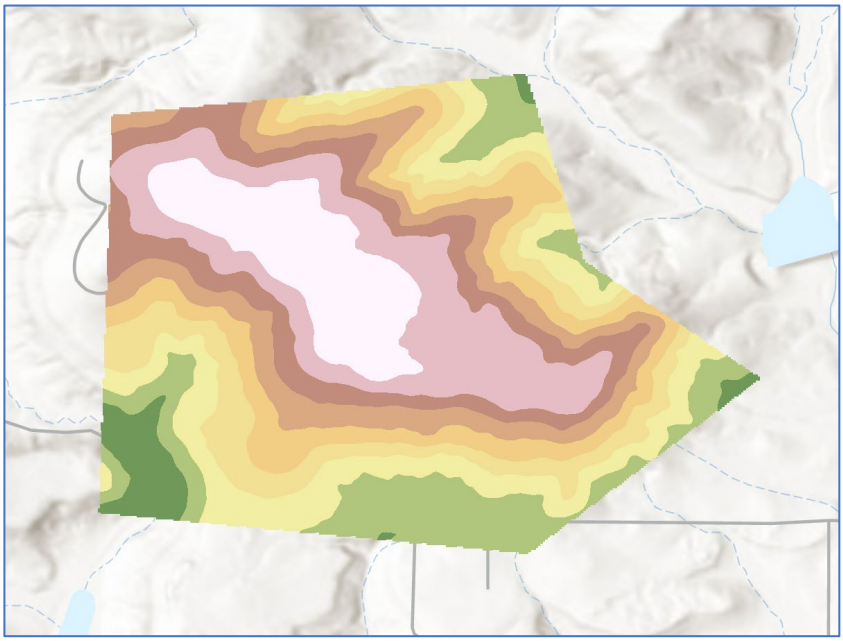
3. Scroll down to **Raster Analysis (see below)** and click on the drop-down menu under **Mask** and pick *Area of Interest*.



4. Before you click **Run** at the bottom, go back to the **Parameters tab** at the top, next to the **Environments tab**, and under **Output surface raster**, rename this raster *TopoToR_Mask*.

5. Now you're ready to click **Run** at the bottom.

The below image shows the result of the interpolated surface with a mask.



The first thing you'll notice is that the raster surface is the same shape as the *Area of Interest* polygon. The elevation information is also more detailed and nuanced.

Take a moment to compare the two surfaces you just created and see how the mask made a difference in how the software interpreted the data.

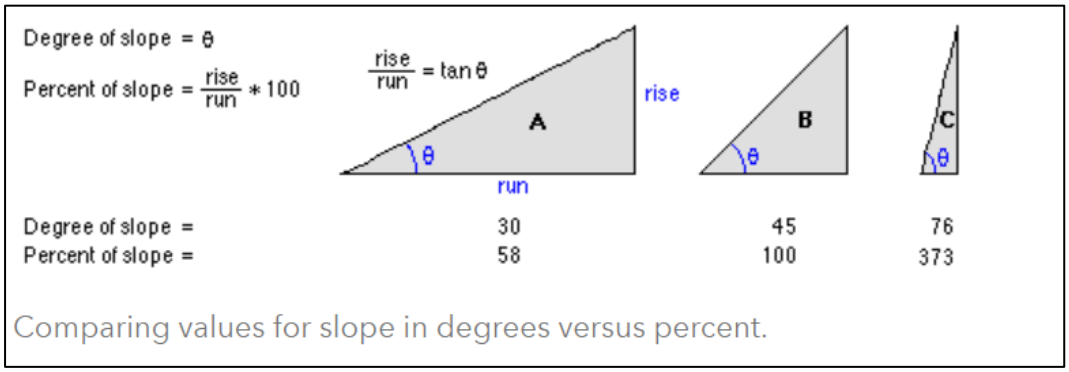
Check out how the clipped contour lines match up with the second interpolated surface and how it differs between the two raster datasets.

******Make sure to save your project! ******

Using the Slope and Hillshade Spatial Analyst Tools

Slope

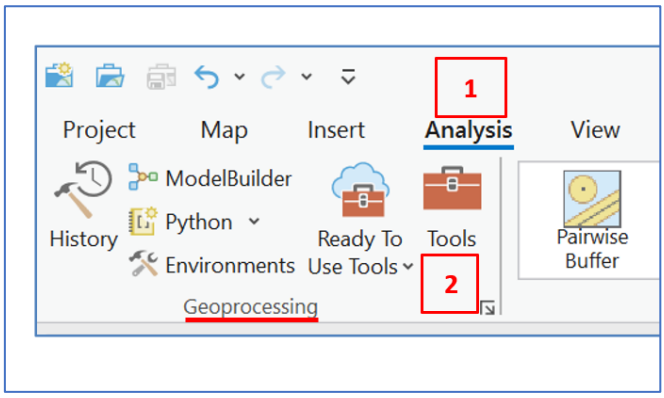
The Slope tool identifies the steepness of each cell in a raster surface. The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain. The output slope raster can be calculated in either degrees or percent (percent rise). The percent rise can be better understood if you consider it as the rise divided by the run, multiplied by 100. Consider triangle B below. When the angle is 45 degrees, the rise is equal to the run, and the percent rise is 100 percent. As the slope angle approaches vertical (90 degrees), as in triangle C, the percent rise begins to approach infinity.

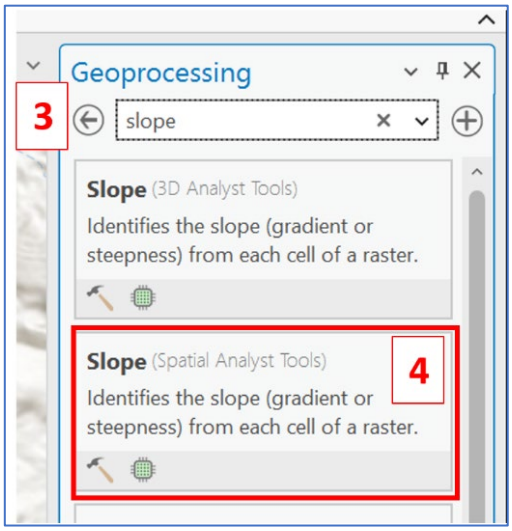


For more information about Slope, check out this link: [How Slope works—ArcGIS Pro | Documentation]

The Slope tool is most frequently run on elevation datasets. Below are the steps for creating a slope raster:

1. From the **Analysis Tab (1)**, click on **Tools (2)**, then search for slope **(3)** in the **Geoprocessing Window**. Select **Slope (Spatial Analyst tools) (4)** from the tools offered in the list.





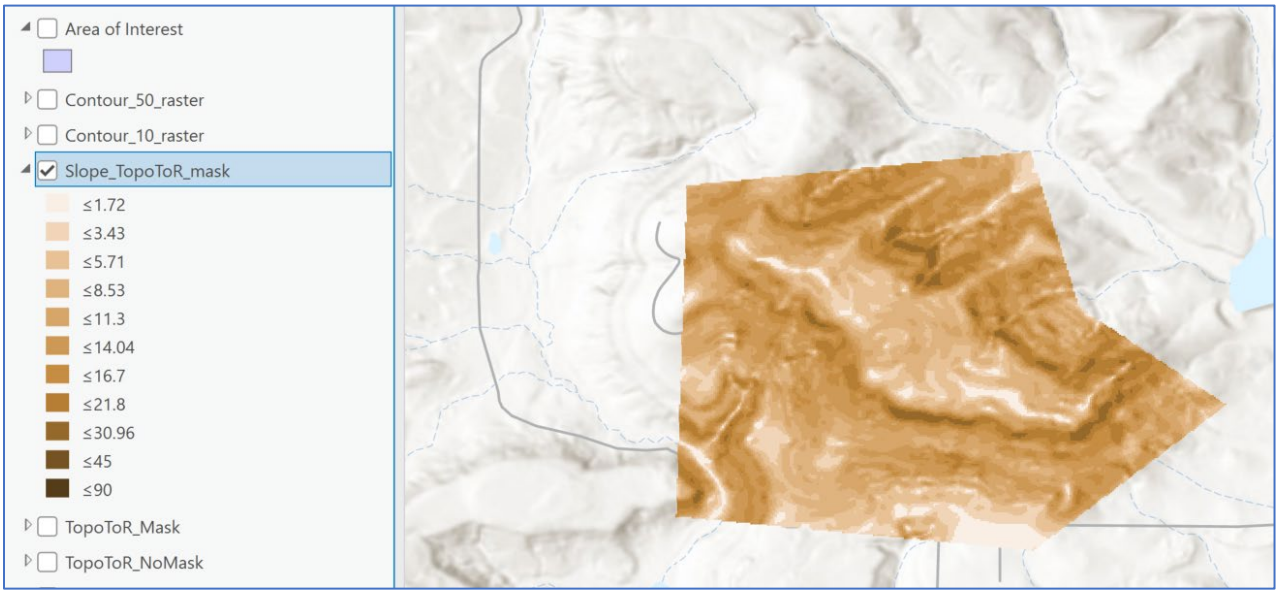
2. In the **Slope Geoprocessing Window**, for **Input Raster,** click the down arrow and choose *TopoToR_Mask*.

3. For **Output Raster**, rename your output raster to whatever makes the most sense to you. The default is *Slope_TopoTo1*, but you might rename it to *Slope_TopoToR_mask*, since we used the Topo to Raster interpolation tool to create two surfaces, one with a mask and one without.

4. For **Output Measurement,** you could choose either **degree** or **percent rise**. Let's choose **degree**.

5. Leave the other options as their defaults and then Click **Run**.

Your map should look something like this image below, although the colors may be different. The darker areas represent steeper slopes, and the lighter areas represent flatter ground.



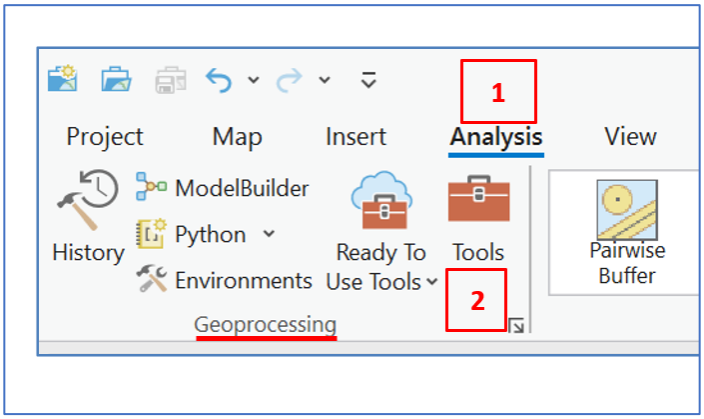
Hillshade

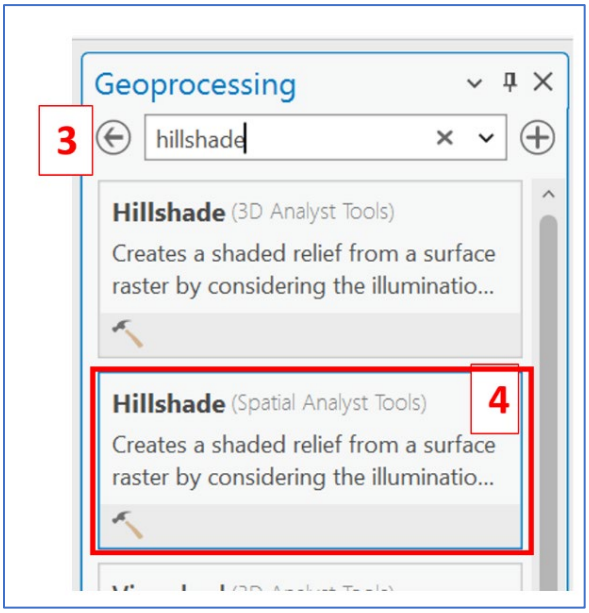
The Hillshade tool produces a grayscale 3D representation of the terrain surface, with the sun's relative position considered for shading. Hillshading is a technique for visualizing terrain determined by a light source and the slope and aspect of the elevation surface. It is a qualitative method for visualizing topography and does not give absolute elevation values. If you want to give your maps depth and dimension, try using a hillshade effect on them. Hillshades enhance the three-dimensional appearance of the terrain by using patterns of light and shadow to create a 3D representation of the surface that makes it easier to identify landscape features. To create this effect, you can use digital elevation models (DEM), a type of raster that contains elevation value within each cell.

For more information about Hillshade, check out this link from Esri: [Hillshade function—ArcGIS Pro | Documentation]

Follow these steps to create a hillshade raster:

1. From the **Analysis Tab (1)**, click on **Tools (2)**, then search for hillshade (3) in the **Geoprocessing Window**. Select the **Hillshade (Spatial Analyst Tools) (4)** from the tools offered.





2. In the **Hillshade Geoprocessing Window**, for **Input Raster,** click the down arrow and choose *TopoToR_Mask.*

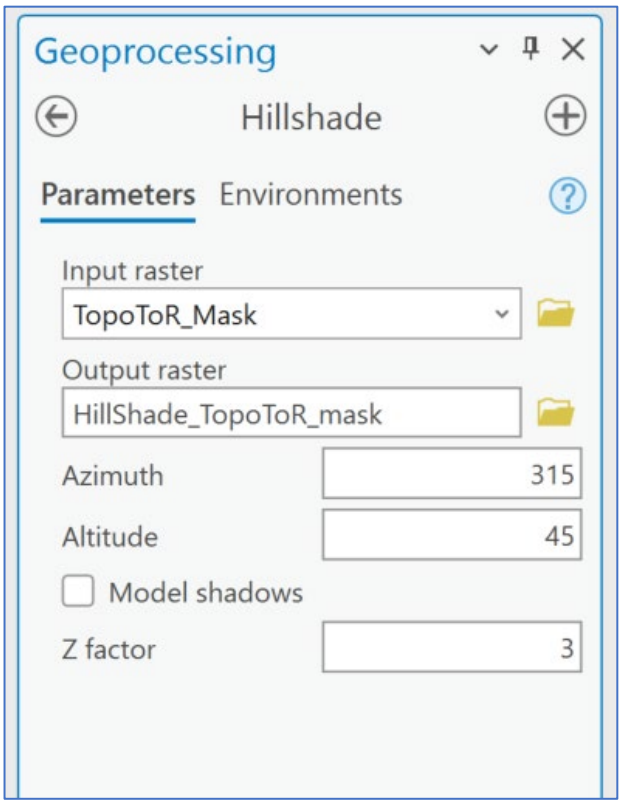
3. For **Output Raster**, rename your output raster to whatever makes the most sense to you. The default is *HillSha_Topo1*, but you might rename it to *Hillshade_TopoToR_mask* since we used the Topo to Raster interpolation tool to create two surfaces, one with a mask and one without.

4. NOTE: the name here is similar to the slope raster we created in the step above. The names are simple enough to understand the source of the data and what each raster is showing. Simple file names are key, especially when working with larger projects.

5. For **Azimuth** and **Altitude**, leave them as their default values.

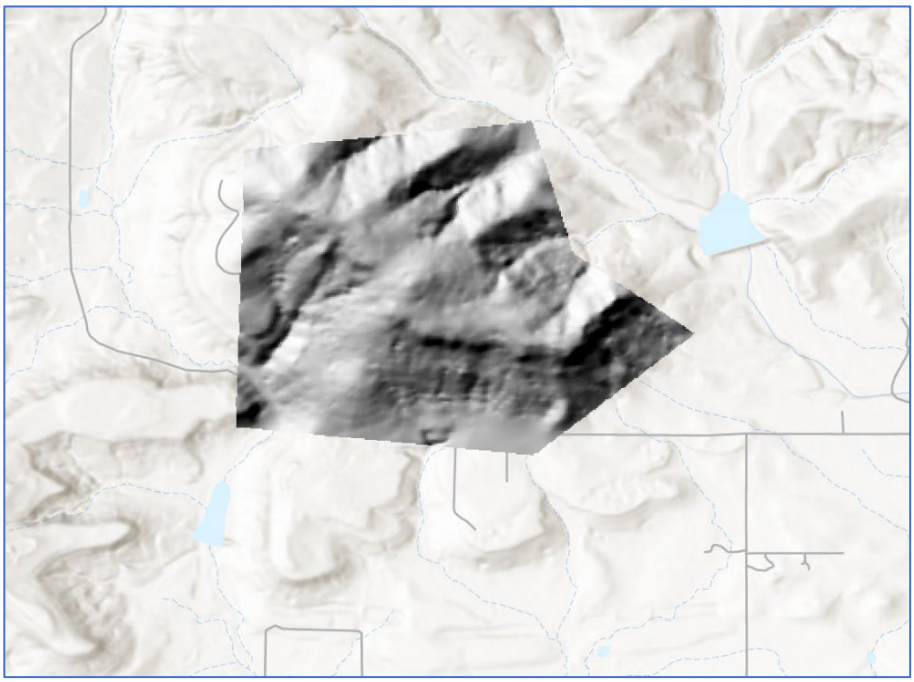
6. For the **Z factor**, you can leave it as the default value, but for this exercise, change it to 3. This will increase the vertical exaggeration of the Hillshade raster. You can test out different values for this option and compare the final products.

   Your **Hillshade Geoprocessing Window** should look like this:



7. Click **Run** at the bottom.

Your Hillshade raster should look something like this:



For more information on how to create different Hillshade effects in ArcGIS Pro, check out this link: Create Amazing Hillshade Effects Quickly and Easily in ArcGIS Pro (esri.com)

Congratulations!

We hope this tutorial was helpful. Remember to save your project with any name you choose before closing the ArcGIS Pro application.