

Delineating Watersheds from a Digital Elevation Model (DEM)

Updated January 17, 2012

(Using example from the ESRI virtual campus found at <http://training.esri.com/Courses/NatRes/index.cfm?c=153>)

Download locations for additional DEM data:

USGS Seamless DEM website – <http://seamless.usgs.gov/>

Sample data for this tutorial: S:\Tutorials\ESRI\VirtualCampus\NatRes\Create\SriLanka. Please copy and paste it into your storage device.

Step 1 - Start ArcMap and add data

- Make sure the Spatial Analyst extension is turned on. (Customize → Extensions)
- Add your Elevation DEM (sl_elevation) and mask shapefile (sl_mask.shp).



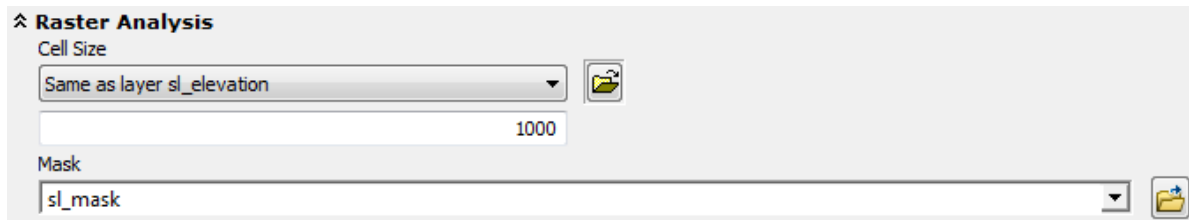
Step 2 – Set Geoprocessing Environment

- Under *Geoprocessing*, choose *Environments*
- Set the following environment settings:
 - Workspace**
 - Scratch Workspace: Set this to a location you want your temporary files to be located. (ex. H:\SriLanka\WtrShedDEM\Scratch)



b) Raster Analysis Settings

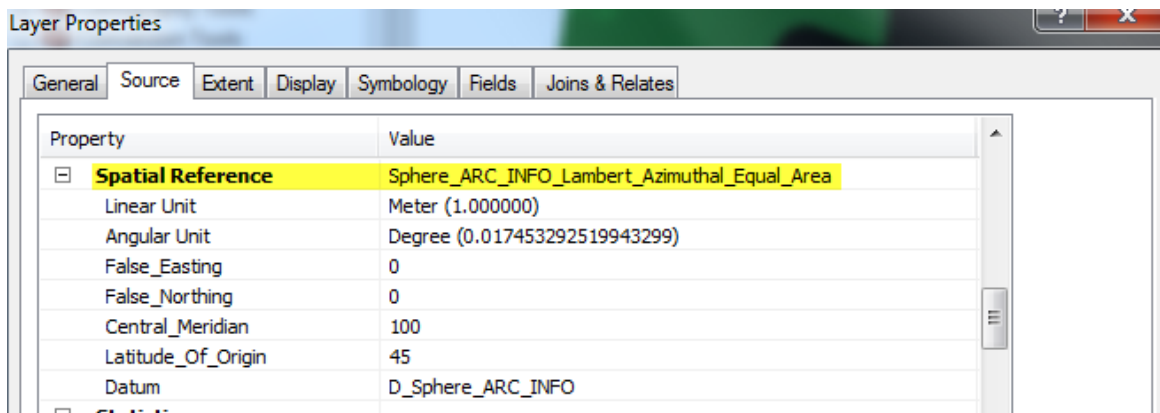
- Cell Size: same as Layer "sl_elevation"
- Mask: (Ex. H:\SriLanka\sl_mask.shp)



- Click OK

Step 3 – Check data properties

- Right-click sl_elevation and choose *Properties*, then click the *Source* tab.
- Scroll down to review the properties of the sl_elevation raster. Check that there is a spatial reference. If so, it will look something like the following:

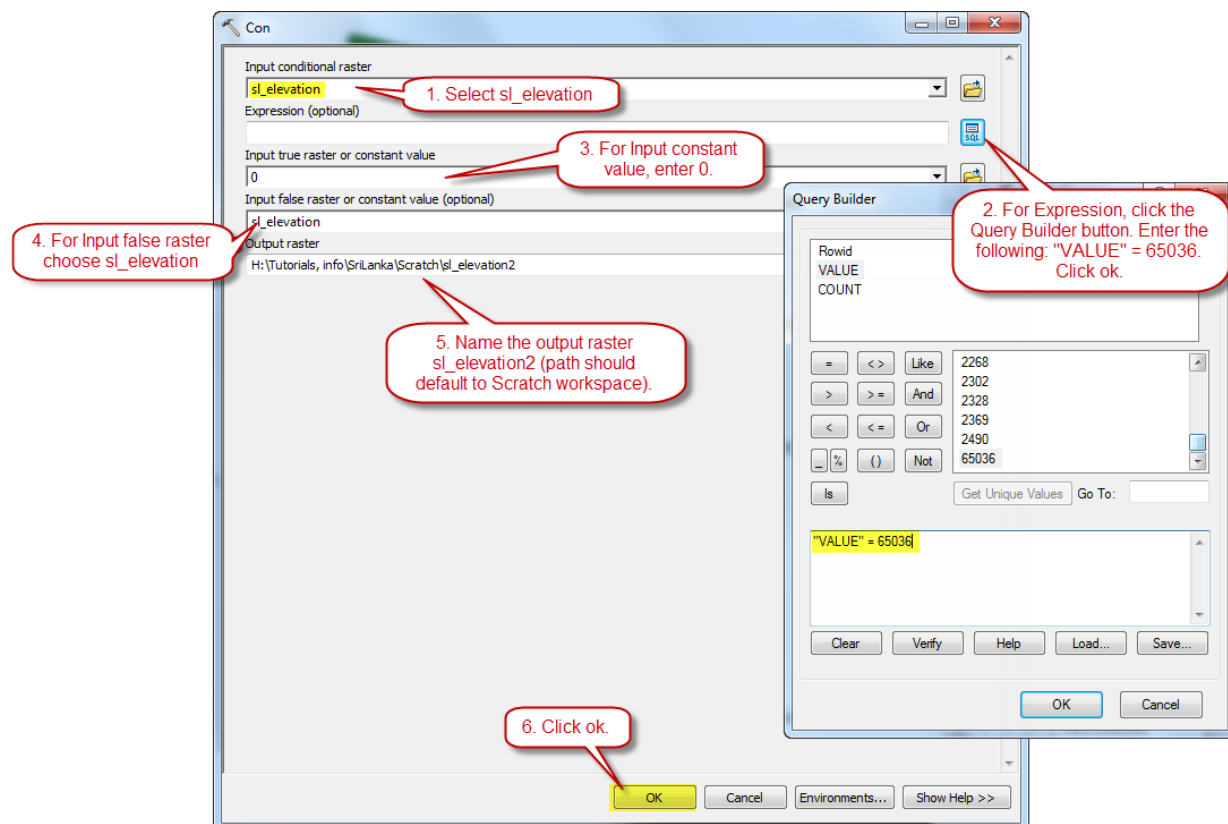


- If there is not, open Toolbox → Data Management Tools → Projections and Transformations → Define Projection . You'll have to know how the projection of your raster should be defined. This information can be found in the metadata information for the raster.
- Once you have confirmed that your raster has a spatial reference, close the Properties dialog box.

Step 4 – Use the Con tool

- It's important to be sure that all elevation values are reasonable (i.e. No 65036 values). One possibility is that a group of unusually high values represents the ocean mask value in the original image. Using the **Identify** tool, click around on your area to see if this is a reasonable assumption.

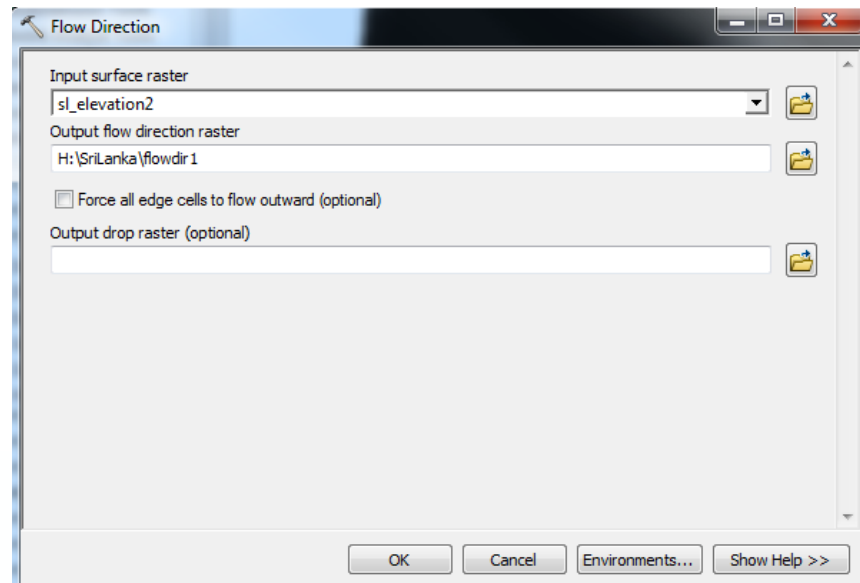
- To make sure that this value does not create problems during the data creation and analysis processes, you'll use the Con tool to change it to 0 (i.e., sea level).
- Expand the Conditional toolset in the Spatial Analyst Tools toolbox. Open the Con tool.
- The Con tool allows you to change the values of cells based on a conditional statement. For example, if the ocean is currently represented by a value of 65036, it will be replaced with a value of 0. Otherwise, the cell will retain its elevation value.
- Fill out the dialog box as follows:
 - For Input conditional raster, choose sl_elevation.
 - For Expression, click the Query Builder button. In the Query Builder, build the following statement:
 - Value = 65036
 - Click OK.
 - For Input true raster or constant value, enter 0.
 - Click OK.
 - For Input false raster or constant value, enter 0.
 - Name the output raster sl_elevation2. (The path should default to your Scratch folder.)
 - Click OK to run the Con tool.
 - When the new layer is added, turn off sl_elevation and sl_mask. sl_elevation2 will now be the elevation DEM you work with.



Step 5 – Set flow direction

Your first step in creating the watersheds is to set flow direction for the elevation raster. Determining the direction of flow through each cell is always the first step in surface hydrology analysis, because all the other hydrology tools need this information to work.

- The Flow Direction tool finds the flow direction for a cell by comparing its elevation to those of its neighbors. The output is a code that identifies the neighbor into which water will flow.
- Expand the Hydrology toolset.
- Double-click Flow Direction.
- For Input surface raster choose sl_elevation2.
- Name the output flow direction raster flowdir1.
- Click OK.



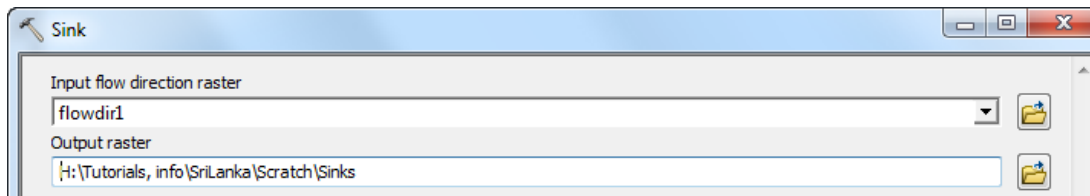
5. Flow Direction Results

Step 6 – Locate sinks

With the flow direction set, you can check your data for sinks.

- A sink is a group of one or more cells that have lower elevations than all the surrounding cells. When water flows into a sink, it cannot flow out and contribute to the flow downstream; therefore, flow direction cannot be assigned one of the eight valid values in a flow direction grid.
- Sinks in elevation data are most commonly due to errors in the data. These errors are often due to sampling effects and the rounding of elevations to integer numbers.
- From the Hydrology toolset, open the Sink tool.

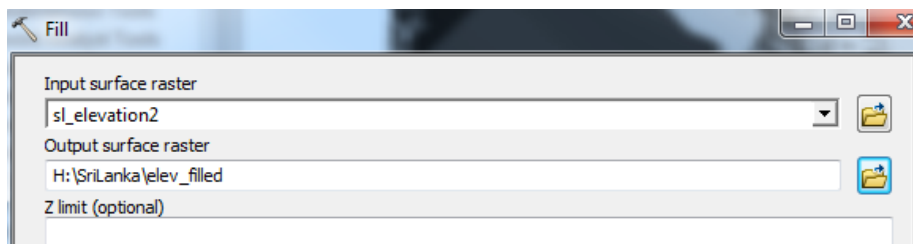
- For Input flow direction raster, choose flowdir1.
- Name the output raster “sinks”.



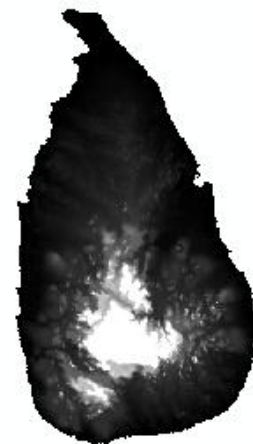
- Click OK.
- When processing is complete, turn off all other layers to see the sinks.
- You'll need to fill the sinks before creating the watersheds.

Step 7 – Fill sinks

- From the Hydrology toolset, double-click the Fill tool.
- The Fill tool finds the sinks (their elevation is lower than all the surrounding cells) and then "fills" them to the elevation of their lowest neighbor.
- For Input surface raster, choose sl_elevation2.
- Name the output raster elev_filled.
 - Tip: If there are depressions in the terrain that represent real sinks (e.g., lakes), they can be excluded from sink filling by setting the Z limit.
 - All sinks that are less than the z-limit lower than their lowest adjacent neighbor will be filled to the height of their pour points.



- Click OK.

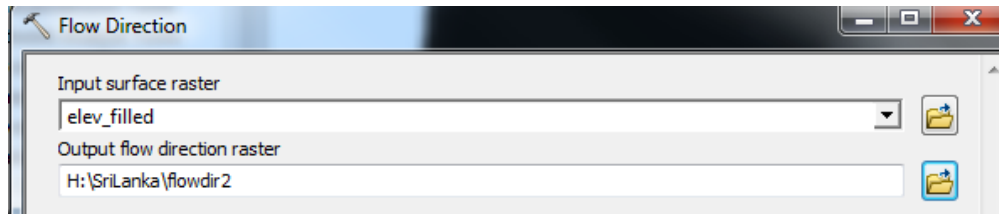


7. Filled Sink Results

Step 8 – Set flow direction for filled elevation layer

Now you'll need to determine the direction of flow for the new elevation raster.

- Open the Flow Direction tool.



- Choose elev_filled for the input raster.
- Name the output raster flowdir2.
- Click OK.

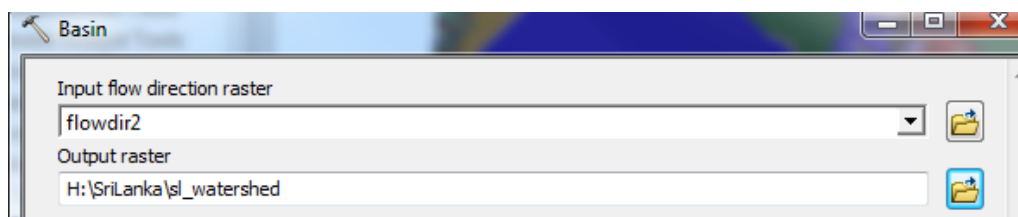


8. Flow Direction Results

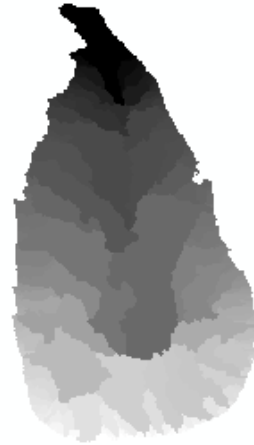
Step 9 – Create watersheds (Raster)

Now you're ready to create the watersheds.

- From the Hydrology toolset, double-click Basin.
- Why use the Basin tool instead of the Watershed tool?
 - ArcGIS includes two surface hydrology tools that create watersheds for pour points—Basin and Watershed. Pour point data (either vector or raster) represent locations above which the contributing area will be determined.
 - The Basin tool finds its own pour points and creates watersheds for the whole map.
 - The Watershed tool creates watersheds for the pour points that you provide.



- Choose flowdir2 as the input raster.
- Name the output sl_watersheds.
- Click OK.

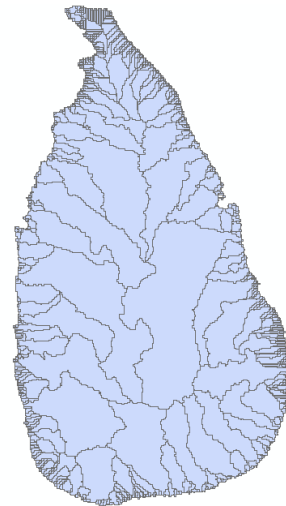


9. Watershed Result

Step 10 – Create watersheds (Shapefile)

Now that you have your watershed delineated in raster format, you can convert this to a shapefile with the basins as individual polygons.

- In the toolbox, navigate to Conversion Tools → From Raster → Raster to Polygon
- Choose sl_watersheds as the input raster.
- Unclick simplify polygons.
- Name your output shapefile watershed_poly.



10. Polygon Watershed Result