**EEOS 383 - GISCIENCE FOR WATER RESOURCES RESEARCH – Spring 2010**

**Instructor: David E. Tenenbaum**

# Exercise 03: Watershed Delineation from DEMs

## Introduction

In our last exercise, we tackled watershed delineation using contour data. As you now know, using that approach is a somewhat subjective process, with the experience of the interpreter playing a large part in determining the resulting watershed delineation. In this exercise, we will make use of a more objective approach to achieve a similar product. By making use of the D8 digital terrain analysis sequence in conjunction with a gridded digital elevation model, we can delineate watersheds by finding all grid cells that drain to a specified grid cell based upon a simple rule that drainage follows the direction of steepest descent. In addition to being able to create watershed delineations in this fashion, the D8 process will also allow the production of a set of very useful intermediate products that describe the movement of water through the watershed on a cell-by-cell basis.

## Data

The exercises in the first half of the course will use spatial data from the vicinity of the Coldstream Creek catchment, a small watershed in Okanagan Valley of British Columbia, Canada. This exercise will use the following 2 datasets:

- dem – This gridded digital elevation model has a cell size of 50 meters.
- sampling2.shp – This point shapefile marks 8 sampling sites and channel characteristics at those locations

## Procedure and Questions

<u>Filling Pits</u>

- Add the dataset to your map document
- As described in the reading material (Marks et al., 1984; Jenson and Domingue, 1988) and lecture proceeding this exercise, the D8 flow direction algorithm, that for each cell seeks out which of its eight neighbors represents the direction of steepest descent, relies on at least one of the eight neighbors being at a lower elevation. If this is not the case, the cell of interest is a pit. Pits are unacceptable for use with D8 digital terrain analysis, so the first step requires that all pits in the DEM be filled.
- The tools we will need to perform the D8 sequence are located within the *ArcToolbox*, specifically in the section of the *Spatial Analyst Tools* entitled *Hydrology*. Click on the red toolbox icon if the *ArcToolbox* is not already visible within your map document, and navigate down to the appropriate section. Therein you will find a tool simply entitled *Fill*.
- Use the *Fill* tool to fill any pits in the DEM. Make the DEM the *Input Surface Raster* and set the *Output Surface Raster* to an appropriate name and location (e.g. filleddem in your H:\ space … remember, no spaces in GRID filenames)

- Now, use the *Raster Calculator* to calculate the difference between the filled DEM and the original DEM (i.e. the expression would be [filleddem] – [dem])

*Question 1 –* *Were there any pits in the original DEM? How common were pit cells compared to non-pit cells (**Hint: Use the attribute table of your Calculation to figure this out**)? What was the average depth filled in all the pit cells?*

*Question 2 –* *What are some possible sources of pits in this landscape? Can you make some reasonable guesses based on the configuration of groups of pit cells (**Hint: Use a unique value symbolization on the Calculation to see this clearly**)?*

<u>Creating the D8 Flow Directions GRID</u>

- Now that you have a pit free DEM, you are ready to apply the D8 approach. Use the *Flow Direction* tool on your filled DEM to create the D8 flow directions GRID (i.e. in this tool, filleddem will be the *Input surface raster* and you can again name the *Output flow direction raster* as you wish).
- The resulting output should be a GRID consisting of cell values including the values 1, 2, 4, 8, 16, 32, 64, and 128, as described in the accompanying slideshow and the ArcGIS documentation (if you have values other than these 8 specified values, something has gone not quite right). These values correspond to the 8 directions in which flow could potentially proceed from any given grid cell, thus specifying the direction of steepest descent at that location in the GRID.

*Question 3 –* *Describe the appearance of the D8 flow direction GRID, paying particular attention to the how cells of the same value are positioned with respect to each other. Include a printed map of this flow direction GRID with your exercise, and make sure it has the following characteristics: It should have an appropriate title (be sure to use the Layout View for this), as well as a legend that indicates the correspondence between raster cell symbologies and flow directions (do this by editing the Flow Direction GRID's legend, changing the Labels for each value to the appropriate descriptions of directions).*

<u>Creating the D8 Flow Accumulation GRID</u>

- Now that you have the D8 flow directions GRID, you can create the D8 flow accumulation GRID using the *Flow Accumulation* tool (i.e. in this tool, the flow direction GRID will be the *Input flow direction raster* and you can again name the *Output accumulation raster* as you wish).
- The resulting D8 flow accumulation GRID should have a wide range of values. Many cells should have low values, reflecting the fact that they are in upslope positions with few cells that drain to them, with fewer cells having large values that reflect that they are in downslope positions with many cells draining to them.

*Question 4 –* *What is the value of the D8 flow accumulation GRID at the BCCOL06 sampling site? What does this mean in real world units (**Hint: Remember the size of grid cells in these data layers**)?*

*Question 5 –* *What is the highest value of the D8 flow accumulation GRID you created? Where is it located in the GRID? In watershed terms, what is the significance of this location?*

*Question 6 –* *In general, how can we interpret the meaning of the D8 flow accumulation GRID (i.e. what are we seeing when we see connected grid cells with high flow accumulation values)?*

<u>Creating the Watershed Delineation</u>

- Now that you have the D8 flow accumulation GRID, you can find the set of cells that drain to any cell of interest in the GRID. To do this, you first need to be able to indicate the cell of interest. The easiest way to do so is create a point shapefile that contains a single point denoting the location of interest.
- We will create such a shapefile by selecting the BCCOL06 record in the sampling2.shp shapefile, and then exporting just this selected record, producing the single point shapefile we need. First, select the appropriate record in sampling.shp (either by opening the attribute table and selecting it there, or selecting it in the data view using the selection tool). Next, right-click on the sampling2.shp layer in the *Table of Contents* and choose *Data → Export Data*. Now *Export Selected features*, leaving the coordinate system as is and naming the output shapefile appropriately.
- Now, use the *Watershed* tool to find all the cells that drain to the cell below the BCCOL06 point, using the D8 flow direction GRID for the *Input flow direction raster* and your new single point shapefile for the *Input raster or feature pour point data*.

*Question 7 –* *Does the resulting watershed for BCCOL06 have the shape you expected (you can discuss this in terms of a comparison to the shape you came up with in your contour-based delineation)? Hand in a printed map of your resulting watershed delineation, use the Layout View to create a map with an appropriate title (remember, this is Upper Coldstream Creek) and legend etc.*