Technology
Technical Note MO-5

LiDAR SURFACE USER'S GUIDE for ESRI® ArcMap 10.0™

October 30, 2013

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LiDAR Surface User's Guide for ESRI® ArcMap 10™

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A. <u>LiDAR Data Overview</u>

LIDAR (**Li**ght **D**etection **A**nd **R**anging) bare earth surface scans via aircraft have been acquired for several coverage areas in Missouri. This data is available in various formats. This Users Guide focuses on using the data in an ESRI Grid raster format with ArcMap 10.

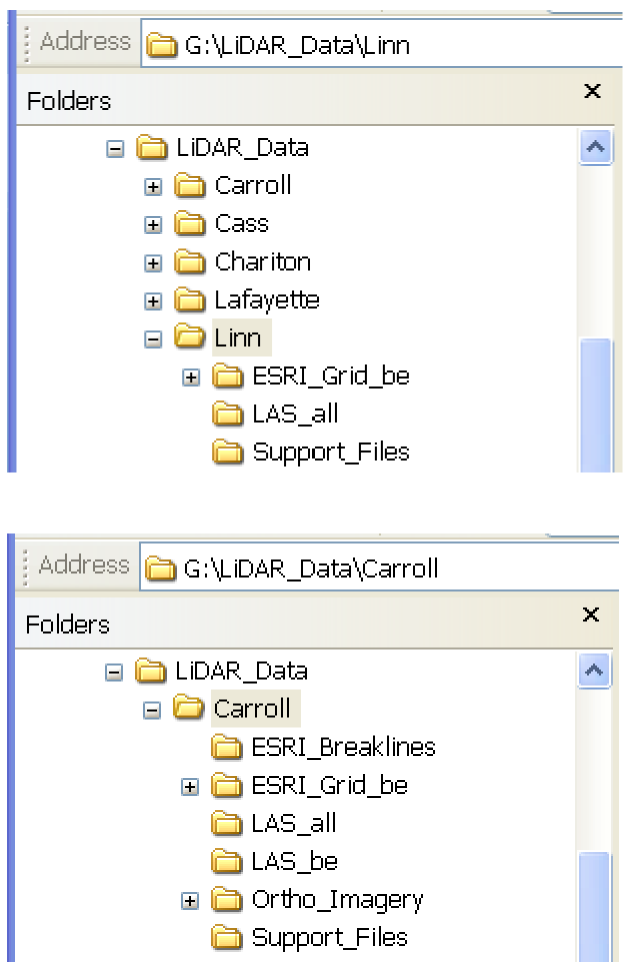
The LiDAR data provides a GIS elevation model of the ground surface that can be useful for conservation planning. LiDAR data also has some limited use for conservation practice application when it is field verified at the site for accuracy. The LiDAR elevation model is an additional resource tool that must be used within the limits of its accuracy and in conjunction with data collected in the field. **The availability of LiDAR data will not replace the need to gather on site data.**

B. <u>Folder Structure</u>

The data and imagery are available in several formats that are stored on an external hard drive with a file folder structure as shown in *Figure 1*. The data is located within the **LiDAR_Data** folder.

In the **LiDAR_Data** folder are **County** folder(s) with subfolders containing the data. The data subfolders will vary from county to county depending on the data formats available. (For example Linn County only has **ESRI_Grid_be** and **LAS_all** data formats while Carroll County has additional data formats.)

<u>Figure 1</u>: Folder Structure



LiDAR Surface Data Formats:

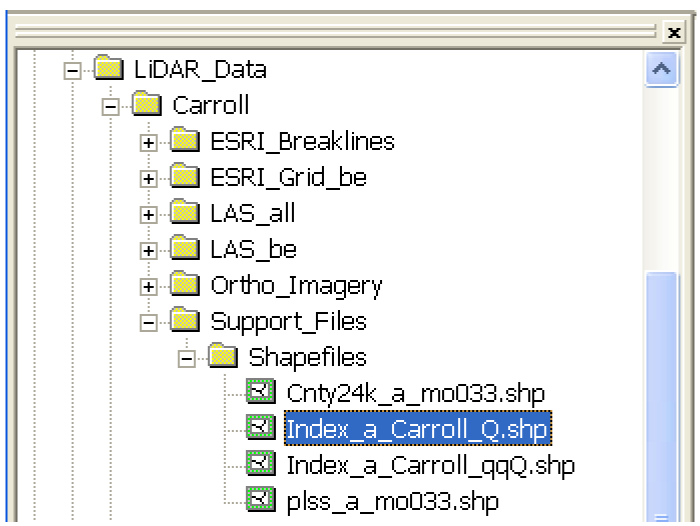
Each county folder contains an MS-WORD file in the **Support_Files** folder named **Data Description - xxxx County.docx**. Refer to this file to find information about the LiDAR data's format, datums, accuracy and classification.

1. **ESRI_Grid_be** folder *(Usable in ArcMap and AutoCAD)*
   Bare earth ground surface in ESRI Grid format raster files.
    a. **Note that in some cases, the bare earth elevation models are stored in folders called Hydro_Flattened_DEM. Some are in .img rather than GRID format.**
2. **ESRI_Breaklines** folder *(Usable in ArcMap and AutoCAD)*
   ESRI polyline shape file format containing hydro-enforced breaklines.
3. **LAS_be** folder *(Usable in MARS, ArcMap and AutoCAD)*
   LAS binary file format. Data are the bare earth returns only of the LiDAR point cloud and breaklines converted to mass points with water surfaces removed.
4. **LAS_all** folder *(Usable in MARS, ArcMap and AutoCAD)*
   LAS binary file format. Data are the bare earth and non-bare earth returns of the LiDAR point cloud; refer the point classification to determine what surface the point represents.
5. **Ortho_Imagery** folder *(Usable in MARS, ArcMap and AutoCAD)*
   Georeferenced aerial photography taken concurrently with the LiDAR acquisition, file formats vary.

C. Finding the Right LiDAR Data File

LiDAR Data is stored in individual files that have a rectangular coverage area or tile. The size of these tiles varies by county.

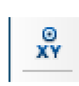
Figure 2: ***ArcMap Index Project Location***



Index shape files are available to assist in locating the correct tile(s) needed for a project area. These shapefiles are in most cases located in the **Shapefiles** subfolder of the **Support_Files** folder. The folder structure differs some by LiDAR acquisition – look for tile index shapefiles under Delivery Index or Tile Index or other logical folder names.

In Figure 2 for example the tile index shapefile for Carroll County's tiles are **Index_a_Carroll_Q** and **Index_a_Carroll_qqQ**. In the file name, the **Q** indicates the tile is of a Quadrangle and the **qqQ** indicates that it is of a quarter-quarter Quadrangle.

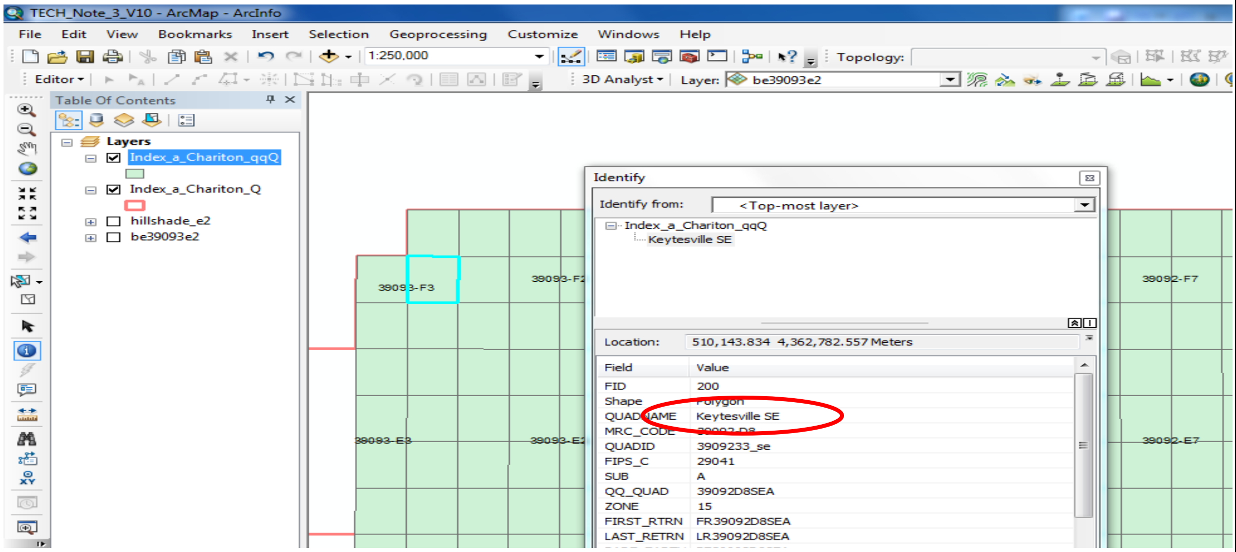
Use the Index shapefiles in conjunction with other geo referenced layers such as ortho aerial photography, public land surveys, etc. or coordinate data to assist in locating the correct tile(s).

If coordinates of the study area are known then the **Go to XY** tool 

can be used to find the location.

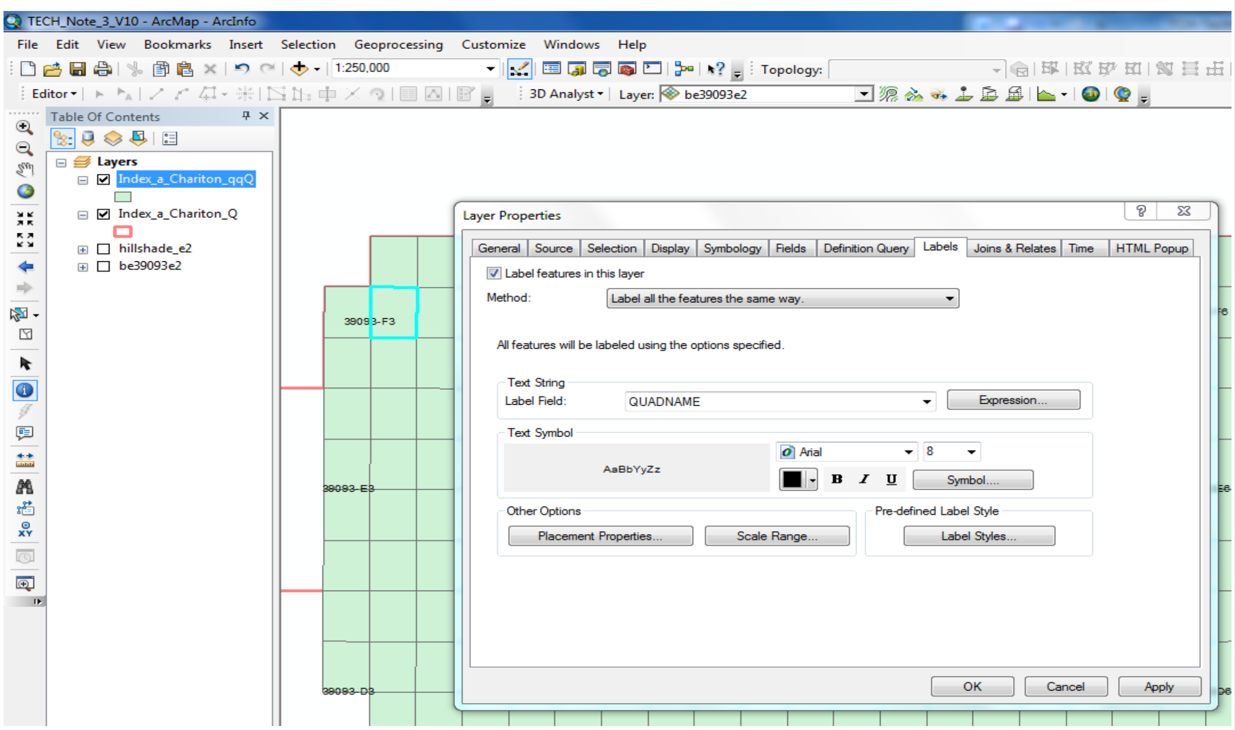
The **Identify** tool on the ArcMap tool bar can be used to display the name of the desired tile once it is located graphically as demonstrated in Figure 3.

Figure 3: ***ArcMap Index Project***



The features within the Index shapefile can also be labeled to assist with locating the tile name as shown in Figure 4.

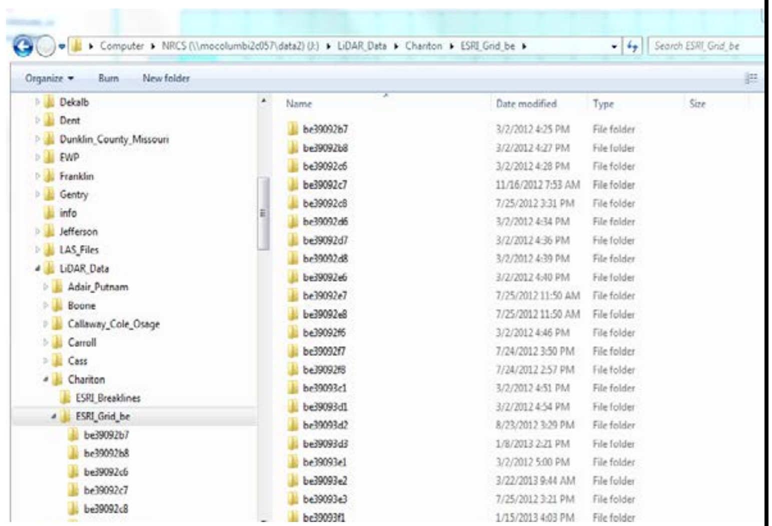
Figure 4: ***Labeling Index Feature Names***



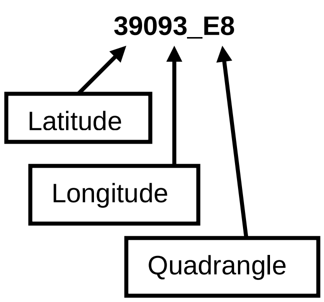
Quadrangle Tile Names

Some coverage tiles correspond to standardized 7.5 minute quadrangles. These tiles use a naming convention that incorporates the latitude, longitude, quadrangle and quarter-quarter quadrangle grid identification.

Figure 5: ***Example File Names***



Files that have a coverage area of a full quadrangle look like this:



Files that have a coverage area of a quarter-quarter quadrangle look like this:

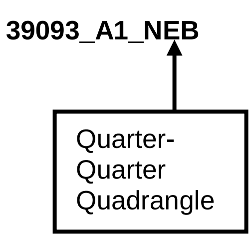
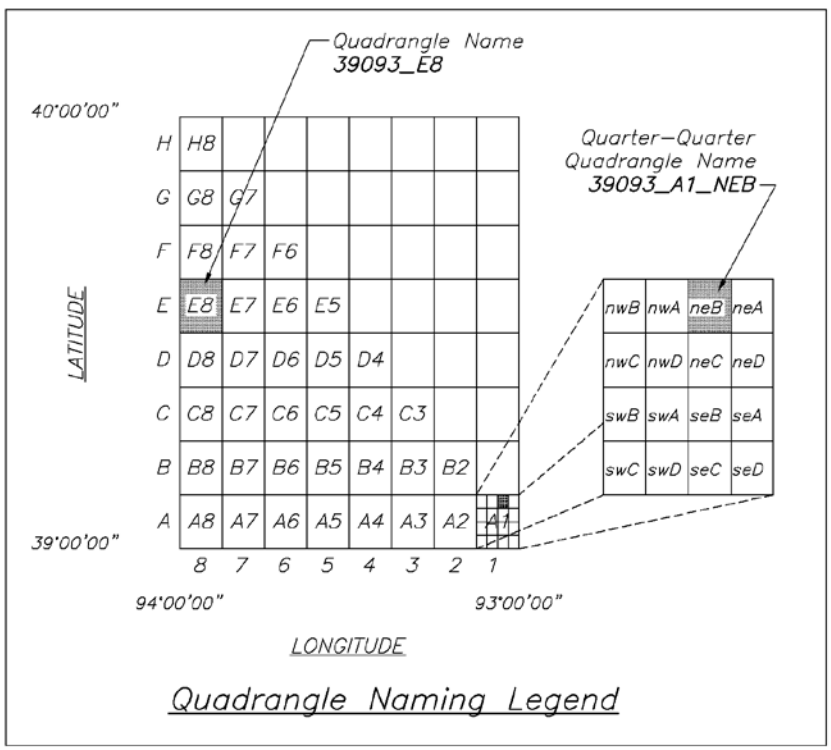


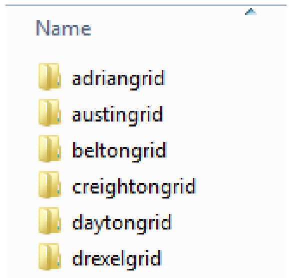
Figure 6: ***Quadrangle Naming Legend***



Alternate Tile Names

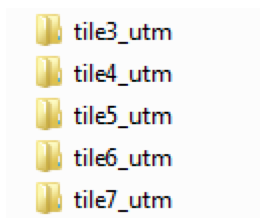
Some coverage tiles correspond to standardized 7.5 minute quadrangles, but are named using abbreviations of the quadrangle name. **Figure 7** illustrates an example of this naming convention.

Figure 7: ***Example File Names***



Other coverage tiles are arbitrary and do not correspond to standardized 7.5 minute quadrangles. These tiles use a variety of naming conventions. The example in **Figure 8** shows a naming convention where the tiles are sequentially numbered tiles.

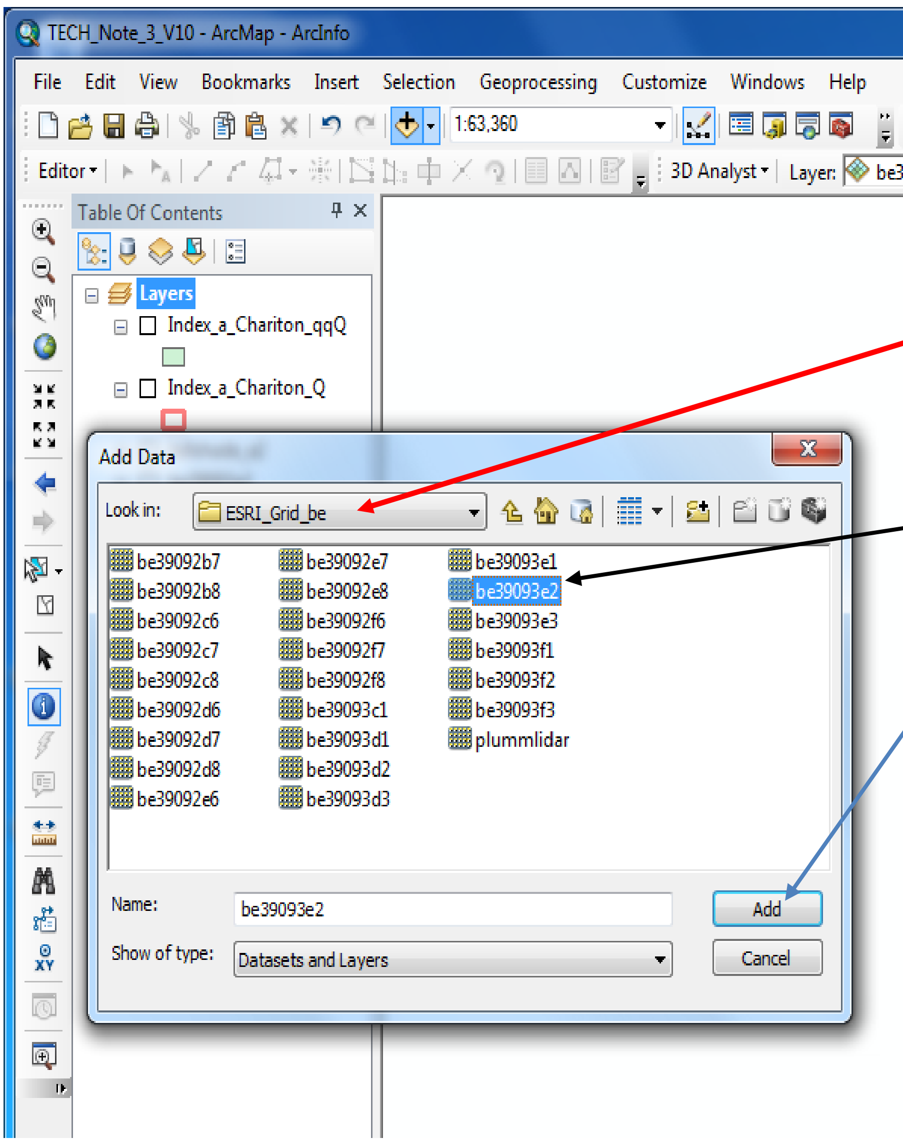
Figure 8: ***Example File Names***



D. Adding and Displaying an ESRI Grid Raster (DEM)

Add ESRI Grid raster files using ArcMap's **Add Data**  button to add the desired ESRI Grid raster files to the project. The ESRI Grids are actually a series of files contained within a common folder. Do not navigate beyond the folder name when adding the ESRI Grids.

Digital Elevation Models, DEM, in other file formats can be inserted in a similar manner. Examples of alternate DEM formats are **Image** (**.img)** or **Geotiff** (**.tif)**. Please note that the ArcMap functions referenced throughout this Technical Note will still work if the DEM format is something other than ESRI Grid raster.

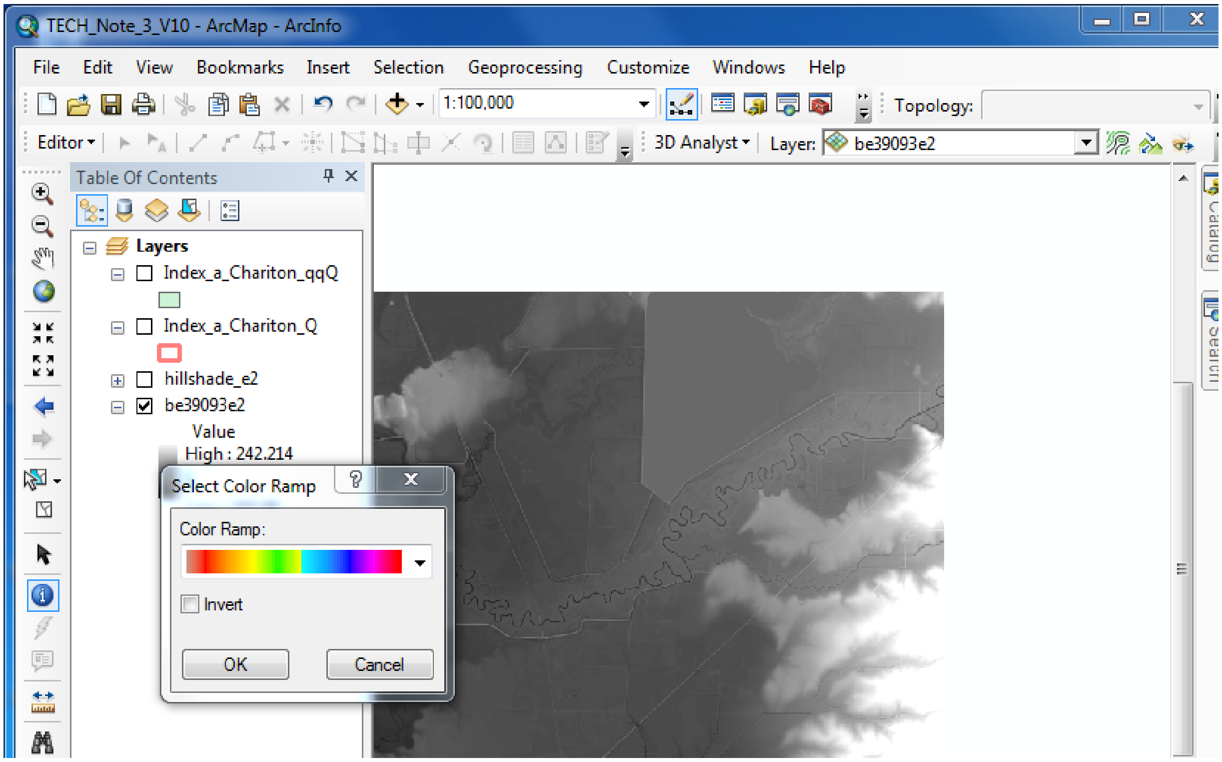


Using the Add Data dialogue box, set the **Look in:** box to the correct folder.

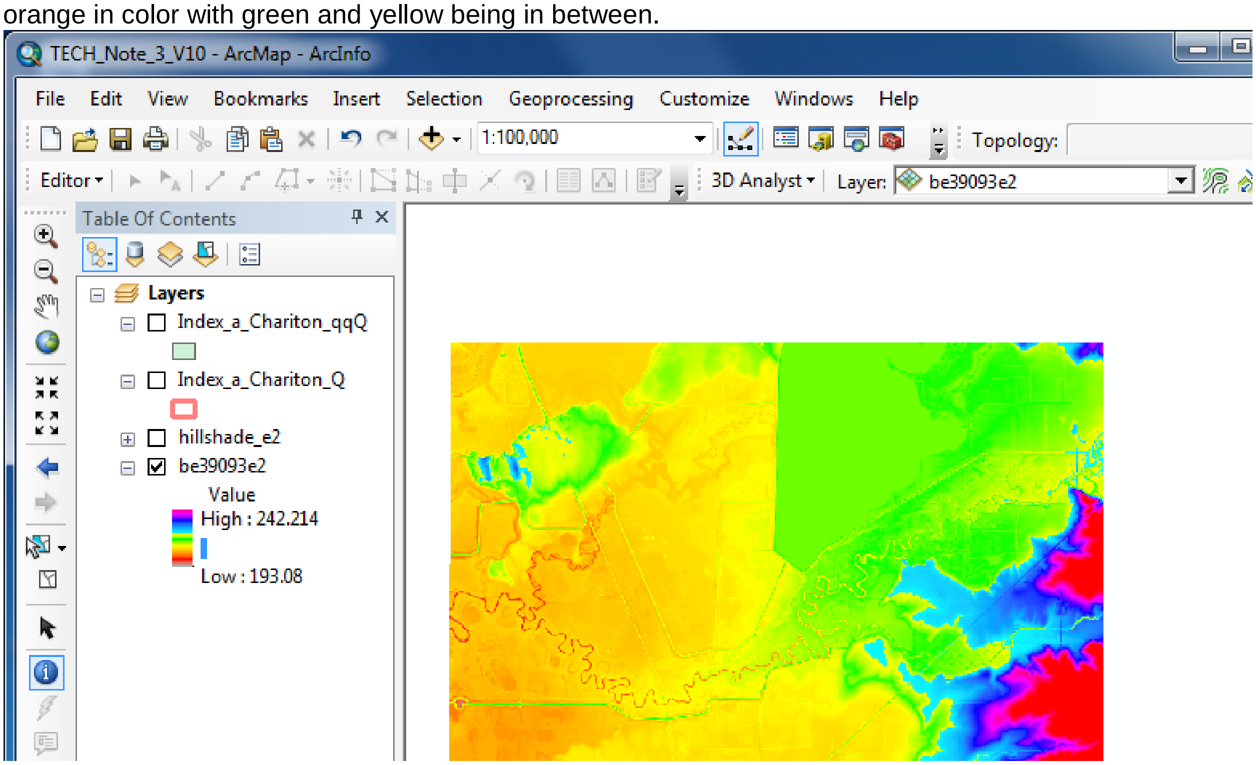
Next, select the desired ESRI Grid folder

Then, click the **Add** button.

The ESRI Grid will be added and displayed with a grey scale color ramp that is keyed to elevations. The color ramp can be changed by double clicking on the color ramp legend associated with the ESRI Grid. This action will open a **Select Color Ramp** dialogue box from which a new color ramp can be picked.

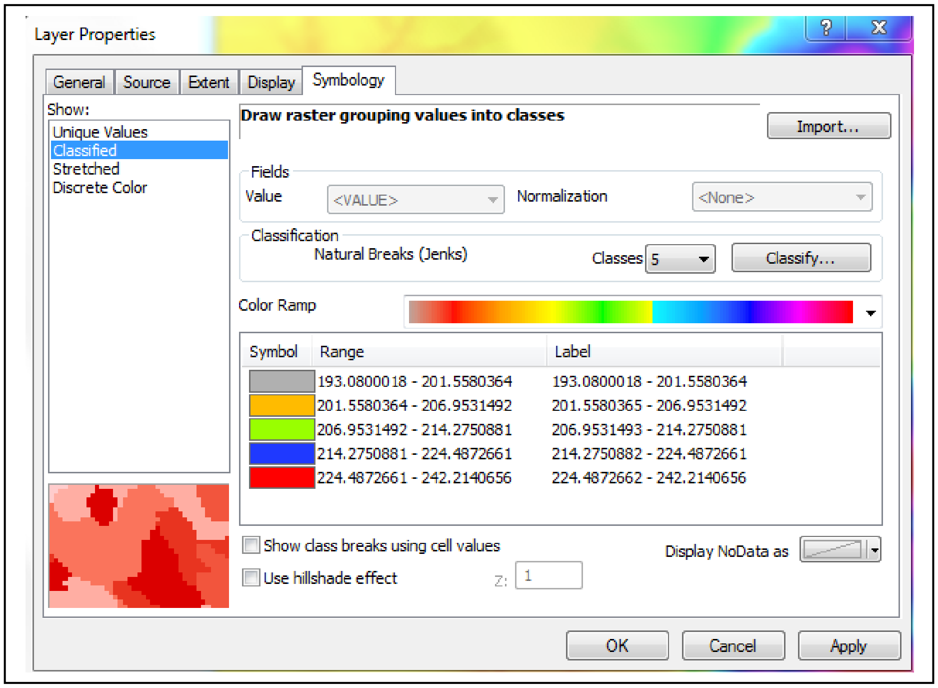


With the color ramp in the example below, the highest elevations are displayed in red and the lowest are orange in color with green and yellow being in between.



The raster display can be further customized by changing the Symbology to classify the color ramp according to a variety of methods. For example the color ramp can be set to correspond to an equally spaced elevation interval. The example below will classify the color ramp on even 1 meter intervals for areas with a ground surface between 225 and 245 meters:

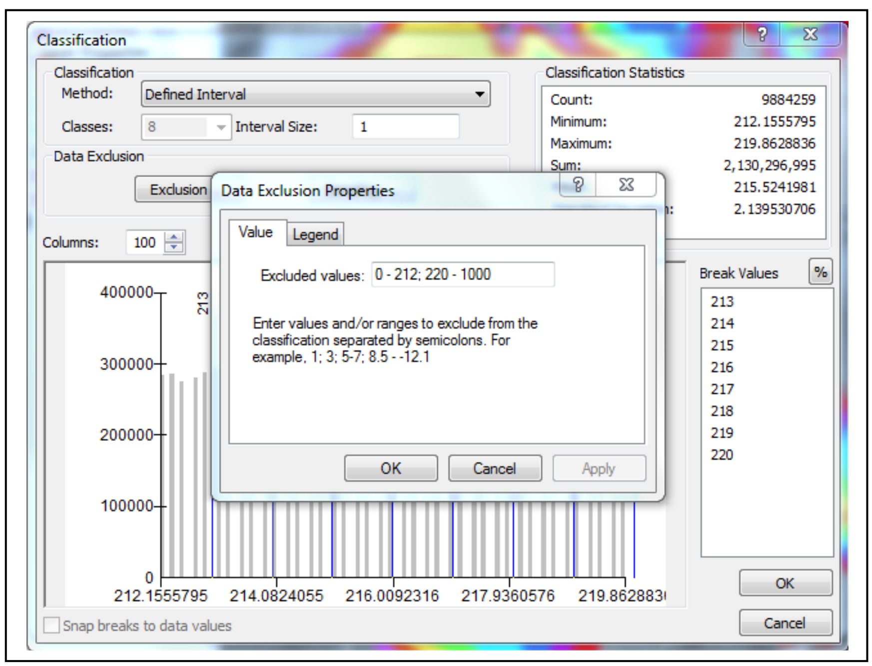
Begin by displaying the **Layer Properties** dialogue box for the ESRI Grid Raster and select the **Symbology** tab.



Next click the **Classify** button to open the Classification dialogue box. Then click the **Exclusion** button.

Set the **Excluded values** to 0-212; 220-1000 in order to exclude these values from the classification range.

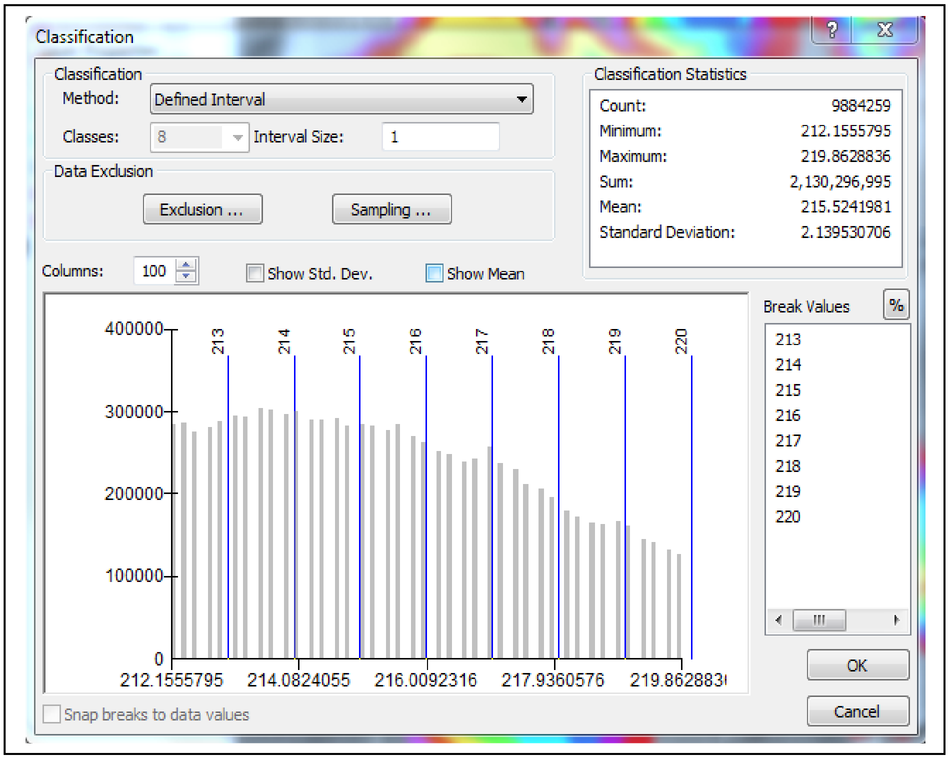
Click **OK** to close the dialogue box and return to the **Classification** dialogue box



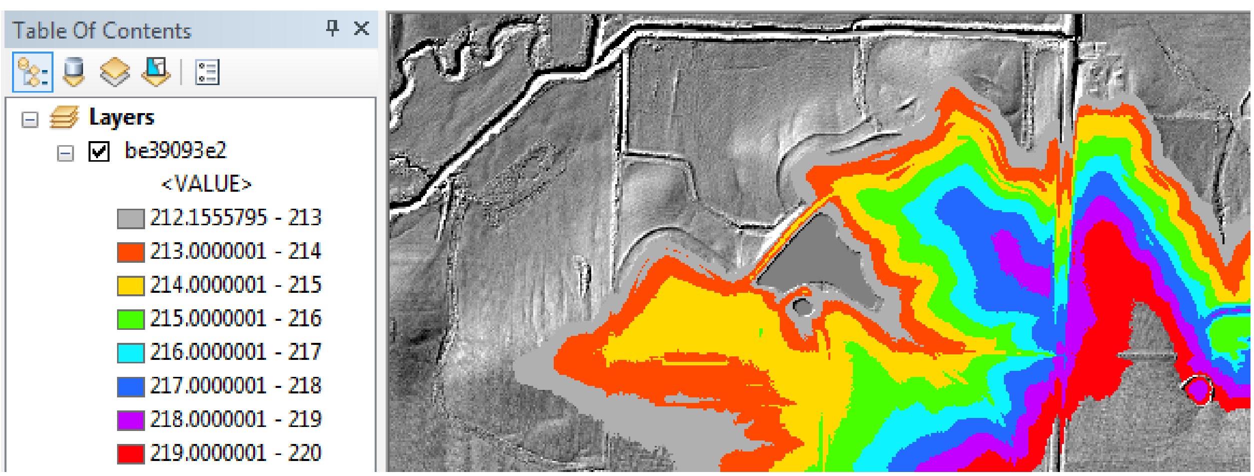
Now select the **Defined Interval** method of classification and set the **Interval Size** to 1.

This action will reset the **Break Values** to every meter in the elevation range of 212 to 220.

Click **OK** to accept these changes in the classification of the color ramp.



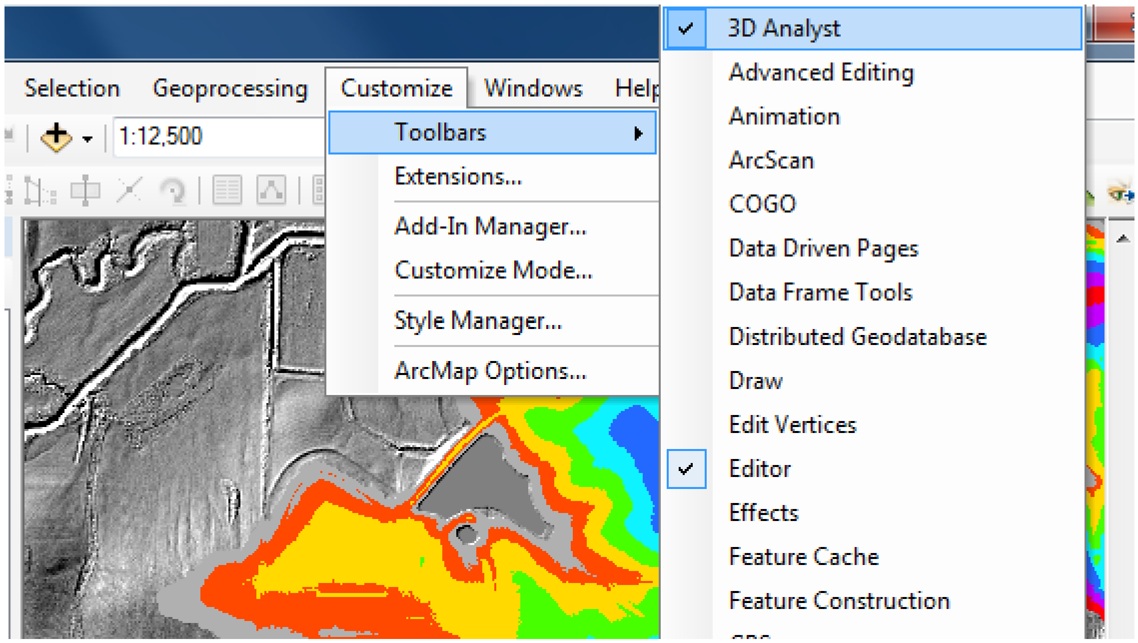
The map will now display the ESRI Grid with a color change every meter and the areas lower than elevation 212 or higher than 220 will not be displayed with any color as shown below:



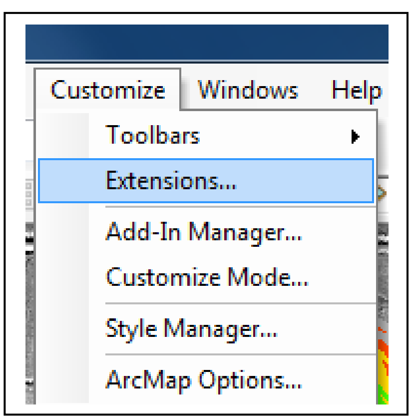
E. Loading 3D Analyst

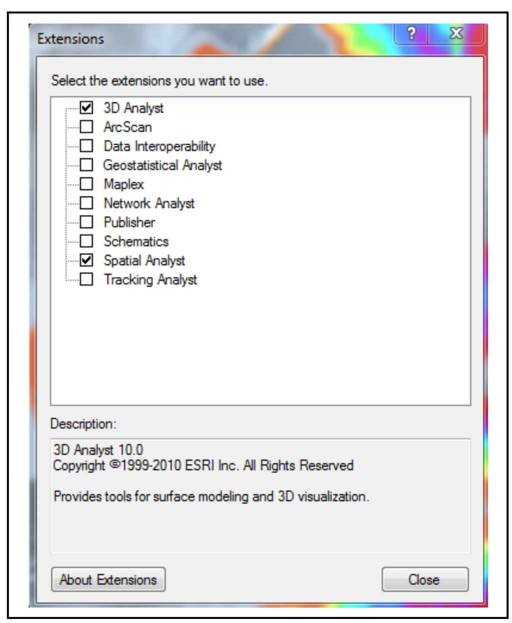
The **3D Analyst** extension is used to make contours and hillshades as well as complete other tasks. If the extension's toolbar is not already available and active in ArcMap, follow the steps below:

First, add the 3D Analyst tool bar by selecting **Customize, Toolbars ►** then check **3D Analyst** on the list.



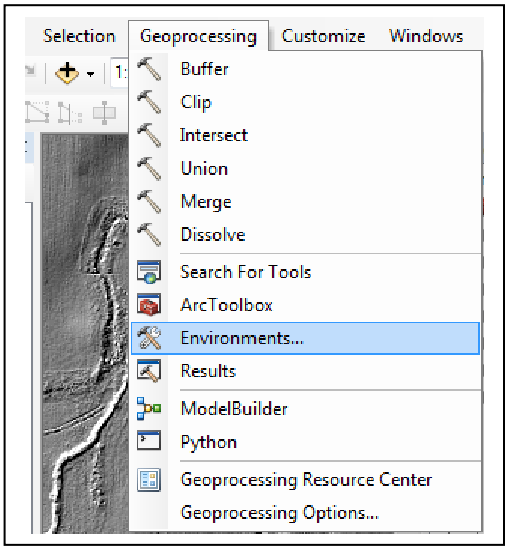
Now, activate the extension by selecting **Customize**, **Extensions…** and checking the **3D Analyst** box on the list. **3D Analyst** will now be ready to use.



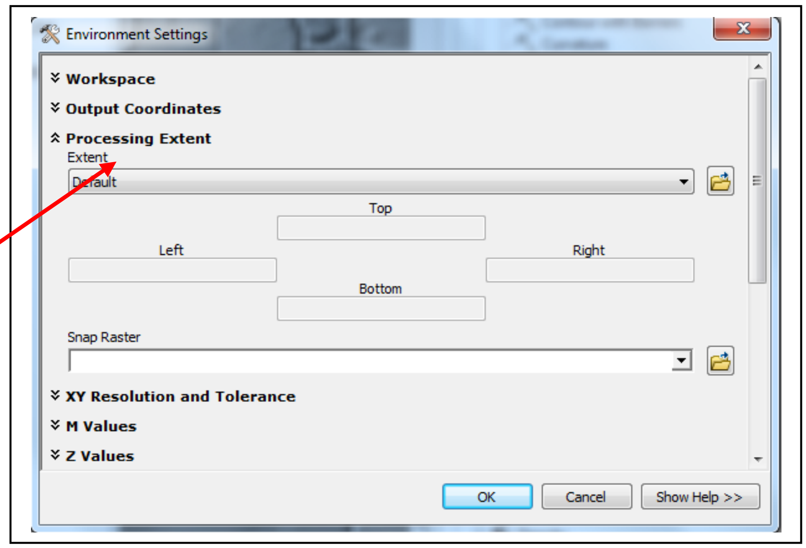


F. Environment Settings

Select the Geoprocessing Tab and open the Environments Settings box.



Several Options can be set. The **Processing Extent** tab allows you to set the rectangular area to be analyzed (Top to Bottom and Left to Right).



Properties extent options:

<u>Same as Display</u> will only analyze that area which is currently viewable in the ArcMap display window.

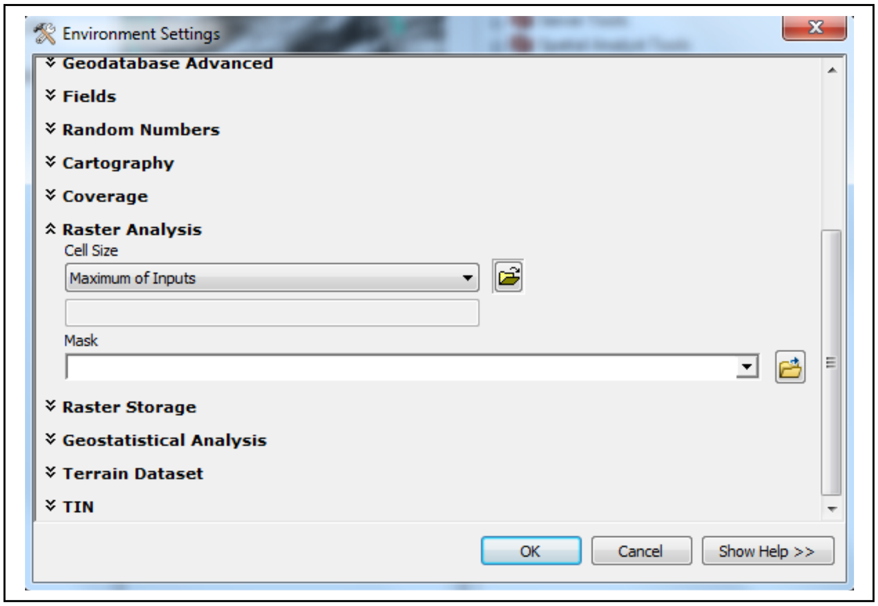
<u>Intersection of Inputs</u> allows definition of the extents to be the common areas between multiple inputs.

<u>Union of Inputs</u> allows definition of the extents to be all of the area defined by multiple inputs combined.

<u>As Specified Below</u> will use the values you manually input for Top, Bottom, Left and Right.

<u>Same as Layer</u> will use the extents of the selected layer.

The **Raster Analysis** tab allows the setting of the size of the raster cell that will be used to generate the surface analysis. The cell size will determine the density of the elevation points that represent the surface. A larger cell size will result in smoother contours; however, definition of surface features will be lost as the cell size increases.



Cell Size Options:

Maximum of Inputs will use the maximum cell size of the input layer.

Minimum of Inputs will use the minimum cell size of the input layer.

Note: Because all of the cells are the same size within a raster file, choosing either of the two options above will result in the same cell size if only one input layer is being used.

As specified Below allows the manual input of the cell size.

Same as Layer sets the cell size to match that of the selected layer.

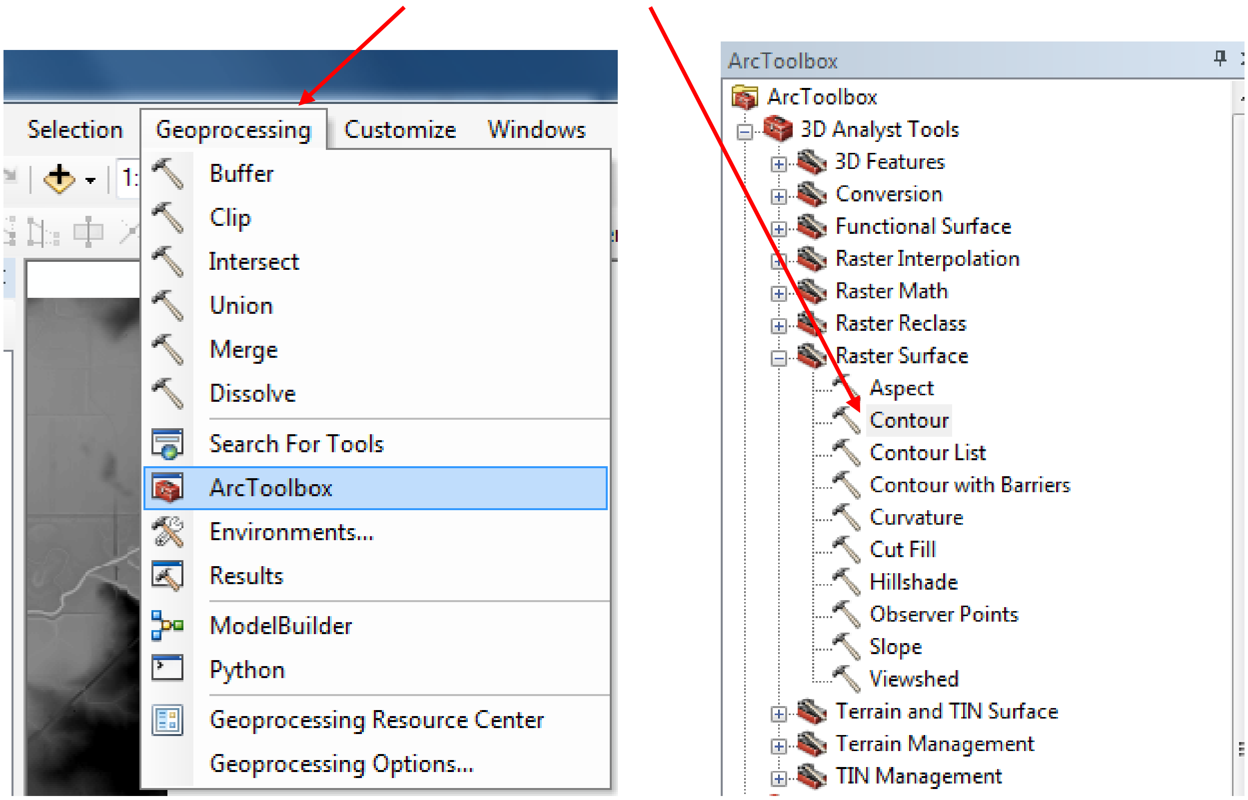
NOTE: Setting environment settings from the Geoprocessing drop-down sets the default settings for all geoprocessing tools that are subsequently run. Alternatively, each tool in ArcToolbox (ex. Raster Surface Contour) has an Environments tab. The tool-specific Environments apply to one run of the tool and thus can be used to override the settings set using the Geoprocessing Environment settings. For example, if you set the Processing Extent in Geoprocessing settings to “Same as Display”, when you run the Raster Surface Contour tool in ArcToolbox, the extent will be the display extent at the time you set it. If instead you wish to make the contours for the entire DEM, you may change the Processing Extent in the Contour tool’s Environment settings to Same as Layer using the DEM as the layer named.

G. Making Contours (3D Analyst Tools)

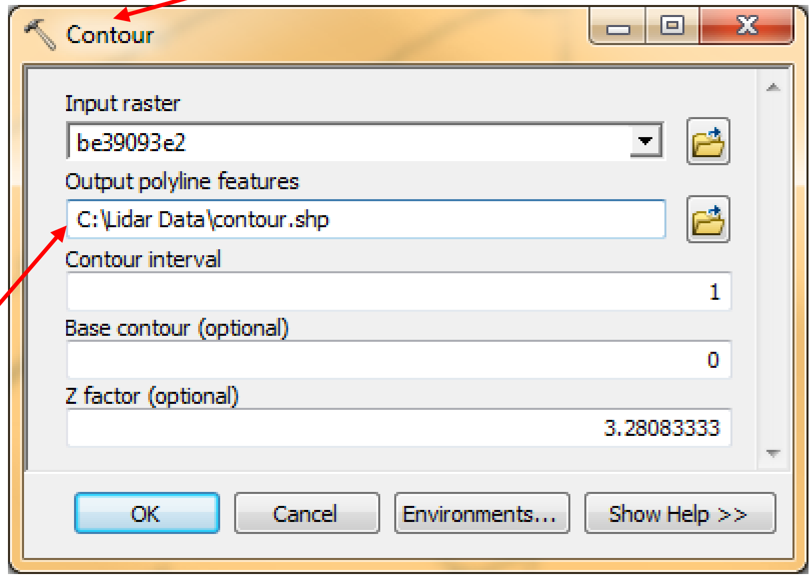
Contours can be generated from any of the ESRI Grid raster files using ArcMap's 3D Analyst. Use the **Add Data** button to add the desired ESRI Grid raster file(s) to the project. See Section **D. Adding and Displaying an ESRI Grid Raster**.

Set options as explained in Section **F. Environment Settings** or using the Tool Environment settings

After setting the **Environment**, the contours are made using **3D Analyst Tools** in the **ArcToolbox** under the **Geoprocessing** tab. Open the **3D Analyst** Tool tab to find **Raster Surface** and select **Contour**.



Prepare to make the contours by setting the variables on the **Contour** dialogue box.



Input surface: Using the pull down menu box set the Input surface to the correct ESRI Grid raster file. The surface elevations from this file will be used to generate the contours.

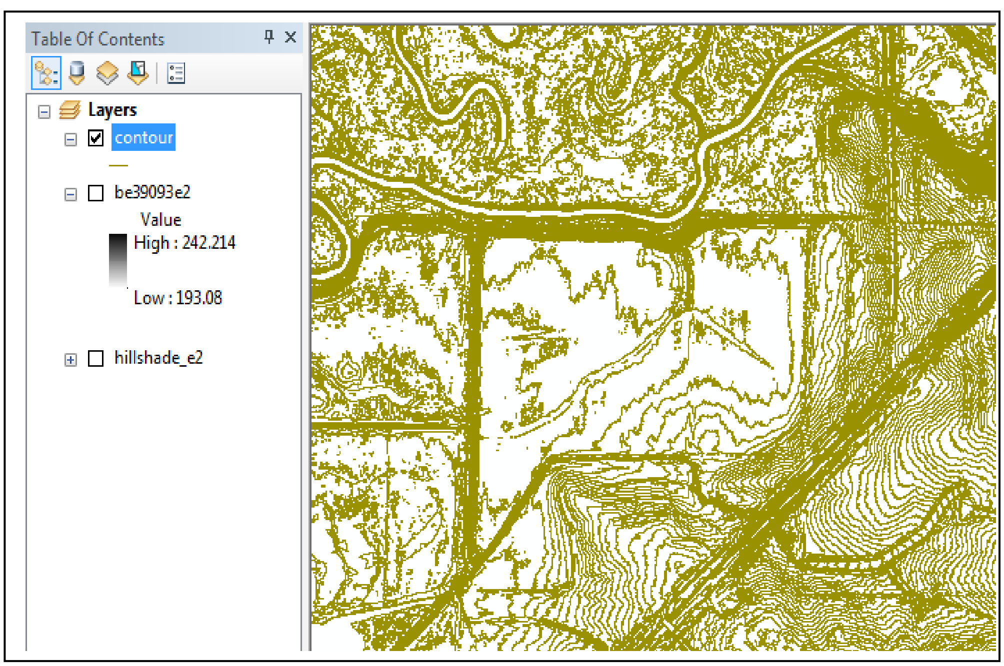
Output polyline features: The contours will be saved in an ESRI polyline shape file, the path and name of which is set at this menu location. **Make sure to designate the path and name of your output; the default location is a feature class in a default geodatabase and will be very confusing to try to find!**

Contour interval: This will determine the spacing interval between the contours. This will be in the same units as the elevations in the raster file if the Z factor is set to "1".

Base contour: The base contour is the first contour that is generated. The remaining contours will be spaced above and below the base contour at the contour interval. (For example using a base contour of "0.5" will generate contours at 700.5, 701.5, 702.5 and so on. Using a base contour of "0" will generate contours at 700, 701, 702, and so on.)

Z Factor: The Z Factor is a number by which all of the raster cell elevation data will be multiplied. Using a Z factor of **"3.28083333**" will convert the contour lines from metric meters to U.S. Survey feet if the raster cell elevations are in meters, which is the case with the LiDAR data in this example.

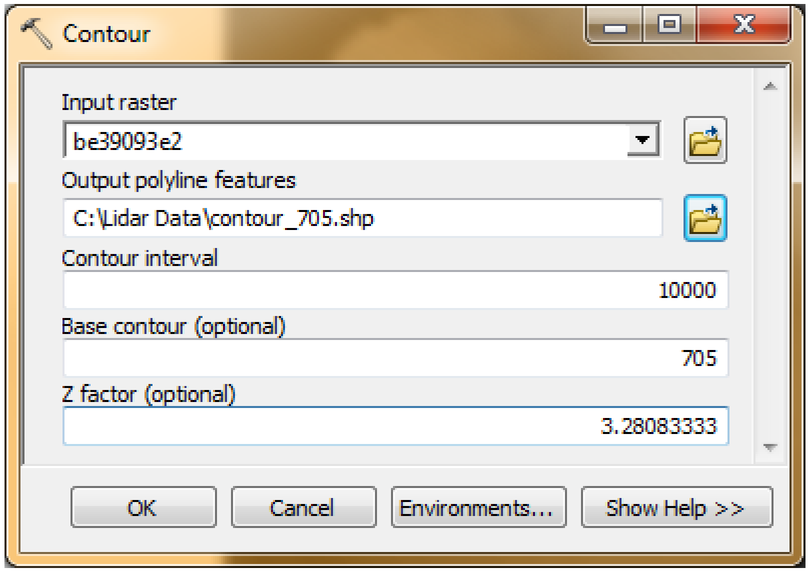
In the example, the contours generated will be based upon elevations found in the be39093e2 raster file, the contour interval will be 1 foot and the contours will be to the even foot. The contours will be saved in an ESRI shape file named contour.shp in the C:\Lidar\ folder.



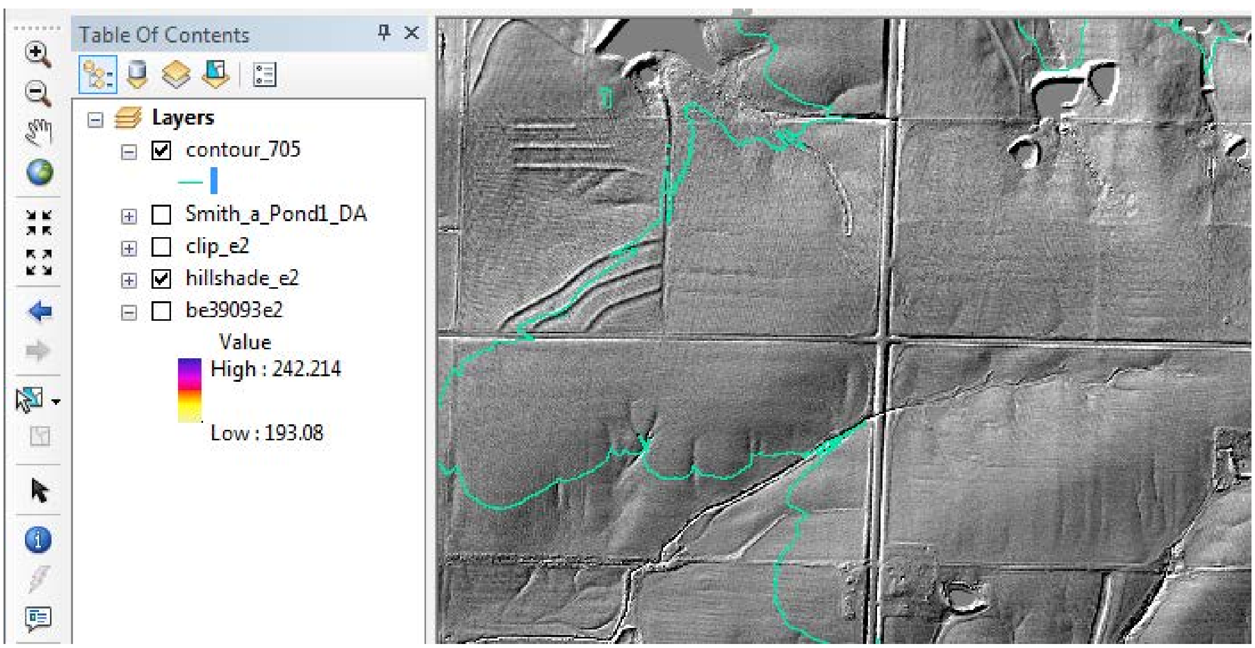
It is possible to generate a shape file containing a single contour.

To make a shapefile with a single contour line set the Base contour value to the desired elevation for the contour line.

*Also set the Contour interval to a value that is larger than the difference between the **Zmin** and **Zmax** values so only the base contour will be generated.*



*In this example a contour line at elevation 705 has been generated and saved in a shapefile named **contour_705**.*

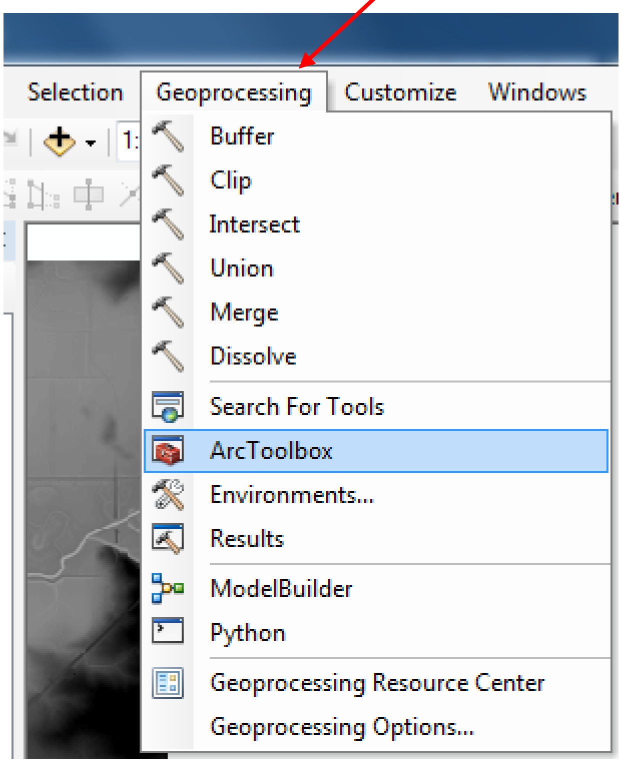


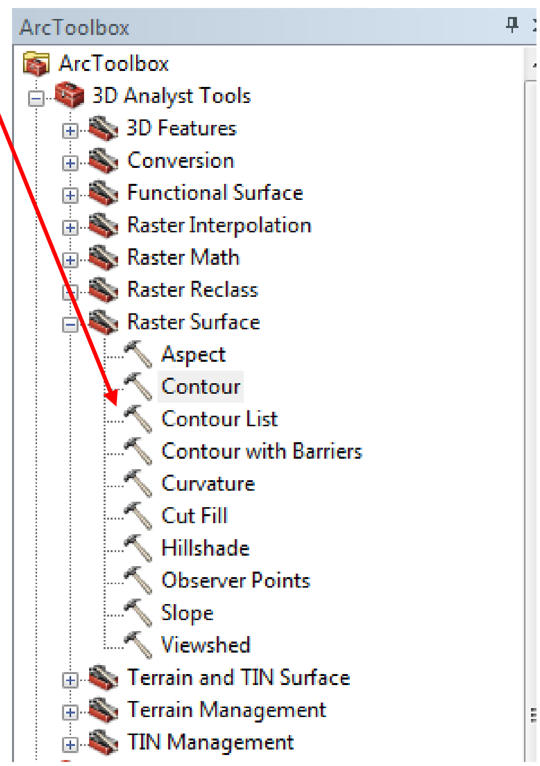
H. Making Contours using a Contour List (3D Analyst Tools)

A set of user defined contours can be generated from any of the ESRI Grid raster files using ArcMap's 3D Analyst. Please note that a Z-factor cannot be applied using this tool. Use the **Add Data** button to add the desired ESRI Grid raster file(s) to the project. See Section **D. Adding and Displaying an ESRI Grid Raster**.

Set options as explained in Section **F. Environment Settings**.

After setting the **Environment**, the contours are made using **3D Analyst Tools** in the **ArcToolbox** under the **Geoprocessing** tab. Open the **3D Analyst** Tool tab to find **Raster Surface** and select **Contour List**.

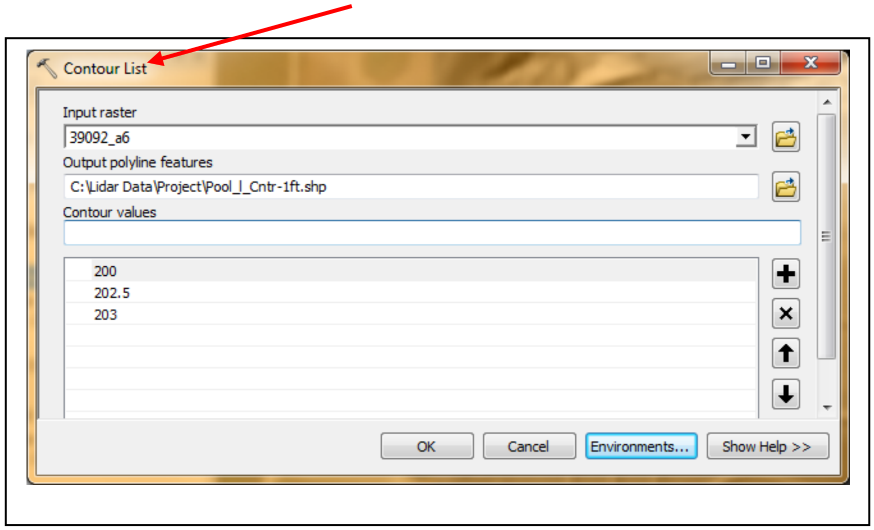




Prepare to make the contours by setting the variables on the **Contour List** dialogue box.

Contour values: Enter a list of contour elevations by typing an elevation then clicking the plus  button to add it to the list.

See section G**. Making Contours** for a description of the remaining variables.



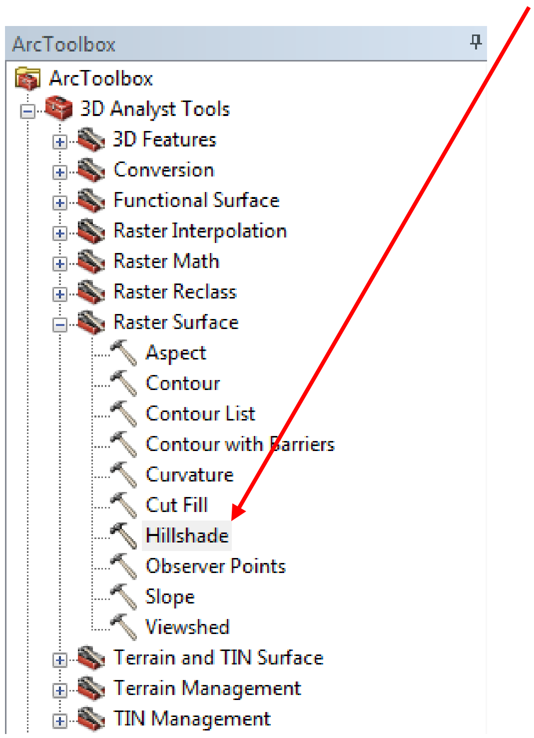
I. Making Hillshades (3D Analyst Tools)

Hillshade renderings of a surface can be generated from any of the ESRI Grid raster files using ArcMap's 3D Analyst.

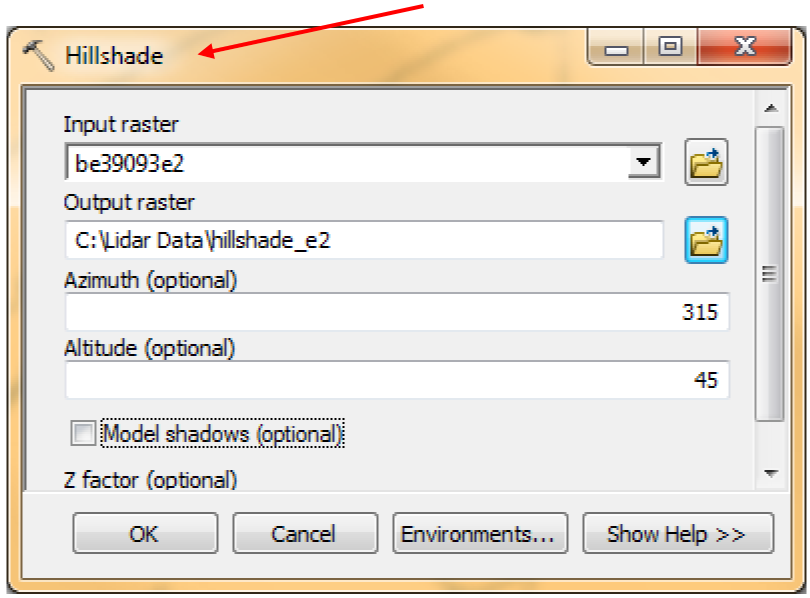
Use the **Add Data**  button to add the desired ESRI Grid raster file(s) to the project. See Section **D. Adding and Displaying an ESRI Grid Raster**.

Set options as explained in Section **F. Environment Settings**.

After setting the **Environment**, the hillshade is made using the tools available on the **3D Analyst Tools** in the **ArcToolbox** Window. Under the Raster Surface tab select the **Hillshade** Tool.



Prepare to make the hillshade rendering by setting the variables on the **Hillshade** dialogue box.



Input surface: Using the pull down menu box set the Input surface to the correct ESRI Grid raster file. The surface elevations from this file will be used to generate the hillshade.

Azimuth: The angular direction of the illumination source. The default of 315 is usually O.K. to use.

Altitude: The angle of the illumination source above the horizon. The default of 45 is usually O.K. to use.

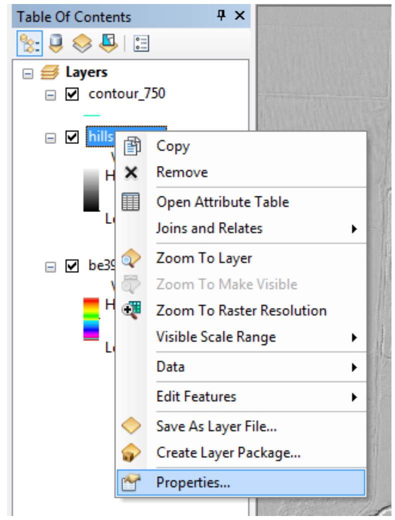
Leave Model shadows unchecked.

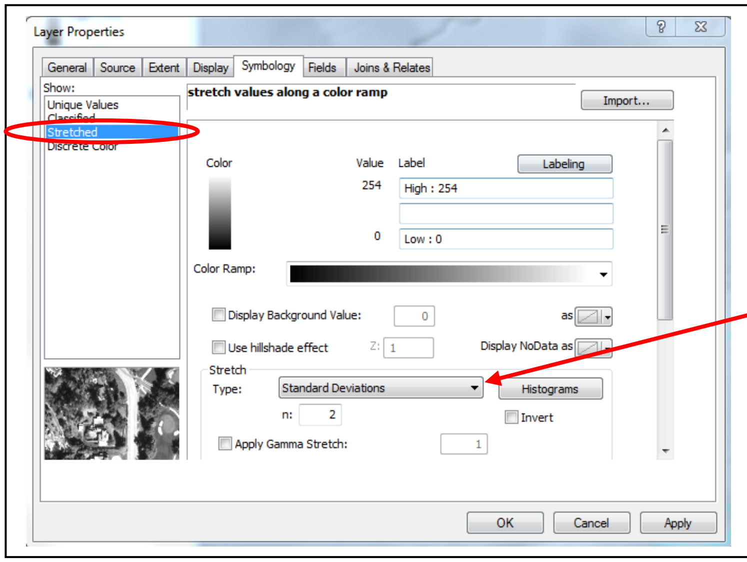
Z factor: Leave the Z factor set to 1 unless the x,y units are different from the z units. The units for the NRCS supplied ESRI Grids should be the same.

Output raster: Enter a path and file name if saving a permanent file is desired.

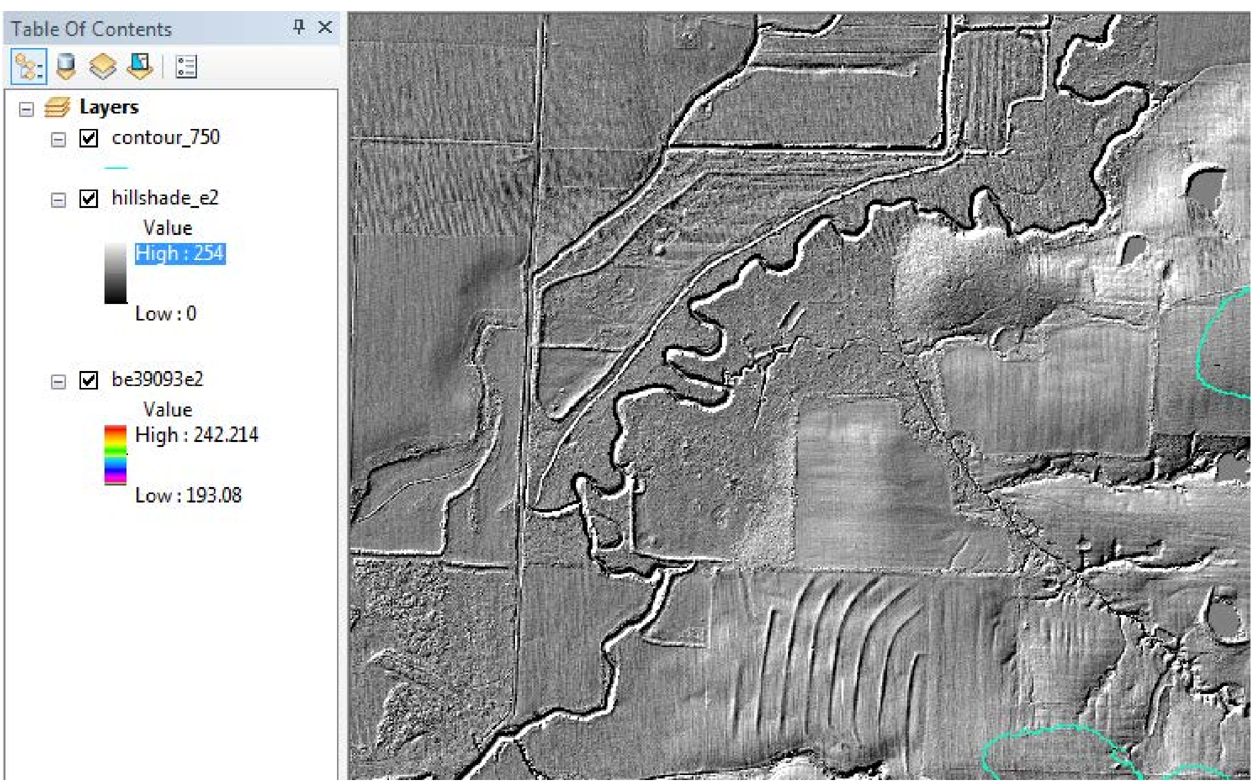
In the example, the hillshade generated will be based upon elevations found in the be39093e2 raster file, with an illumination source from the NW at 45 degrees above the horizon.

The display properties of the Hillshade can be modified by right clicking on the Hillshade name in the table of contents, then selecting the Properties item from the popup menu.





Select the **Symbology** tab and change the **Stretch Type**: to Standard Deviations with **n**: of 2. This setting generally results in a Hillshade image that provides good elevation relief.



J. Making Slope Rasters (3D Analyst Tools)

A land slope raster can be generated from any of the ESRI Grid raster files using ArcMap's 3D Analyst.

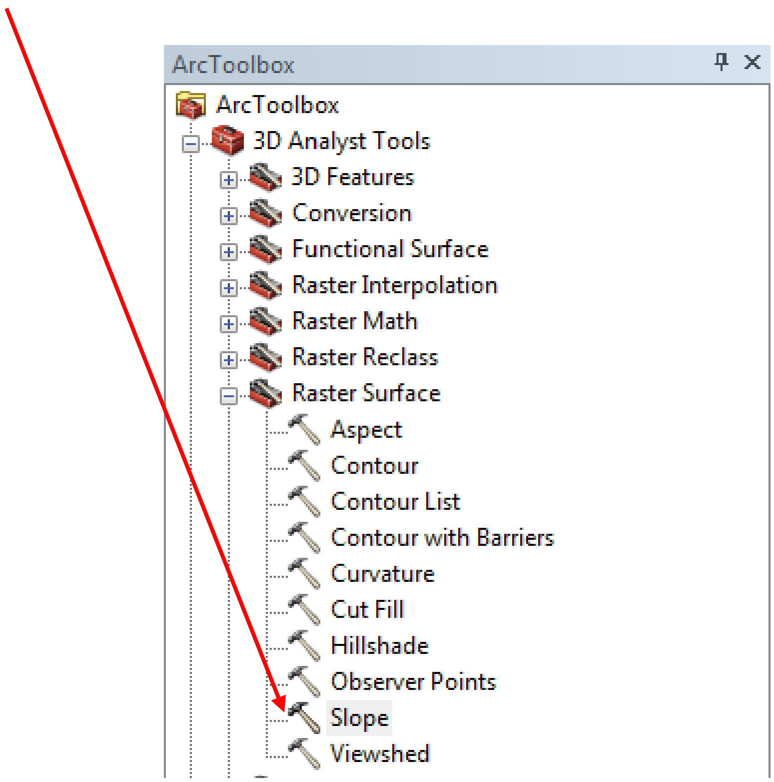
Use the **Add Data** button  to add the desired ESRI Grid raster file(s) to the project. See Section **D. Adding and Displaying an ESRI Grid Raster**.

The follow procedure is written assuming that the ESRI Grid raster files have a common unit of measure for x, y and z (i.e. all meters or all feet).

Set options as explained in Section **F. Environment Settings**.

After setting the **Environment**, the slope raster is made using the tools available in the **3D Analyst Tools** in the **ArcToolbox Window.**

Next, select **Raster Surface ► Slope** on the **3D Analyst Tools**.



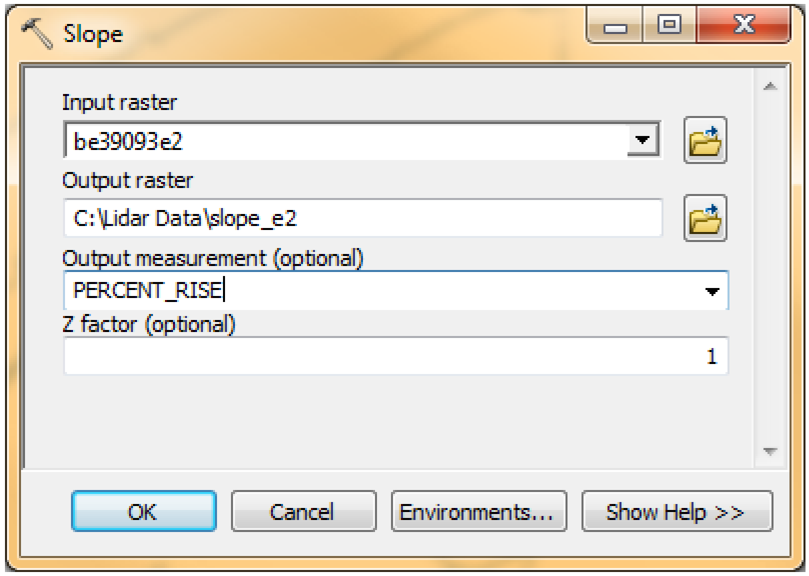
Prepare to make the slope raster by setting the variables on the **Slope** dialogue box.

<u>*Input surface*</u>: Using the pull down menu box set the Input surface to the correct ESRI Grid raster file. The surface elevations from this file will be used to generate the slope raster.

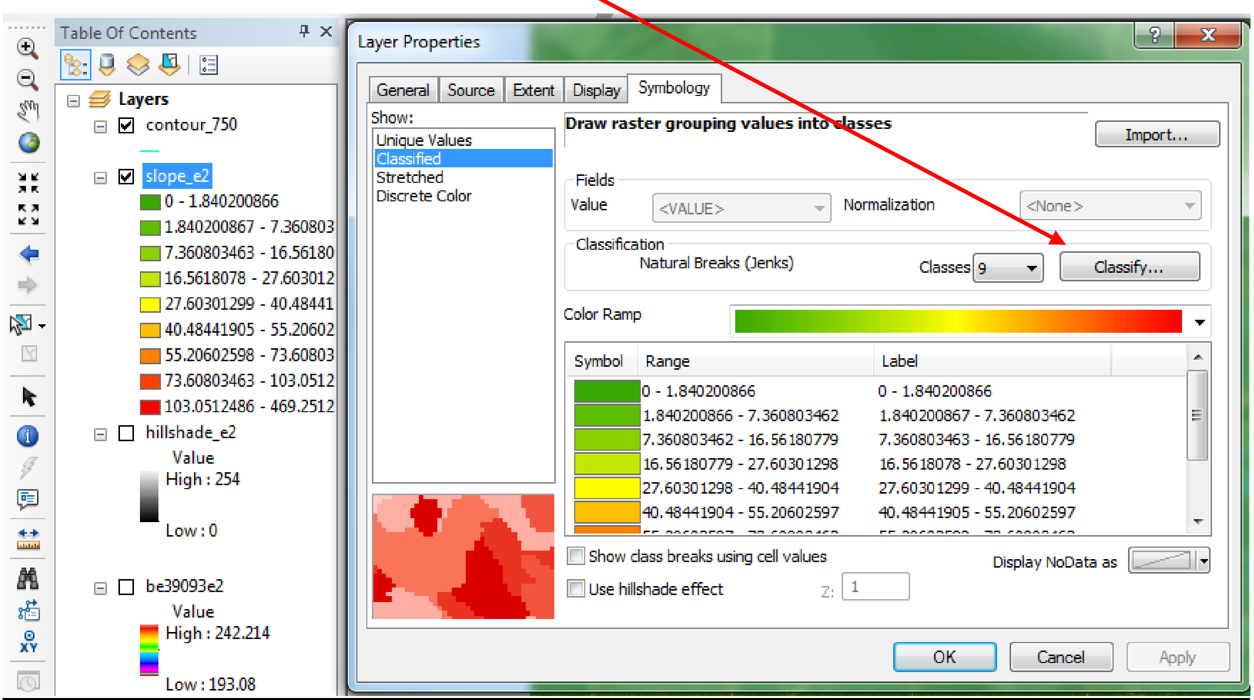
<u>*Output measurement*</u>: Select the desired units for the slope output. Normally Percent_Rise is selected.

<u>*Z factor*</u>: Leave the Z factor set to 1 unless the x,y units are different from the z units. The units for the NRCS supplied ESRI Grids should be the same.

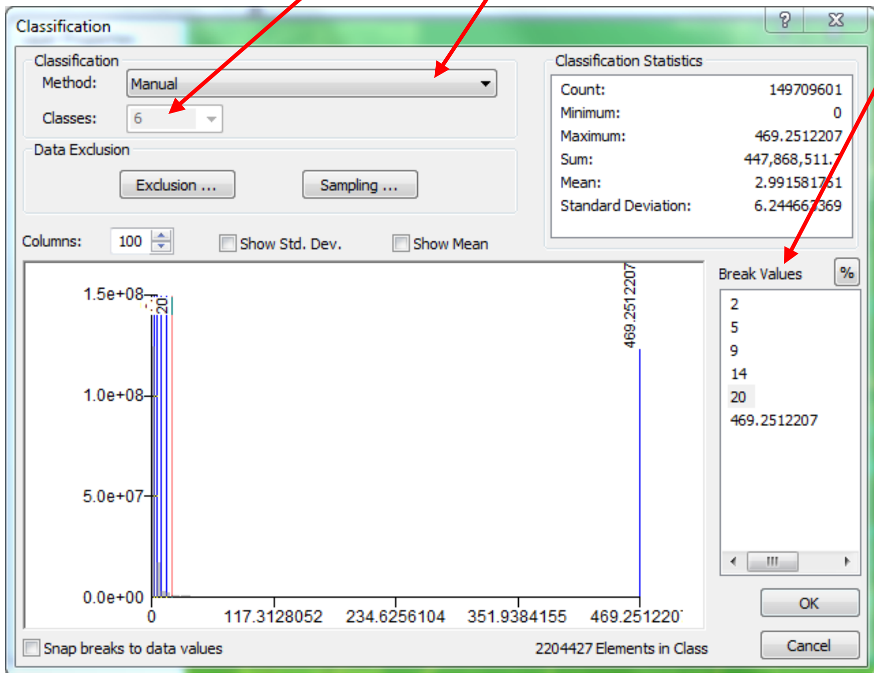
<u>*Output raster*</u>: Enter a path and file name.



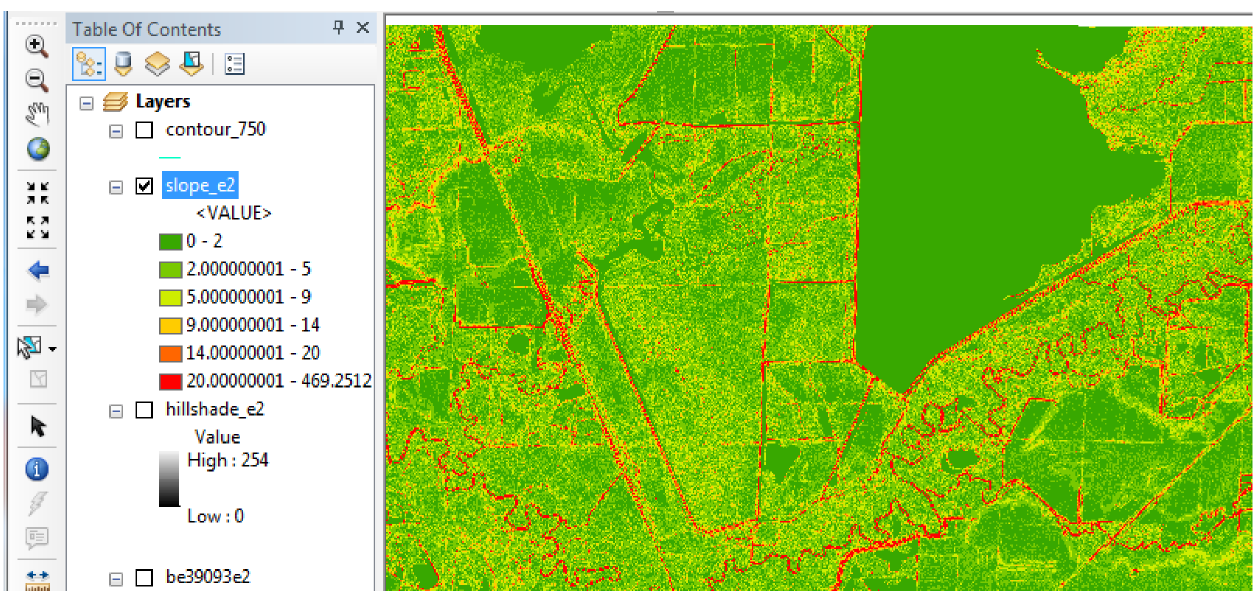
*In the example, the slope raster generated will be based upon elevations found in the be39093-e2 raster file. The slope raster file will be named slope_e2. ArcMap has applied a symbology classification using natural breaks it found in the range of slope values contained in the raster. It is often desirable to change the **Classification** method on the Symbology tab by opening the **Layer Properties** (right click on the raster name to open*
*the **Layer Properties** dialogue box).*



*For example, change the number of **classes** to 6, set the **Method** to Manual and then edit the **Break Values** by entering 2, 5, 9, 14 and 20.*
then click OK

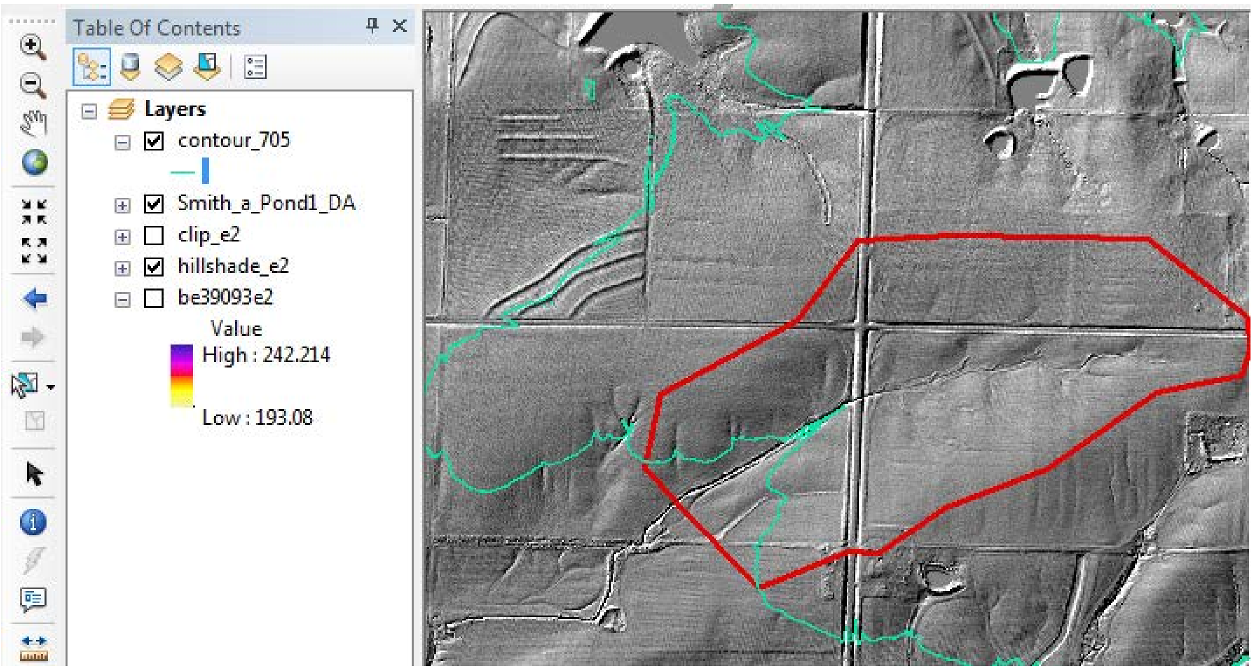


<u>*The resulting classification for the example will appear a shown below:*</u>

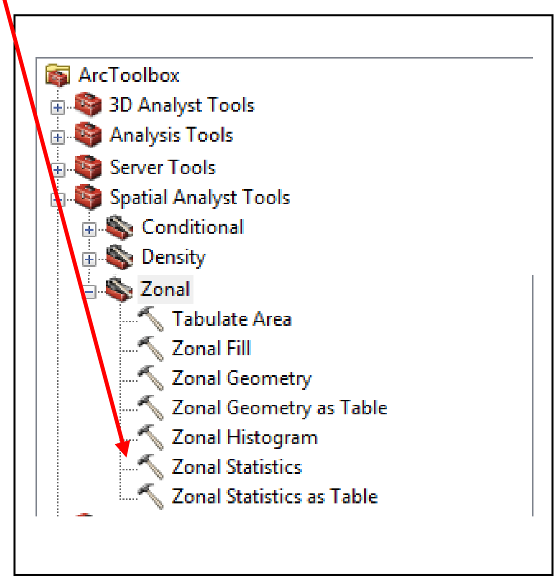


K. Calculating the Mean Slope of an Area

Several statistics can be computed from a slope raster including calculating the mean of the slope values within an area such as a drainage area as in the following example:



Once the area has been defined with a shapefile use the **Zonal Statistics** tool that is one of the **Spatial Analyst Tools** within **ArcToolbox**



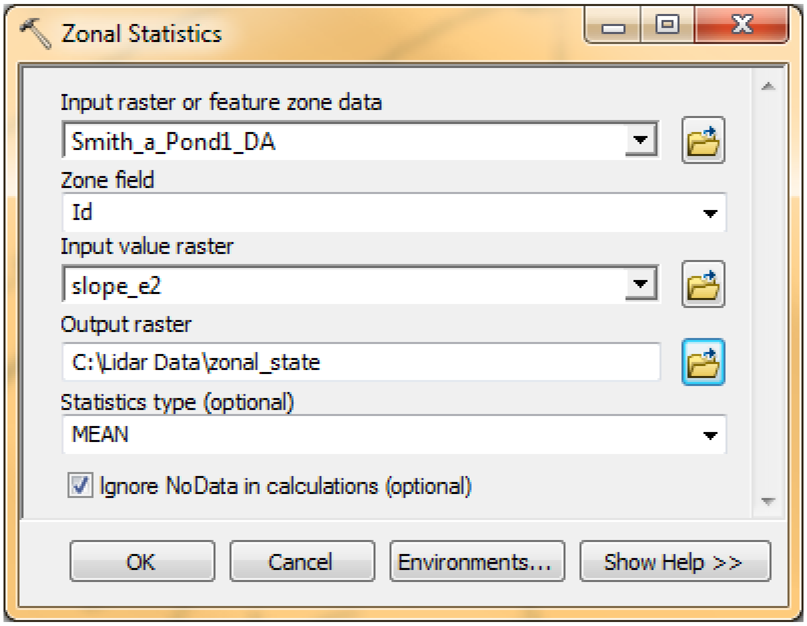
Input raster or feature zone data: Using the pull down menu box set the Input feature to the correct file. This will define the boundary of the area to be analyzed.

Zone field: Select the desired field. Normally just use the default value.

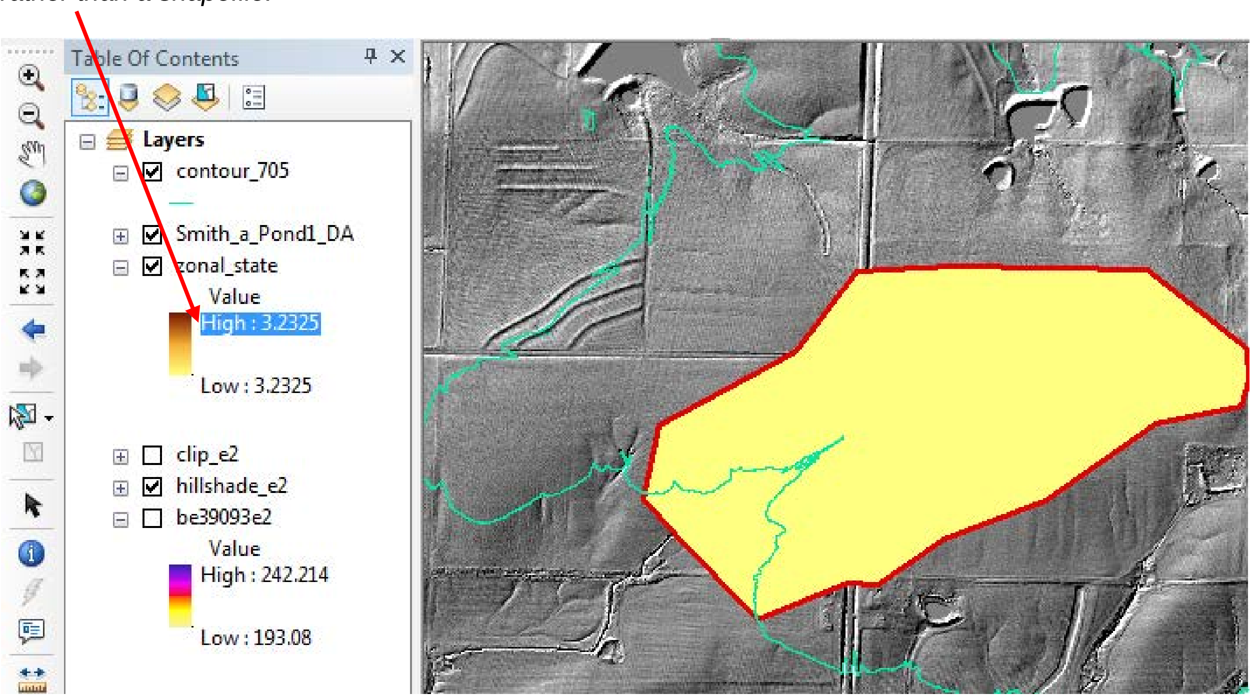
Input value raster: Using the pull down menu box select the slope raster.

Output raster: Enter a path and file name for the output raster where the results will be stored.

Statistics type: For this example select MEAN from the pull down list.

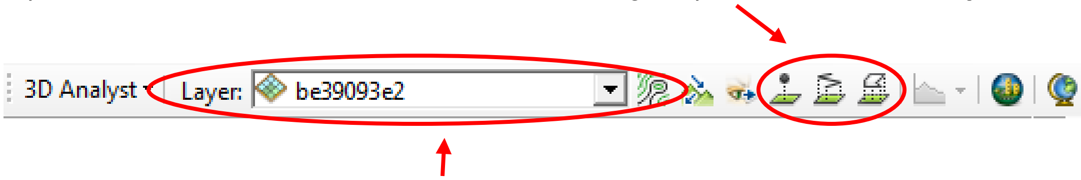


*The results of the example can be found in the **zonal_state** output raster. All of the raster cells will contain the same value and that value is the **Mean Slope** for the area. In this example the **Mean Slope** is 3.2%. Alternatively, one could use Zonal Statistics As Table which produces a table of statistic(s) rather than a shapefile.*



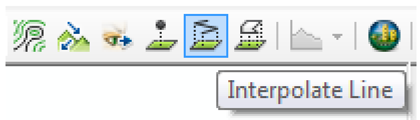
L. Extracting a Profile

A profile can be extracted from an ESRI Grid file using the profile tools in **3D Analyst**.

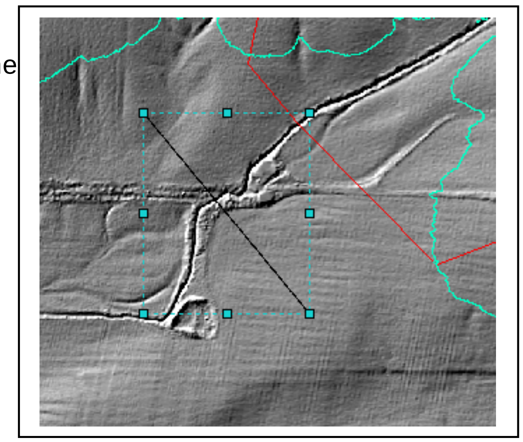


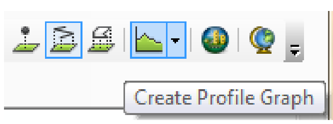
To extract a profile first select the Layer (ESRI_Grid) from which the profile will be drawn.

Next, draw an alignment by selecting the **Interpolate Line** button from the **3D Analyst** tool bar:



Once the **Interpolate Line** tool is activated use the mouse pointer and a left click to establish points on the profile alignme Double click to end the profile alignment.

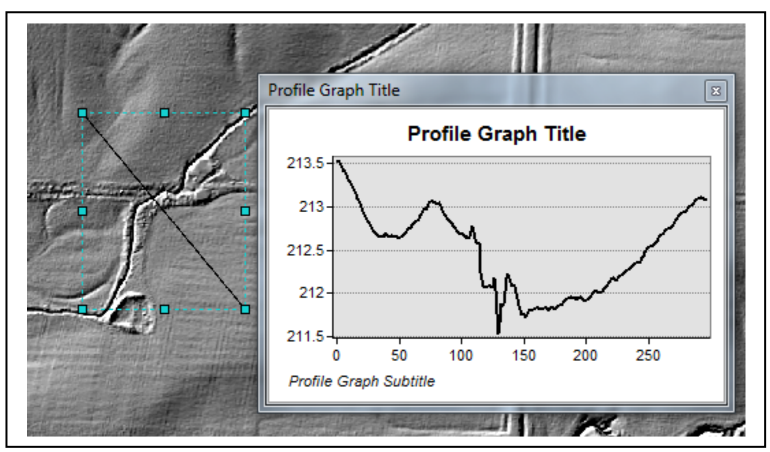




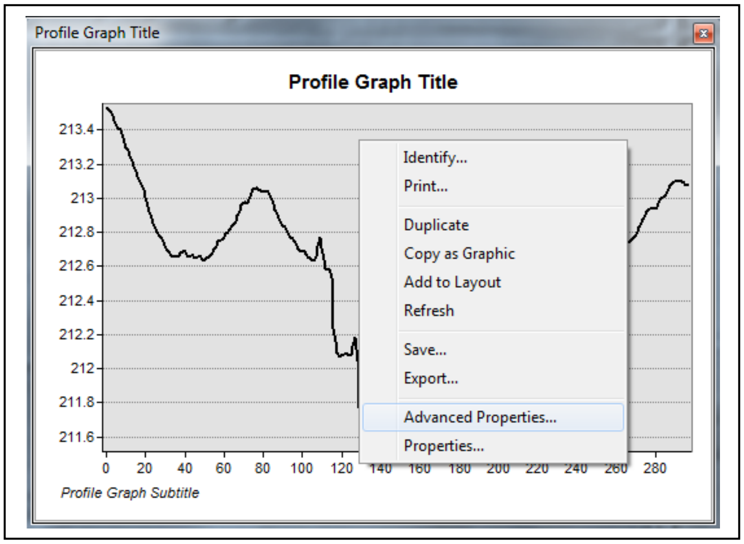
Now that the profile alignment has been drawn, the profile graph can be created by selecting the **Create Profile Graph** button from the **3D Analyst** tool bar.

The profile graph elevations will be in the same units as the ESRI Grid file. The distances will be in the units of the coordinate system currently set for the Data Frame properties. In this example the units are both meters.

The graph will be plotted in the same order that the line was drawn (Distance zero, 0, will be the first point drawn.).

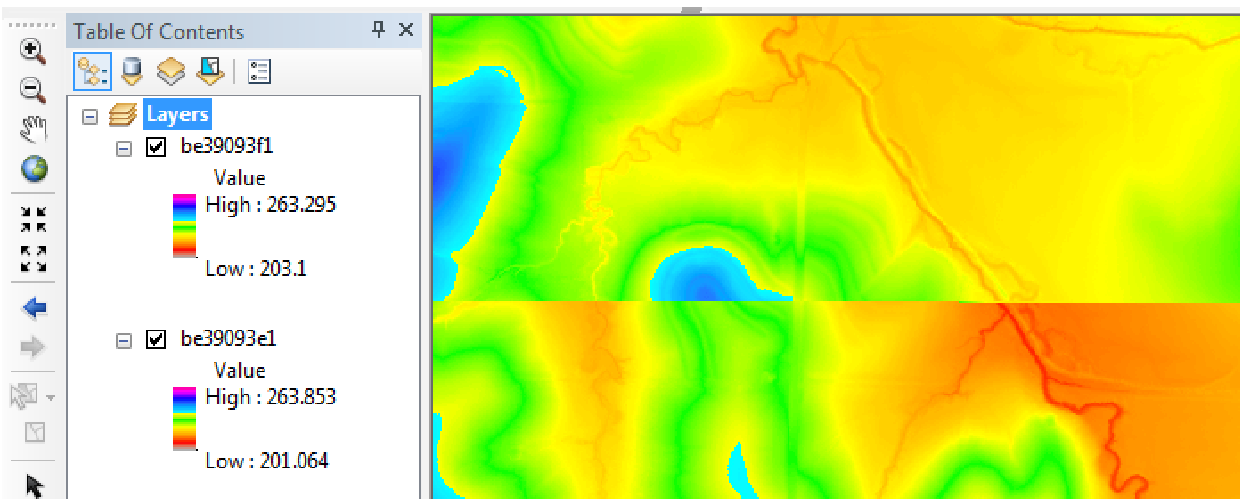


Right clicking while hovering the mouse pointer over the graph activates a pop-up menu that allows for customizing of the graphs appearance as well as exporting and printing of the profile.

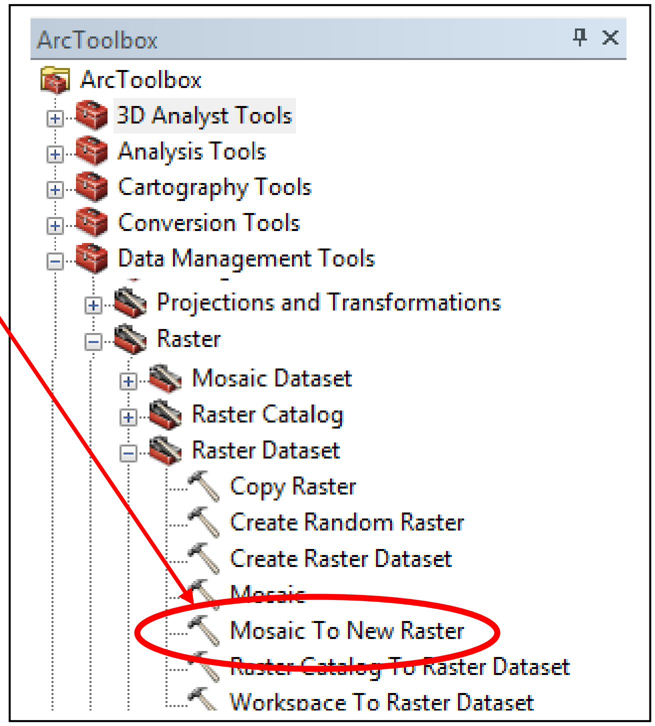


M. Merging ESRI Grid Files (Raster Mosaic)

In the example below, two ESRI_Grid rasters have been added to an ArcMap project. Both rasters are using the same color ramp to display the elevation range; however, a seam is created at the boundary of the two rasters. If the two rasters were merged into one then this boundary would be eliminated.



When a project area spans more than the coverage of a single ESRI Grid File it is helpful to merge the individual grid files into a single file. ESRI Grid Files can be merged using the **Mosaic to New Raster** tool that is one of the **Data Management Tools** within **ArcToolbox**



Select the ESRI_Grid raster files that you want to mosaic.

If the rasters have already been added to the ArcMap project then use the drop down list to select them.

If the rasters have not been added to the project then use the browse button to locate and select the raster files.

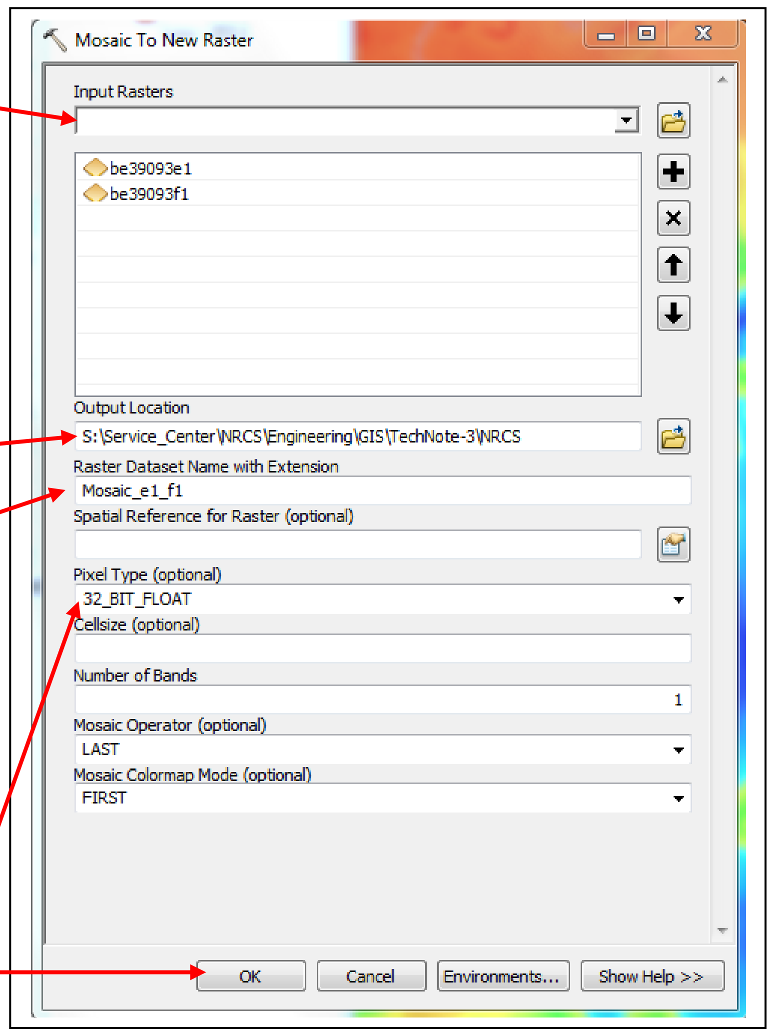
Select an output location folder where the new raster will be stored.

Type in a name for the new raster. **ESRI Grid Raster names must be 13 characters or less with no special characters or spaces.**

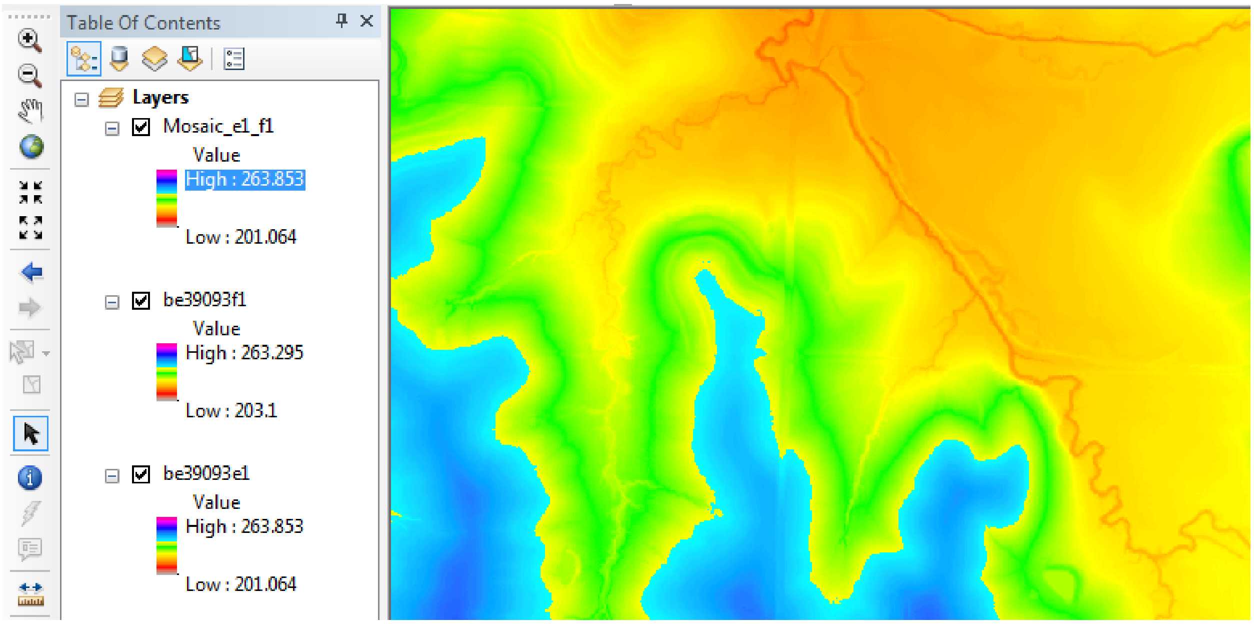
These files can be large, so do not save them on server locations where space is limited. Same them to a local drive, such as a folder on the C: drive. Also use a descriptive name that helps identify the coverage area of the DEM.

Select 32_BIT_FLOAT for the Pixel type

Click **OK** to make the new raster.

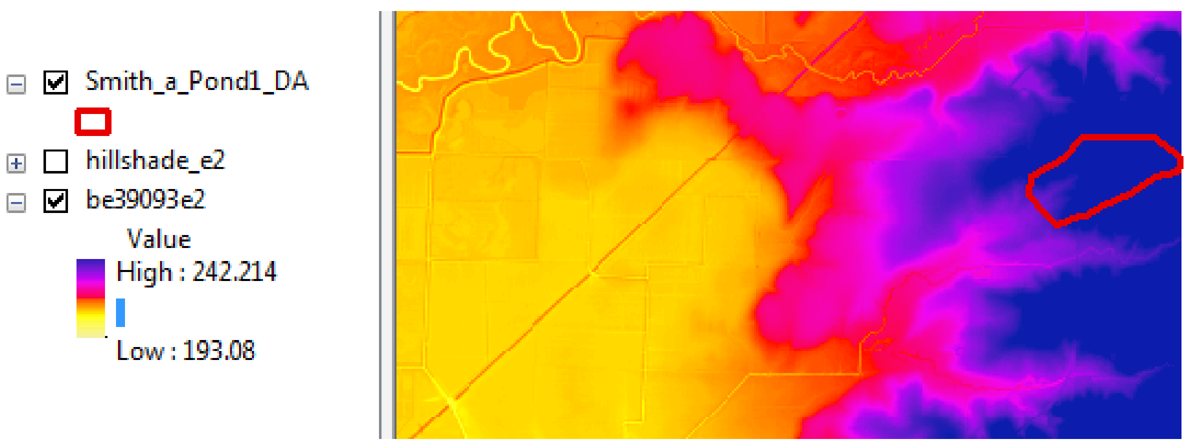


For the example, the boundary has been eliminated in the new mosaic raster.

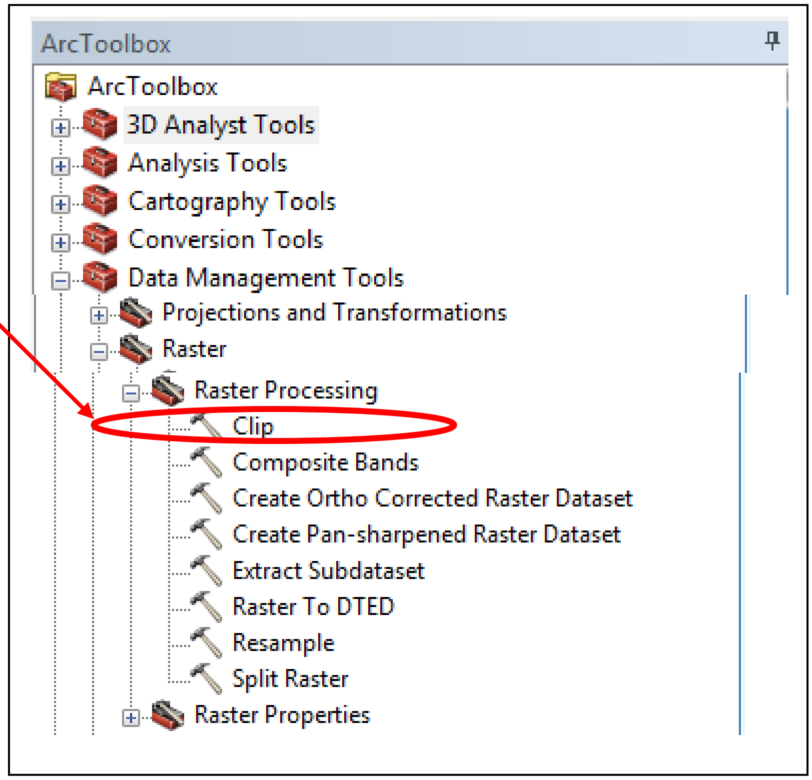


N. Clipping ESRI Grid Files (Raster Clip)

For some projects it may be advantageous for reasons of processing time or storage space to clip out the study area of the ESRI_Grid raster. In the example below the **Drainage_Area** polygon shape file will define the extents of the area to be clipped from the ESRI_Grid raster named **39093-e2**.



A portion of an ESRI Grid File can be clipped into a new ESRI_Grid raster file using the **Clip** tool that is one of the **Data Management Tools** within **ArcToolbox**

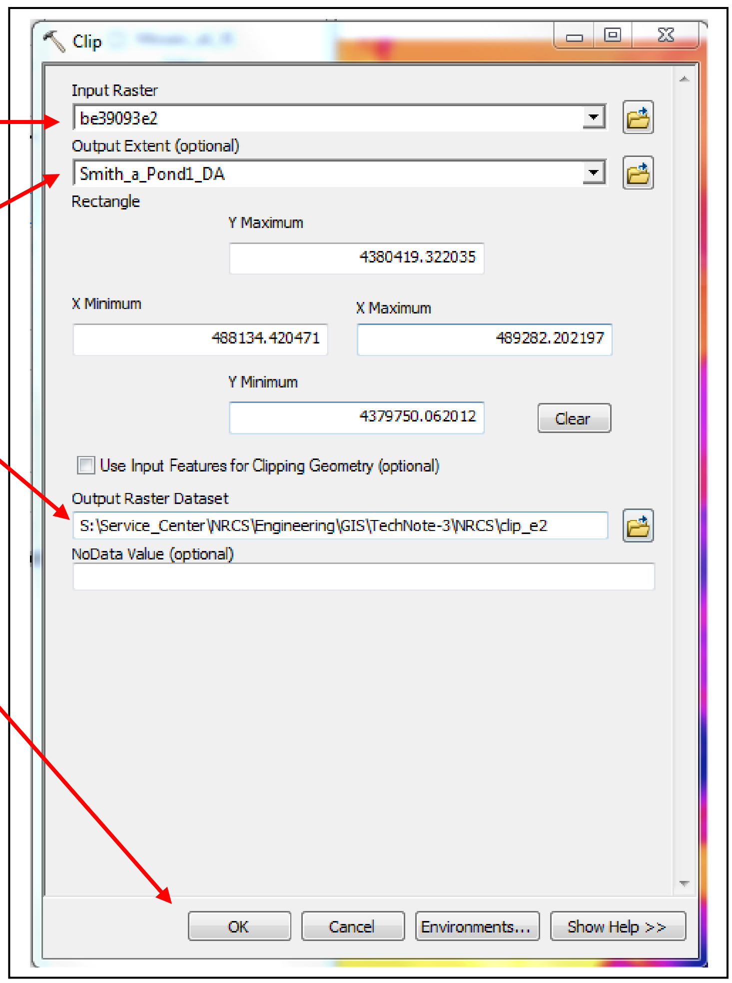


Select the ESRI_Grid raster file that will be clipped.

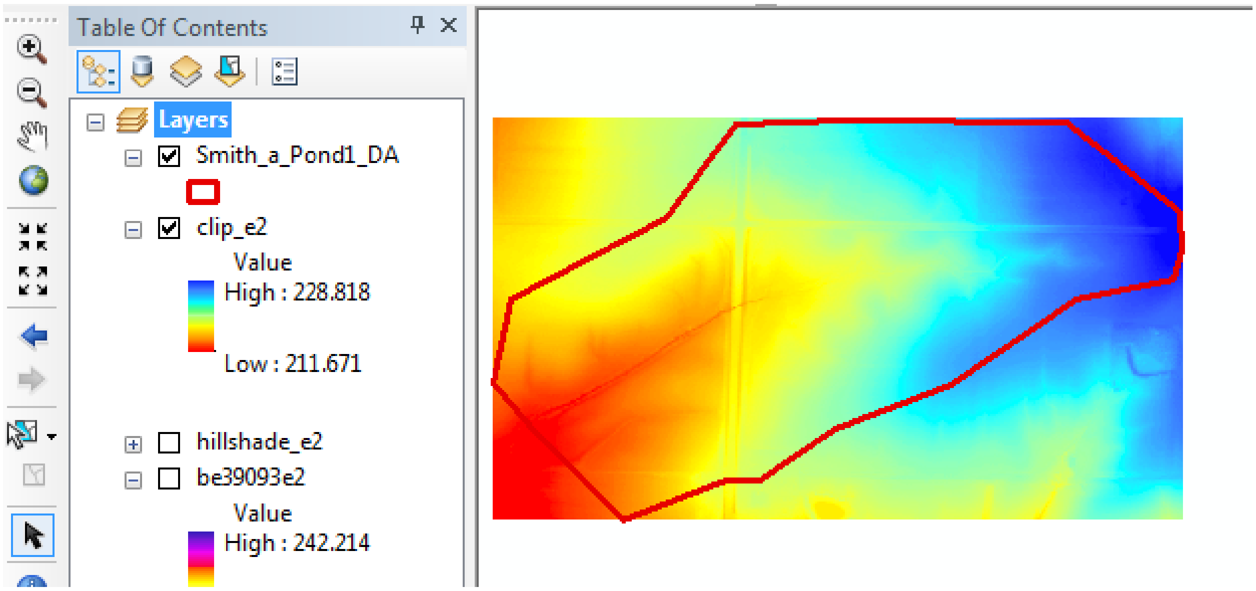
The rectangular extents of the clip can be set by either selecting an existing shape file from which the extent coordinates will be taken or the coordinates can be entered manually.

Enter a path and file name for the new clipped raster.

Click OK to make the new raster.



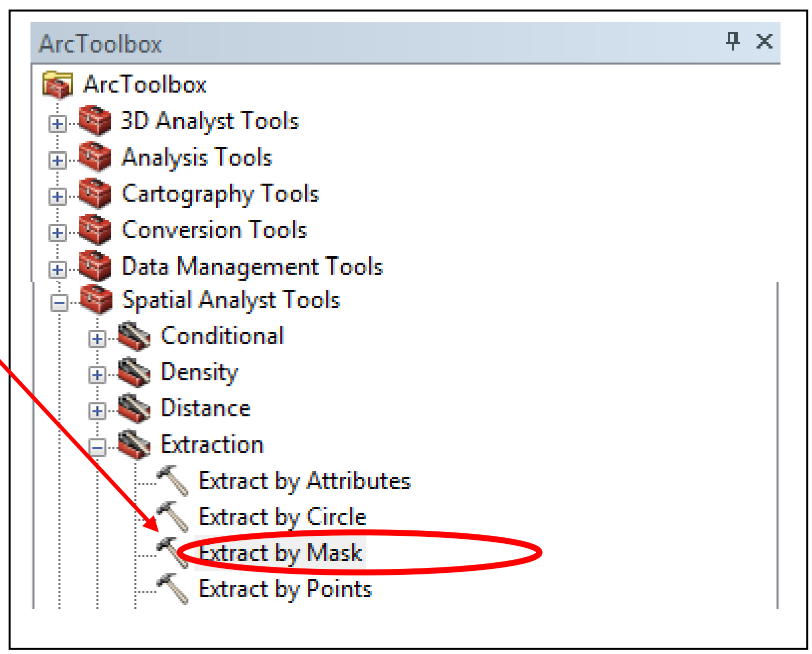
For the example, the extents of the new ESRI_Grid raster named **Clip_e2** match those of the **Smith_a_Pond1_DA** shape file.



O. Clipping ESRI Grid Files (Extract by Mask)

An alternative to clipping an ESRI Grid raster using **Raster Clip** is to use **Extract by Mask**. Using **Extract by mask** will clip the raster to a polygon instead of the polygon's extents.

Use the **Extract by Mask**, which is one of the **Spatial Analyst Tools** within **ArcToolbox**

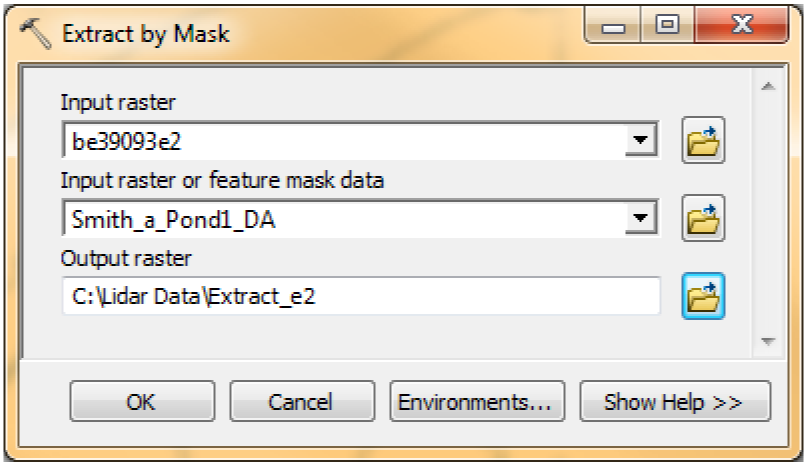


Input raster: Using the pull down menu box set the Input feature to the correct ESRI_Grid raster file.

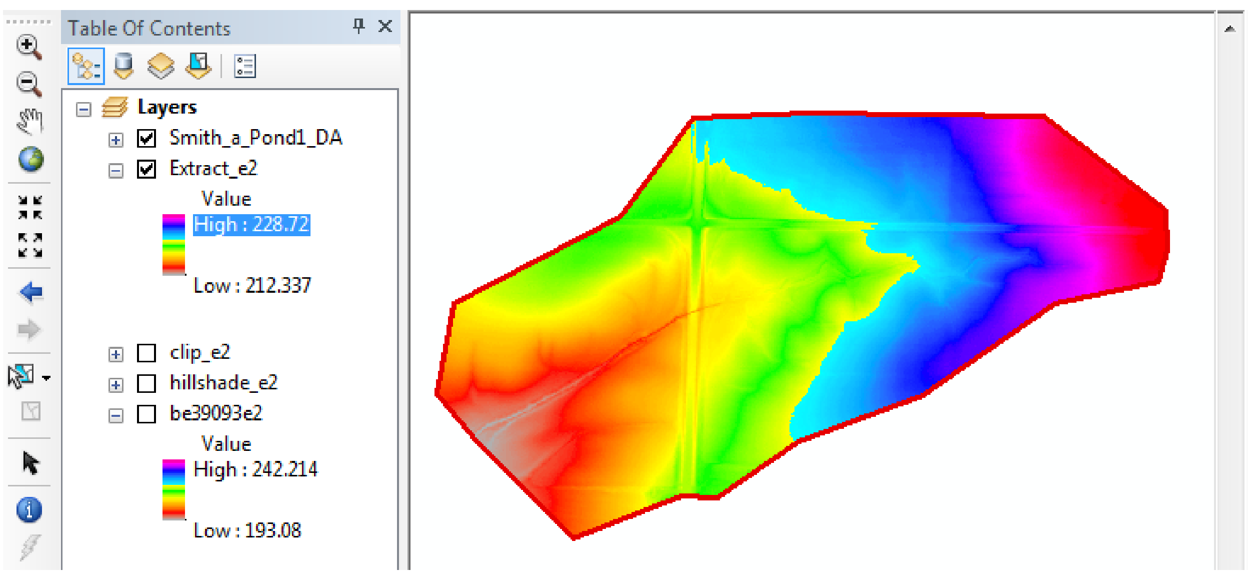
Input raster or feature mask data: Using the pull down menu box select the shapefile that will be used as the boundary for the extraction.

Output raster: Enter a path and file name for the output raster where the results will be stored.

Click OK to make the new raster.



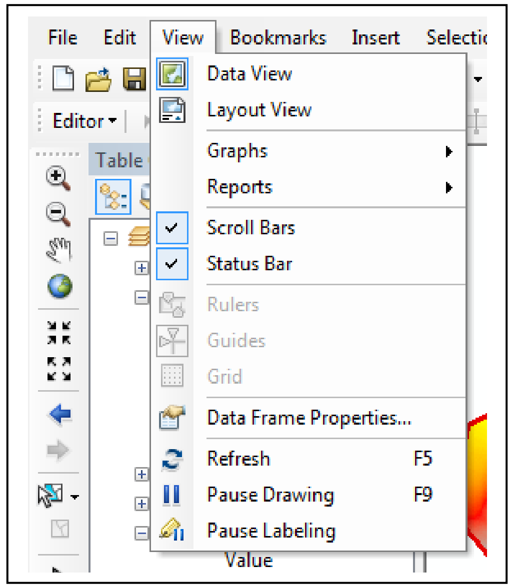
For the example, the border of the new ESRI_Grid raster named **Extract_e2** match those of the **Smith_a_Pond1_DA** polygon shape file.



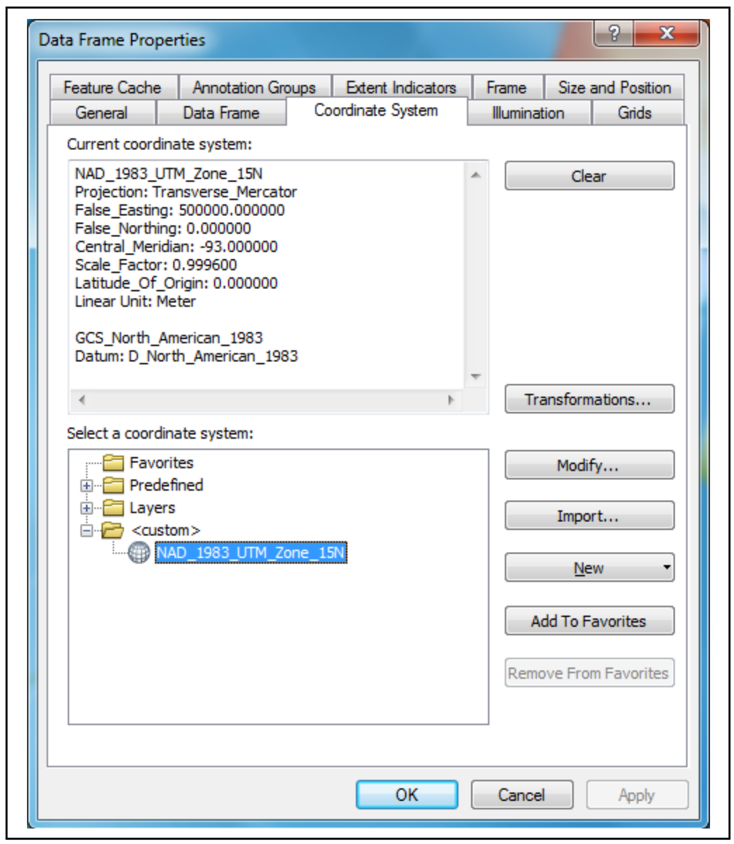
P. Converting an ESRI Grid Raster from Meters to Feet

The projection and units of the original LiDAR ESRI_Grid Raster files are not to be changed; however, it may be useful to change how ArcMap displays the x,y projection and units of those files.

To change the x,y projection of ArcMap's display select **View** ► then click **Data Frame Properties**. (This action does not actually change the projection of the ESRI_Grid raster file, but only how it is displayed in the current ArcMap session.)



Under the **Coordinate System** tab, select a coordinate system that is in US Feet. If not already available then rename and modify an existing system as shown on the next page.

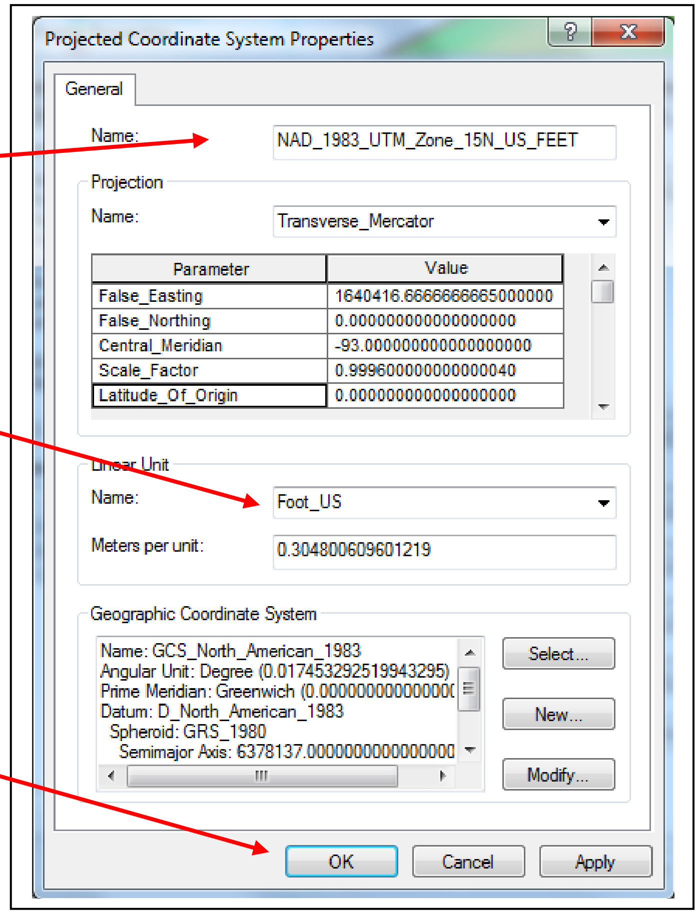


Rename the coordinate system by adding "_US_FEET" to the end of the original name.

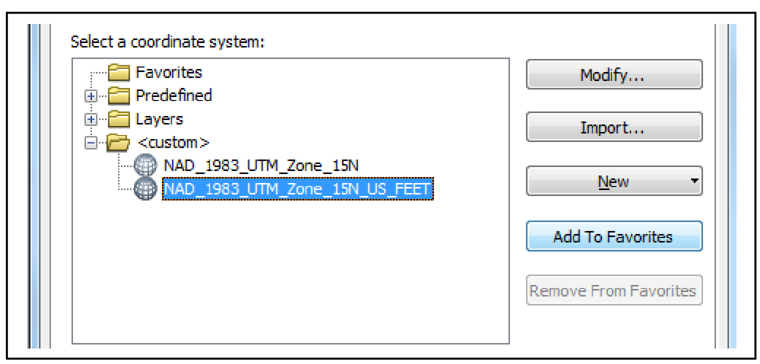
<u>DO NOT MAKE CHANGES TO THE ORIGINAL COORDINATE SYSTEM unless it has been renamed!!</u>

Select Foot_US for the Linear Unit

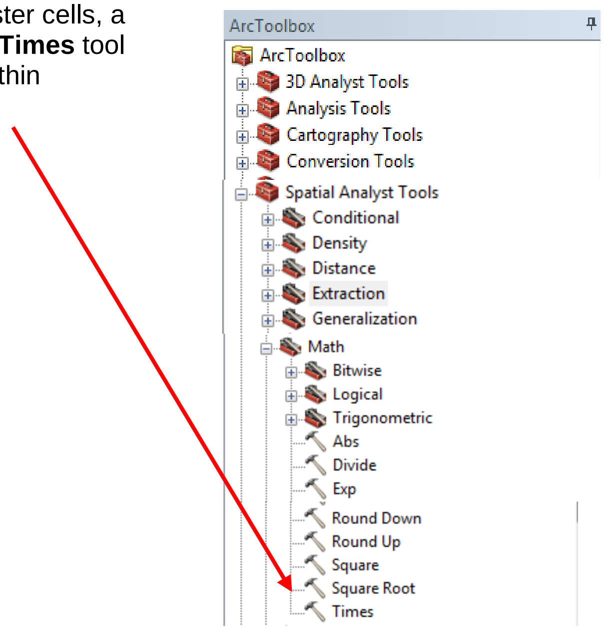
Click OK to make the new coordinate system.



The modified coordinate system can be saved for future use by adding it to favorites by clicking the **Add to Favorites** button.



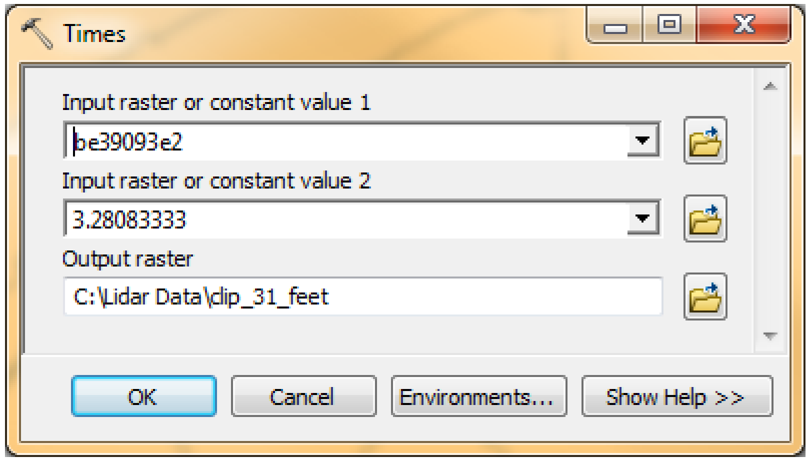
To change the z value (elevation) of the raster cells, a copy of the raster is made using the **Math, Times** tool that is one of the **Spatial Analyst Tools** within **ArcToolbox**



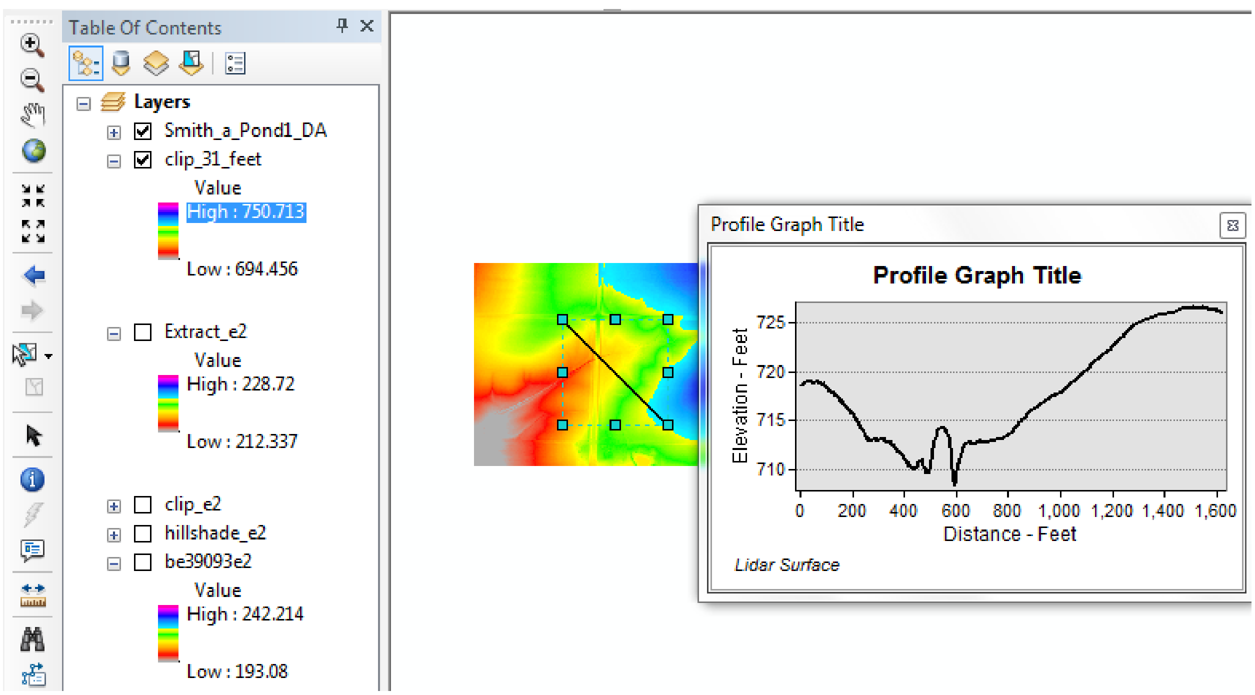
Using the **Times** dialogue box, select the ESRI_Grid raster that will be converted.

Also set the conversion constant for converting from meters to feet (3.28083333)

Enter the path and file name for the new ESRI_Grid raster file, then click **OK** to make the new raster.



In this example, the new ESRI_Grid raster named **clip_31_feet** is used to create a profile graphic, which is now in the units of feet instead of meters. The elevation (y-axis) is feet because the elevation unit of the Grid was changed using the Math>>Times function; the horizontal distance along the profile (x-axis) is in feet because the Data Frame Properties were changed to display in UTM_US_Feet.

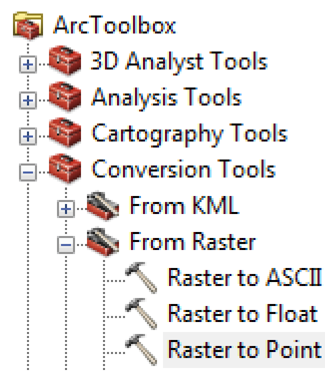


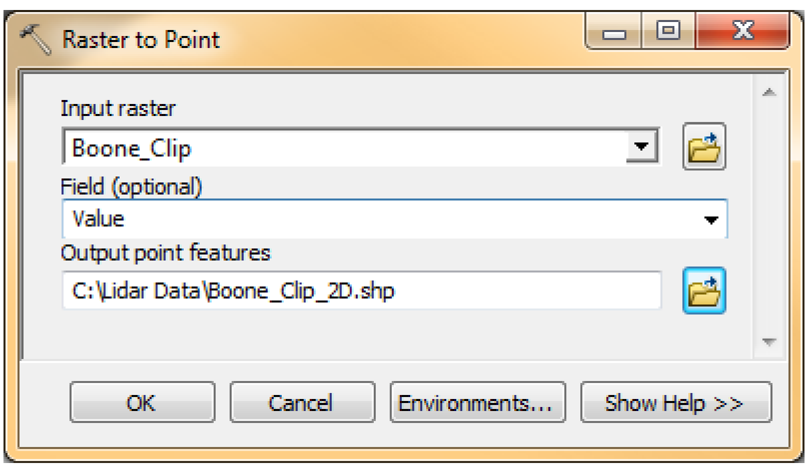
Q. Extracting an ASCII x,y,z File from an ESRI Grid Raster

It is possible to extract an ASCII x,y,z point file from an ESRI_Grid raster using ArcMap. This process involves creating a 2D Point feature file, then converting it to a 3D Point feature file and finally exporting to the ASCII point file. Since a 1 meter cell size raster will generate over 4,000 points per acre, it is advisable to prepare a clipped raster or a clipped feature point file that only includes the study area.

Making a 2D Point Feature.

Select **Conversion Tools ► From Raster, Raster to Point** from the ArcMap toolbar.



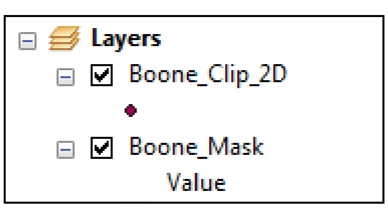


Input raster: Using the dropdown list, select the correct ESRI_Grid raster, if it is currently added to the ArcMap project. Otherwise, use the browse button to navigate to the raster's location.

Field (optional): The field to assign values from the cells in the input raster to the points in the output dataset.

Output point features: The output feature class that will contain the converted points.

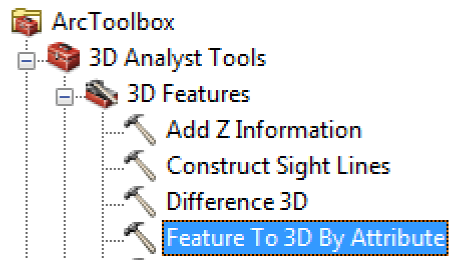
Click **OK** to make the new feature file.

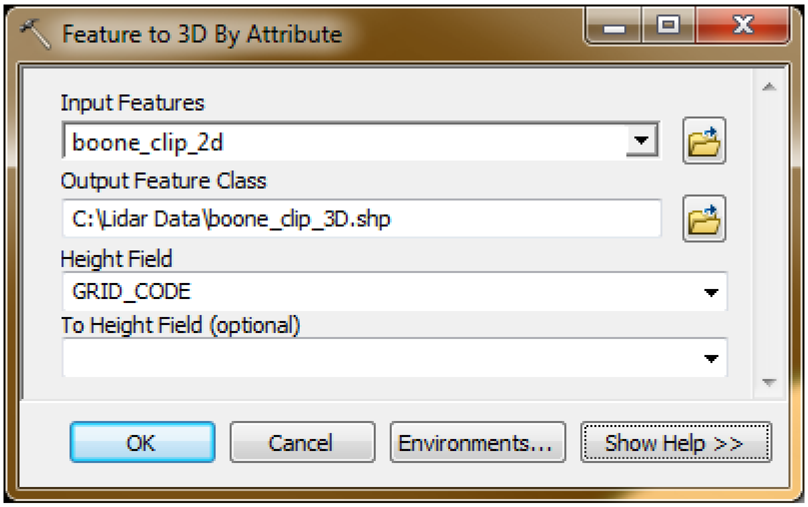


The new feature file will be automatically added to the ArcMap project. In this example it is named **Boone_Clip_2D**.

Converting a 2D Point Feature to a 3D Point Feature.

Select **3D Analyst Tools, 3D Features, Feature to 3D by Attributes** rom the Arc Toolbox toolbar.





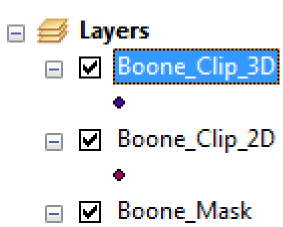
Input features: Using the dropdown list, select the 2D point feature.

Output Feature Class: Enter or browse to the desired path and file name for the new feature (3D point shapefile) that will be created.

Height Field: The field contained in the 2D feature whose values will define the height of the resulting 3D features.

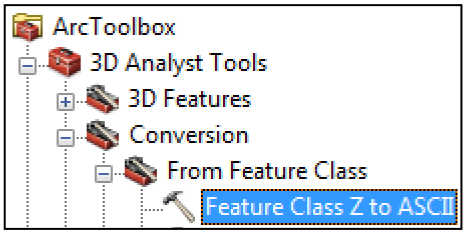
To Height Field (Optional): An optional second height field used for lines. When using two height fields, each line will start at the first height and end at the second (sloped).

Click **OK** to make the new feature file.

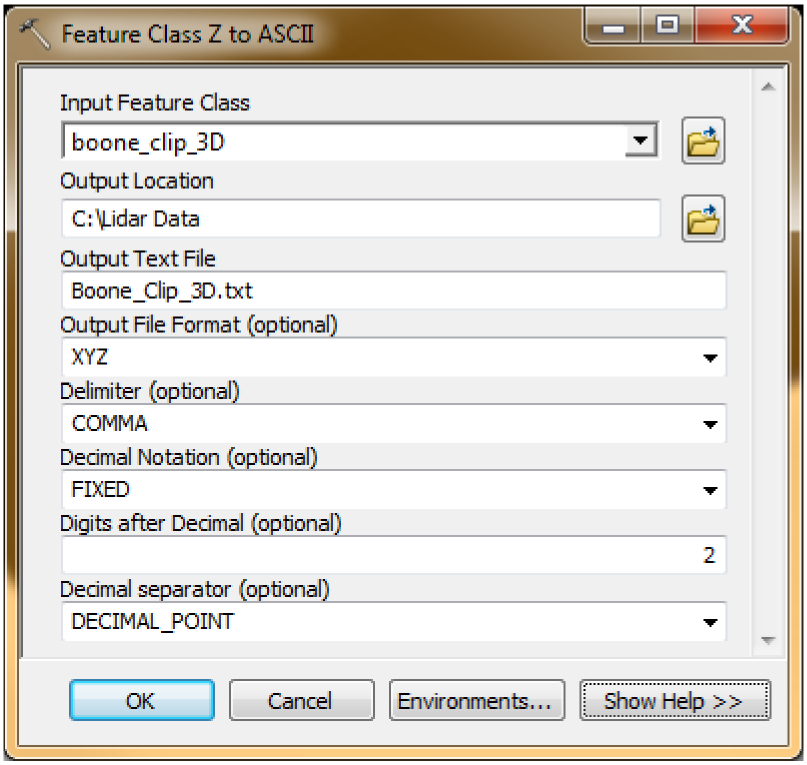


The new feature file will be automatically added to the ArcMap project. In this example it is named **Boone_Clip_3D**.

Extracting an ASCII x,y,z point file from the 3D Point Feature.



Using ArcToolbox,
select **3D_Analyst Tools, Conversion, From Feature Class ► Feature Class Z to ASCII**.



Input Feature Class: Use the dropdown list to select the correct 3D Point Feature.

Output Location: Browse to the folder where the ASCII file will be stored.

Output Text File: Enter the name and extension for the ASCII point file.

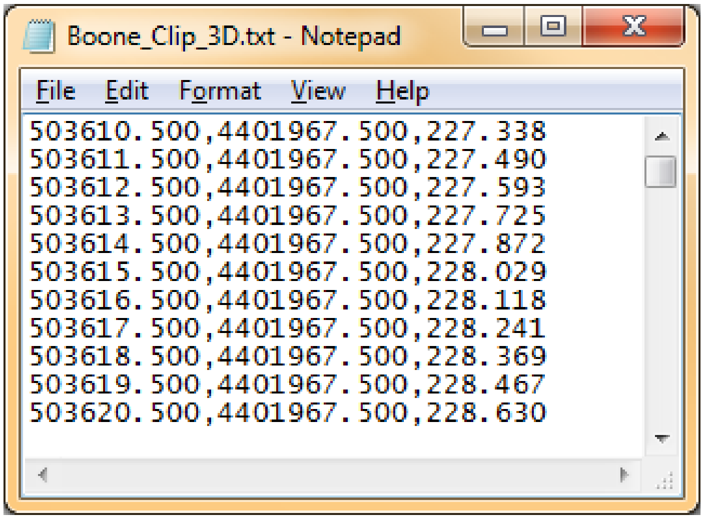
Output File Format: Using the dropdown list select **XYZ**.

Delimiter: Using the dropdown list select the desired data separation character.

Decimal Notation: Using the dropdown list select either Automatic or Fixed.

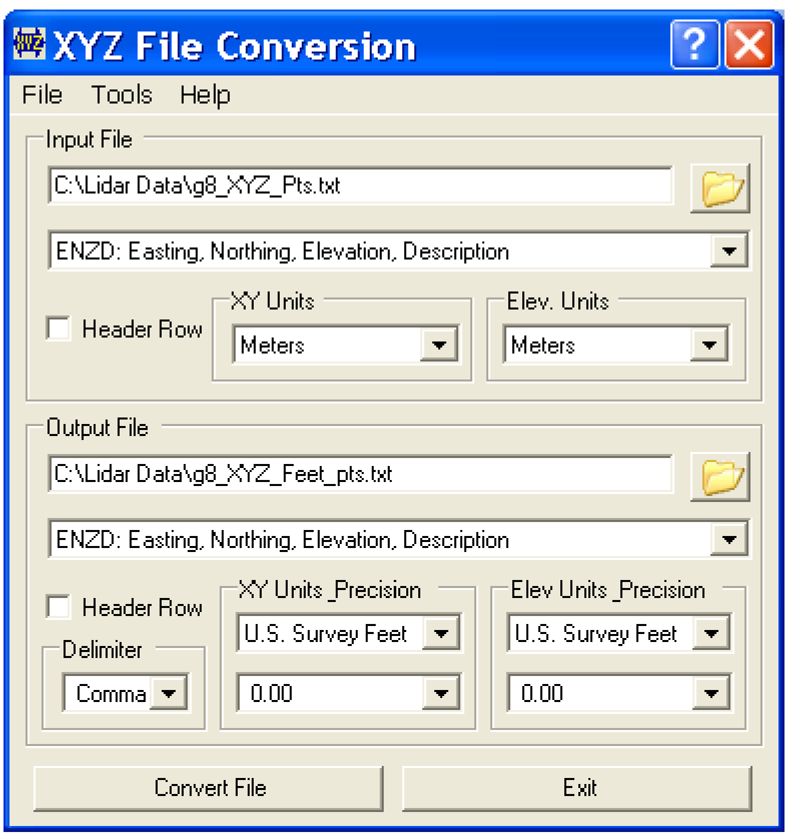
Click **OK** to make the ASCII point file.

In this example a text file named **Boone_Clip_3D.txt** was created. The units will be the same as those from the raster file, in the example this is meters.



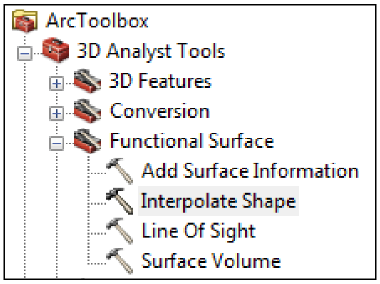
XYZ File Conversion

If necessary, use the **XYZ File Conversion** program to convert the units of the ASCII point file (for example from meters to US Feet). The XYZ File Conversion program can be found in the **Support_Files** folder on the LiDAR drive.

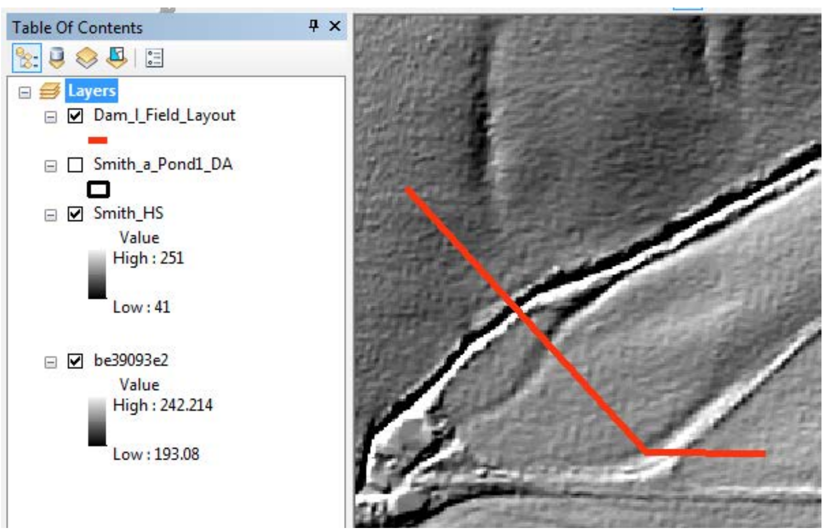


R. Interpolating Elevations of Feature Shapes from an ESRI Grid Raster

Elevations (Z values) for points or locations along a polygon or polyline from a shape file can be interpolated from an elevation raster surface using the **3D Analyst Tools, Functional Surface, Interpolate Shape** tool. This process is an alternative to using the **Feature to 3D by Attributes** as described in **Section Q**.



In the example below, a polyline shapefile (**Dam_I_Field_Layout**) was collected in the field along the centerline of a proposed dam. The goal is to the generate a profile of the dam centerline named **Dam_I_Field_Layout** using the field survey line with elevations from the LiDAR surface named **be39093e2**.



Using ArcToolbox, select **3D_Analyst Tools, Functional Surface, Interpolate Shape**

Input Surface: Is the elevation raster to use for the Z values.

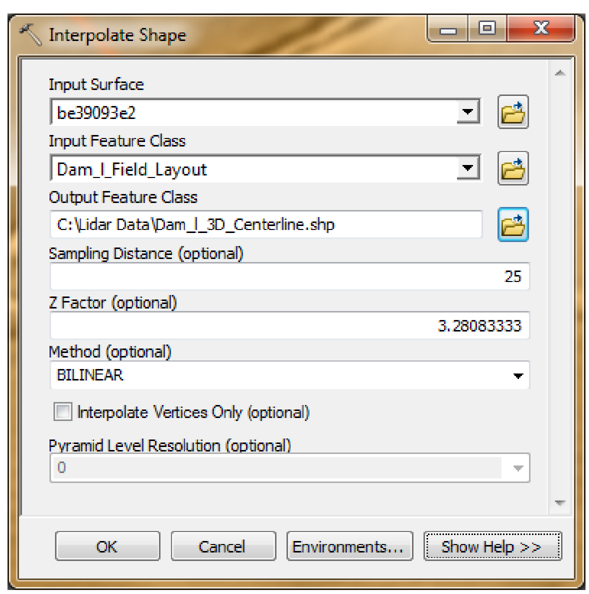
Input Feature Class: Is the existing 2D polyline shapefile.

Output Feature Class: Is the new shapefile that will store the 3D polyline created by the tool.

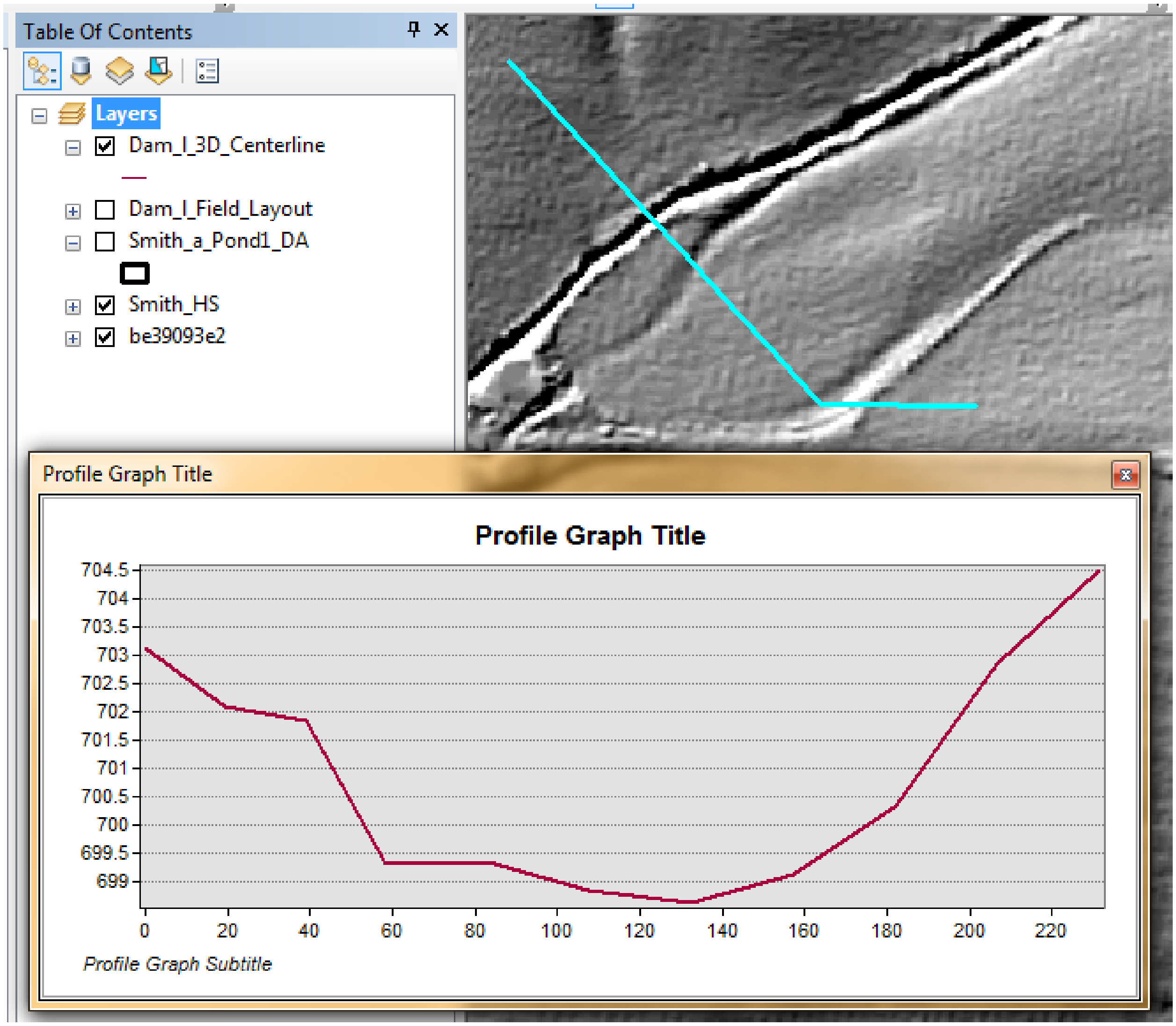
Sampling Distance (optional): Is the interval distance along the polyline where Z values will be calculated.

Method (optional): Select **BILINEAR**.

Click **OK** when done.



The resulting 3D polyline shape line, named **Dam_I_3D_Centerline**, can then be used to generate a profile using the 3D Analyst toolbar. See **Section L**, Extracting a Profile. The 3D polyline can also be used with the **Feature Class Z to ASCII** tool described in **Section Q** to create a point file.



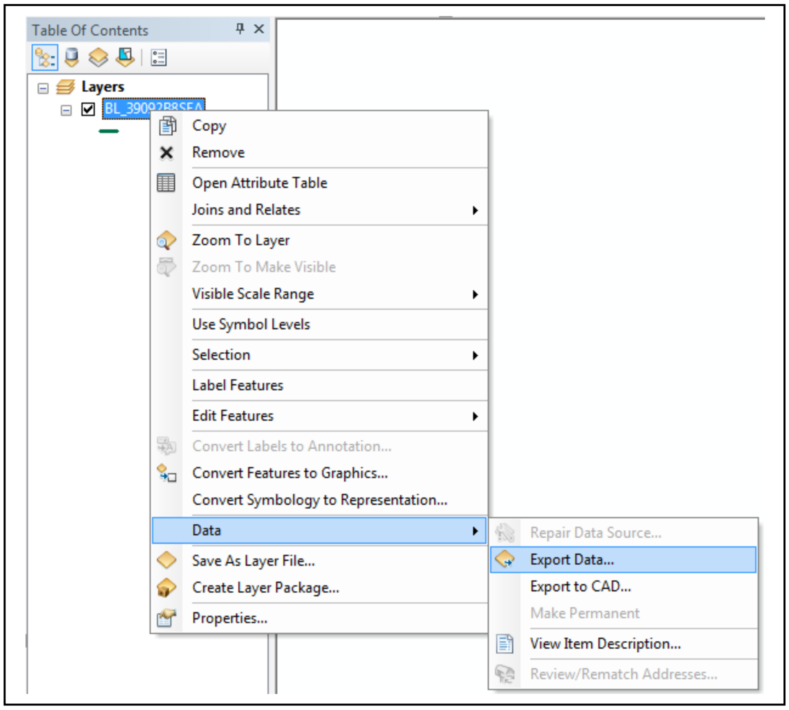
S. <u>Converting Elevations of Break Line Poly Z Files from Meters to Feet</u>

Break lines are helpful when using points that are actual LiDAR returns, which are usually stored as LAS files. The break lines define features such as channel banks or channel centerlines. Break lines for some coverage areas have been stored as ESRI Poly Z shapefiles. When importing these files into AutoCAD it may be desirable to first adjust the Z values from meters to feet using ArcMap.

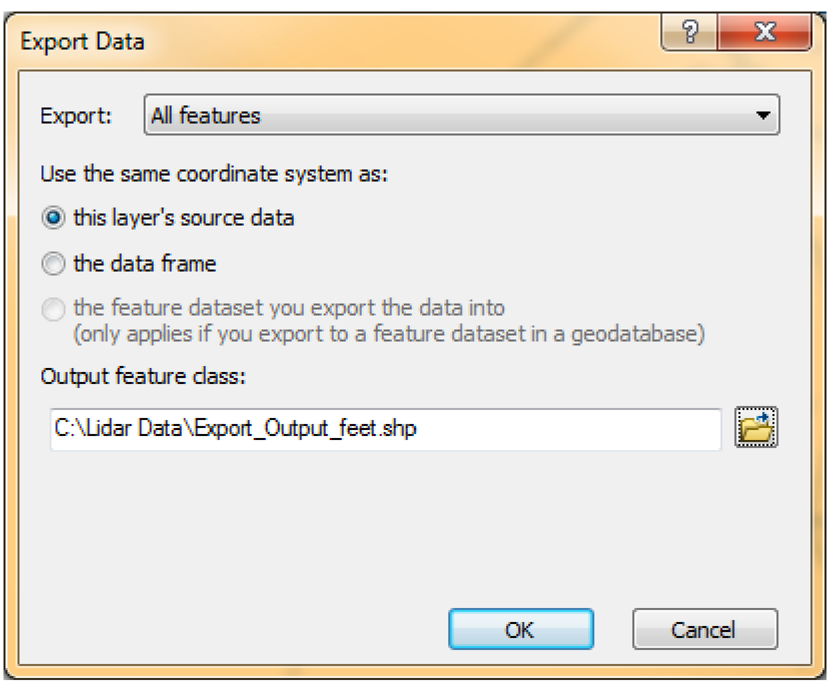
<u>DO NOT ADJUST THE Z VALUES OF THE ORIGINAL BREAKLINE FILES!!</u>

FIRST,
<u>Make a copy</u> of the break line shapefile or extract the needed polylines to a new shapefile.

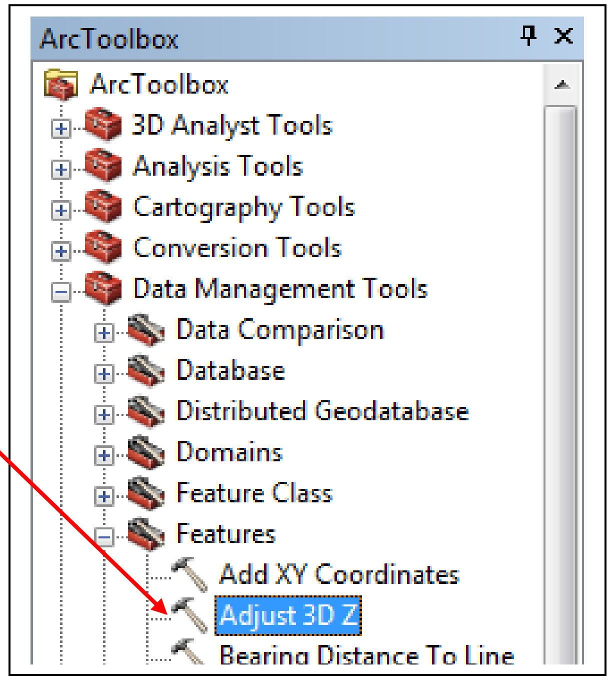
This can be accomplished by right clicking on the break line shapefile then click
Data ► Export Data.



Give the new shapefile a name that implies that the Z values are in feet.



Once the new shapefile is created, use **Adjust 3D Z**, which is one of the **Data Management Tools** within **ArcToolbox**



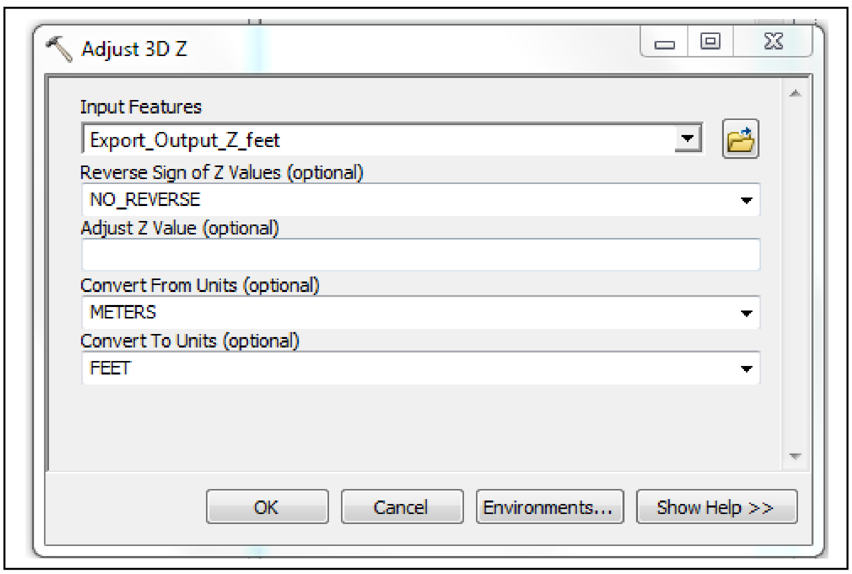
__Input Feature__: Use the dropdown list to select the new shapefile.

__Reverse Sign of Z Values__: Set this value to NO_REVERSE

__Adjust Z Value__: Leave this field blank (if used it will add a constant value to every Z).

__Convert From Units__: Select Meters.

__Convert To Units__: Select Feet.

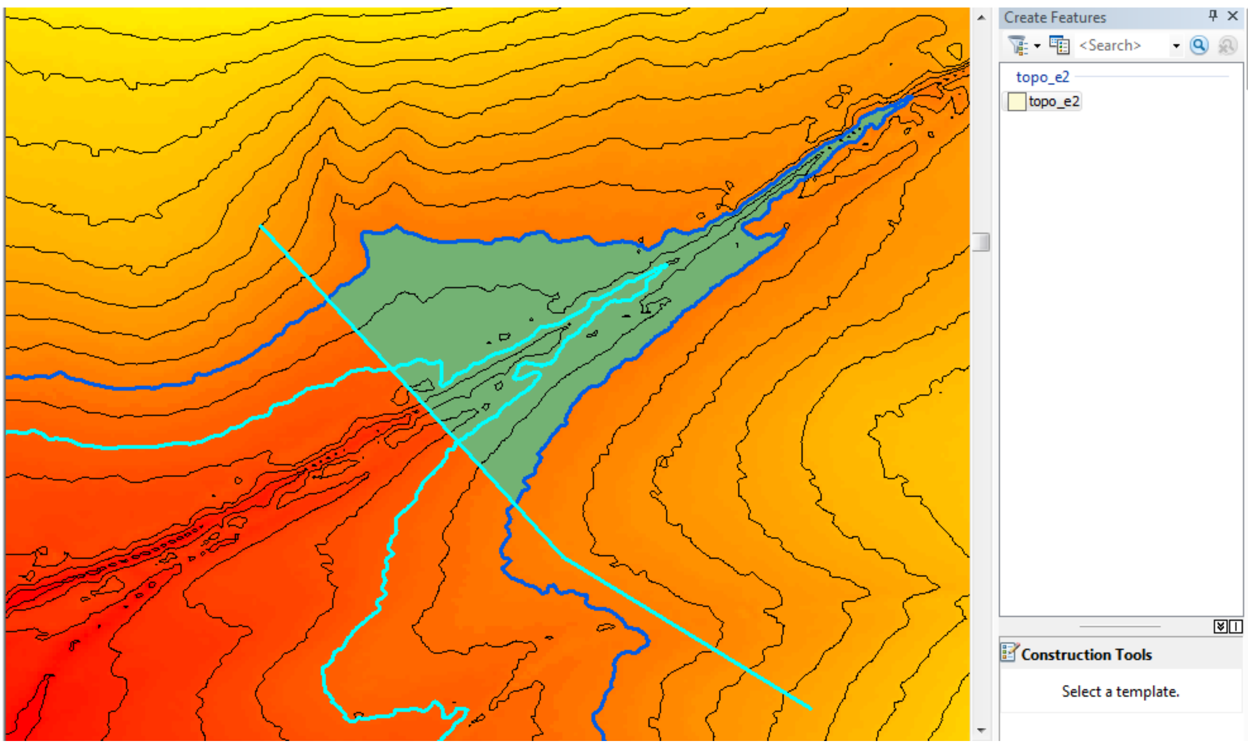


Click **OK** to make the adjustment to the shapefile.

T. Using Contour Lines to Make Polygons

Contour Lines may be used to create polygons to determine the surface area for a series of pool elevations to develop a stage vs. storage table. To complete this task upload both the contours for the basin and the centerline of the Dam; **Contour_clip_DA** and **CL_I_DA** for the example below. This procedure will use the **Topology** toolbar.

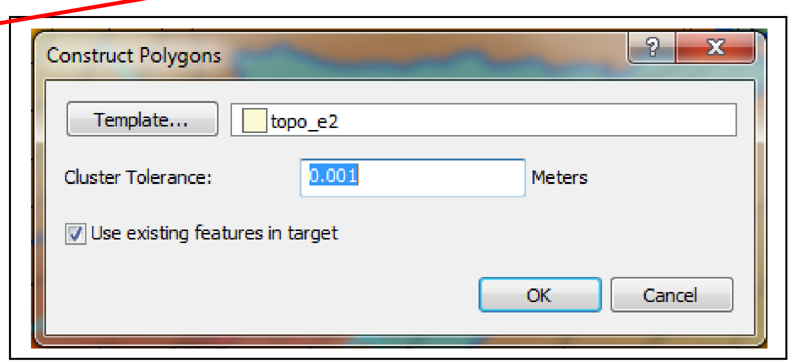
Create a polygon shapefile where the pool area polygons can be stored, **Poly_e2** for example, and add it to the **Table of Contents**. Next, place the shapefile in edit mode. Now select the contour and centerline of the dam using the selection tool.  Use the shift key to select both.



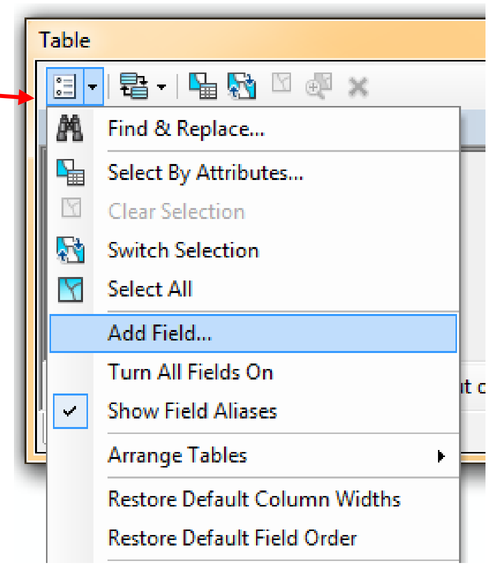
With both lines selected, click the **Construct Polygons** icon on the topology toolbar and select the Shapefile just created as the template.

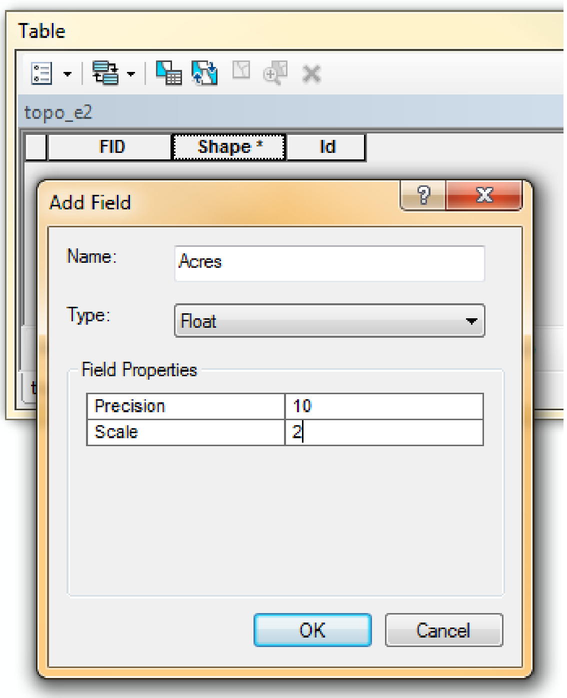
Check the Use existing features in target box.

Select **OK**. The polygon will be created. Repeat this process for each of the remaining contour lines.



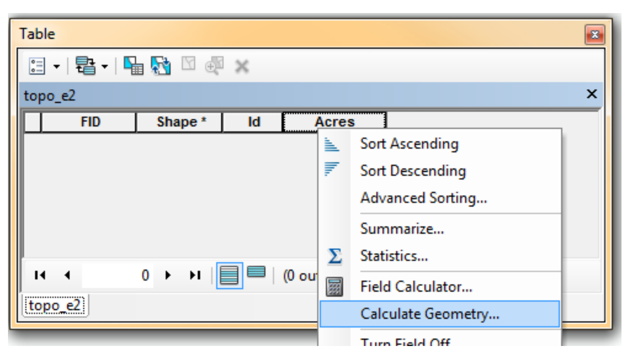
Open the attribute table for the polygon shape file and add a field for the area named “Acres” (**Table options** drop-down in upper left -> Add Field).





Set the properties for the new “Acres” field to:
Type = “Float”
Precision = “10”
Scale = “2”

After making the “Acres” Field, “Right click” on the field name in the attribute table and use the **Calculate Geometry** tool with the **Property** set to “Area” and the **Units** set to “Acres” to populate the area values for each contour polygon.

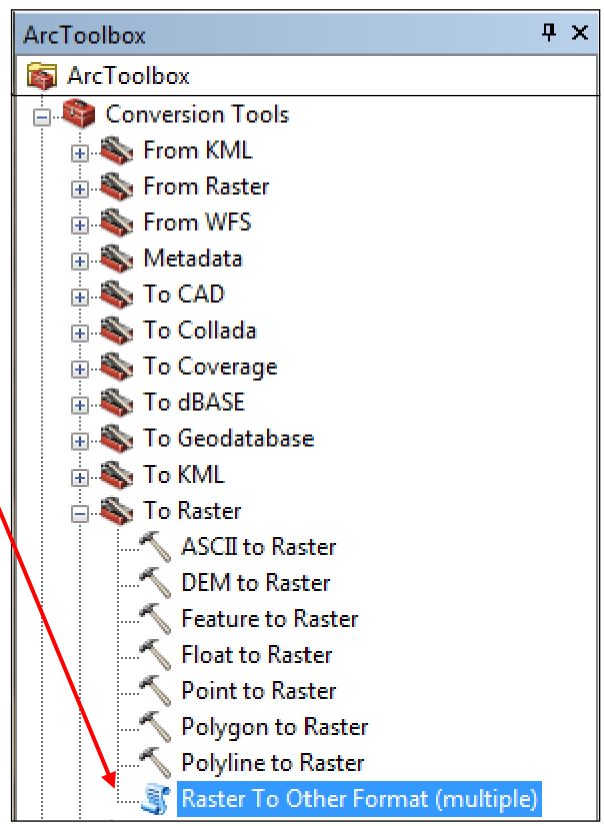


U. Making a GeoTIFF Raster from an ESRI Grid Raster

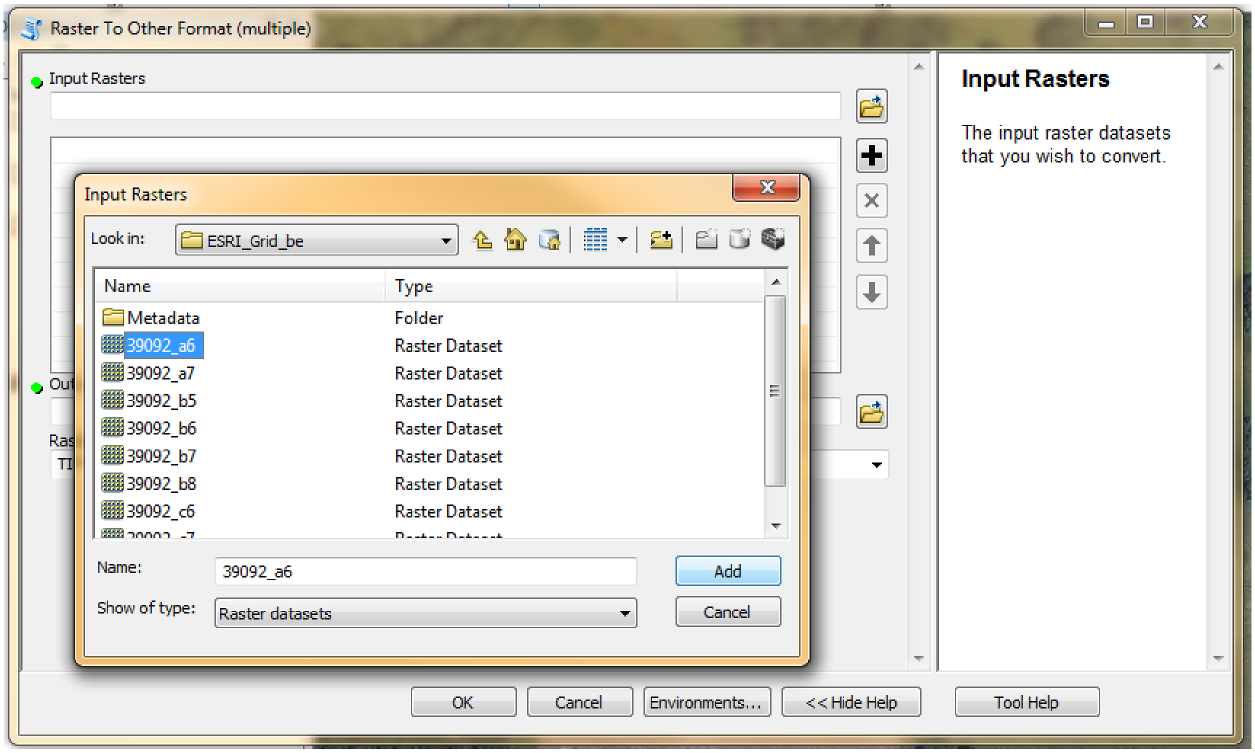
The Engineering Field Tools (EFT) program has the ability to use a Digital Elevation Model (DEM) for a design ground surface. Currently, the format of that DEM must be a GeoTIFF raster. A subset of the ESRI Grid raster can be created in GeoTIFF format using the **ArcToolbox tools**.

First, In the map view, zoom to the coverage area that is desired for the GeoTIFF raster as shown in the example below.

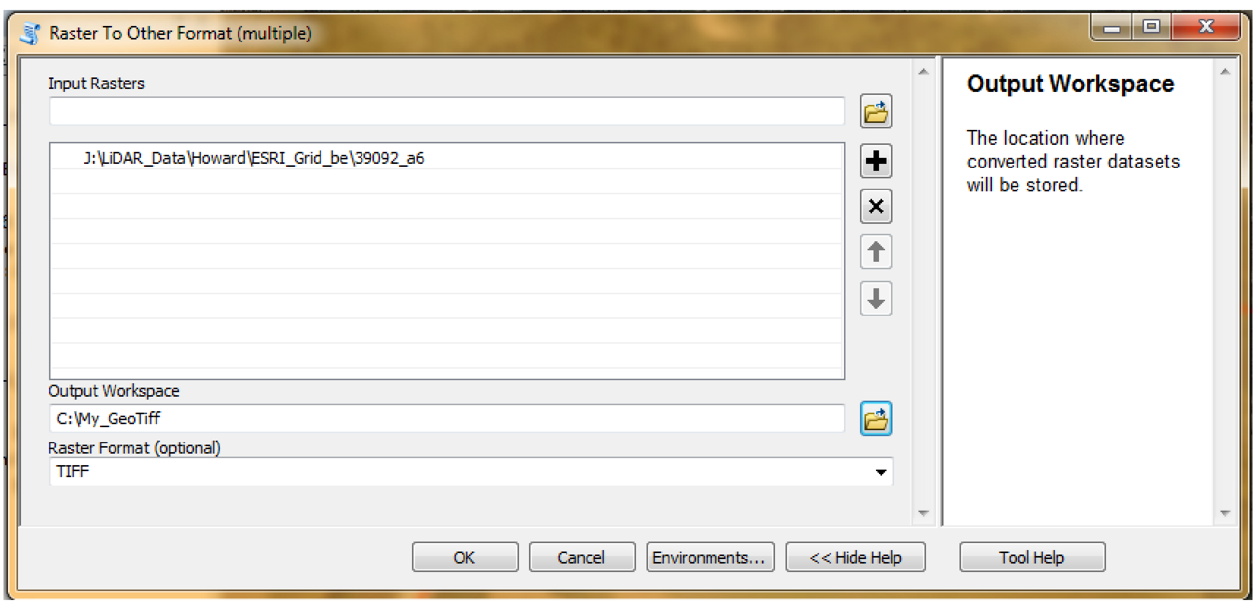
Next, use **Raster To Other Format (multiple)**, which is one of the **Conversion Tools, To Raster** tools within **ArcToolbox**



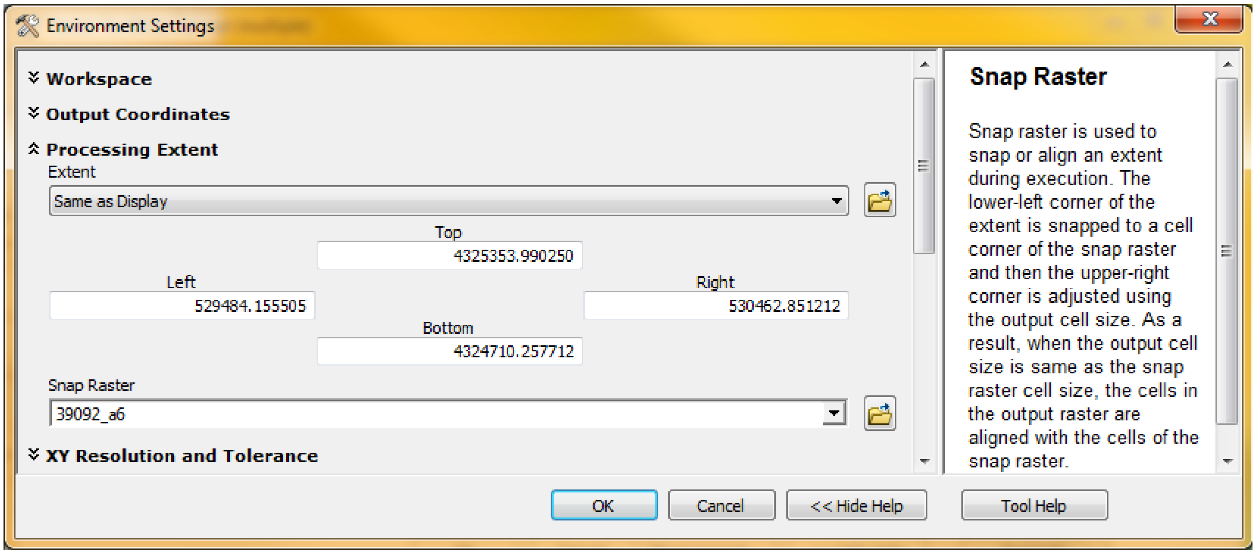
Set the field for **Input Raster** by navigating  to the the folder containing the ESRI Grid raster



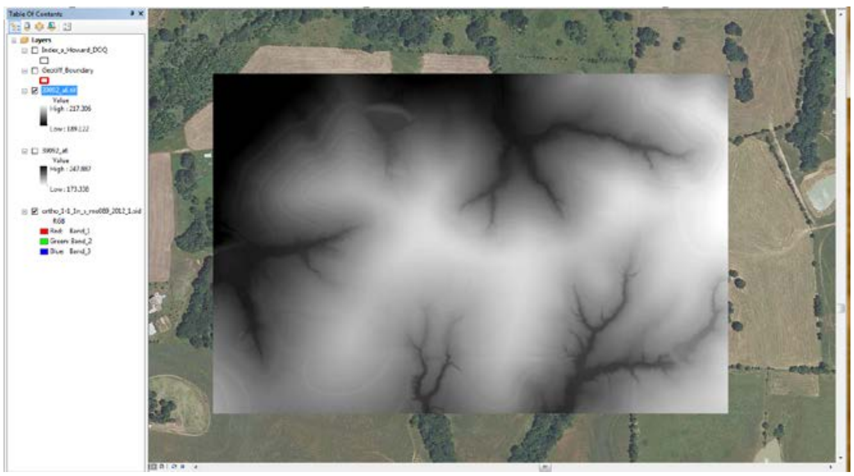
Also set the **Output Workspace** to a folder of your choosing and set the **Raster Format** to **TIFF:**

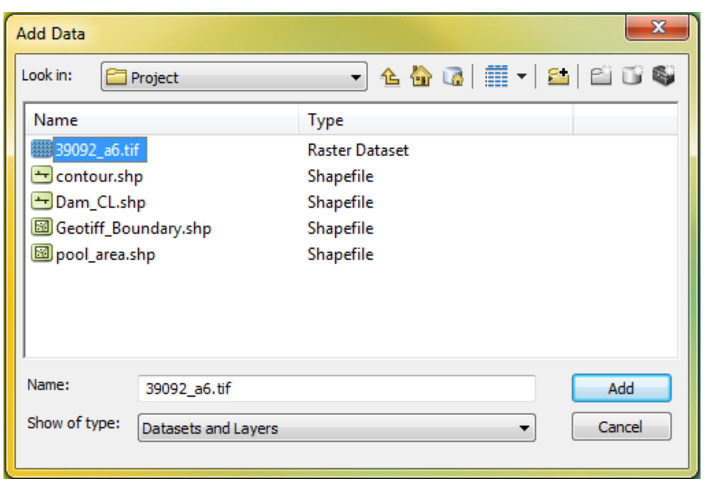


Last, set the **Environment Settings**, **Processing Extent** to limit the coverage area of the GeoTIFF., and set the **Snap Raster** field to the ESRI Grid raster.



The resulting GeoTIFF will have the same name as the orignating ESRI Grid raster with an extension of ".tif". The coordinate system of the GeoTIFF will also be the same as the ESRI Grid raster (usually meters **UTM NAD1983, Zone 15N or 16N**).





V. **Establishing Horizontal and Vertical Datums at a Project Site.**

Transferring points, lines and polygons from a digital model, like ArcMap, to the ground at a project site requires establishing benchmark references at the site. The benchmarks must be a reference for both horizontal (x,y) and vertical (z) datum.

The preferred method of establishing a benchmark reference at a project site is to use an existing control point that has accurate coordinates such as a National Geodetic Survey (NGS) station control point. This would be accomplished by using appropriate surveying methods to establish a new benchmark at the site using the NGS station as a reference. An alternate method is to establish the new benchmarks using survey grade GPS equipment and the NGS Online Positioning User Service (OPUS).

If establishing the benchmark using the above method is not an option, then an alternative is to use a mapping grade GPS receiver with a horizontal accuracy of 1 meter or less and a level. This method is less accurate and can easily introduce a couple of tenths of vertical error. It may not be suitable for all conservation practice needs. Use the following steps to complete this method:

1. Identify two or more areas in the project location that are relatively flat (+/- 0.2 feet) with a minimum area of 20 feet by 20 feet. The surfaces of these areas must not have been altered since the time of the LiDAR data accusation.

2. From the LiDAR data, determine the ground elevation of the areas and the horizontal coordinates of the center of each area.

3. Using a mapping grade GPS, navigate to the center of one of the areas.

4. Set up a level and record a back sight (BS) rod reading. Using the LiDAR elevation of the ground in the center of the area and the BS, compute a height of instrument (HI).

5. Navigate to the center of the second area. Using the established HI, record a fore sight (FS) and calculate the elevation of the ground at this location. Compare the calculated elevation to the LiDAR elevation. If the difference between the two elevations is acceptable, +/-0.2 feet for example, then proceed to the next step. If the difference is unacceptable, then survey additional areas for comparison.

6. Once you have determined confidence in the HI's relative accuracy as compared to the LiDAR elevation, use it to establish temporary benchmark(s) (TBM) at the site using appropriate surveying procedures.