# Hydrology: Working with LiDAR Digital Elevation Models

**Introduction:**

In this experiment we will be analyzing the flow direction, flow accumulation, and watershed boundaries of the respected study area. To do this, high-resolution LiDAR (light detection and ranging) DEMs (digital elevation models) will be used. LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and calculating the reflected light. With these DEMs we will be able to get a clear
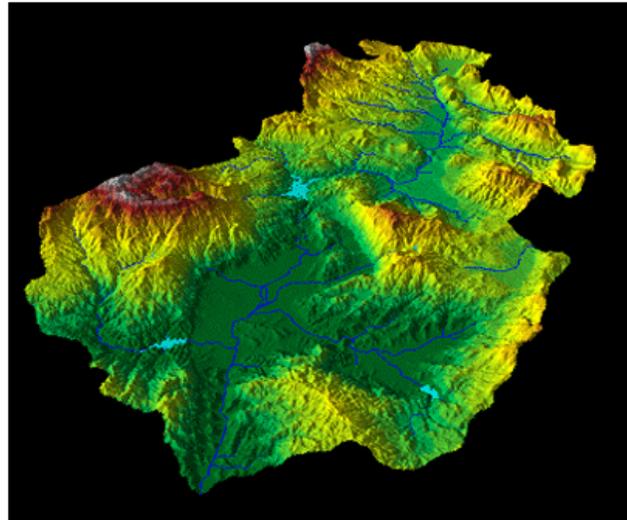


**Visualization of a raster DEM surface.**

understanding of the elevation in the study area. By understanding the elevation it is possible to determine the flow of water which will provide us with the necessary information to determine watershed boundaries.

It is important to complete this analysis because it will enable us to map the surface flow direction toward storm water sewer collectors (grates, curb collectors, rain-garden overflow collectors). This analysis will also help determine subsurface connections. The completion of this analysis is necessary because runoff concentrations of P and N may be high enough to harm streams and lakes in the metro area and beyond.

**Goals:**

The goal of this technical guide is to help students perform specific procedures to develop conclusions about water runoff in his or her study area. By developing the required data inputs and producing the required outputs, he or she will determine both the surface and subsurface flow network. When the student has developed substantial information and data, watershed boundaries will be drawn out. These steps will help identify conditions that may be the cause of poor water quality in urban runoff.

DEM → SInks & Fill → Flow Direction → Flow Accumulation → Watershed

**Background:**

Using hydrologic modeling tools such as those presented here, we are able to develop a better understanding of water runoff. It is possible to identify sinks and fill them, determine flow direction, calculate flow accumulation, and create watershed boundaries through ArcGIS. Without this knowledge we would not be able to create stream networks. Stream networks allow us to plan and make future decisions in regards to water movement. In our study we are using these outputs to analyze and estimate the cause of poor water quality in urban runoff. It is important to develop this information in order to manage our resources and maintain the ecosystem.

**Data Required:**

When modeling the flow of water, it is important to know where the water came from and where it is going. Digital Elevation Models give a better understanding of the ground's slope. The movement of ground water is caused by gravity; therefore, mapping out high to low elevations will tell us the

direction of water flow. Flow across a surface will always be in the steepest downslope direction. Once the direction of flow out of each cell is known, it is possible to determine which and how many cells flow into any given cell.

The inputs for the analysis include:

- Locations of storm sewer collectors. From the locations of the sewer collectors we can estimate where the subsurface sewer lines are located. Typically they link the collectors and flow downhill.

- Digital Elevation Model (cell based raster) of the study area.

- Shapefiles of hydrology in the study area to understand where the stormwater ends up.

**Steps and Outputs:**

Step 1: Add DEM

Click the "**Add Data**" icon, locate the DEM and select it. The DEM raster should appear on the screen. 

Step 2: Identify Sinks

Next, determine whether the DEM is depressionless or if there are any sinks. Sinks are errors in the model where all water traveling into the cell will not travel out. Sinks can be located using the **Sink** tool. Use the DEM raster as the input and name the output "sink". If sinks are located make sure that there is a sewer inlet or natural sink at that location. If not, this location is going to need to be filled. The product of identified sinks is shown on the next page.

Step 3: Fill

Use the original DEM as the input for the **Fill** tool
and name the output "fill". You have now
eliminated the sinks.

**Note: the product of this function will not
change much visually; the changes take place in
the attribute table associated with the DEM.**
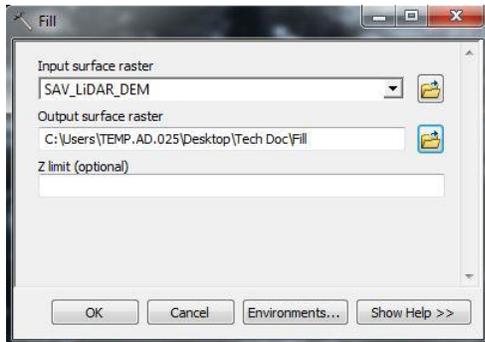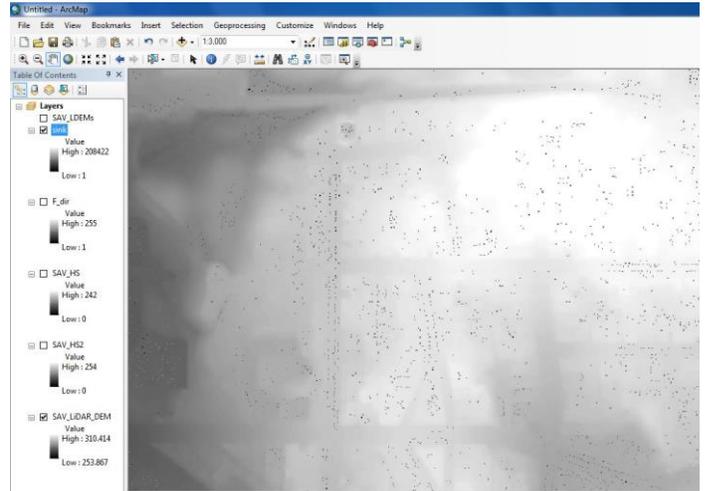


Step 4: Flow Direction

The fourth step is to determine the flow direction of the study area. The direction of flow is determined
by the direction of steepest descent or
maximum drop, from each cell.  Find this and
other tools in *ArcToolbox→Spatial Analyst
Tools→Hydrology.* The input for the **Flow
Direction** tool is the DEM raster representing
a continuous surface (your original DEM).
Name the output something easily
identifiable for future steps (for example "F_Dir").
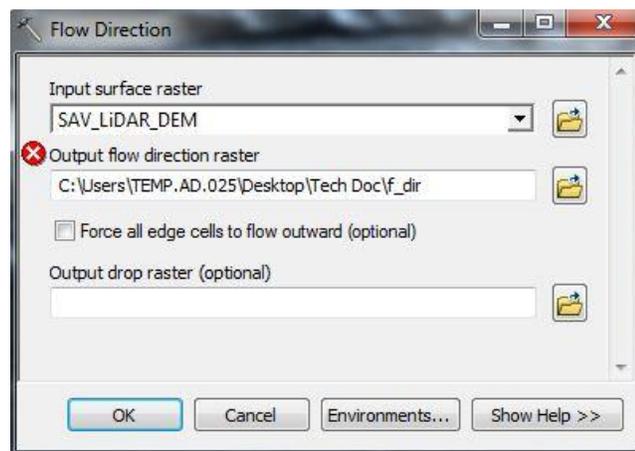
Step 5: Flow Accumulation

Flow accumulation is used to identify areas of concentrated flow and may be used to identify stream channels and topographic highs.

The **Flow Accumulation** tool (found in the same toolbox) calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. The accumulated flow is based on the number of cells flowing into eac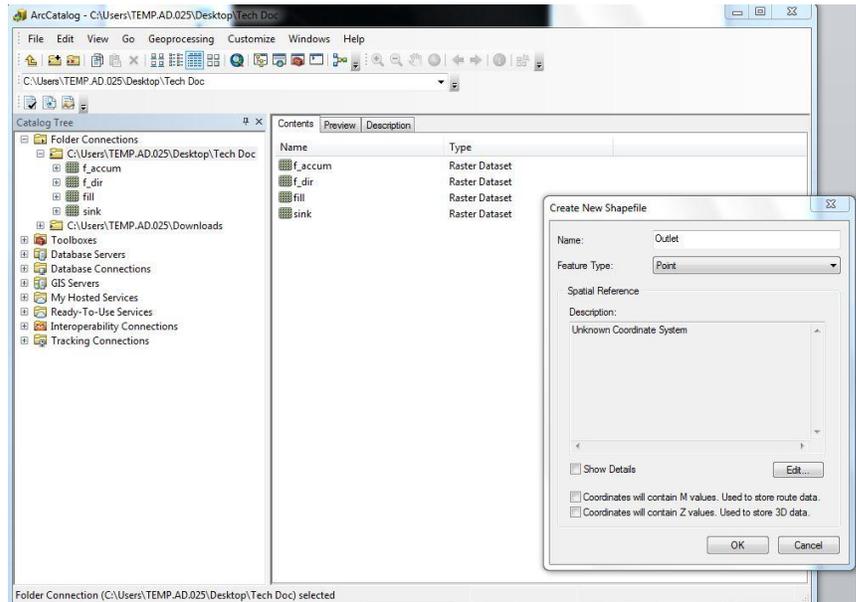h cell in the output raster. Use "F_Dir" as the input raster. Name the output "F_Accum". The product should look similar to the example below. The areas of accumulation are the highlighted lines in the operating screen.
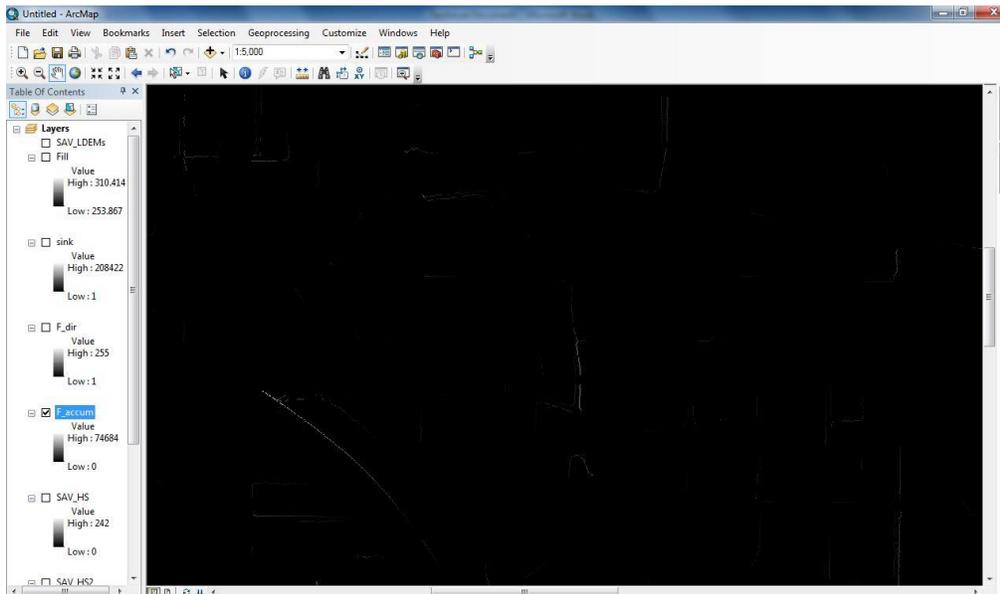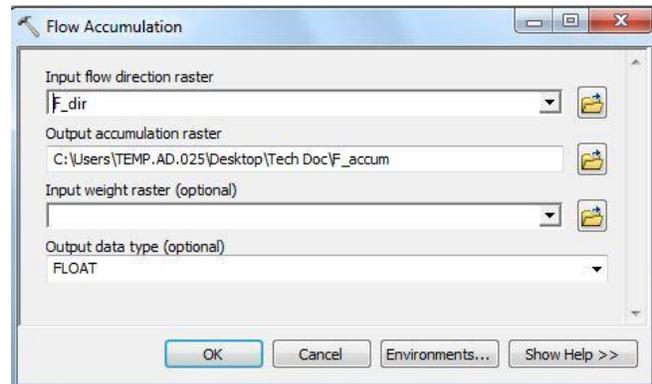
Step 6: Identify an Outlet

To create an outlet point you need to create a new point layer shapefile. In Arc Catalog select the drive being used. Right click on the folder and select "**New Shapefile**". Name the new shapefile "Outlet" and select the feature type as **point**. The coordinate system must match that of the original DEM. In this case we are using NAD83 UTM ZONE 15N. Next, identify the

outlet from the Flow Accumulation raster. The outlet is where all lines converge together. To place an

outlet point, *open the editor toolbar→click the dropdown editor button→start editing →create features*

*window→click on outlet*. Now, place point(s) in the appropriate locations.
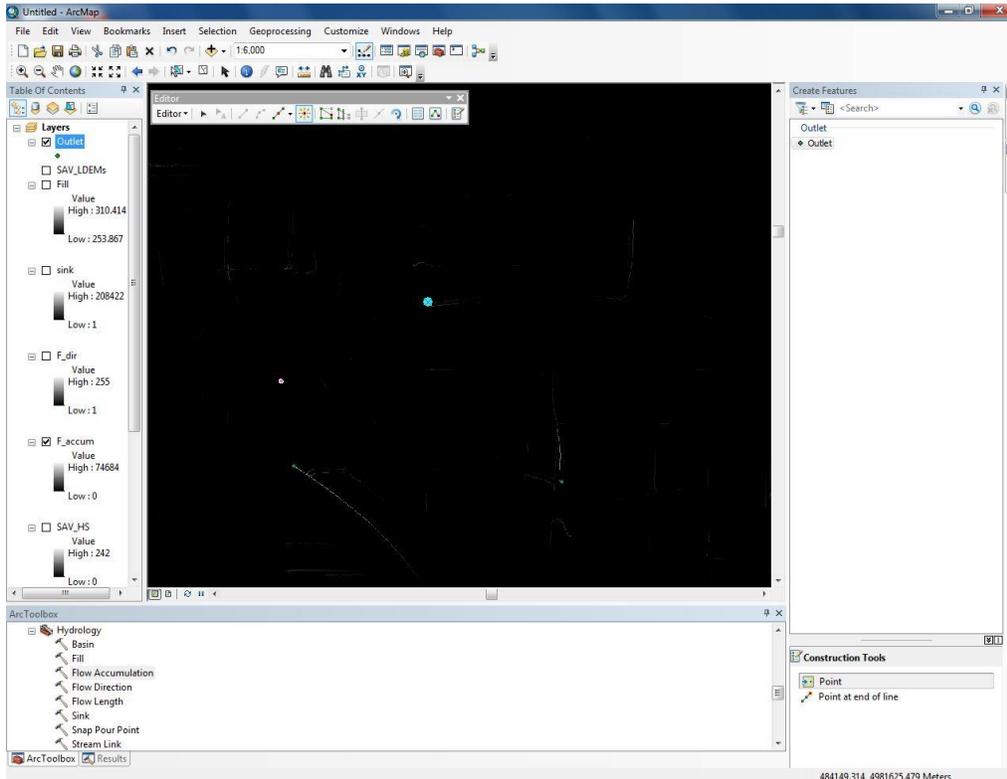


Step 7: Snap Pour Point

The outlet, or **pour point**, is the point on the surface at which water flows out of an area. It is the lowest

point along the boundary of a watershed. To perform this function select the **Snap Pour Point** tool. Use

"Outlet" as the input raster or feature pour point data. Select "F_Accum" as the input accumulation

raster. Name the output raster "s_pour_pnt" and set the snapping distance to 1.
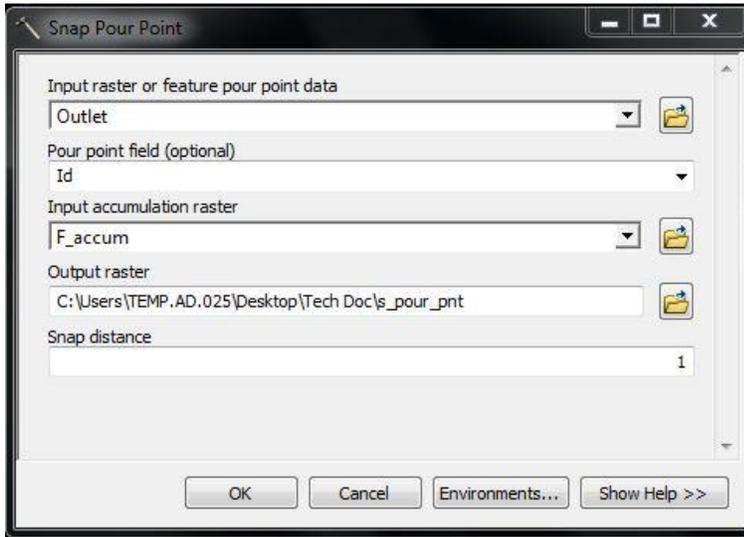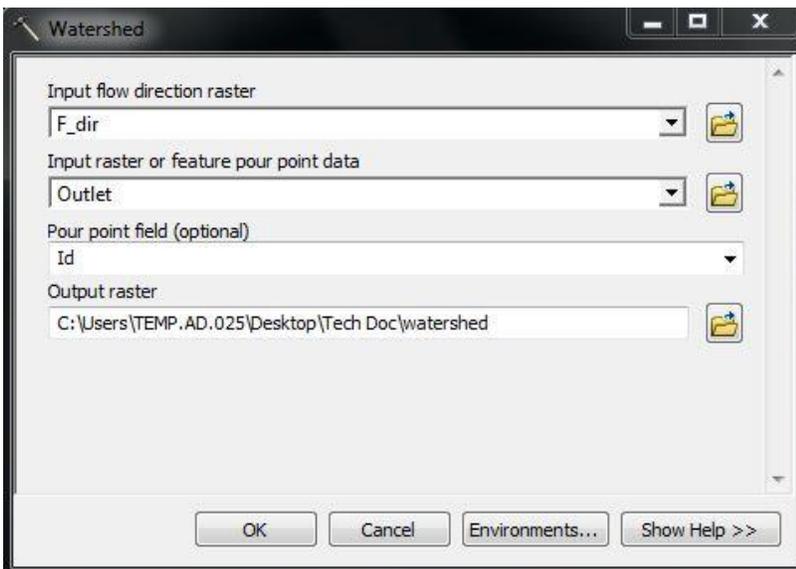


Step 8: Watershed

The final step of the analysis

creates the watershed

boundaries. A watershed is the

upslope area that contributes

flow to a common outlet as
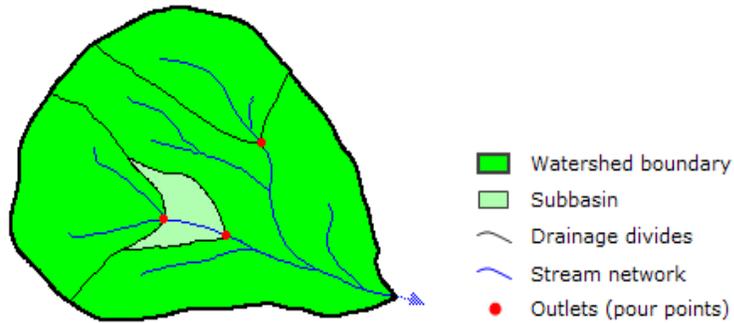


Example of a single watershed and its features.

concentrated drainage. It can be part of a larger watershed and can also contain smaller watersheds,

called subbasins. The boundaries

between watersheds are termed

drainage divides.

Perform this step using the

**Watershed** tool. Use "F_Dir" as the

input flow direction raster and use

"Outlet" as the feature pour point data. Name the output raster "watershed". The final display of the

watershed boundaries should resemble the figure below.