

## Exercise 7 – Watershed Delineation Using ArcGIS Spatial Analyst – Last Updated 3/12/2014

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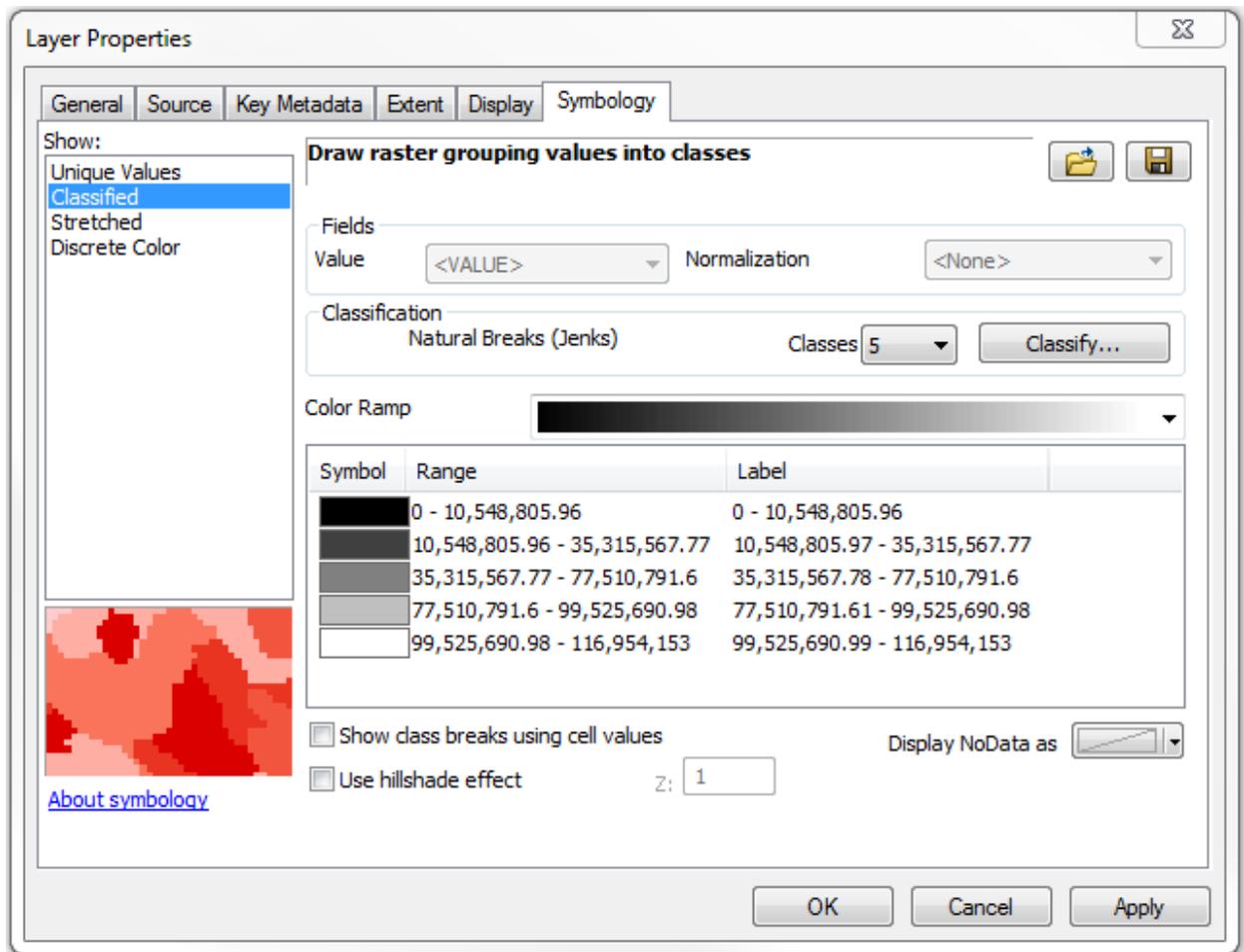
Within this document, the term NHDPlus is used when referring to NHDPlus Version 2.1 (unless otherwise noted).

There are several ways to use the NHDPlus data to do watershed delineation. See the Discussion section at the end of this exercise for more details. This exercise will take the most basic approach, using the Watershed tool available in ArcGIS Spatial Analyst. This exercise assumes that NHDPlus V2.1 Exercise 1: Setting Up the Data, has been completed.

The tools described in this exercise will work on any NHDPlus data you have downloaded and unzipped. The examples shown in this exercise, however, use data from VPU 06: specifically the NHDPlusBurnComponents, NHDSnapshot, and 06a\_FdrFac components. Because we wish to illustrate specific data issues in this exercise, you should make sure you have downloaded and installed the above data components for VPU 06 before beginning this exercise.

### Displaying the NHDPlus “Synthetic Streams” Using the *fac* Grid

1. Open ArcMap and create a fresh MXD. Name it something like ***Ex7work.MXD*** and save it wherever you'd like.
2. Use the **File, Add Data** menu. In the **Add Data** dialog, navigate to the ***NHDPlusMSWHDPlus06WHDPlusFdrFac06a*** folder, select the ***fdr*** and ***fac*** grids. Click **Add**.
3. Right-click on the ***fac*** grid, and choose **Properties**. Select the **Symbology** tab. Change the renderer from Stretched to Classified as shown below.



Click the **Classify** button next to the number of classes.

The Classification menu will appear. Change the number of classes to 2, then change the first Break Value to 100, as shown below. Click **OK**.

Classification

Classification Method: Manual

Classes: 2

Data Exclusion

Exclusion ... Sampling ...

Classification Statistics

Count:	117724274
Minimum:	0
Maximum:	116,954,153
Sum:	2,655,969,650,000
Mean:	22,560.93463
Standard Deviation:	1,285,501.963

Columns: 100  Show Std. Dev.  Show Mean

Break Values %

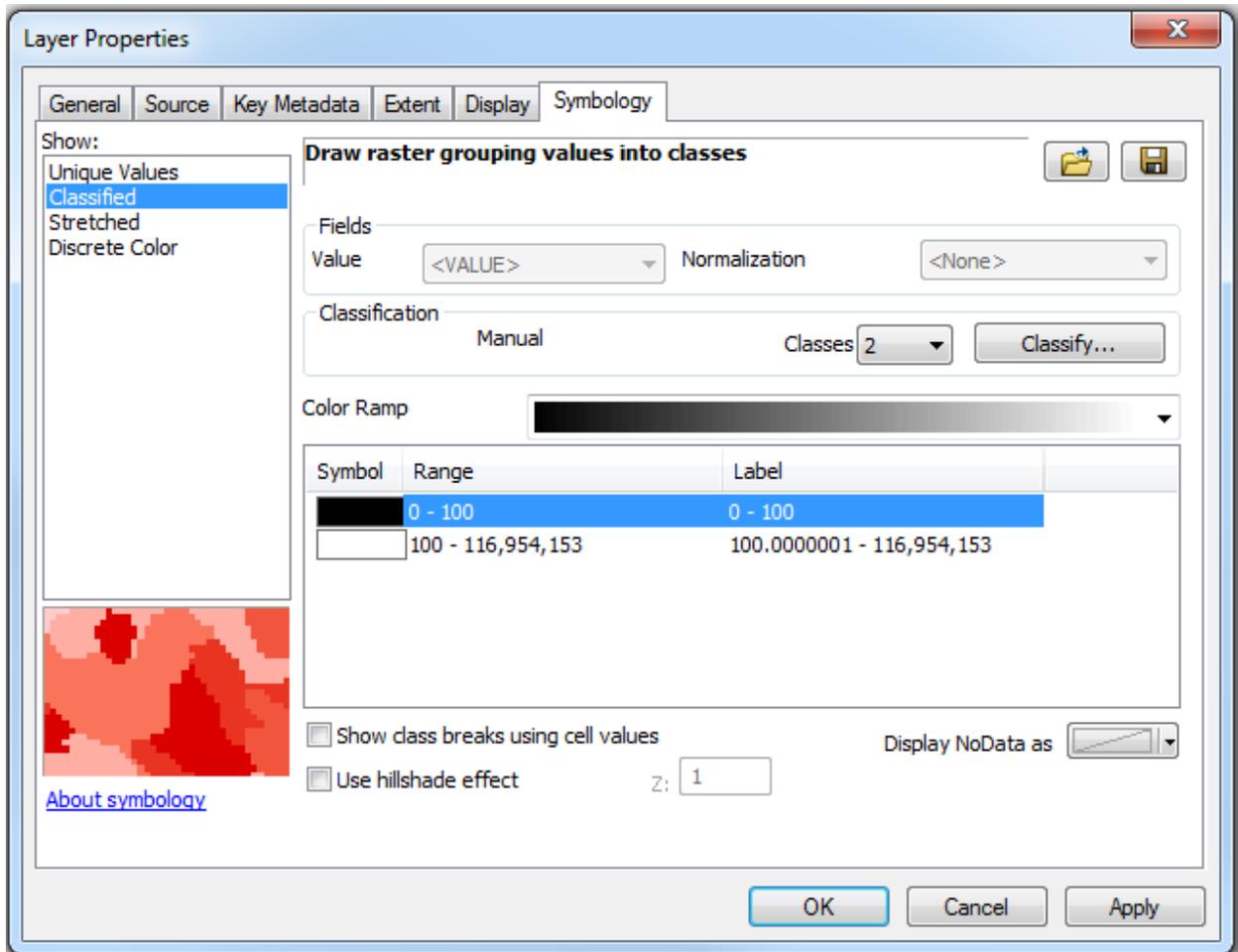
100
116,954,153

1 Elements in Class

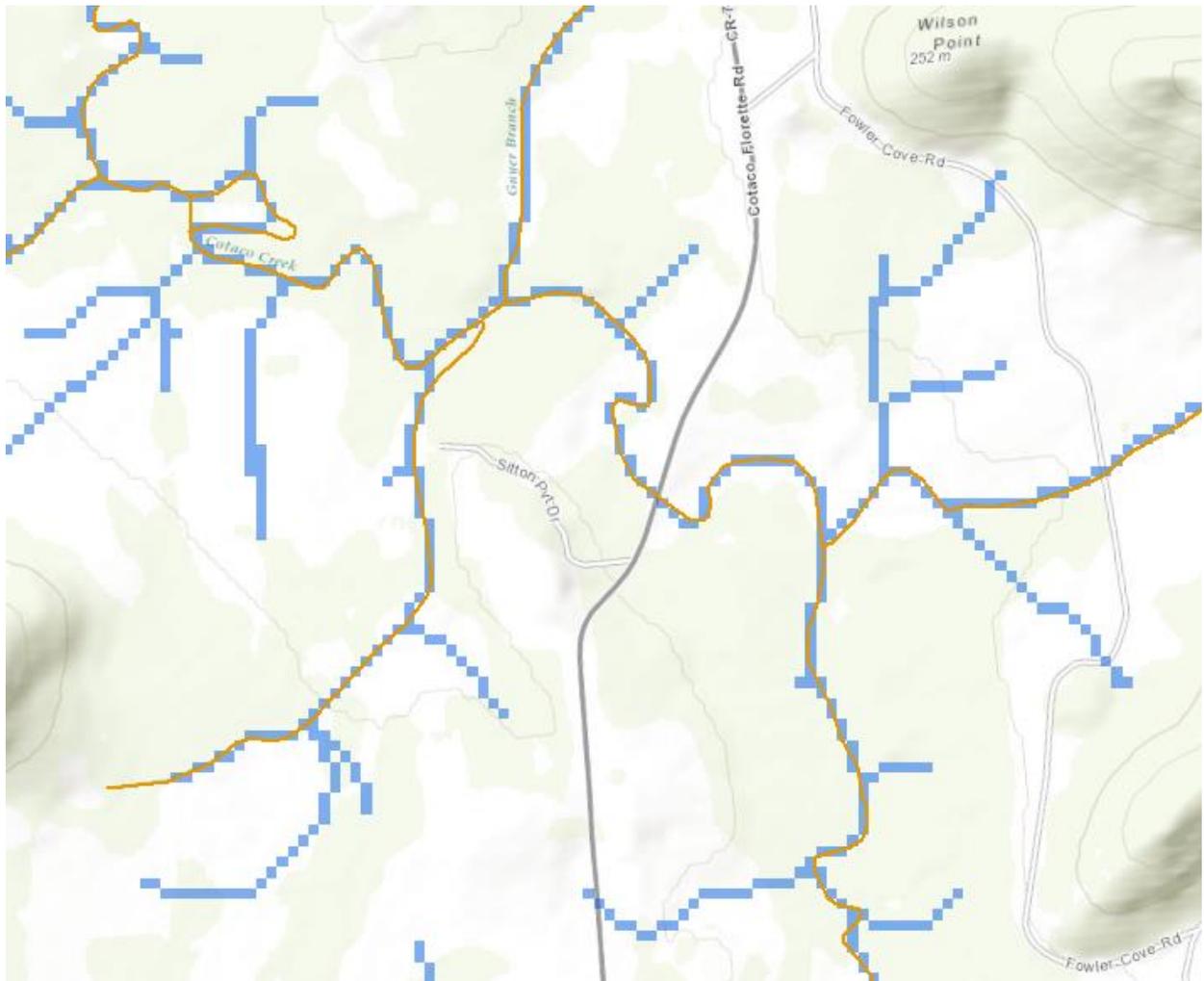
Snap breaks to data values

OK Cancel

Now back on the **Layer Properties Symbology** menu, double-click on the black box under Symbol next to the 0 - 100 Range, then choose No Color on the color menu that pops up.

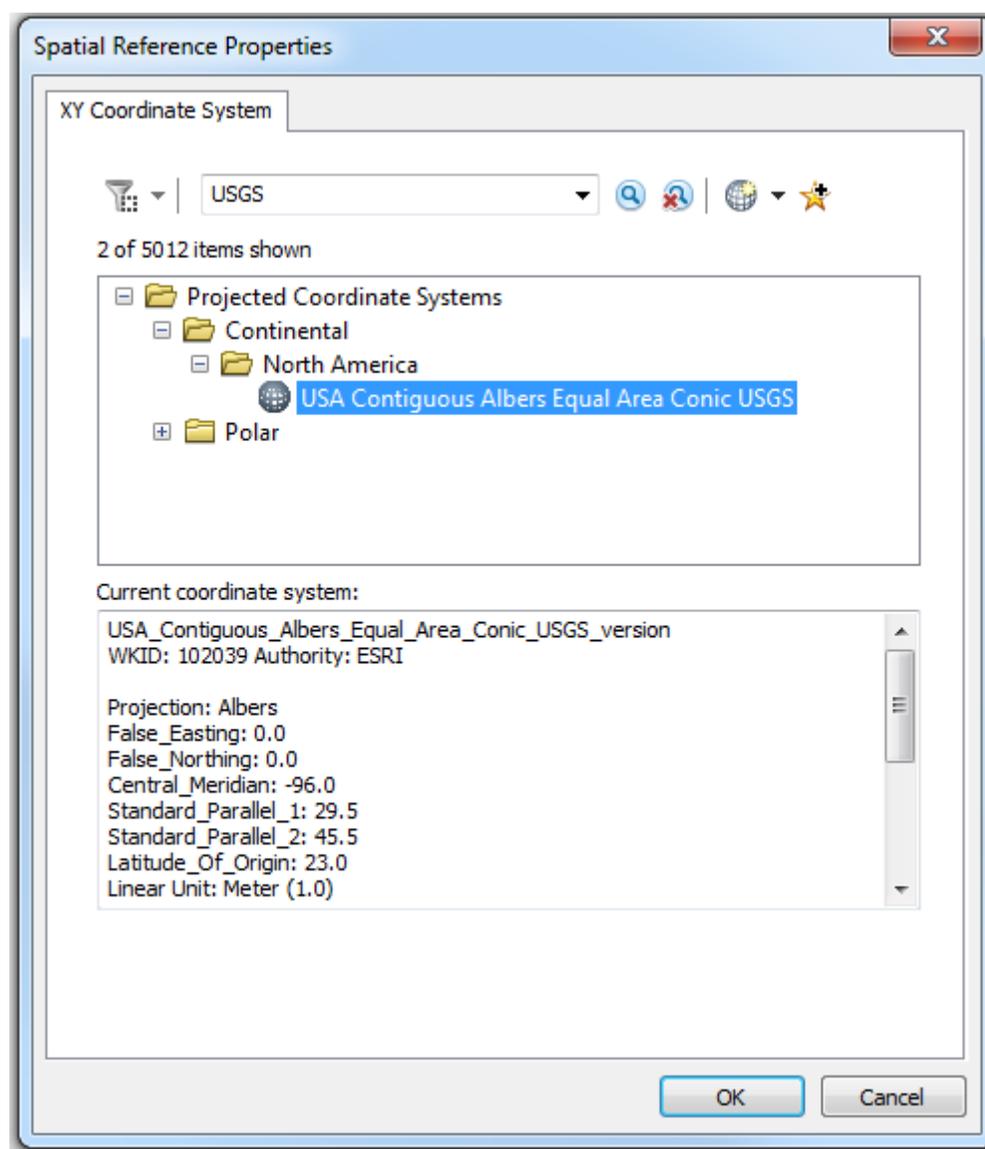


In a similar manner, change the other color to a dark blue. Optionally, on the Display tab of the Layer Properties menu, you can set the transparency to something like 50%, so the dark blue grid cells do not completely obscure map content in layers below the **fac** layer. Zoom in somewhere so you can see the dark blue **fac** grid cells. The **fac** cells that are dark blue are cells having 100 or more cells upstream, and indicate where drainage channels are on the HydroDEM. These cells are sometimes called “synthetic hydrography”, because they are derived entirely from the HydroDEM, and may or may not represent actual streams. In general these should follow the NHD Flowlines closely, since all networked NHD Flowlines were burned into the HydroDEM. The threshold of 100 is shown for illustrative purposes, but any threshold may be chosen. A threshold of around 3000 to 5000 has been found to result in a drainage density similar to the medium resolution NHD Flowlines, although this varies considerably throughout the NHD. Below is an example showing the 100-cell threshold **fac** grid in dark blue, with NHDFlowline in orange, overlaid on the World Topographic Map web service (a basemap service from ESRI.)



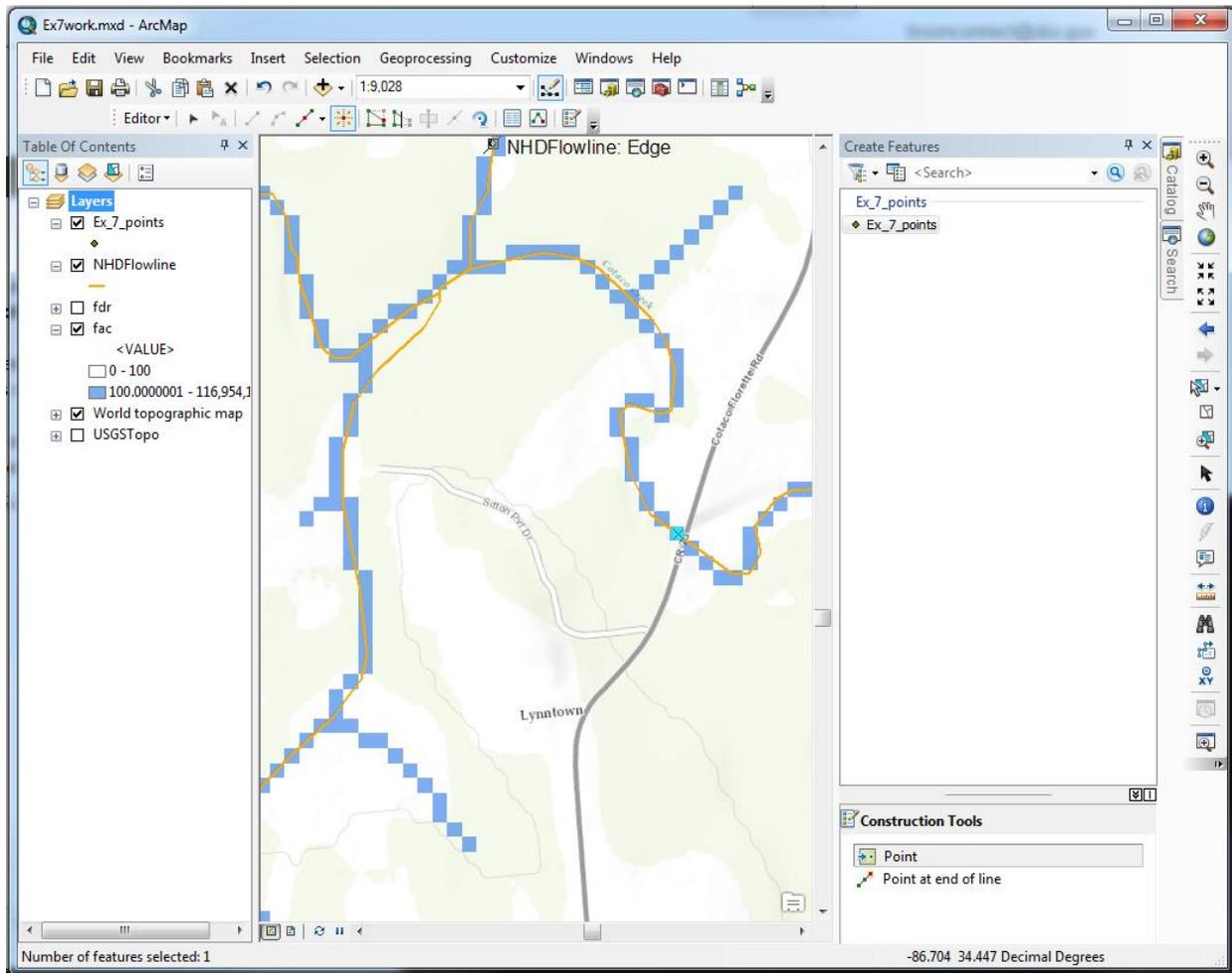
## Using the NHDPlus Data for Watershed Delineation

4. We need a point feature class (shapefile) from which to delineate our watersheds. From the ArcCatalog tab, navigate to the folder in which you wish to create the shapefile, right-click, and choose **New->Shapefile**. Type in a name for the shapefile, such as **Ex\_7\_points**, then click on the **Edit** button below the Description box under Spatial Reference. In the Spatial Reference Properties menu that pops up, type USGS in the search box, and choose “**USA Contiguous Albers Equal Area Conic USGS**” under **Projected Coordinate Systems/Continental/North America**, as shown below:

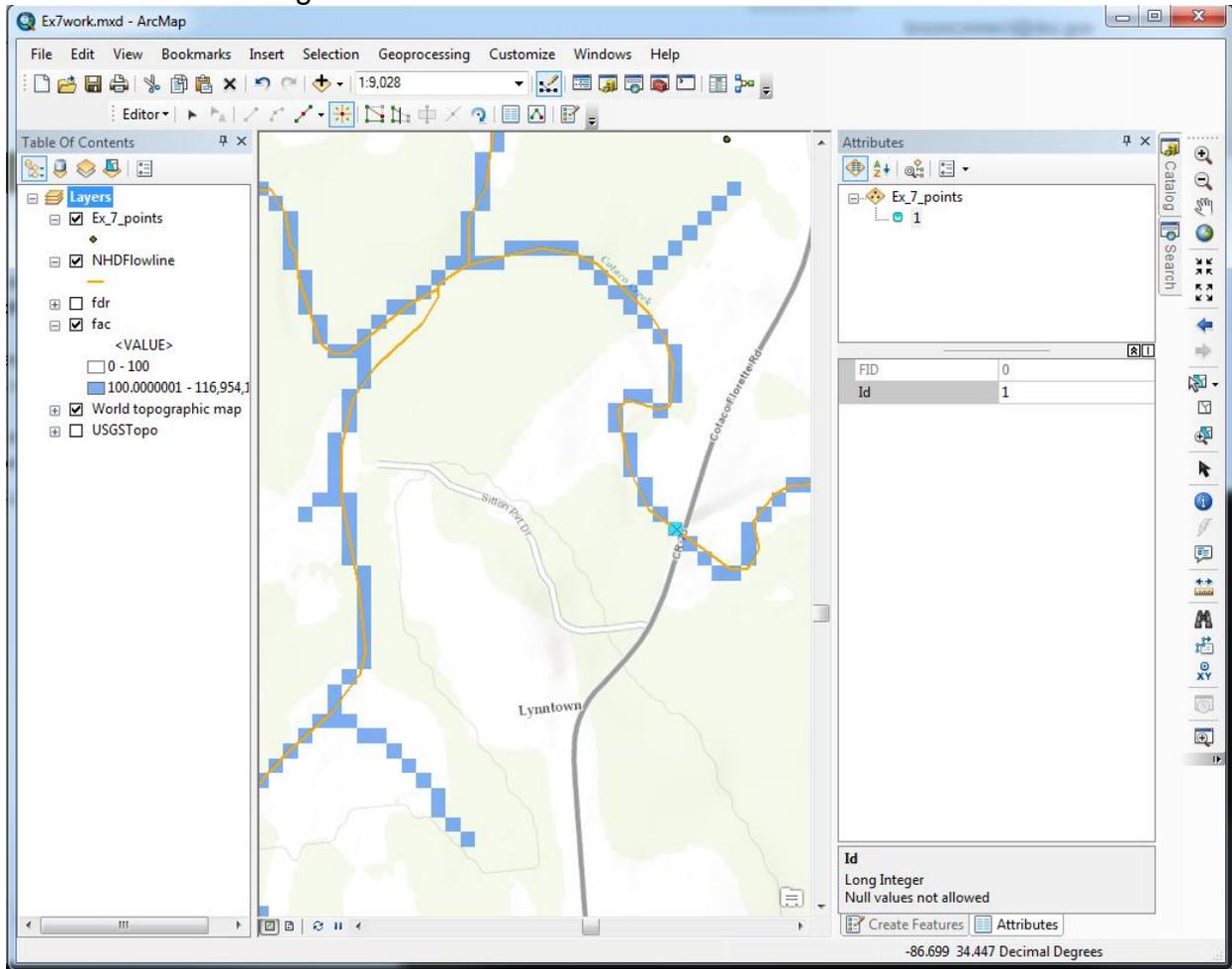


Click **OK** to create the new empty shapefile. Add the newly created shapefile to the ArcMap project.

5. There are some issues we wish to highlight in this exercise, so we will delineate specific watersheds in order to show these issues. On the ArcMap Tools click on the Go To XY tool (  ), set the units to Decimal Degrees in the pulldown menu, type in -86.7009 and 34.4396 into the Long and Lat boxes, then hit Return. Zoom in so you can clearly see the fac grid cells and can place a point inside one of the grid cells.
- Turn on the Editor Toolbar, and choose Start Editing from the Editor pulldown menu. Choose the empty point shapefile we just created (**Ex\_7\_points**) for editing. If you receive warning messages, you may dismiss them without taking any action. Click the Create Features button (  ) on the right end of the Editor Toolbar to open the Create Features Menu. Under the Construction Tools in the lower box of the Create Features menu, click on the Point tool, then click on the center of a blue fac grid cell where the road in the center of the map crosses the stream. A point will be added and will be highlighted in light blue. Your ArcMap screen will look something like this:

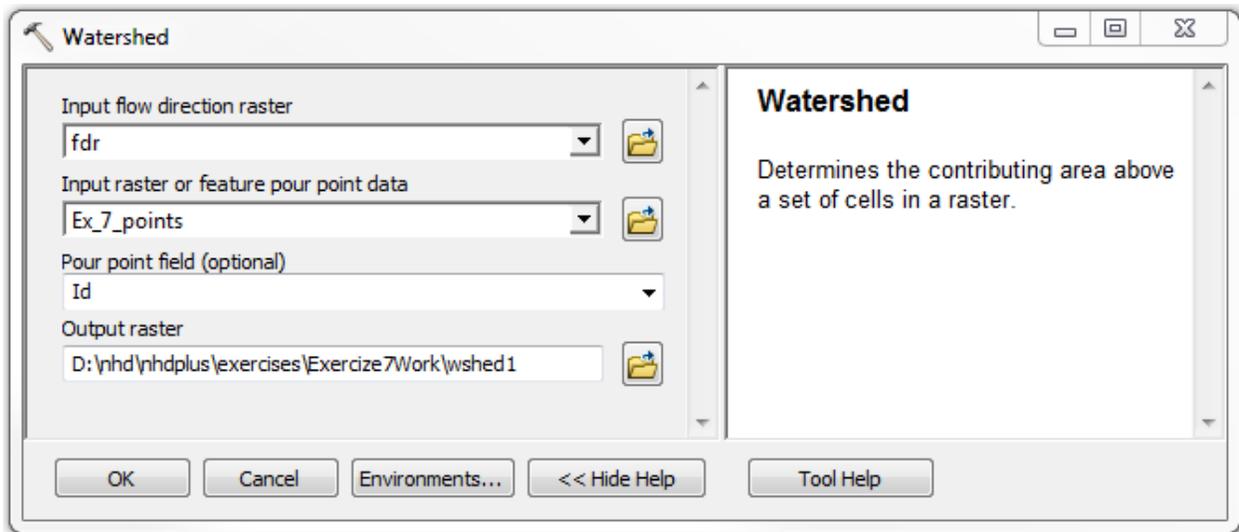


- Click the Attributes button (  ), third from the right on the Editor Toolbar. The Attributes menu will appear on top of where the Create Features menu was. Click to the right of the Id field name and type in the value "1". Your ArcMap screen will look something like this:

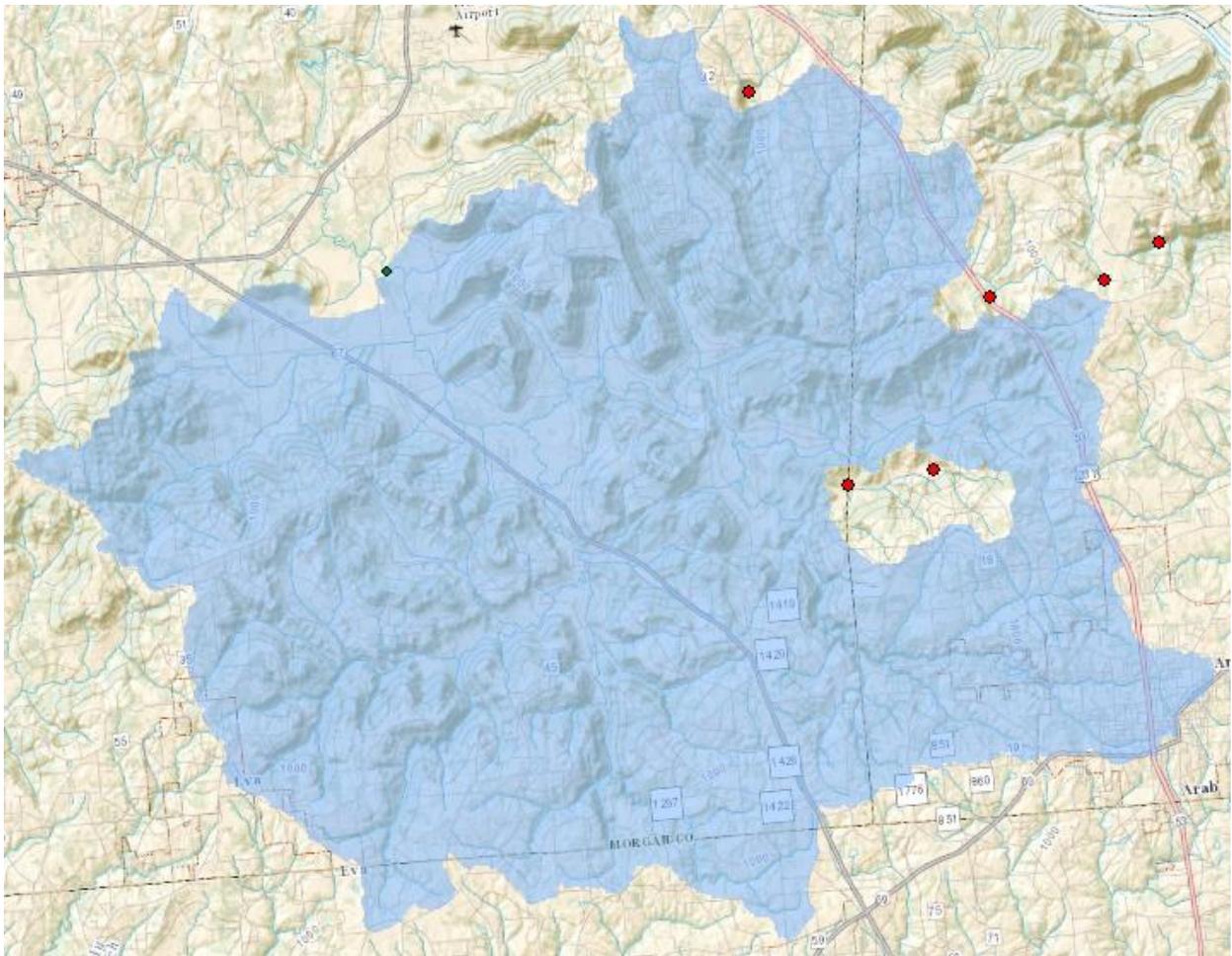


Now you can close the Attributes and Create Features menus by clicking the X in the upper right, so we can see the whole map. From the Editor Toolbar Editor pulldown, choose Stop Editing, and save your edits.

- In the ArcToolbox, under Spatial Analyst Tools/Hydrology, find and double-click the Watershed tool. Fill in the menu as below, placing the Output raster wherever you like.

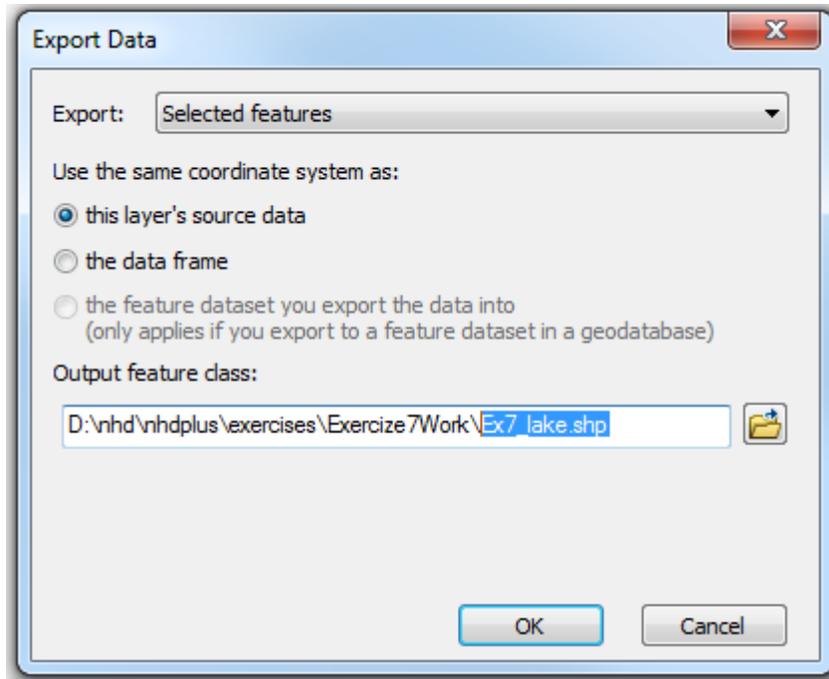


8. The watershed grid we have created has been added to the map. You may wish to set the transparency of the watershed grid so you can see the base map through it. If you zoom out so you can see the whole watershed, you will notice a “hole” in the watershed:



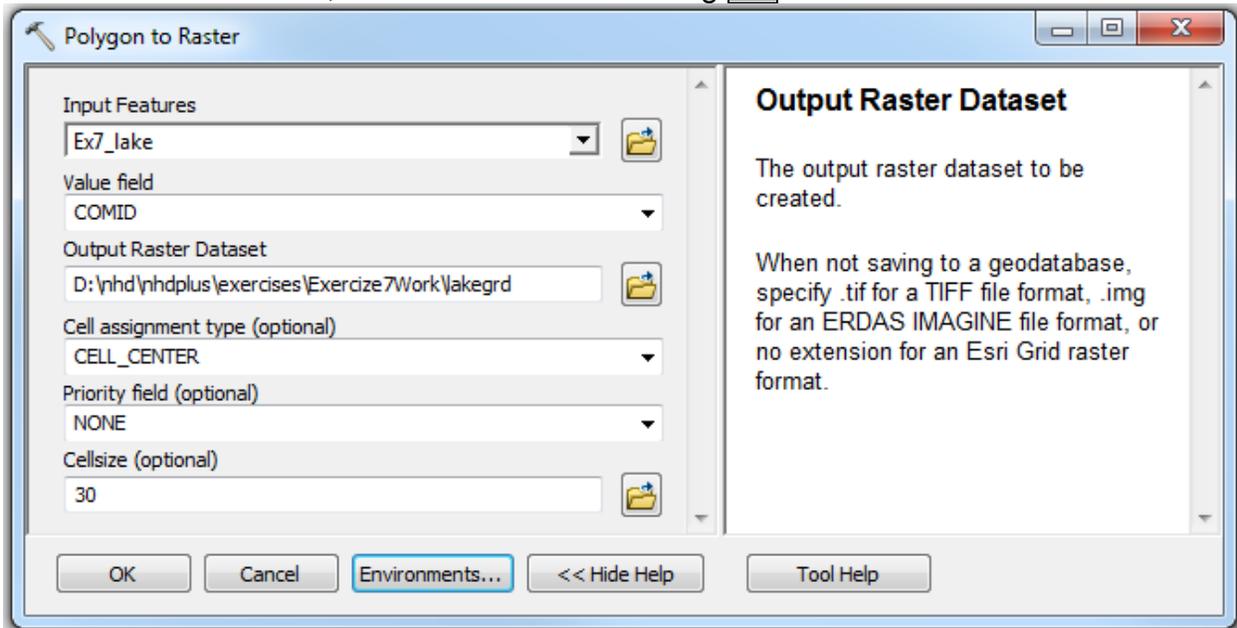
Why is this? If you add the sink feature class from **NHDPlusMSWHDPlus06WHDPlusBurnComponents** (red dots above) you will see there are a couple sinks at the ends of isolated stream networks that cause the hole. Zoom in to those sinks and look at the topographic base maps, and decide if you think the sinks are real, or if the “hole” area would actually drain via surface water to the point from which you delineated the watershed. Note a good source of topographic base maps is the USGSTopo layer, which can be added as an ArcGIS Service from <http://basemap.nationalmap.gov/ArcGIS/rest/services>. The NHDPlus V2.1 was designed to treat areas that drain to isolated stream networks such as these as non-contributing drainage areas. Note also there are similar non-contributing areas draining to sinks on the northern and northeastern edges of the delineated watershed. From the topographic maps it is apparent that these areas do not drain anywhere via surface flow. The water that drains into those sinks may ultimately flow into a stream via an underground pathway. To determine exactly where the water goes would require field dye studies, but the NHDPlus does not have information regarding such pathways. Whether to include such areas in the watershed is dependent on the user’s application, and is left to the user to interpret.

9. At times it may be desirable to delineate the watershed for a feature other than those represented by the **NHDFlowline** features, such as a smaller stream from more detailed maps, or a lake/pond that is isolated from the **NHDFlowline** network. Recall that in Step 3 we chose 100 cells as the threshold to display **fac** grid cells to represent “synthetic streams”. One could choose a smaller threshold and delineate as before for a smaller stream. What about a lake, though? Let’s delineate the watershed for a small isolated pond. Add the **NHDWaterbody** feature class from the **NHDPlusMSWHDPlus06WHDSnapshotHydrography** folder, then zoom to -86.918, 35.749 decimal degrees, as we did above in Step 5. Select the **NHDWaterbody** feature at that location using the Select Features () tool from the ArcMap Tools toolbar. Right-click on the **NHDWaterbody** layer in the ArcMap Table of Contents, and choose Data/Export Data. Fill in the Export Data form as shown below:



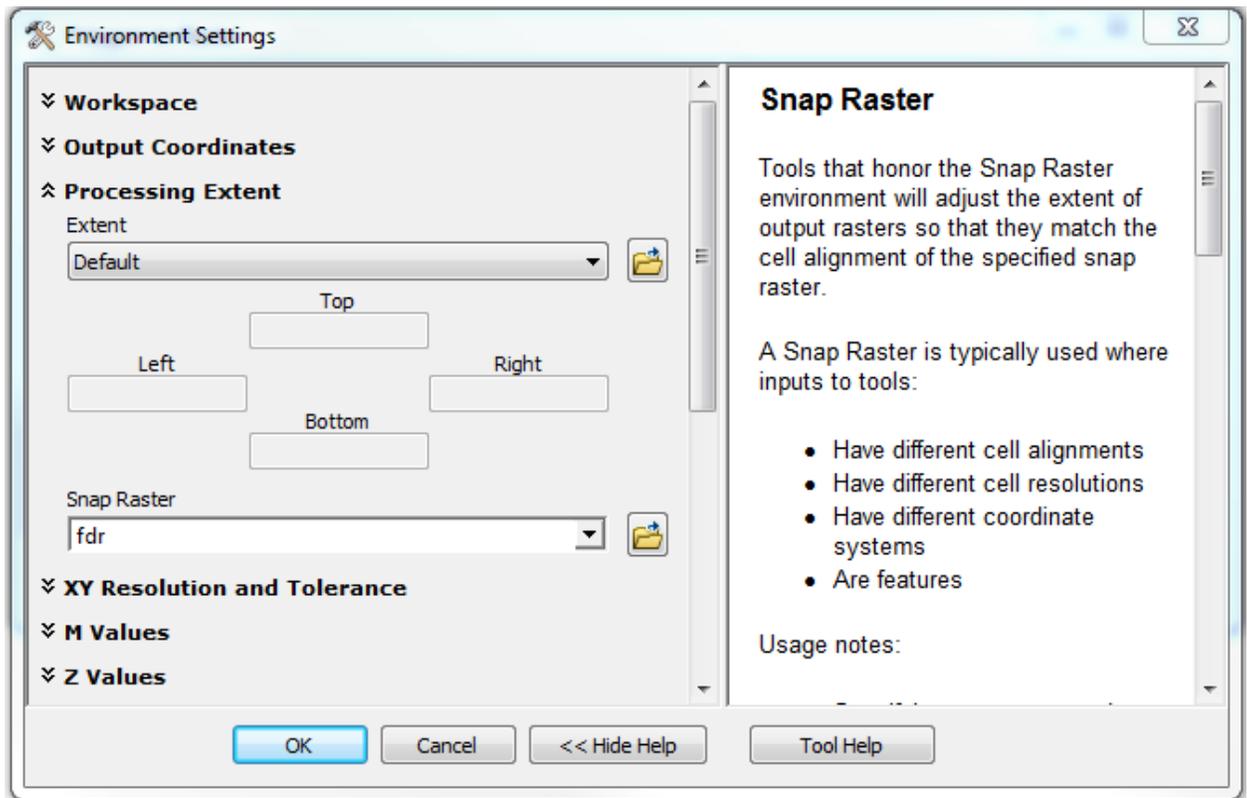
This will create a new polygon shapefile named Ex7\_lake.shp. Add this file to the map.

- The **Watershed** tool we used above in Step 7 works on either a point feature class or a raster, so we will convert this polygon to a raster. From the ArcToolbox **Conversion Tools/To Raster** toolset, double-click **Polygon to Raster**. Fill in the menu as follows, but read on before clicking **OK**:



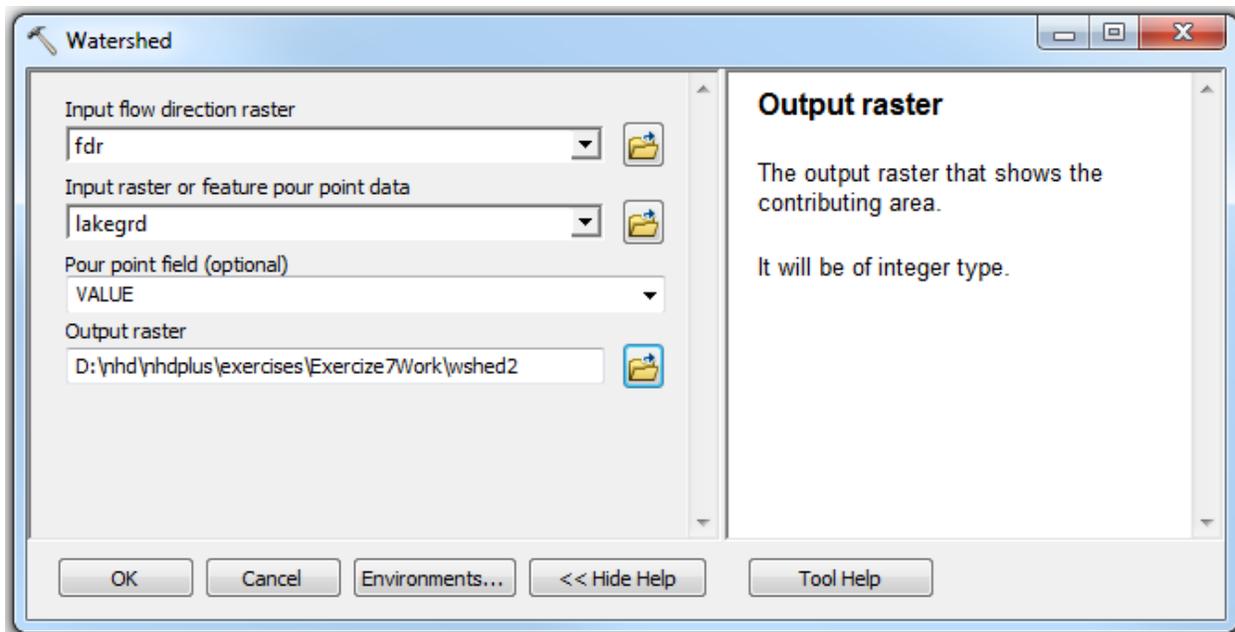
Before clicking **OK**, we need to set some things in the processing environment. Click the **Environments...** button. Expand the Processing Extent section of the

Environment Settings menu, and choose fdr from the Snap Raster pulldown list, like this:

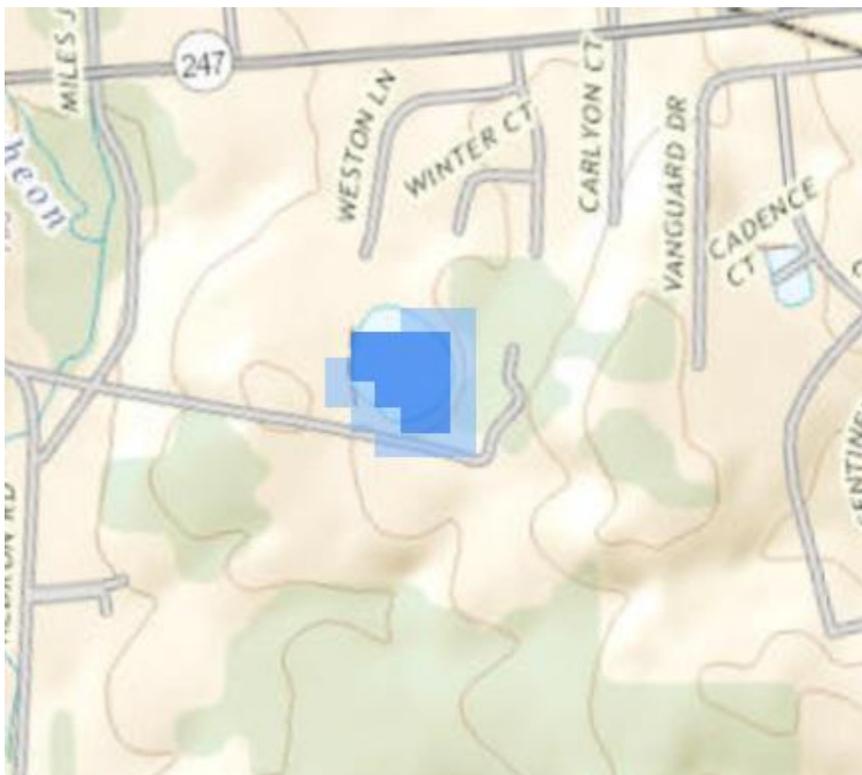


It is important to set the snap raster so that the output raster cells align with the flow direction and other NHDPlus grids. If the snap raster environment is not set, the raster cell representation of a vector object could shift around by up to half a grid cell. Such seemingly minor differences can sometimes cause large differences in delineated watersheds, however. When ready, click **OK** to close the Environment Settings menu, then **OK** on the Polygon to Raster tool menu to execute it.

11. Now we can use the raster version of the lake we created above as input to the Watershed tool. Open the Watershed tool menu as you did in Step 7 above. Fill in the menu as below:



Click **OK** to generate the watershed grid. The lake grid (dark blue) and its watershed (lighter blue) is shown below. Notice the watershed is only slightly larger than the lake itself.



## Discussion

The Watershed tool used in this exercise is the most basic of many available tools that may be used for watershed delineation. Its advantage is it is simple, and does not require any preprocessing of the data. It also is flexible, and can be used on polygons as well as single points, as we have seen. It can, however, be rather slow when processing large watersheds.

Another shortcoming of the Watershed tool as it relates to NHDPlus V2.1 data sets is it is limited to the extent of the **fdr** grid of a single NHDPlus RPU. If, for example, we were to delineate the watershed for the Ohio River at Louisville, KY, we would get a watershed that extended upstream on the Ohio River only as far as RPU 05a extends. To represent the entire watershed above that point, it is necessary to add in the areas covered by RPU's 05c and 05d.

Another option a user may want to consider is the ArcHydro Tools. The ArcHydro Tools are a free download from ESRI. See the ArcHydro Forum (<http://forums.arcgis.com/forums/88-Arc-Hydro>) for details and documentation. Among the advantages the ArcHydro Tools provide are an extensive suite of methods to compute watershed characteristics. The StreamStats (<http://streamstats.usgs.gov>) web application, for example, uses the ArcHydro Tools to quickly delineate watersheds and compute characteristics from any user-supplied point. These characteristics are used with regression equations and other techniques to provide estimates of streamflow statistics. The main disadvantages of using the ArcHydro Tools with NHDPlus V2.1 data are that they require a separate installation, and that they require extensive preprocessing of the data.

A Basin Delineator tool for NHDPlus V2.1 is available on the NHDPlus website <https://www.epa.gov/waterdata/nhdplus-national-hydrography-dataset-plus>. It provides a fast and simple way to delineate complete watersheds for multiple points in a simple batch process.