How to Generate Contours in ArcGIS Pro

This tutorial will show you how to generate contour lines from the LiDAR Image Services located at: https://lidar.geodata.md.gov/imap/rest/services, using ArcGIS Pro (requires Spatial Analyst extension). After the contour lines are generated, you will learn how to build an index and symbolize the lines appropriately.

What are contour lines?

Contour lines are vector features used to represent the landscape in a relatively familiar way. A contour is a line through all contiguous points of equal value.

When are contour lines appropriate?

Contour lines are used as a familiar media for representing the elevations of a land surface above sea level. These lines are typically used for basemaps and general topographic representation; contour lines do this appropriately.
Contours should not, on the other hand, be used for analyzing the surface elevations above and beyond for aesthetic purposes. Users who require the raw data, countywide DEMs are available for download from the MD iMAP LiDAR Download page.
First we will need to connect to the MD iMAP Maryland LiDAR Topography Server, for more information please follow this link to learn How to Access Maryland LiDAR Image Services.

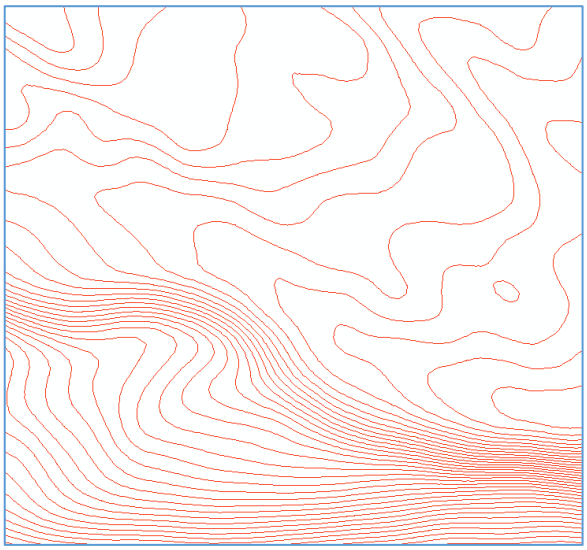
Comparing Raw vs Smooth Contour Lines

Generating Contour Lines in ArcGIS Pro

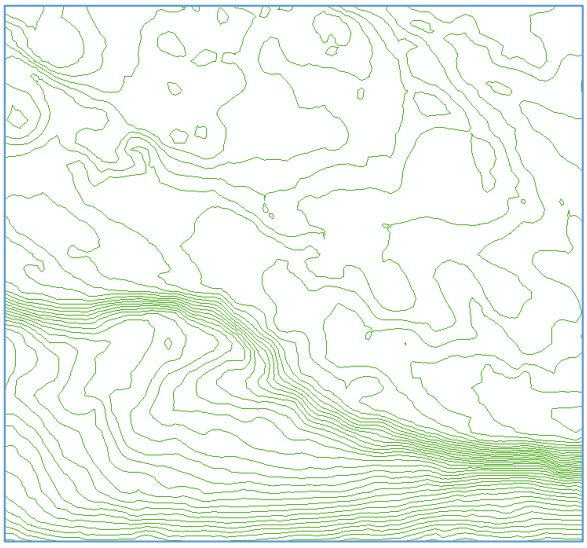
Building Contour Index Lines

Comparing Raw vs Smooth Contour Lines

1. Typically when someone mentions contours lines, the first thing they think of is a topographic map with smooth, rounded curves. See example >>>



2. The problem with the sample show above resides with the fact that it inaccurately represents the land surface.
   If we were to generate contour lines from a raw DEM, we would expect something like: See example >>>



3. If smooth contour lines are the desired final product, we must generate contours that are data-driven. This is critical to preserving the data's accuracy and minimizing the level of error. DO NOT generate contours and smooth the vector lines after they are built; this method does not determine the direction and level of smoothing based on the DEM. This incorrect method of smoothing is not data-driven and therefore nullifies the accuracy of our data.
   The appropriate method for generating smooth data-driven contour lines is by smoothing the input DEM using the focal statistics tool in ArcGIS. This output will be data-driven and will allow us to build contours at different levels of smoothness; leaving the control at the user's hand.

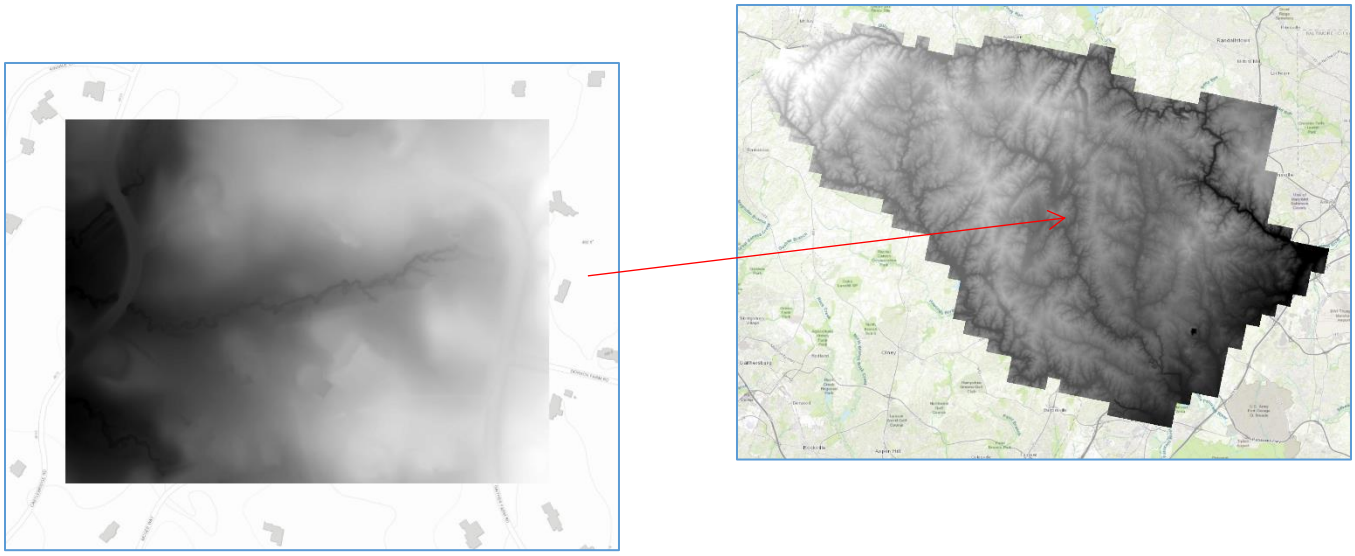
Generating Contour Lines in ArcGIS Pro

1. Open an existing project, or start a new map template, in ArcGIS Pro.

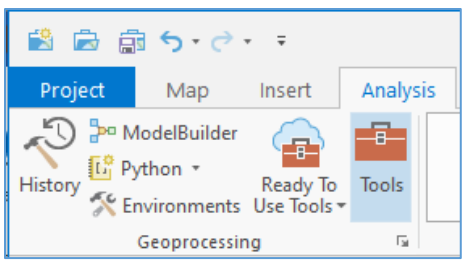
2. Add the desired Image Service to your map.
   For more information on accessing Maryland LiDAR image services, please read How to Access Maryland LiDAR Image Services.

3. Extract your AOI (area of interest) from the image service to allow for local data processing. For more information on the image service extraction process, please read How to Extract from Image Services.

   Example: Howard_DEM_FT
   *If you're planning on generating contours with an interval in feet (ex: 1ft) make sure to start with a product that has elevation units in feet (such as the *_DEM_FT image service*

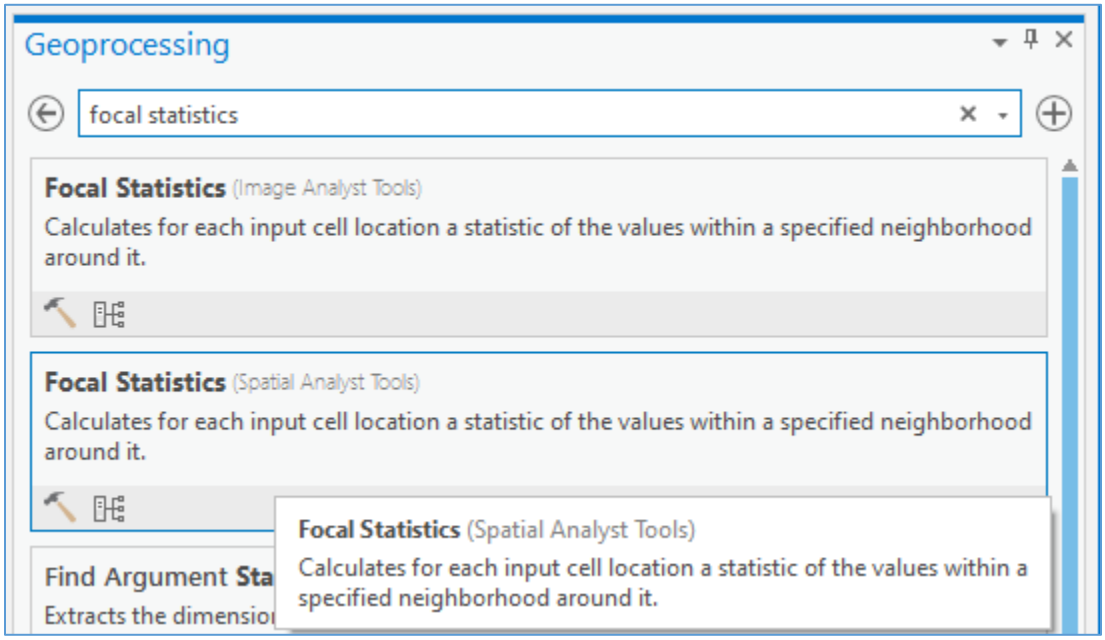


4. This tutorial assumes you are working with the DEM_FT product and do not need to convert to feet elevation units.
   Under the Analysis tab on the Menu Bar, select Tools to open the Geoprocessing pane:

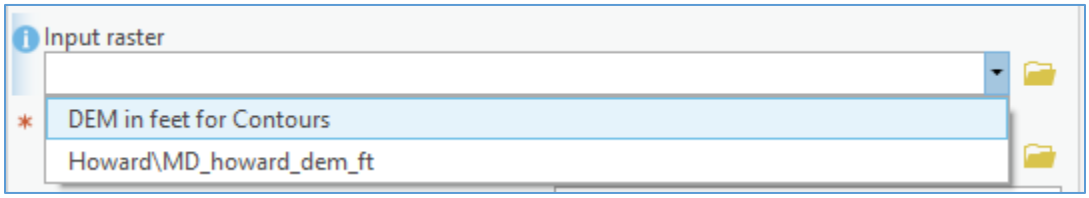


5. In order to create smooth contour lines, we first need to smooth our DEM to ensure the vector output is data-driven. The most efficient way of doing this in ArcGIS Pro is by using the Focal Statistics tool in the Spatial Analyst toolbox.

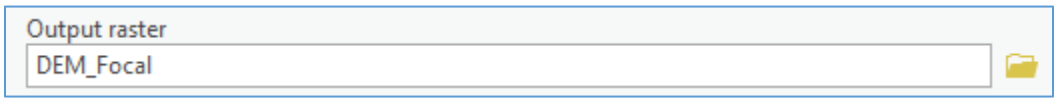
   In the Geoprocessing pane, search for Focal Statistics (Spatial Analyst tool)



6. Select your extracted DEM in feet for the contour input raster:

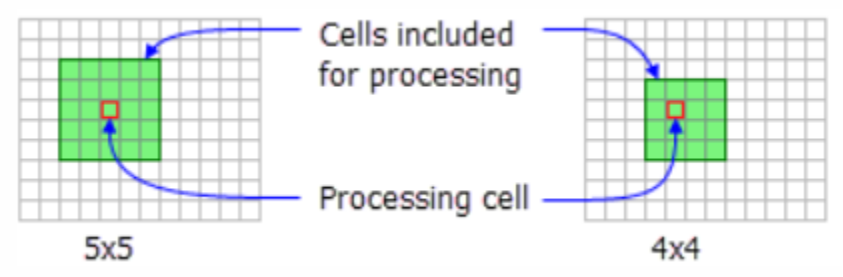


7. Create an output workspace for your output raster – this is important to pay attention to as this output raster should be used ONLY for delineating smooth contour lines. The product should be deleted after the contour delineation or saved somewhere you will not mistake this for the original DEM for other processing workflows.



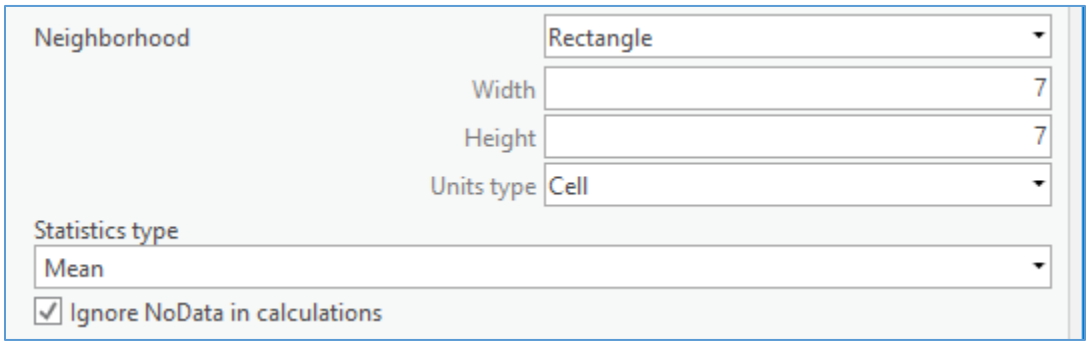
8. The neighborhood operation computes an output raster where the value for each output cell is a function of the values of all the input cells that are in a specified neighborhood around that location. (ESRI)

   To illustrate the neighborhood parameter, the graphic below shows two rectangular neighborhoods, 5x5 and 4x4.



   To avoid truncation, an odd number neighborhood is recommended (ex: 3x3, 5x5, 7x7, etc) for processing when computing focal statistics.

9. In this example, a 7x7 rectangular neighborhood is selected with Cell defined as the units type and Mean defined as the statistics type:

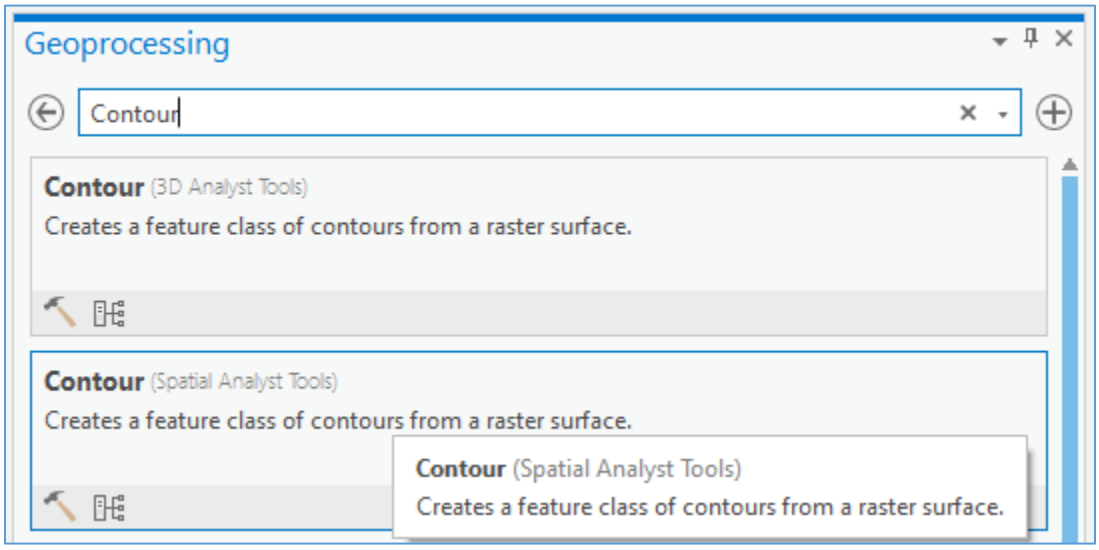


10. Verify tool parameters and click 

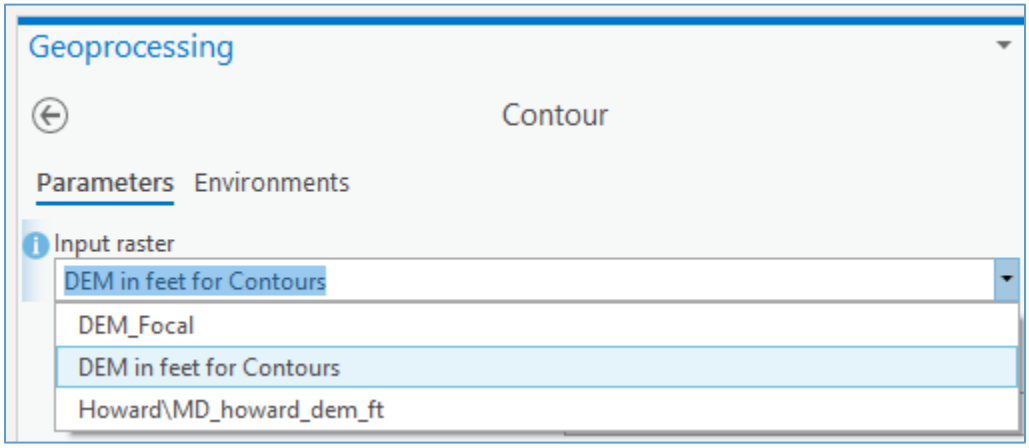
11. The output will look very similar upon inspection to the original DEM. It is critical that users delineate between these two raster DEMs and only use the focal statistic output for operations requiring this data-driven smoothing technique.

    In addition, the cell size resolution of the two raster DEMs will be identical, so ensuring an appropriate naming convention is recommended!

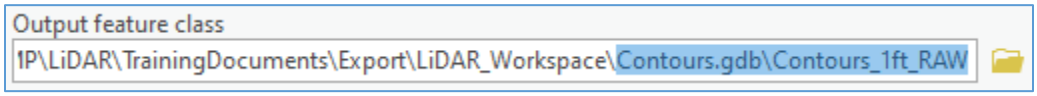
12. Under the Geoprocessing pane, search for Contour (Spatial Analyst tools):



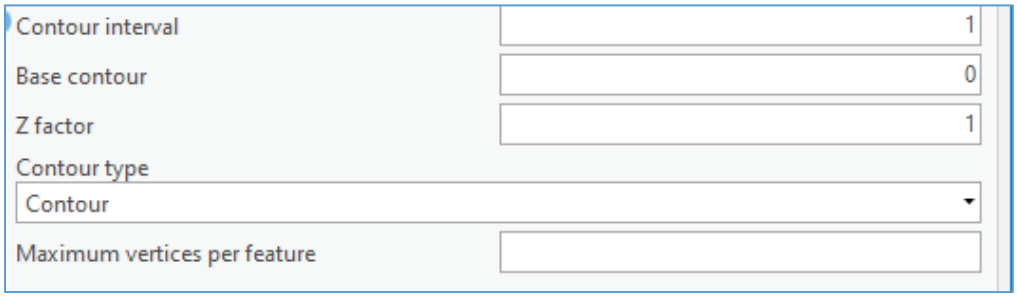
13. The first run though, set your Input raster as the original DEM area of interest, not focally smoothed.

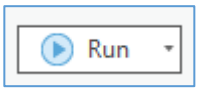


14. Set your output feature class, make sure to name the product appropriately as we will run the tool again for the smooth lines. Example: Contours_1ft_RAW
Note: Contour lines can be very large depending on your AOI (area of interest). Therefore, it is recommended to work within a File Geodatabase in ArcGIS. Large areas of contour lines at 1ft intervals can easily exceed the 2GB limitation set on shapefiles.

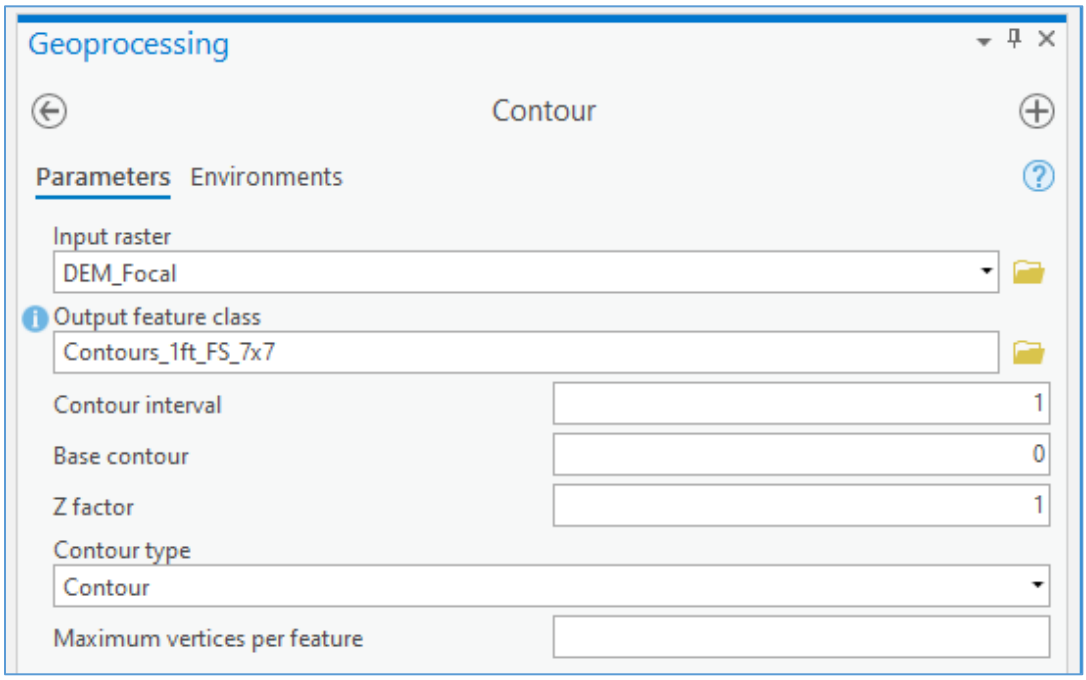


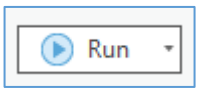
15. Set the contour interval as desired, in this tutorial we are generating 1ft contours, so contour interval will be 1 as we know the vertical units are in feet:



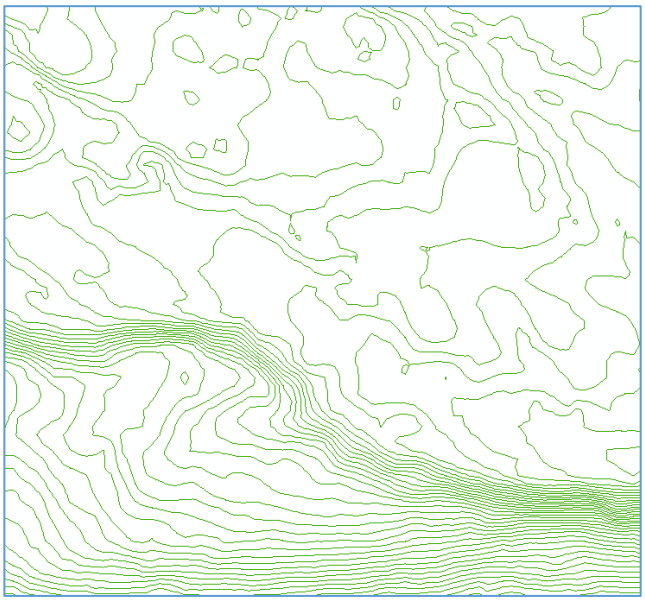
16. Verify the input parameters and click 

17. Run the tool again, this time changing the input raster to the focal statistics DEM output, and changing the output feature class name appropriately. Example: Contours_1ft_FS_7x7. Often it is preferred to include the neighborhood parameters in the output feature class naming convention to help delineate between various smooth contour lines in a situation where multiple neighborhoods may have been defined.

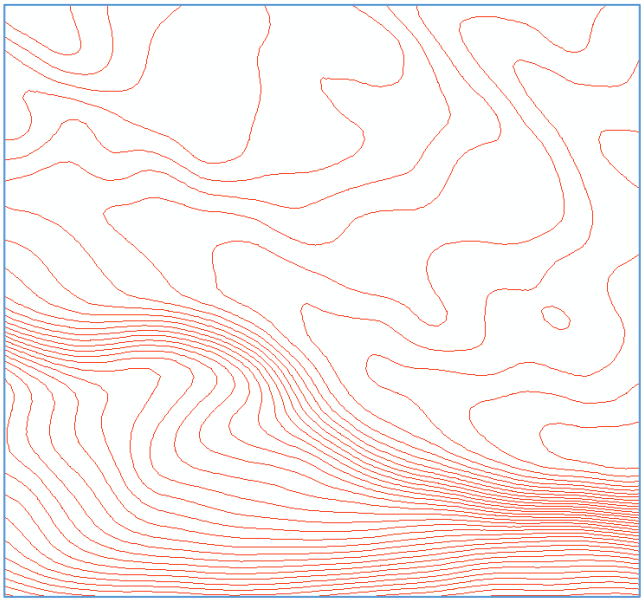


18. Verify the tool parameters and click 

19. Compare the results below:



Contours_1ft_RAW

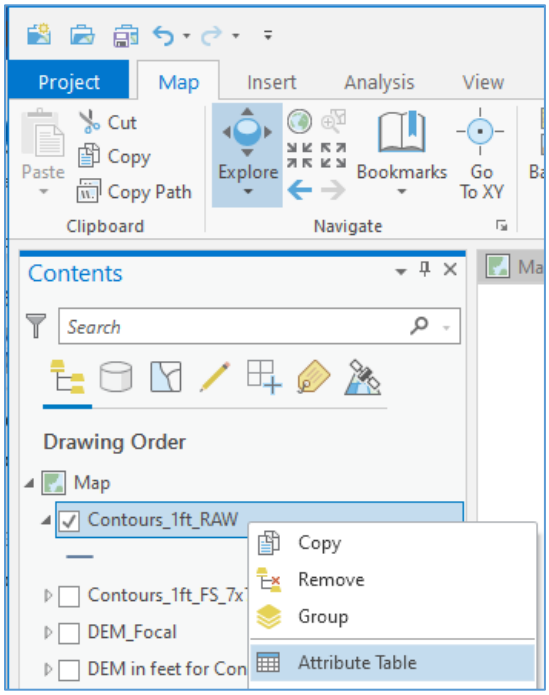


Contours_1ft_FS_7x7

Building Contour Index Lines

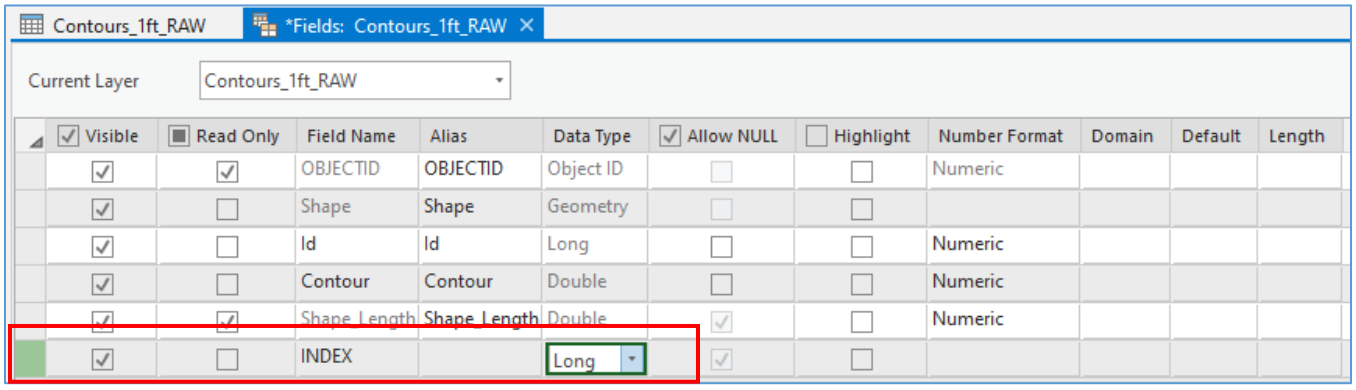
1. Indexing your contours after they have been generated is an efficient way to set up labels and symbology for multiple intervals without requiring additional geoprocessing.

2. Right click the contour feature class in the Contents pane and open the attribute table:

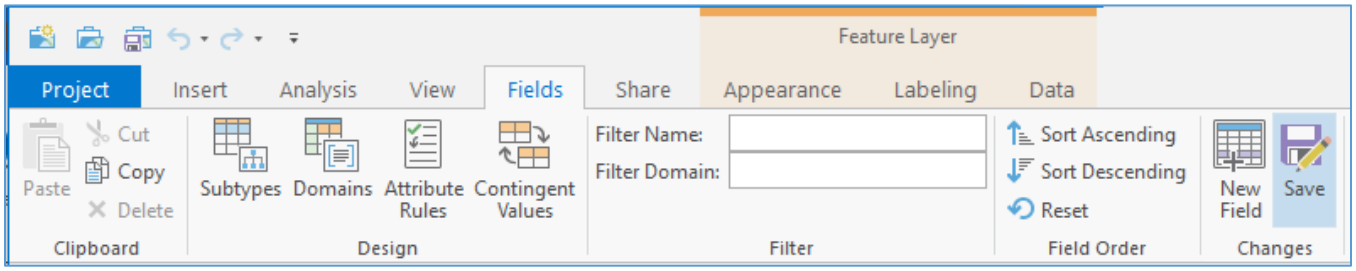


3. Click the button to add a field: 

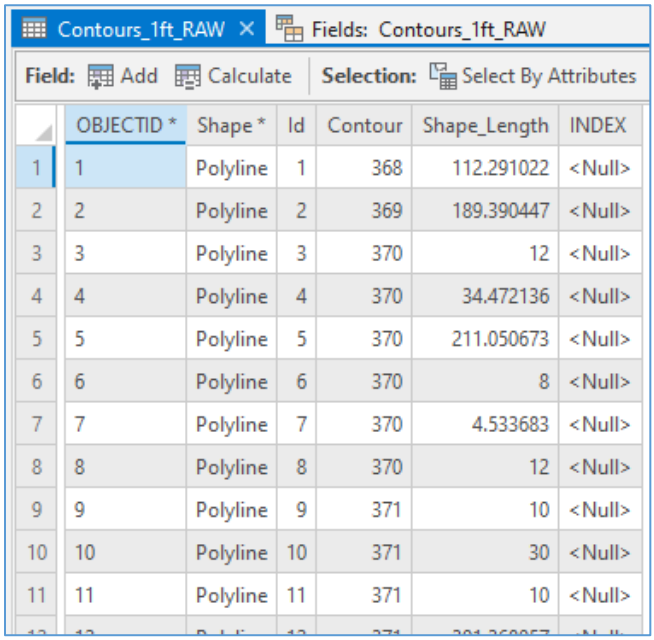
4. Add a field named “INDEX” with a Long data type:



5. Click Save on the Fields Menu Bar:

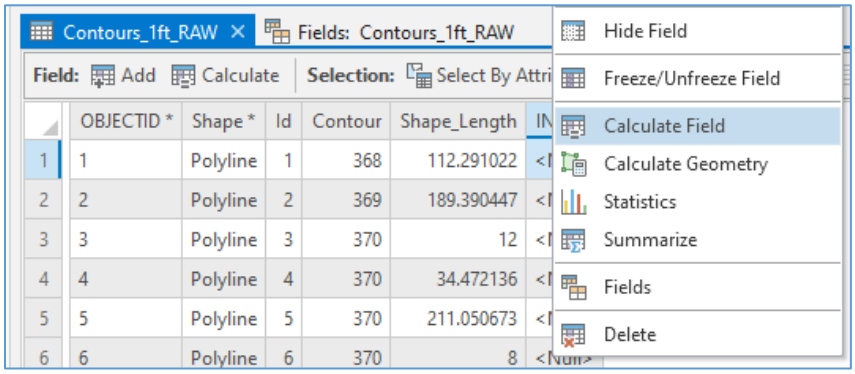


6. Navigate back to the attribute table and verify that the new INDEX field has been added:

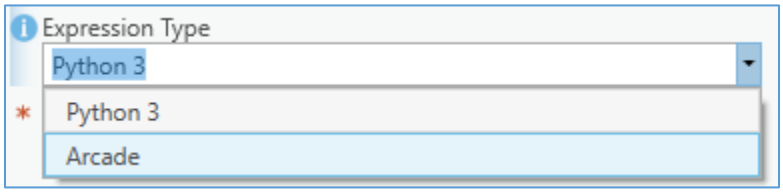


	OBJECTID *	Shape *	Id	Contour	Shape_Length	INDEX
1	1	Polyline	1	368	112.291022	<Null>
2	2	Polyline	2	369	189.390447	<Null>
3	3	Polyline	3	370	12	<Null>
4	4	Polyline	4	370	34.472136	<Null>
5	5	Polyline	5	370	211.050673	<Null>
6	6	Polyline	6	370	8	<Null>
7	7	Polyline	7	370	4.533683	<Null>
8	8	Polyline	8	370	12	<Null>
9	9	Polyline	9	371	10	<Null>
10	10	Polyline	10	371	30	<Null>
11	11	Polyline	11	371	10	<Null>

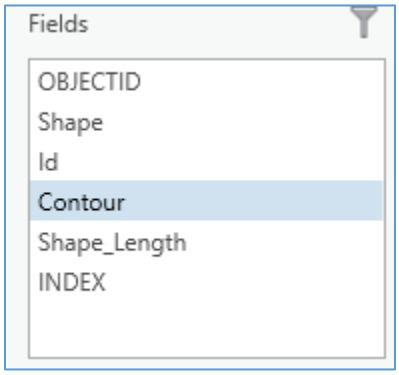
7. Right click the INDEX field header and click Calculate Field



8. For this tutorial, we will change Expression Type to Arcade:



9. Using the Fields window, double click on the Contour field to add it to the expression



10. Using a Modulo operation, we can return the remainder of a division after one number is divided by another. When applying this operation to an expression with the Contour field, we effectively can generate index contours using a modulus.

    Example: if we apply a modulus of 5 to the INDEX field for Contour value, then all contour lines divisible by 5 would return a value of 0, indicating the 5ft index lines. Lines not divisible by 5 would return the remainder of that division, indicating they are not 5ft index lines

    Here is a screenshot of the result from a sample table:

Contour	Shape_Length	INDEX
395	10	0
396	12	1
397	16	2
398	586	3
399	16	4
400	8	0
401	16	1

    Notice how contour line values of 395 and 400 have an INDEX value of 0, indicating they are divisible by 5 and thus represent two separate 5ft index lines in this sample.

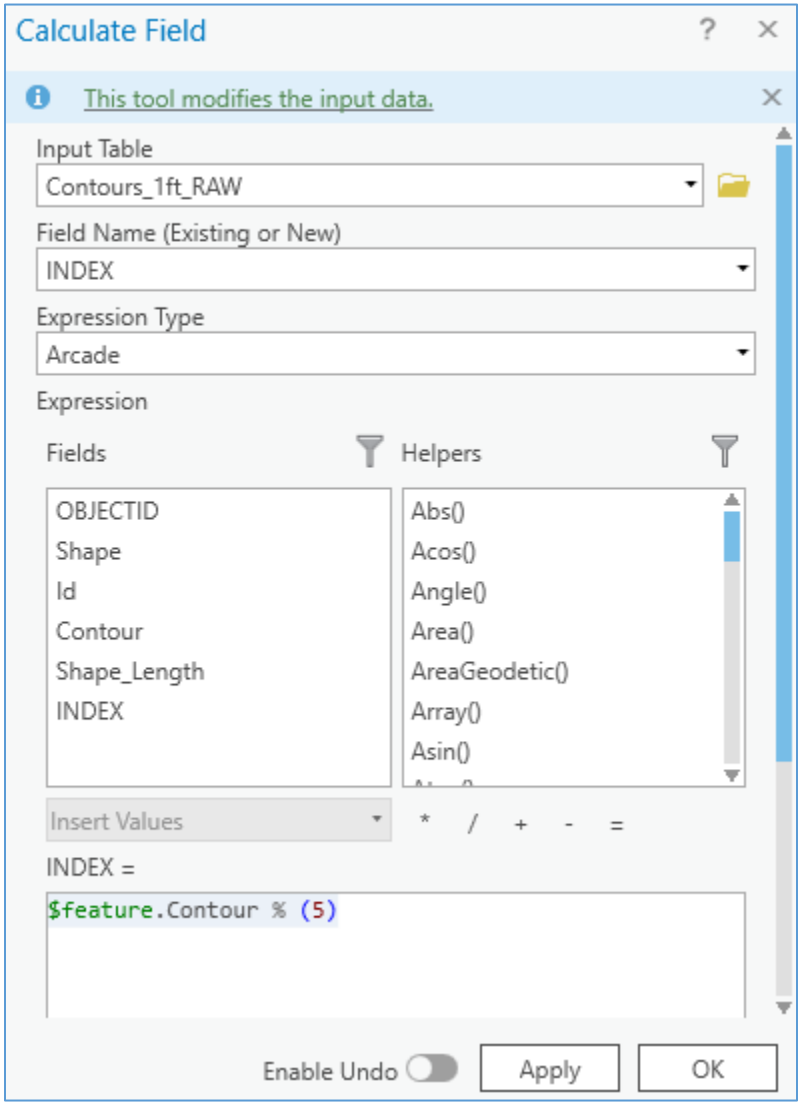
    396, 397, 398, 399, and 401 are not divisible by 5, and therefore are going to return an INDEX value greater than 0.

    After applying a modulo operation, we can simply filter INDEX = 0 and symbolize those features differently as index lines at whatever interval/modulus we desire.

11. In Arcade expressions, the modulo operation is simply written as %(x) where x is the modulus.

    In this example, the Expression reads: $feature.Contour % (5)

    Where $feature.Contour is our contour line value, and %(5) is the modulo operation for a modulus of 5.

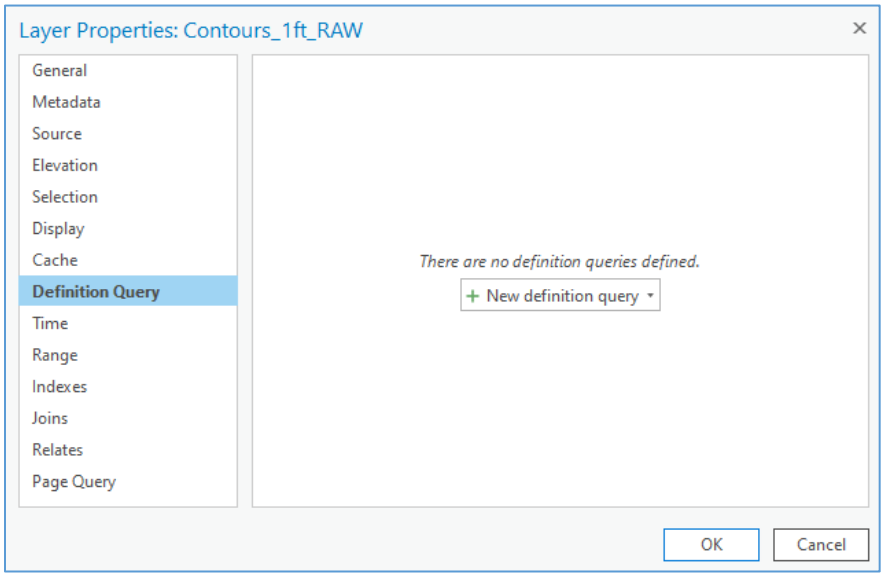


12. Click 

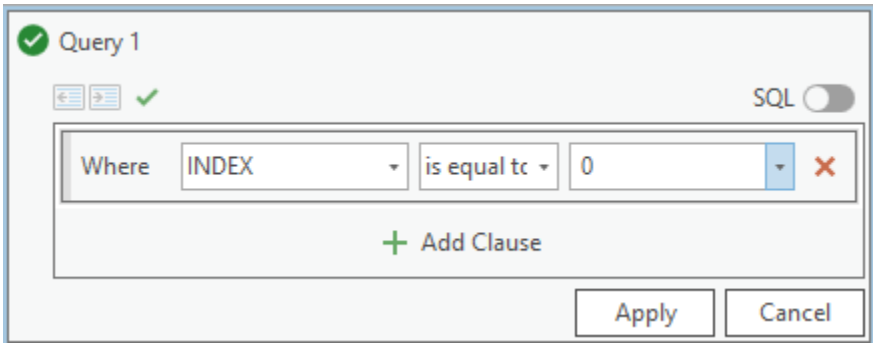
and inspect the table. Ensure the INDEX values are correct before continuing

13. We can now view the contour feature class in a variety of ways.

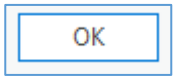
    To filter out only the INDEX based on our defined modulus, open layer properties and select Definition Query:

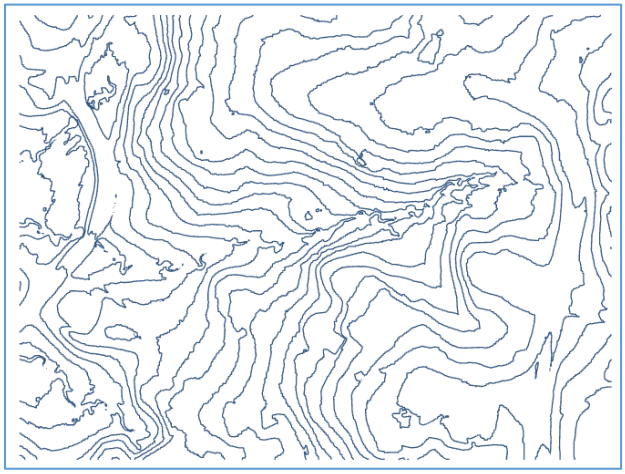


14. Click on New definition query and write a query Where INDEX is equal to 0

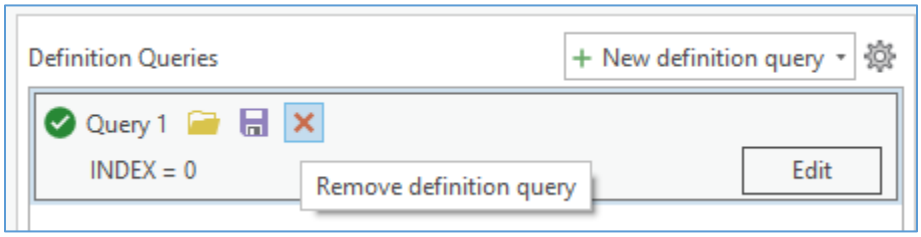


15. Click 

and 

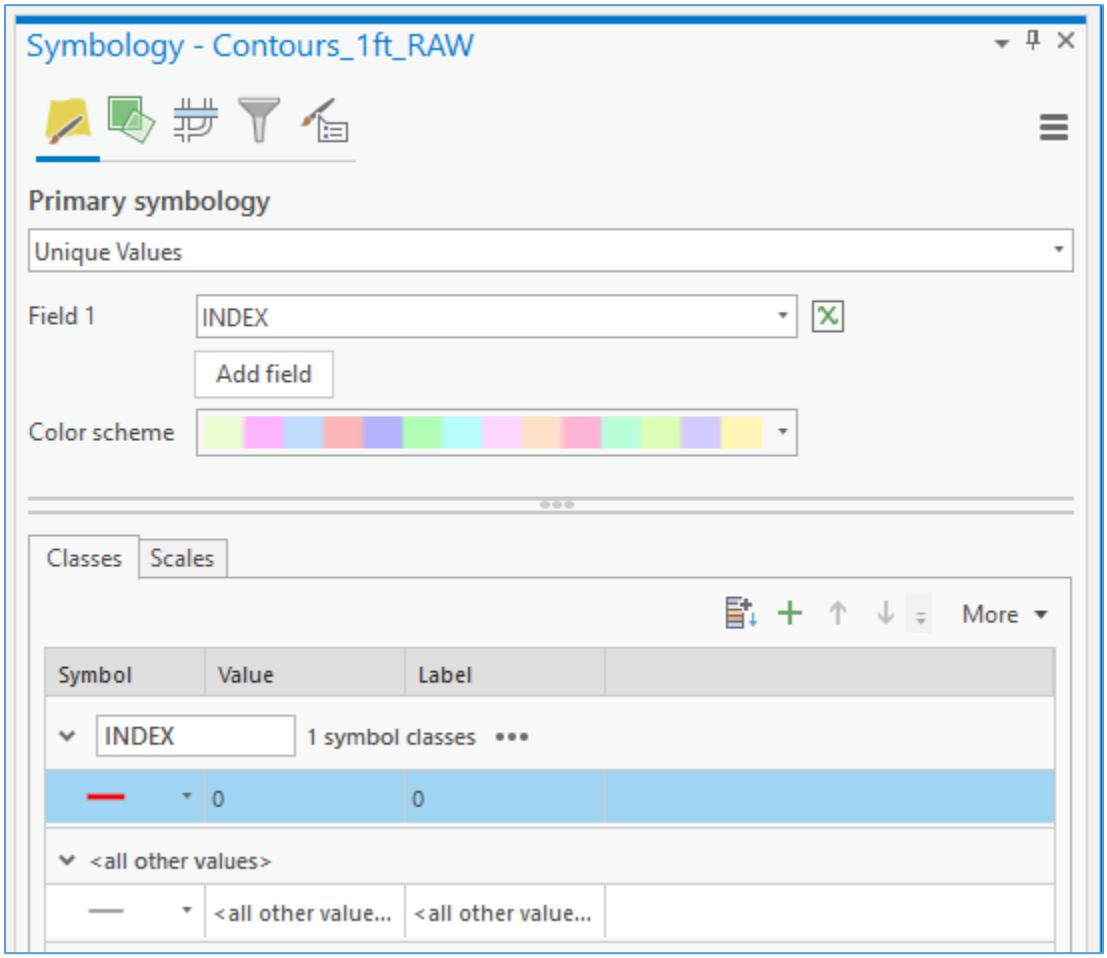


16. Remove the definition query in layer properties:



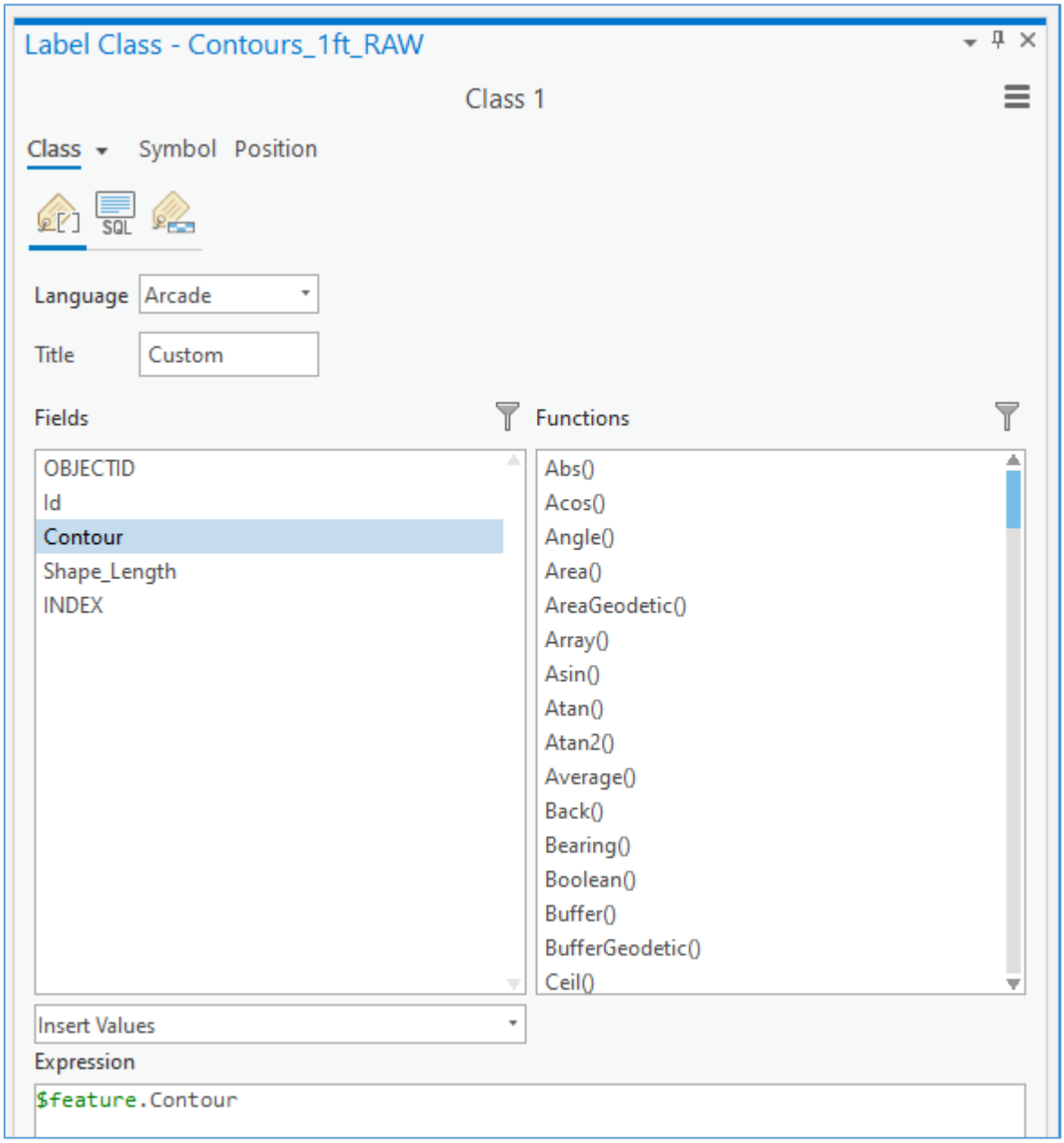
17. Right click the feature class in the Contents pane and open symbology.

18. Select Unique Values as the primary symbology.
    Select INDEX as the field.
    Under the Classes tab, add a class for INDEX value 0 and remove all others.
    Set the color and line properties for value 0 as desired.
    Set <all other values> to a lighter grey color, or as desired:



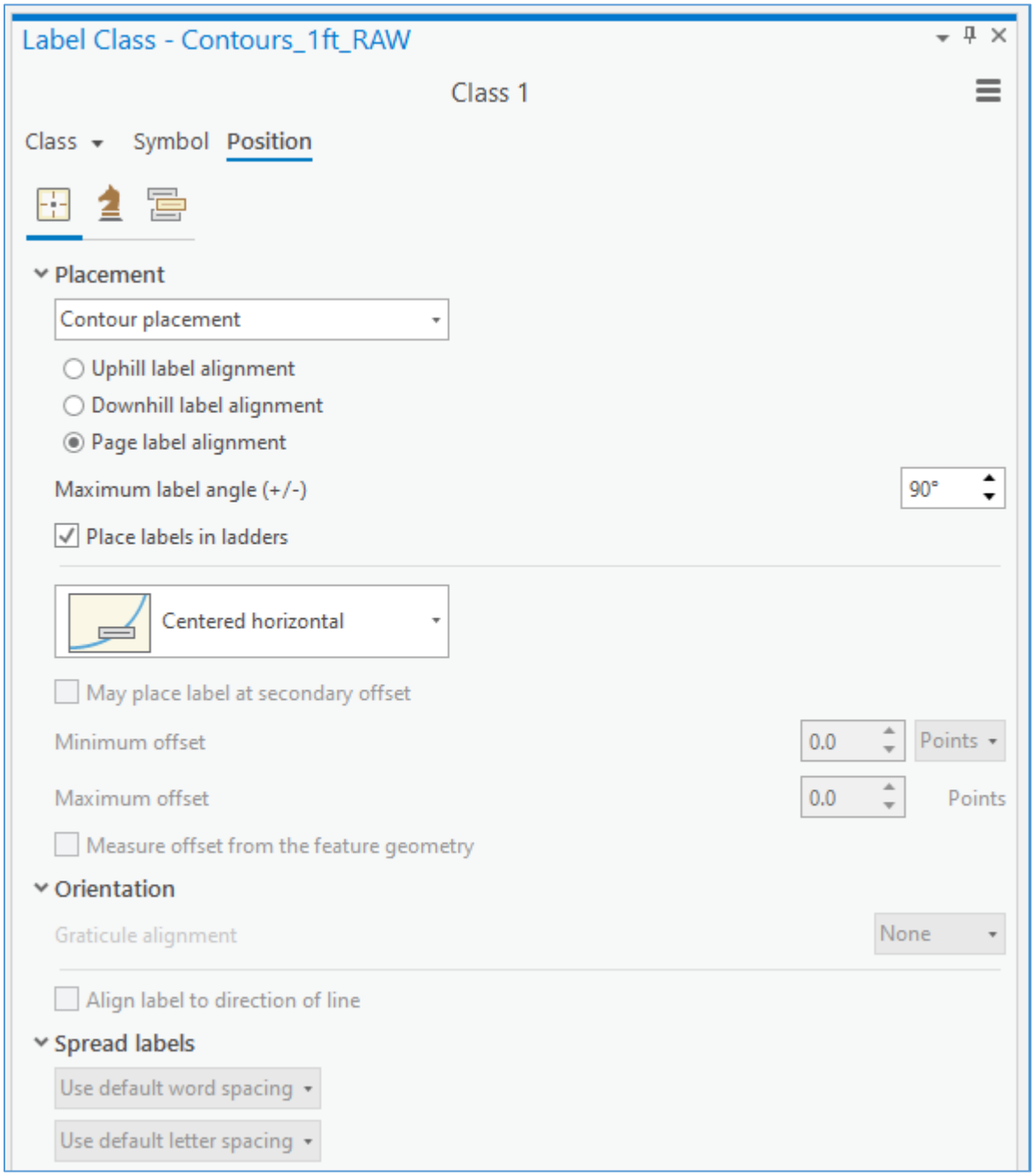
19. Navigate back to the Contents pane and right click the feature class. Open Labeling Properties:

    Under the expression window, set the Contour field as the labeling field by double clicking it in the Fields pane.

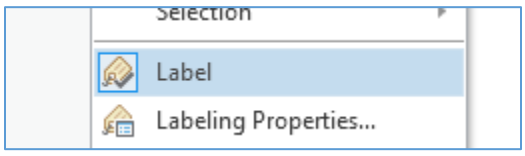


20. Click 

21. Under the Label Properties Position tab, set placement, orientation, and spread as desired:



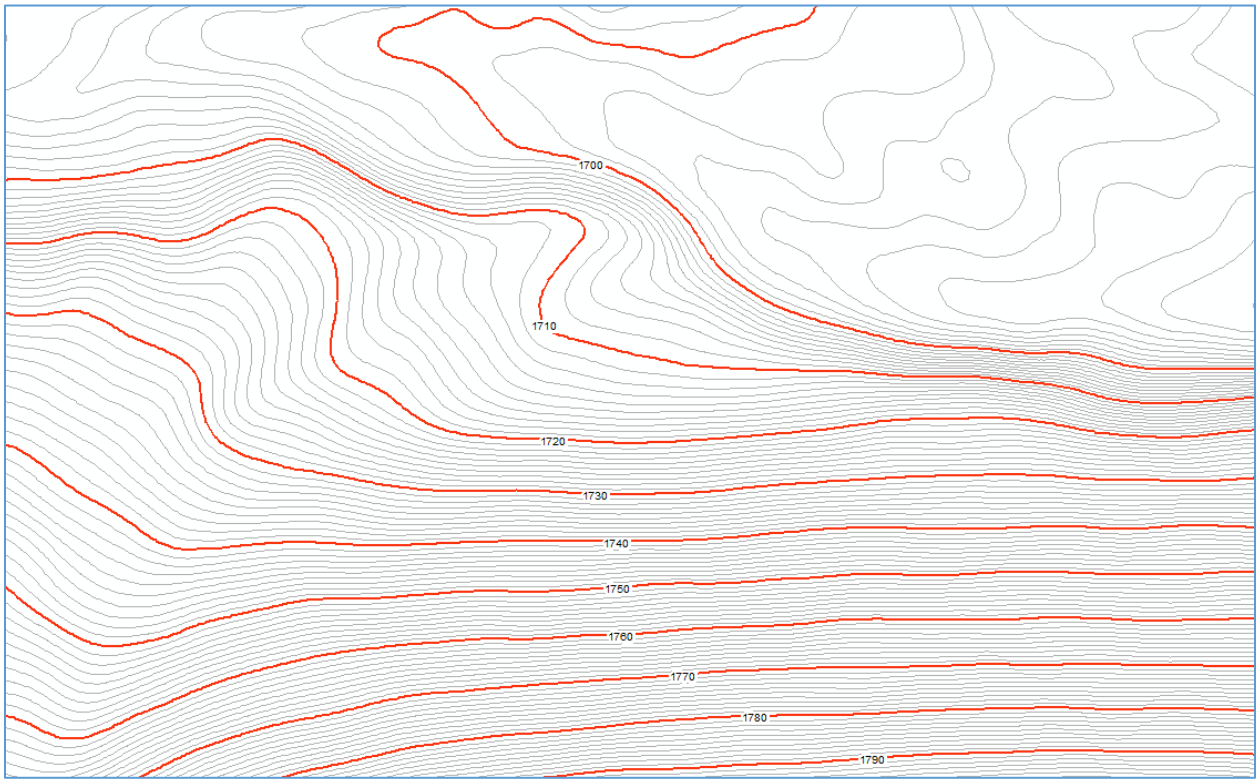
22. Right click the feature class in the Contents pane and click on Label to apply:



23. By adding a field, calculating a modulo operation, and using those INDEX values for a custom symbology, we can create a single feature class for contour lines with a built-in index option.

    The example below shows 1ft contours in grey with 10ft index lines in red. This example is delineated from a focally smoothed DEM and an index field calculated using the modulo function.

    A modulus of 10 is used in this example to delineate 10ft index lines from the contour values.



ADDITIONAL RESOURCES

For more information about Maryland LiDAR, please visit the Maryland LiDAR Overview page

For more information about additional training opportunities, please visit the MD iMAP Training Overview page, or contact Lisa Lowe, Senior GIS Analyst with the Maryland Department of Information Technology, Geographic Information Office at lisa.lowe@maryland.gov.

For additional MD iMAP datasets, please visit the GIS Data Catalog

For all other inquiries related to Maryland LiDAR, please contact the GIO Office at service.desk@maryland.gov.