

Delineating the Subwatersheds of the Tributaries to Bull Creek for Individual Analysis

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CE394K

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Introduction

The health of Bull Creek is of great importance to the City of Austin because it empties into Lake Austin, the lake from which municipal water is taken. One of the primary threats to this health is urbanization within the watershed, which has the potential to degrade water quality among local surface streams. The Bull Creek Watershed itself provides a uniquely well-constrained area in which to study the effects of urbanization because roughly half of the watershed has been urbanized while the other half remains in its natural state as it has been set aside as a wildlife preserve (*Figure 1*). There are various tributaries flowing over each portion. The fundamental aim of this project is to 1.) gather and prepare GIS data related to hydrologic, geologic, and urbanization conditions in the Bull Creek watershed and 2.) demonstrate how to delineate the subwatersheds for the numerous tributaries to Bull Creek so that they can be analyzed with regard to various measures of urbanization as well as a number of natural categories. The portion of this characterization to be handled for CE394K is part of a larger project, in which tributaries in the Bull Creek watershed are being sampled and cross-examined against their contributing subwatersheds. Elevated levels of sodium, potassium, boron, fluoride, chloride, and sulfate have already been measured in urban tributaries when compared to their non-urbanized counterparts.



Figure 1. Urbanization Trends in the Bull Creek Watershed. This figure was prepared by copying satellite imagery from Google Maps and snipping it to a delineated watershed polygon in ArcGIS.

Gathering GIS Files

In order to complete this project, a number of GIS files must be obtained for the Austin Area. Many of the files used have been shared by the City of Austin Department of Watershed Protection as they are interested in the outcome of this project.

- Austin watershed boundaries – This file can be downloaded from the City of Austin GIS Data Sets website (ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html). The file is called “watersheds”

- 1 m DEM of Austin – This file was shared by the city. Alternatively, a DEM can be prepared by downloading contour lines from the City of Austin GIS Data Sets website and then using the *contour to raster* function in ArcGIS.
- Austin soil map – A soil map for the region can be downloaded from the Capital Area Council of Governments (CAPCOG) GIS clearinghouse website (<http://www.capcog.org/data-maps-and-reports/geospatial-data/#water-administrative-boundaries>). The soil map used for this project was shared by the city of Austin.
- Austin geology map – The detailed map used in this exercise was shared by the city of Austin.
- Street centerlines – Street centerlines can be downloaded from the City of Austin GIS Data Sets website.
- Creek lines – Creek lines can be downloaded from the City of Austin GIS Data Sets website.
- Austin Area Land Use - Austin Area Land Use can be downloaded from the City of Austin GIS Data Sets website.

Preparing GIS data

The best way to manage the data involved in this study is to isolate the Bull Creek watershed and clip all of the other layers to this polygon in a geodatabase. This will enable the files to be as small as possible and for them to be organized in a functional location.

Using the Arc Catalog menu through Arc Map, the desired destination for the new geodatabase can be selected and a new geodatabase can be created by right-clicking destination folder, and then selecting *New* and *File Geodatabase*. I have named mine *Bull Creek GDB*.

Next we must load the watershed boundaries file downloaded from the City of Austin GIS data sets into ArcGIS. By selecting and identifying the Bull Creek watershed, we learn that the FID unique to the polygon is 67. Using the *Select* tool in ArcGIS, we can create a new feature class in our geodatabase that has removed the polygons for all other watersheds leaving behind Bull Creek alone (*Figure 2*).

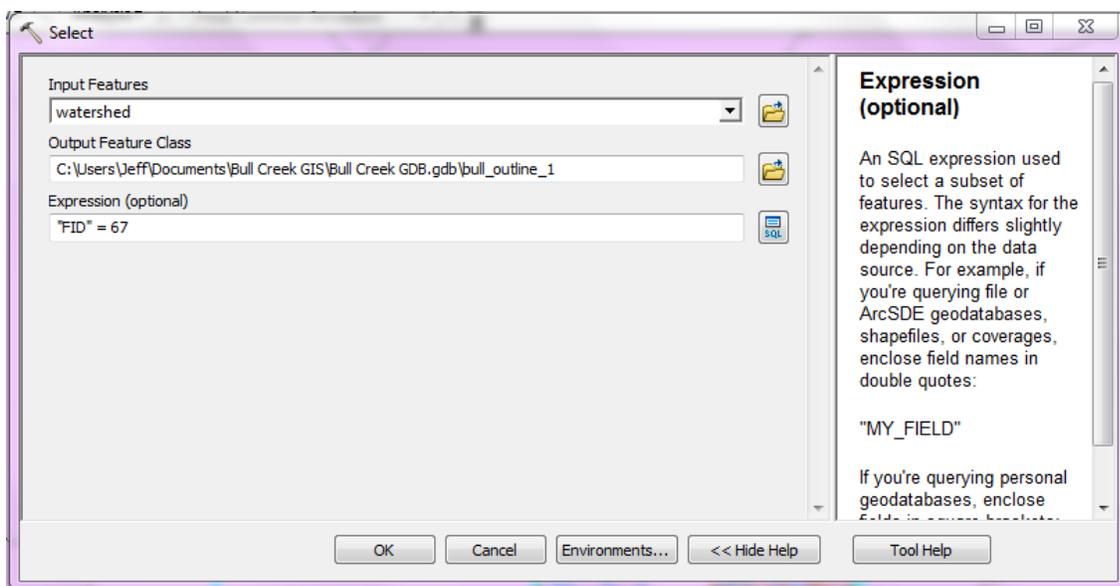


Figure 2. The input parameters for the *Select* tool that creates a feature class containing only the Bull Creek watershed outline polygon.

Now all other files can be clipped to the Bull Creek polygon. In this way, we will create a geodatabase of layers that only span the extent of the Bull Creek Watershed. Using the *Clip* tool, the layer coverages that exist outside of the Bull Creek polygon can be removed. The input for clipping the streets is included as an example (*Figure 3*).

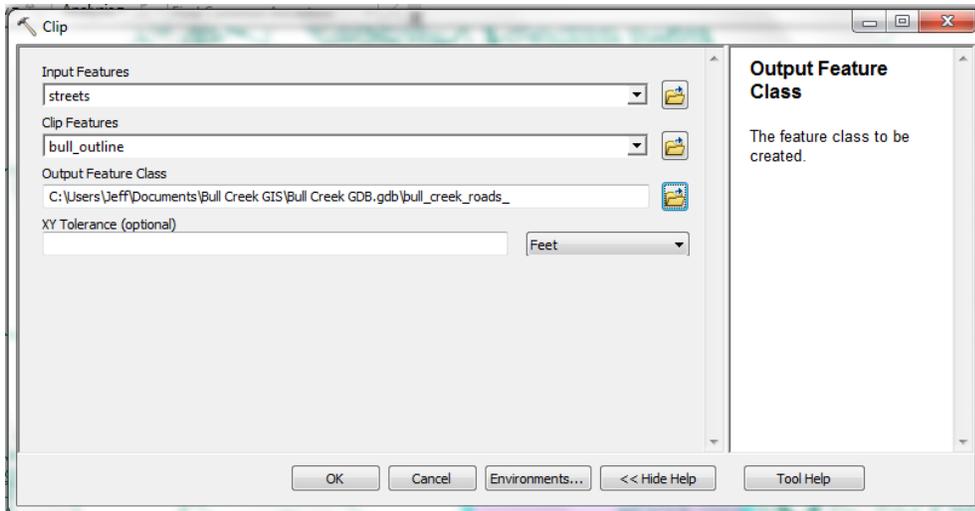


Figure 3. Using the *Clip* tool to generate a roads shapefile that spans the Bull Creek polygon.

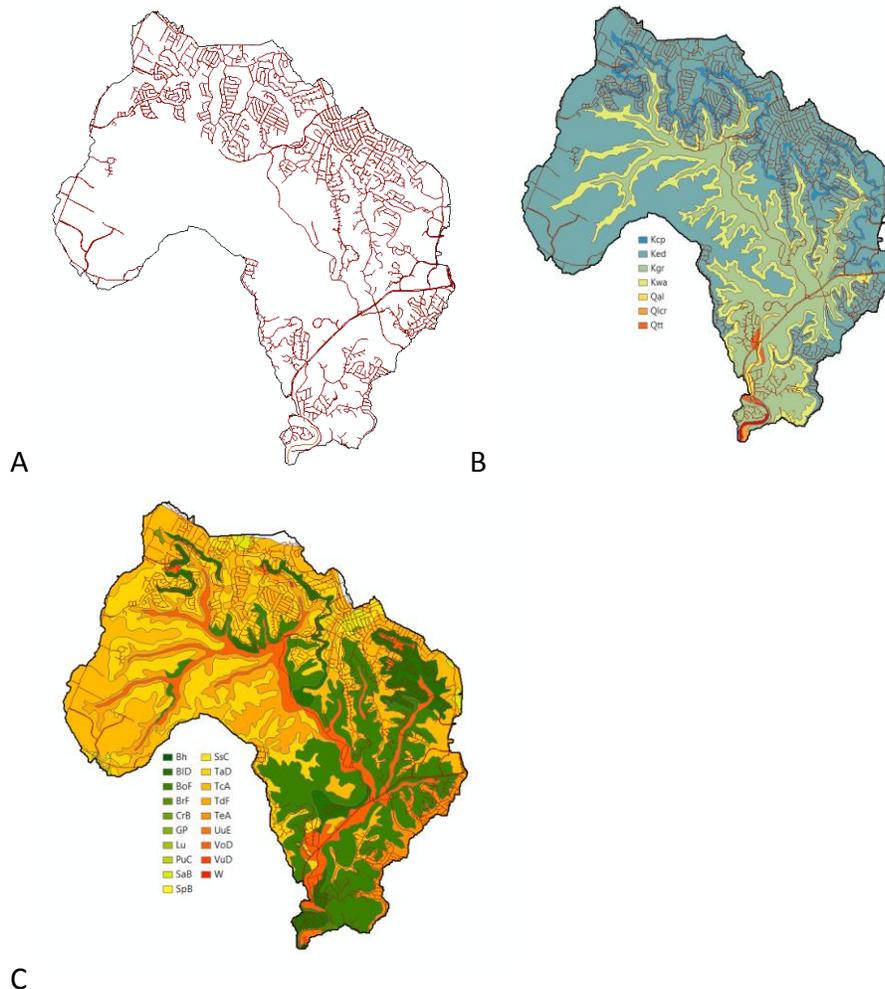


Figure 4. The result of the roads (A), geology (B), and soil (C) clipped to the Bull Creek Watershed.

After the roads, creek lines, geology, soil, land use map, and DEM have been clipped to new feature classes in our created geodatabase, we can begin to prepare the watershed for the delineation of the subwatersheds to the individual tributaries.

Subwatershed Delineation

The first step in the delineation of the subwatersheds is to fill pits in the DEM that will act as sinks for flow during flow direction analysis. Using the *Fill* tool in ArcGIS, input the DEM for bull creek (*Figure 5*).

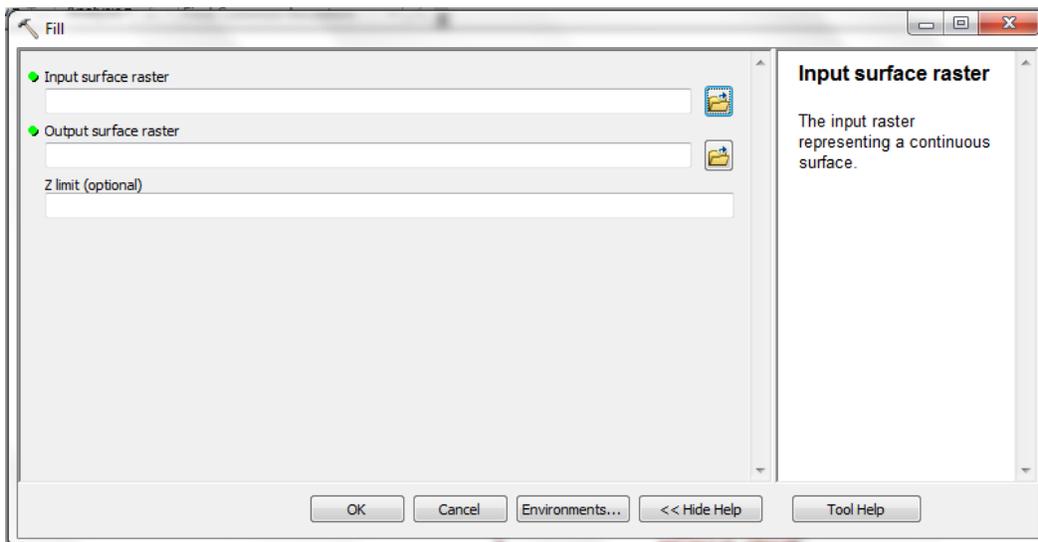


Figure 5. The *Fill* tool in ArcGIS. The Bull Creek DEM will be the input raster and the output raster will cover the same extent, but will have pits removed.

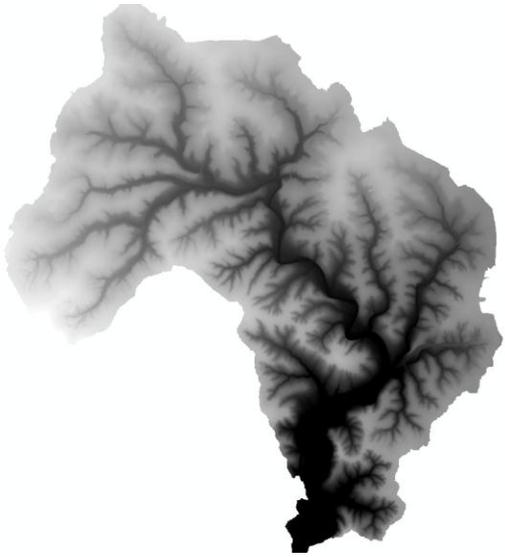


Figure 6. The resulting DEM after the pits have been filled.

After the pits have been filled from the DEM, a flow direction raster can be created. The flow direction raster is essential for watershed delineation. This will be accomplished using the *Flow Direction* tool in the Spatial Analyst Toolbox (Figure 7).

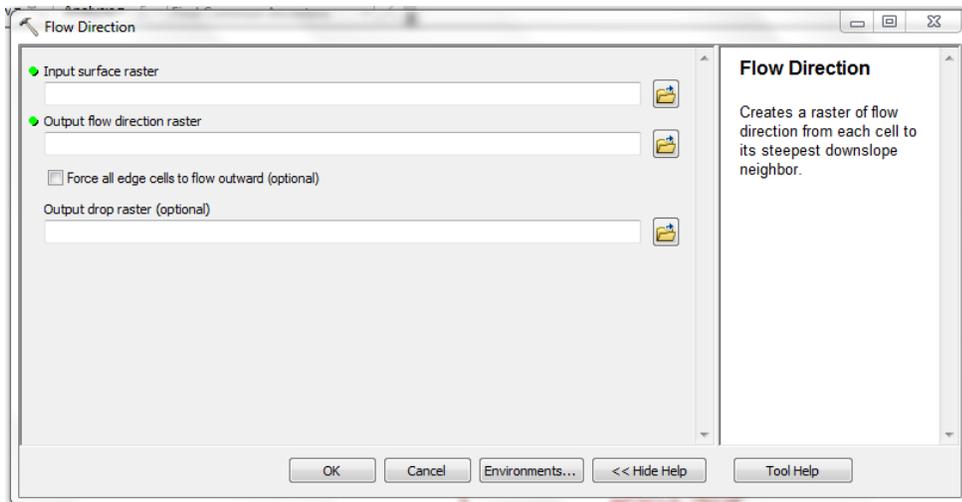


Figure 7. The *Flow Direction* menu. The input surface raster will be the DEM with filled pits.

After the flow direction raster is made, a flow accumulation raster can then be created. The flow accumulation raster will be very useful in finding output points for

each of the individual tributaries. This will be accomplished using the *Flow Accumulation* tool in Spatial Analyst (*Figure 8*).

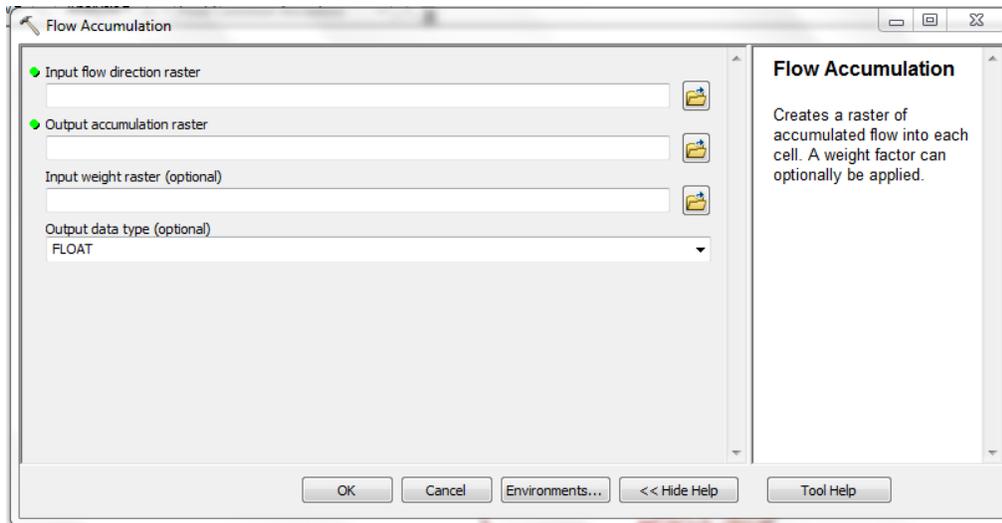


Figure 8. The *Flow Accumulation* menu. The input raster will be the flow direction raster created in *Figure 7*.

The product of this tool will be a raster that symbolizes flow accumulation. This raster will be used when selecting the locations of output points for the subwatershed of any individual tributary.

The inputs necessary to delineate a watershed in ArcGIS are a flow direction raster and an output point. The cells above the output point whose flow will run through that output point (according to the flow direction raster) will make up the watershed upstream of that point. The steps involved in creating the output point are:

- 1) Create new point feature class using the *Create Feature Class* tool.
- 2) Turn on *Editor* in the Editing Toolbar and make sure the new point feature class is selected in the *Create Features* window.

- 3) Place an output point on a flow accumulation raster cell of highest accumulation within a tributary subwatershed upstream of the confluence with the main Bull Creek Body (*Figure 9*). Save edits and turn off *Editor*.

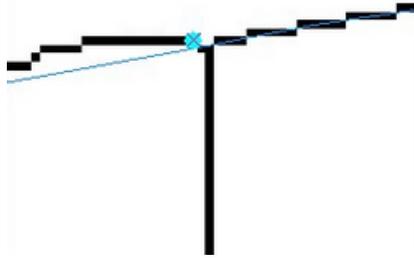


Figure 9. An output point placed along the flow accumulation raster. Figure prepared from an online lecture from Washington University.

Once an output point has been placed for any tributary, the subwatershed for that tributary can be delineated using the *Watershed* tool in the Spatial Analyst Toolbox (*Figure 10*).

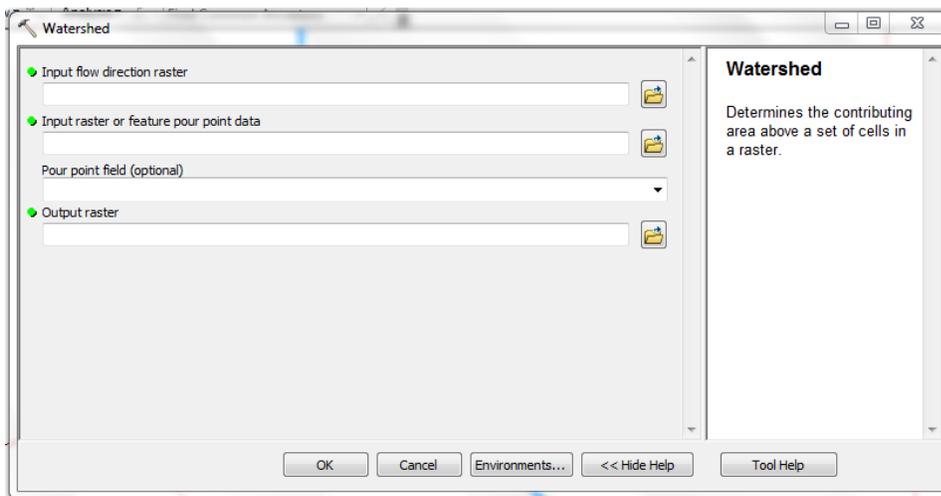


Figure 10. The *Watershed* menu. Inputting the flow direction raster created in figure 7 and the output point as the pour point data will allow this tool to delineate the subwatershed for draining at that specific output point.

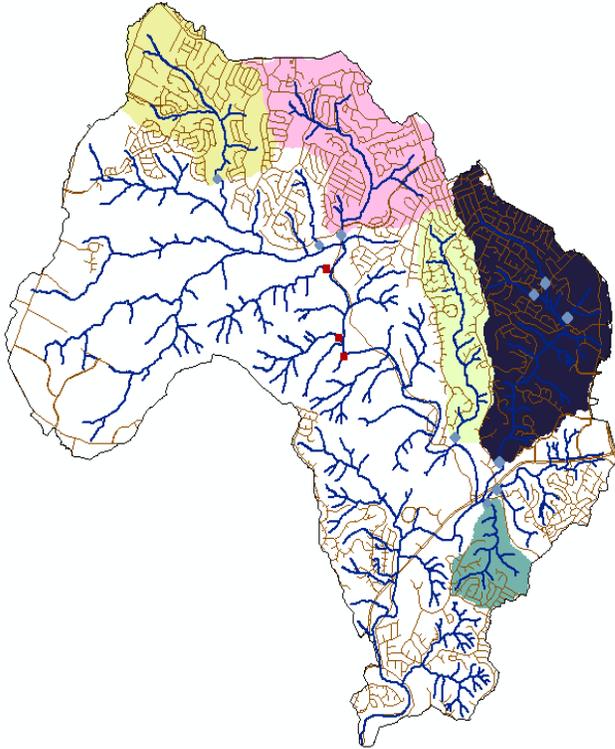


Figure 11. Five subwatersheds delineated using the techniques outlined in this project appear in color. Also included in this map are street centerlines, creek lines, and sample sites (urbanized sites represented by light blue diamonds, rural sites represented by red squares).

Future Analysis

The methods described by this project are successful at isolating subwatersheds for the individual tributaries to Bull Creek. In order to be useful for my study linking Urbanization to water quality, each tributary will be classified based upon natural and anthropogenic categories included in the data we have accumulated. Much like all of the layers were clipped to the Bull Creek Watershed, each layer will be clipped to the subwatersheds for the individual tributaries to provide for this future analysis.

The included layers representing natural categories are soil and bedrock exposures. These will be useful in comparing the chemistries of each individual tributary based on the ions we expect to be present naturally in the streamwater from water/rock

interaction. Clipping the stream lines to each subwatershed will also allow us to calculate stream length. Slope calculations for each tributary can also be included in the natural category.

The included layers representing anthropogenic categories are roads and land use. These will be clipped to each watershed to provide a road density index and an impervious cover estimate, respectively. Municipal pipe maps and census data are being collected as well; they represent relevant anthropogenic data that can be used to provide additional categorization of the individual tributaries.

Ultimately, the goal of the Bull Creek research is to generate a large database of streamwater chemistry so that correlations between chemistry and land use/natural geology across all sampled tributaries can be explored. The delineation of the watersheds in Bull Creek represents a big step in this process as I continue to gather GIS data from various sources and collect samples from the Bull Creek Tributaries.