Drainage Analysis From DEM Using Watershed and Stream Network Delineation

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Introduction-

This project focuses on watershed and stream network analysis starting with DEM Rasters and NHD point and watershed vectors. The process will be very similar to that in Exercise 4 from the course. The methods of stream delineation reported here are useful in taking raw elevation data and processing it to the point where more sophisticated statistics can be drawn from it for use in detailed watershed analysis. The end product of this project could be taken and used to conduct investigations such as flood resilience and flow dynamics of the watershed.

Site Description-

The area that was analyzed was the Clackamas River watershed, eight-digit hydrologic unit HUC 17090011. It lies in the foothills of the Cascade mountain range in Oregon, South-West of Mt. Hood. It has an area of 2441.65 square kilometers. The region is mostly mountainous, particularly to the East. There are some small areas of flood plains to the North-West in the HUC8 as it approaches the Willamette River. The vegetation coverage is temperate pine forest by majority. There are also agricultural areas, deciduous forested areas, and developed areas.

Data-

The data sets that I used were DEM sets and NHD HUC 8 and HUC 12 polygons, as well as NHD Gage points and flowlines as vector points and lines respectively. The DEM rasters were retrieved from OSU's LIDAR Depot at a 30 meter resoltion. The NHD data sets were retrieved via the Oregon Geospatial Data Gateway. They were projected to from to NAD 1983 UTM Zone 10N.

GIS Methods-

The first task was to Bring in our DEM data and NHD Vectors and ensure that all the data was in a consistent projection, which was straight-foreword use of the Project tool. There was one issue with the DEM data. The watershed lies directly at the the intersection of four DEM quads pulled from OSU's LIDAR Depot. Mosaic was used to merge these four rasters into one. Then extract by mask was used over the HUC8 to restrict the DEM data to only cover the watershed, and clean up the look of the map.

Then the procedure of Exercise 4 was used to conduct analysis. The fill function was used to fill areas incorrectly defined as pools. These arise from imperfections in the DEM resulting in numerical artifacts where water would falsely collect along flowlines. After that flow direction was used to determine the direction of flow in our filled elevation data. This is a roving window operation using the elevations of the neighboring DEM cells to determine the hydrologic slope from cell to cell. The next step is to use flow accumulation to determine the accumulated drainage area of points. This is a calculation returning the sum of cells flowing into a given cell derived from our flow direction raster.

Next the HUC12s were overlaid on the map to view our flow accumulation in the context of belonging to the 12 digit subwatersheds. Catchment area upstream from our outlet was defined using the watershed tool. An outlet point was manually created using the editor tool, and then the watershed tool was used to define all the area upstream from this outlet, effectively defining our watershed. I think that since the watershed had already been defined using extract by mask, and the outlet point was the lowest point in the watershed, that reclassify could have been used to define all DEM points as the watershed, resulting in a similar true/false raster covering our watershed, but the outlet point is necessary for later analysis.

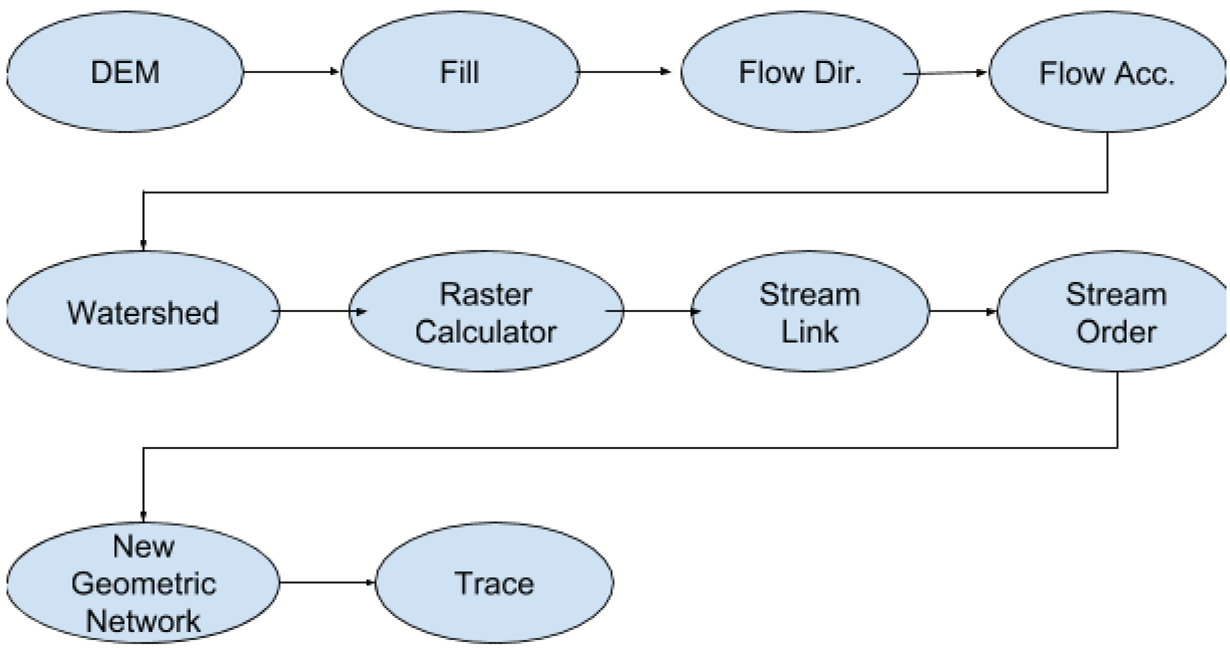
The next series of steps was to define the streams with the raster calculator and flow and watershed thresholds, and then define the stream links and nodes using Stream Link. This created a series of discrete stream segments between junctions which can be used to generate their own subwatersheds, again using the watershed tool similar to what was done for the whole basin. The raster data set generated was converted to vector features using Raster to Feature.

Next, stream orders were defined in a table using the Archydro Stream order tool, followed by zonal statistics as a table, and manipulating that table with basic table operations. The Strahler stream order is generated using the stream features and flow direction as inputs. Those orders are then the inputs for Zonal Statistics as table, which is then joined to the drainage line attribute table.

The next objective was to create subwatersheds relative to our stream gage point data. To do this the tool Snap Pour Point was used to create raster data near the gages that intersected precisely with the flow lines. These points could then be input into watershed to define these subwatersheds for the gages. These subwatersheds are useful in analyzing the watershed with respect to the gages, and allows any gage data collected to be considered at a 1:1 ratio with these gage subwatersheds.

The next task was to create a stream network and using the network analysis tools. To do this the outlet was snapped to the edge of the watershed using the editor tool. Then from the catalogue a new geometric network was created using the drainage line vectors and outlet point, with the outlet as a sink. After the stream network was created, network tools were used to designate the outlet as a sink and display the flow direction arrows. Then the trace function was used to trace up and down stream from an edge flag. Statistics were gathered from the tables using upstream and downstream selections, notably the attributes of the appearant longest flowpath in the watershed.

Basic Methodology



Results-

The results of this process are a verified, manually generated network of streams and their catchments that can have a number of other analyses applied to them. The data is verified because it is derived from the physically linked elevation data, with specific thresholds for streams and flow accumulation. This leaves less ambiguity than what might be inherent in data from other sources. The data is manually generated because a GIS analyst (myself) derived the data from raw DEM raster, with user specified parameters. Directly from this data we can retrieve the catchment area and length up and downstream from any point in the watershed. The limitations of this analysis are the coarseness of the data. The cell size of the DEM is 30 meters which is not terribly coarse, but there are some numerical artifacts from the tools that were used where the grid does not capture perfectly the real world conditions.

Key deliverables from Exercise 4 are provided below.

OBJECTID *	Value	Count
1	1	299974
2	2	221596
3	4	319348
4	8	338569
5	16	456605
6	32	369354
7	64	404681
8	128	300962

Figure 1: Hydrologic Slopes of the Clackamas DEM

Eight Direction Pour Point Model

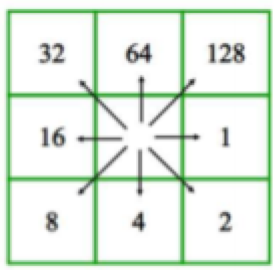


Figure 2: Summary of Hydrologic Slope

Drainage Area of the Clackamas River Basin:

Pixel value: 2704634.000000 = 2,434.17 sq. km

Name of the most downstream HUC 12 in the Clackamas River Basin :

Rock Creek-Clackamas River

Flow Accumulation Area = 737240 cells = 663.48 sq km

Area_Acres Area = 27384.77 Acres = 110.82 sq km

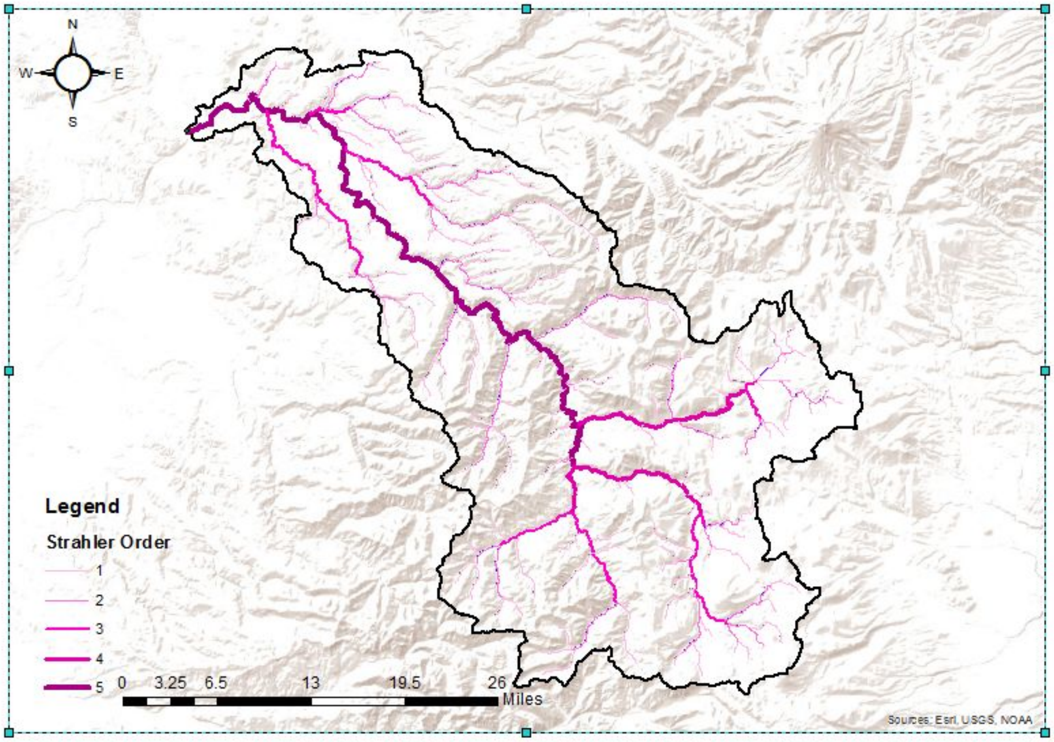
Shape_Area = 110738412.920957 sq. m = 110.74 sq km

The flow accumulation area is so much larger because there are many tributaries entering this subwatershed other than the main channel (the Clackamas River).

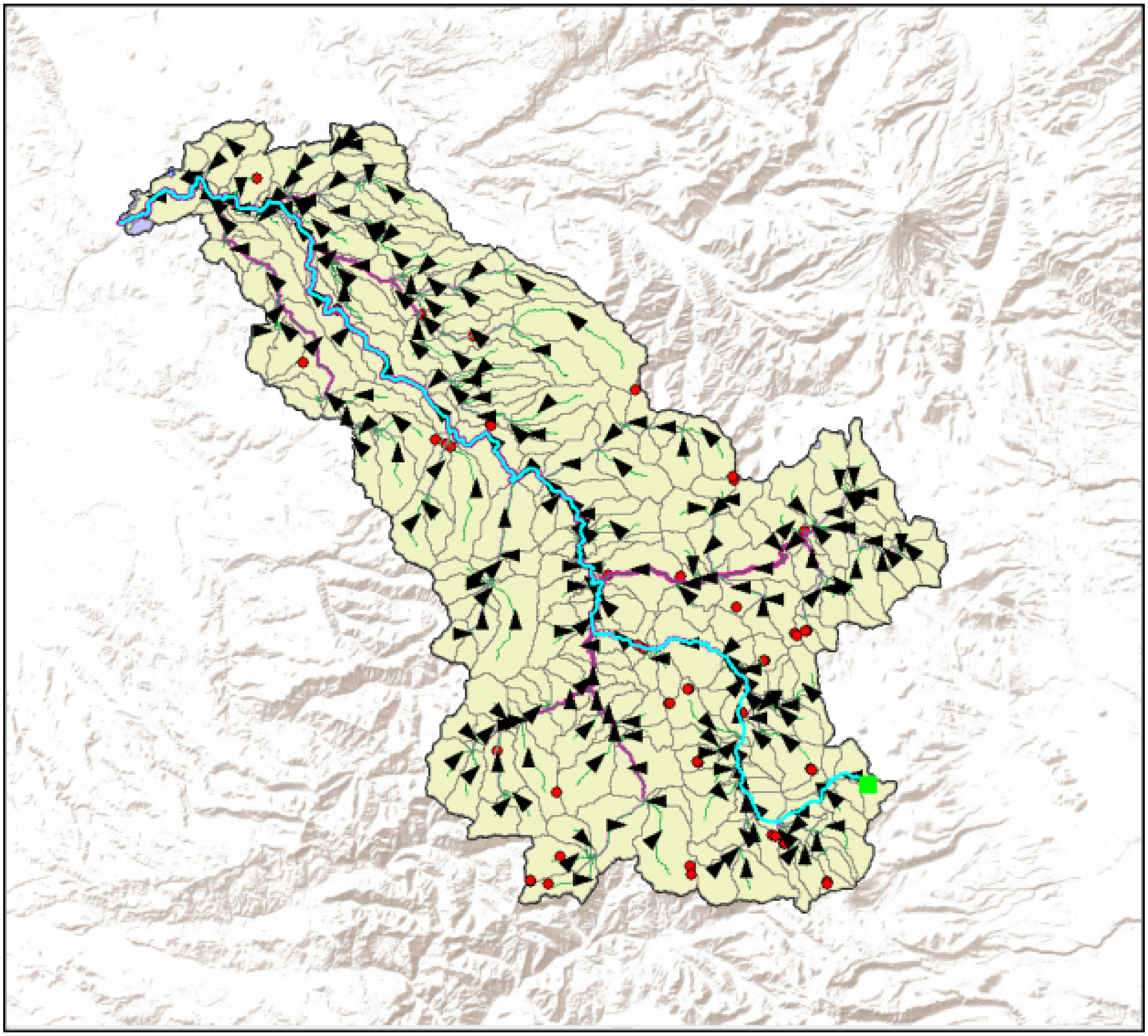
Describe the relationship between StrLnk, DrainageLine, Catchments and CatchPoly attribute and grid values. What is the unique identifier in each that allows them to be relationally associated?

These datasets are all derived based on their relation to the defined streams and the stream link. They are allowed to be relationally associated because of their corresponding network data, unique to each segment and link, or edge and junction.

Clackamas River Basin Streams



Longest Flowpath = 463920 ft. = 141 km



Appendix

Carpenter, K. D., & Geological Survey. (2003). Water-quality and algal conditions in the Clackamas River Basin, Oregon, and their relations to land and water management. Portland, Or. : Denver, CO: U.S. Dept. of the Interior, U.S. Geological Survey ; U.S. Geological Survey, Branch of Information Services [distributor].

Gilford, Andrew. (2003). Clear Creek then & now: an historical watershed analysis.(Clackamas, Oregon). The Science Teacher, 70(5).

Metropolitan Service District. (1997). Clackamas River watershed atlas. Portland, Or.]: Metro.

Oregon. Department of Fish Wildlife, & Northwest Power Planning Council. (1990). Clackamas River : Willamette River subbasin : salmon and steelhead production plan. Portland, Or.: Northwest Power Planning Council.