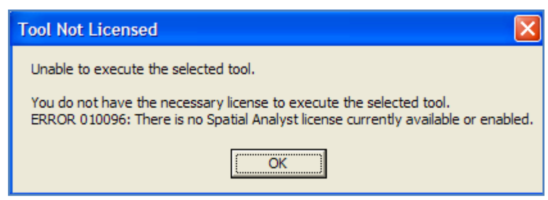
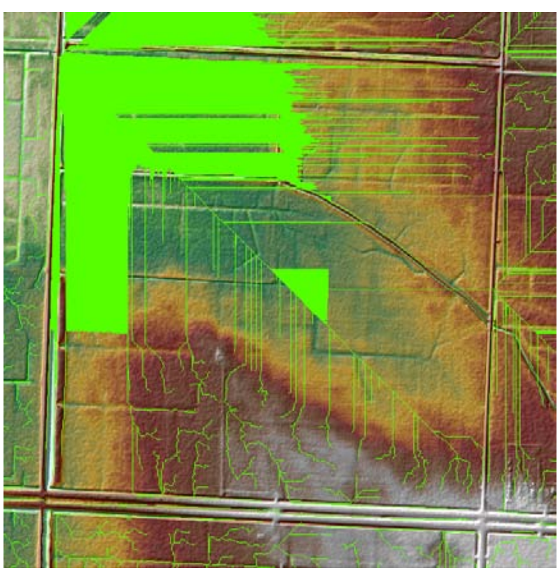
A Method Using ArcMap to Create a Hydrologically – conditioned Digital Elevation Model

High resolution topography derived from LiDAR data is becoming more readily available. This new data source of topography data has wide ranging potential for many water resource applications. However, problems become readily apparent when using standard ESRI ArcGIS-hydrologic tools on LIDAR derived Digital Elevation Models (DEM). One of the most common and programmatic are "Digital dams". Digital Dams are a scale dependant artifact of topography data and GIS processing. Often recognized as noise and hydrologic barriers that need to be overcome in what we now call course or poor resolution topography data, LiDAR derived products represent actual landscape features. Roads are one of the most easily recognized features that prevent an accurate depiction of flow across the landscape; this is especially problematic in flatter terrain.

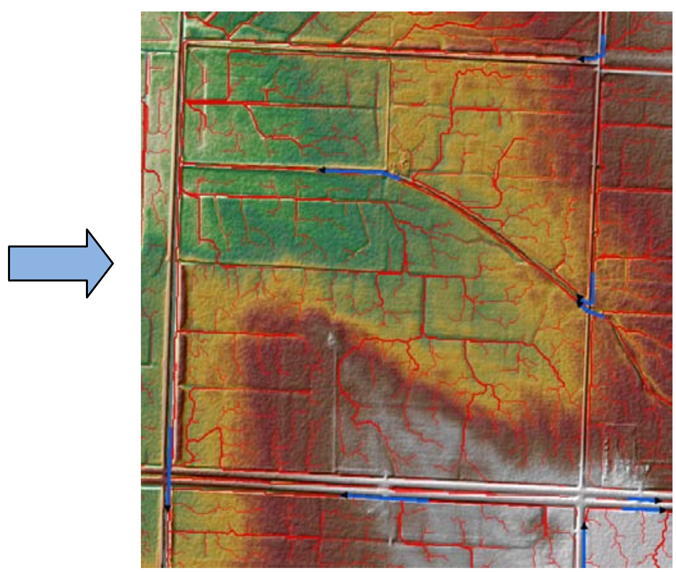
Several options have been developed during the past few decades to "hydrologically condition" DEMs; none are perfect, or necessarily easy to use. The following documentation presents one procedure to hydrologically condition digital elevation models so that they can better represent actual flow across the landscape. This procedure uses standard tools contained within ESRI's ArcGIS Spatial Analyst and 3d Analyst extensions within ArcMap.



Licensing Note: ArcGIS functionality within this document is available with the ESRI ArcView product level. However, Spatial Analyst licensing is required.



Flow network from a filled DEM derived from the raw 3-meter DEM.



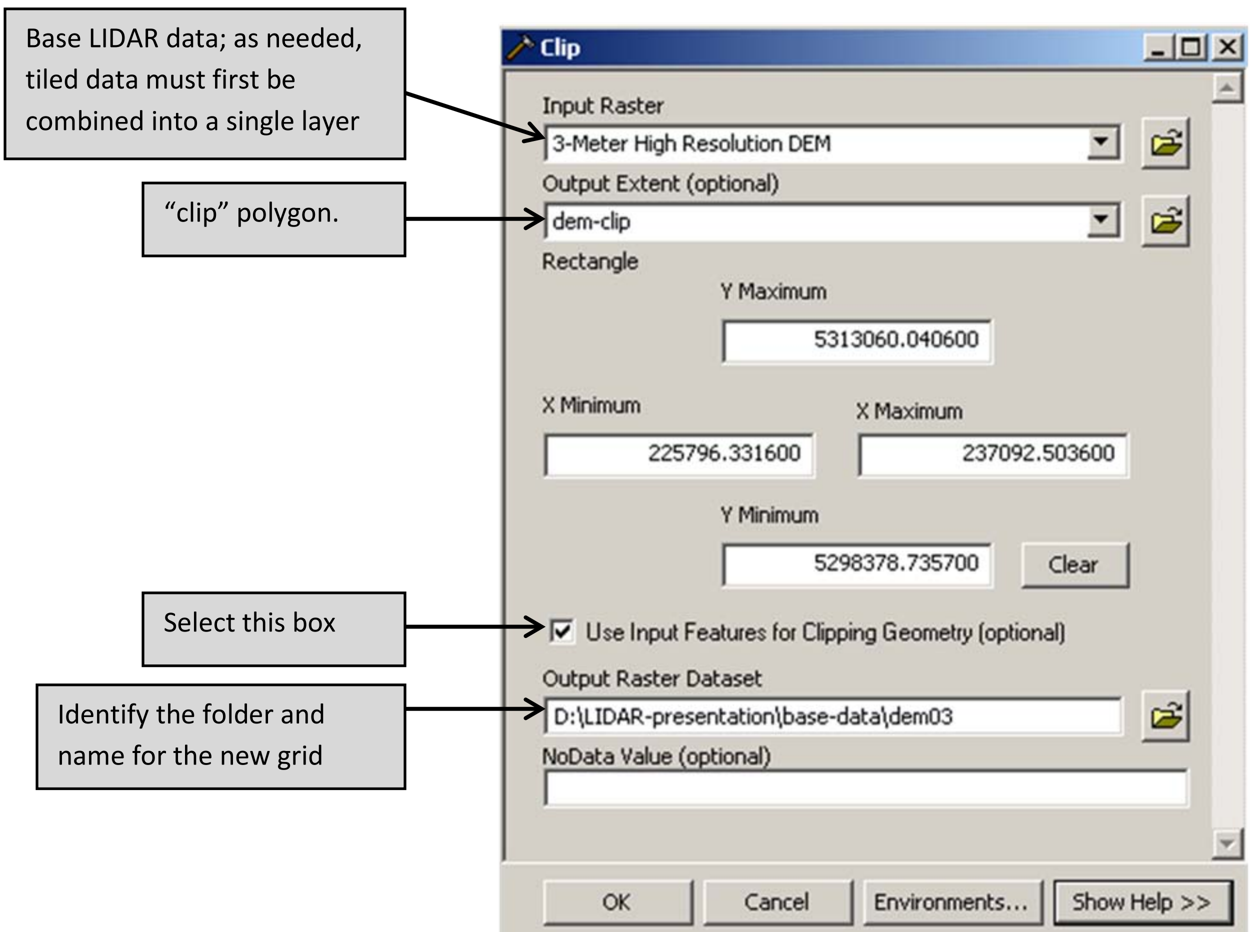
Flow network w/ hydrologic conditioning (6-meter DEM)

1. Clip LIDAR DEM to area of interest

Create a polygon shapefile that is slightly larger than the area of interest. Due to the huge volume of data within LIDAR data sets, this polygon should be just big enough to accomplish desired task. For example, if the area of interest is a 20,000 acre subwatershed, where the watershed boundary is adequately mapped, then clip boundary could be roughly 500 meters larger than the existing watershed boundary. In the following illustration, this shape file was named “dem-clip”.

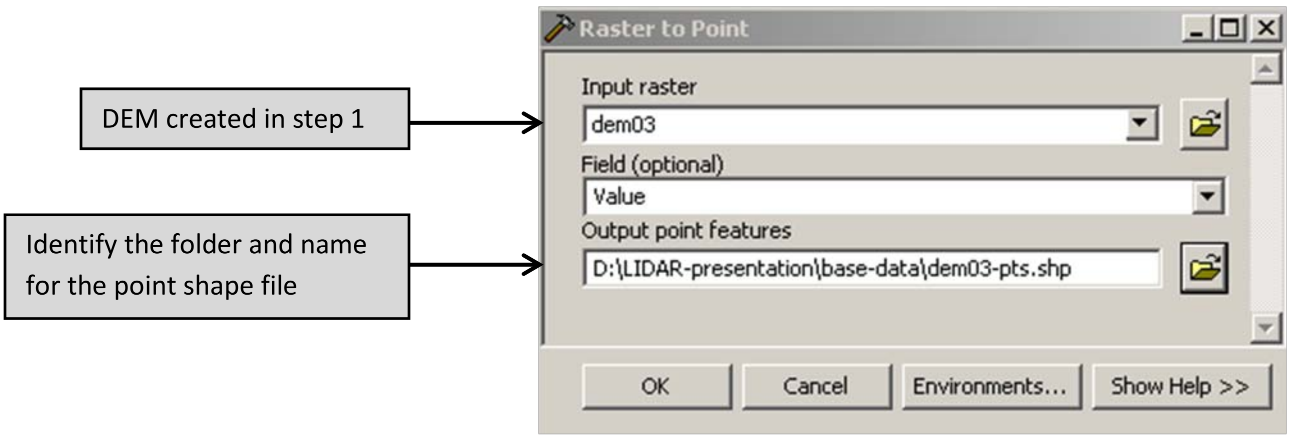
In preparation for step 3, buffer the “clip” polygon by -100 meters, that is, a polygon inside of the “clip” polygon. Save this inside polygon to a separate shape file. As shown in the Step 3 figure, this polygon was named “boundary”. You should have two polygon shapefiles, each with only one feature.

From the ArcMap toolbox, open **Data Management Tools : Raster : Raster Processing : Clip**. Make the appropriate entries as shown below and select “OK” to run the clip routine.



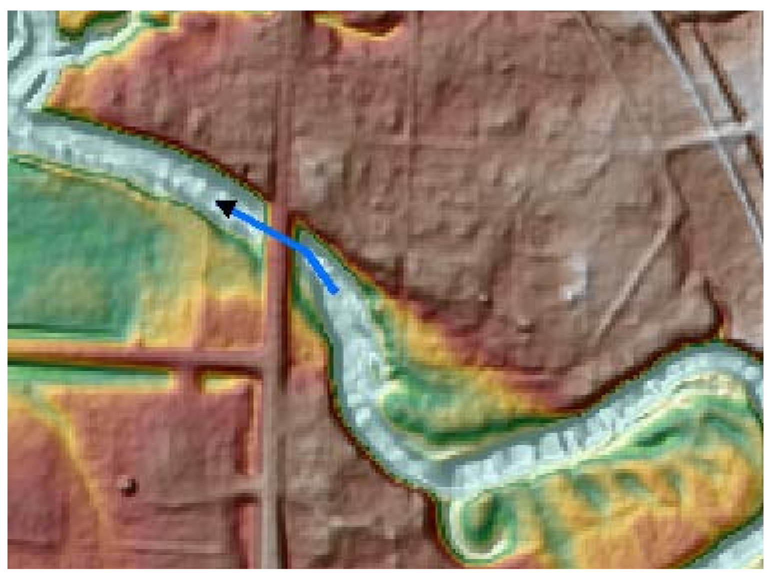
2. Convert the DEM grid to points

The ArcMap **topo to grid** tool uses either point or contour elevation data. So the next step is to convert the DEM grid to a point shapefile. From ArcMap's toolbox, use **Conversion Tools : From Raster : Raster to Point.** Make the appropriate entries as shown below and select "OK" to run the clip routine.



3. Create an arc (line) shape file to identify the digital dams to be broken.

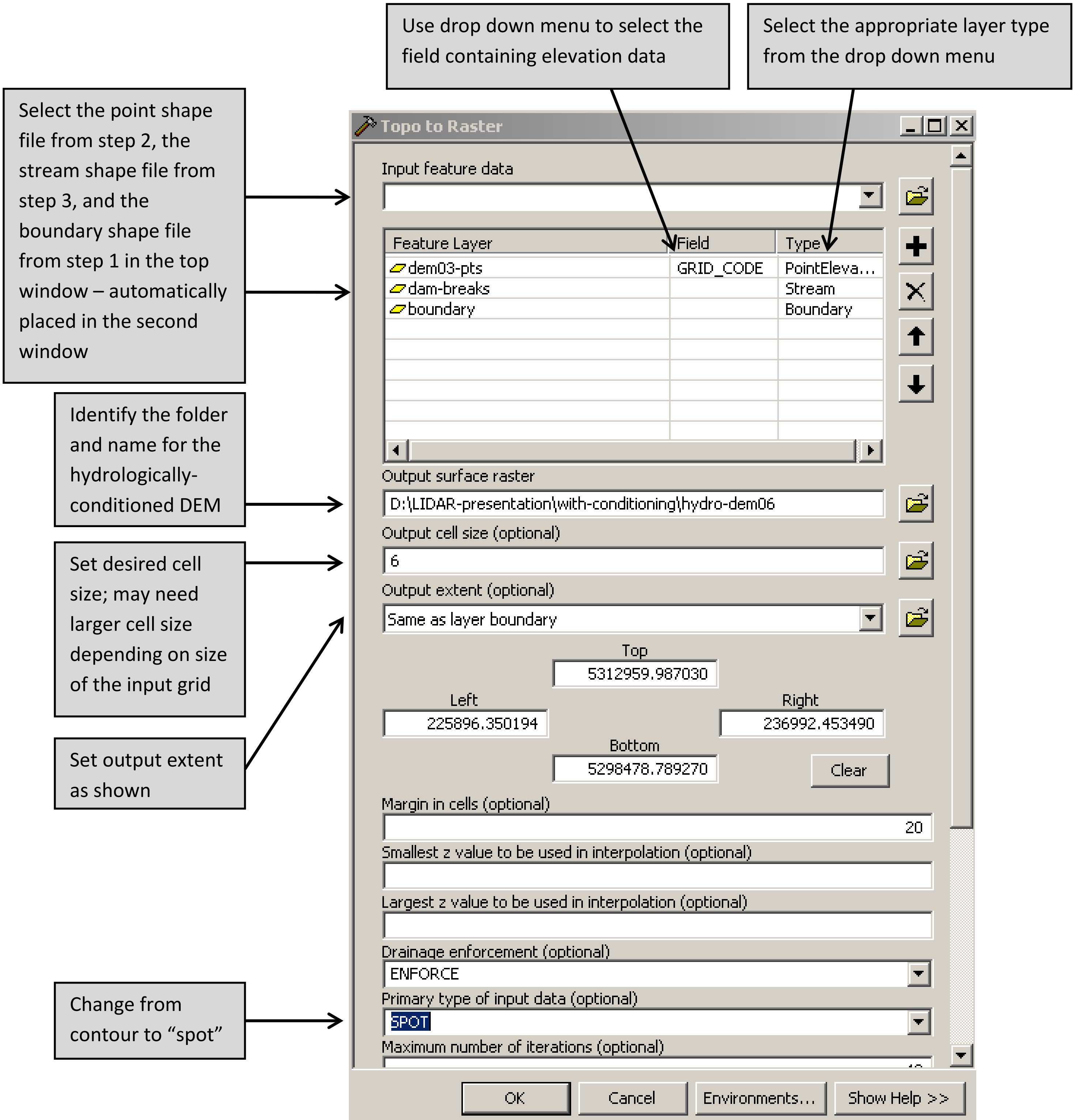
An existing hydrography data layer could be used for this step. But most likely the lines will not be accurate representation of a stream centerline as captured by the LIDAR derived DEM. In addition, the Topo to Grid command requires all stream arcs point in the downstream direction.

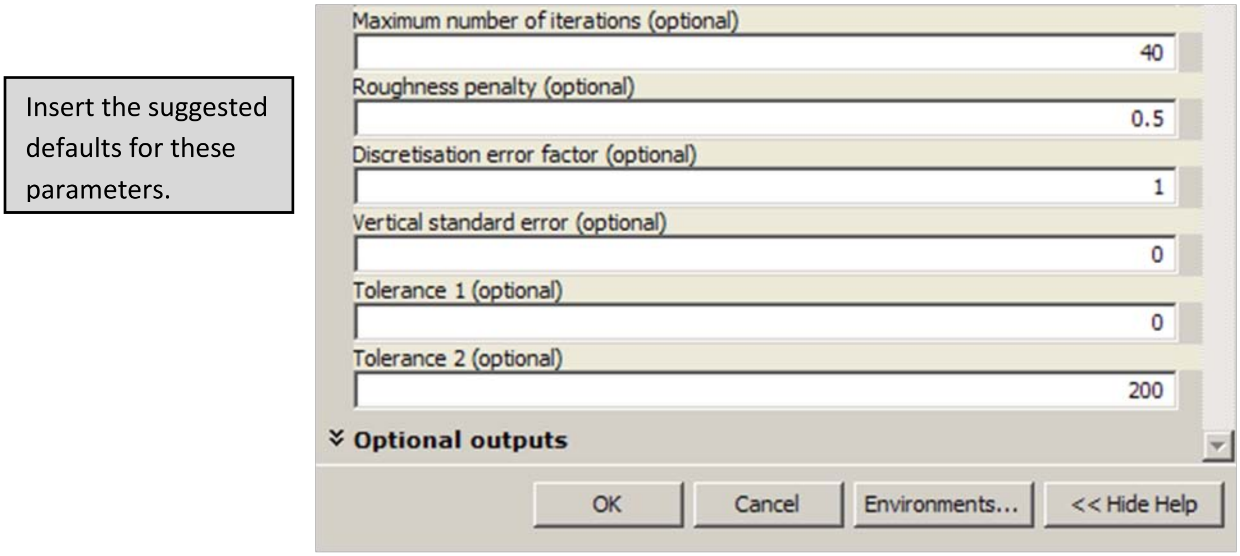


If an existing hydrography shapefile is not used, then a new arc shape file must be created. A new line must be digitized in all locations where it is desired to have a digital dam breached. Start the arc just upstream of the "dam", ending just downstream of the dam. Again, the arc must point in a downstream direction.

4. Create the hydrologically-conditioned DEM

From ArcMap's toolbox, open **3d Analyst Tools : Raster Interpolation : Topo to Raster.** Make the appropriate entries as shown below and select "OK" to run the routine.

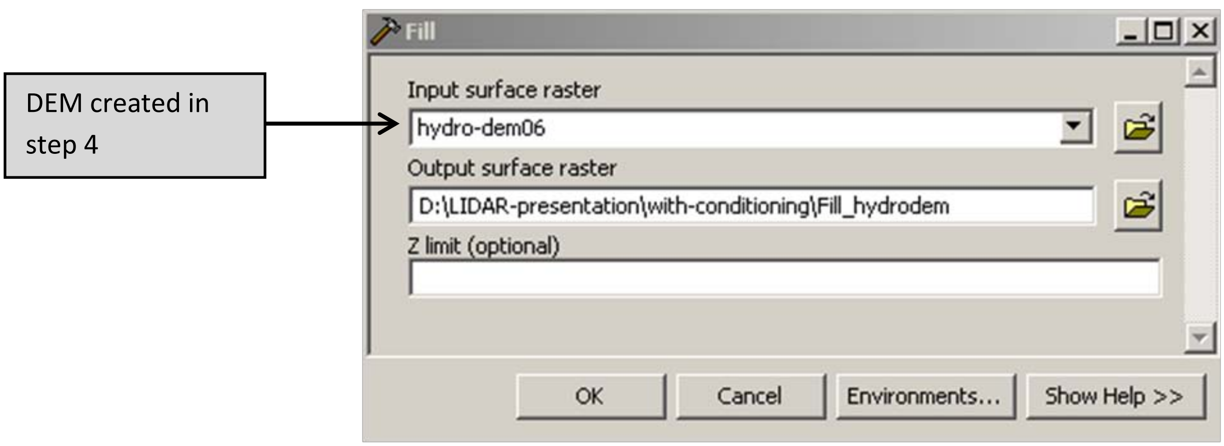




5. Create a digital flow network

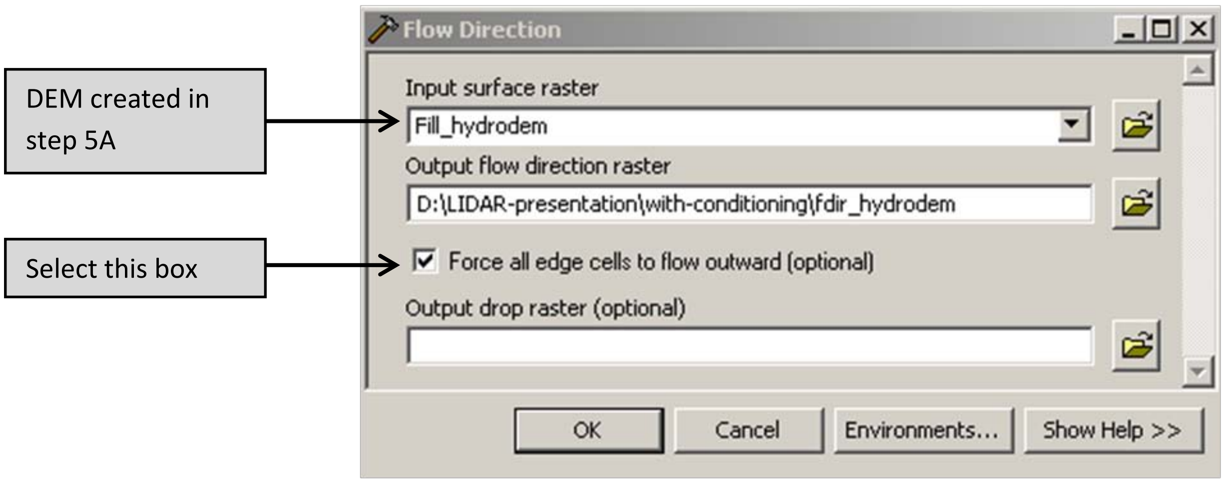
A. Fill Sink

From ArcMap toolbox, open **Spatial Analyst Tools : Hydrology : Fill**. Make the appropriate entries as shown below and select “OK” to run the routine.



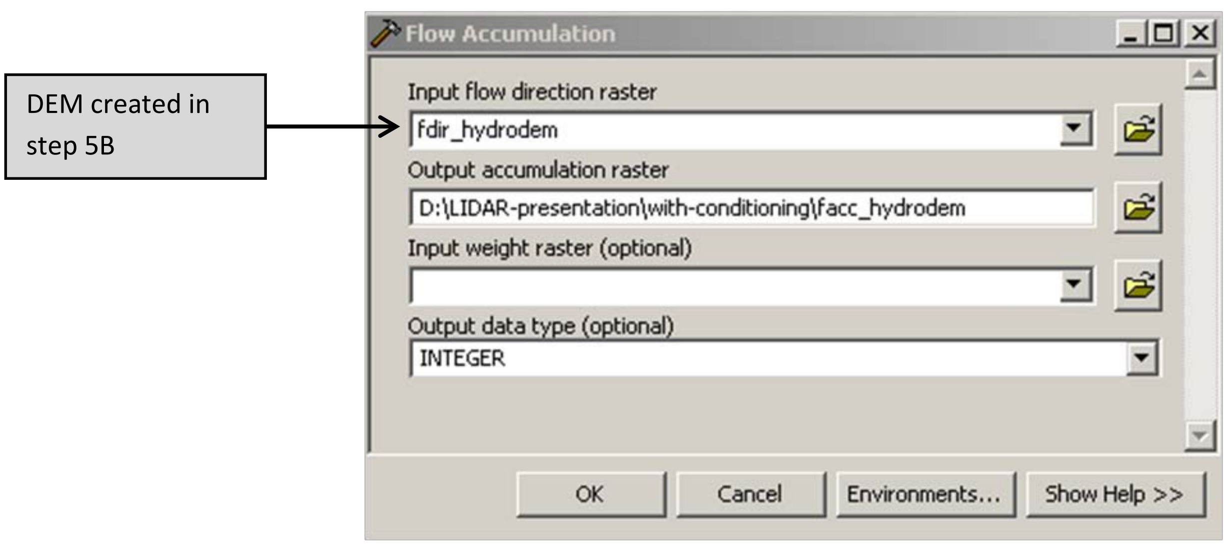
B. Flow Direction

From ArcMap toolbox, open **Spatial Analyst Tools : Hydrology : Flow Direction**. Make the appropriate entries as shown below and select "OK" to run the routine.



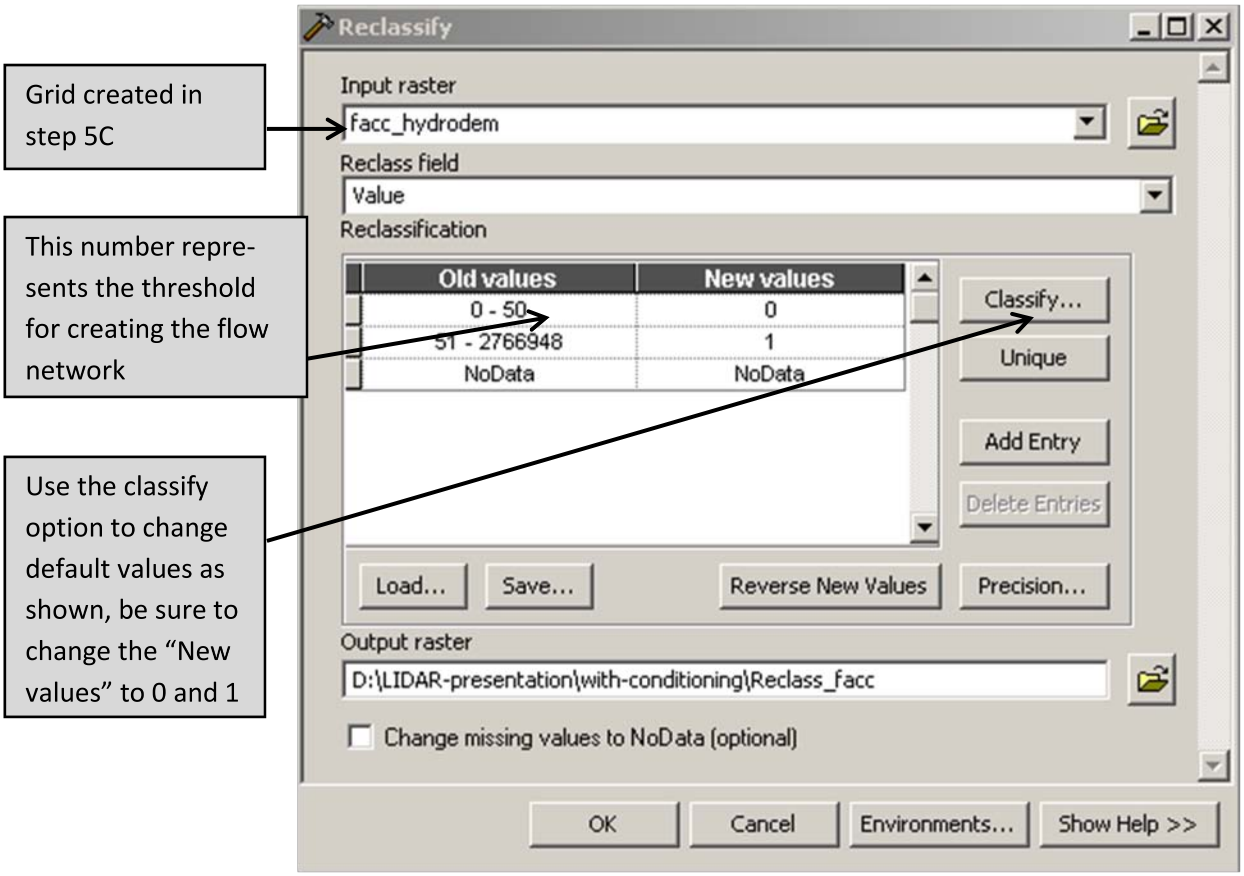
C. Flow Accumulation

From ArcMap toolbox, open **Spatial Analyst Tools : Hydrology : Flow Accumulation**. Make the appropriate entries as shown below and select "OK" to run the routine.

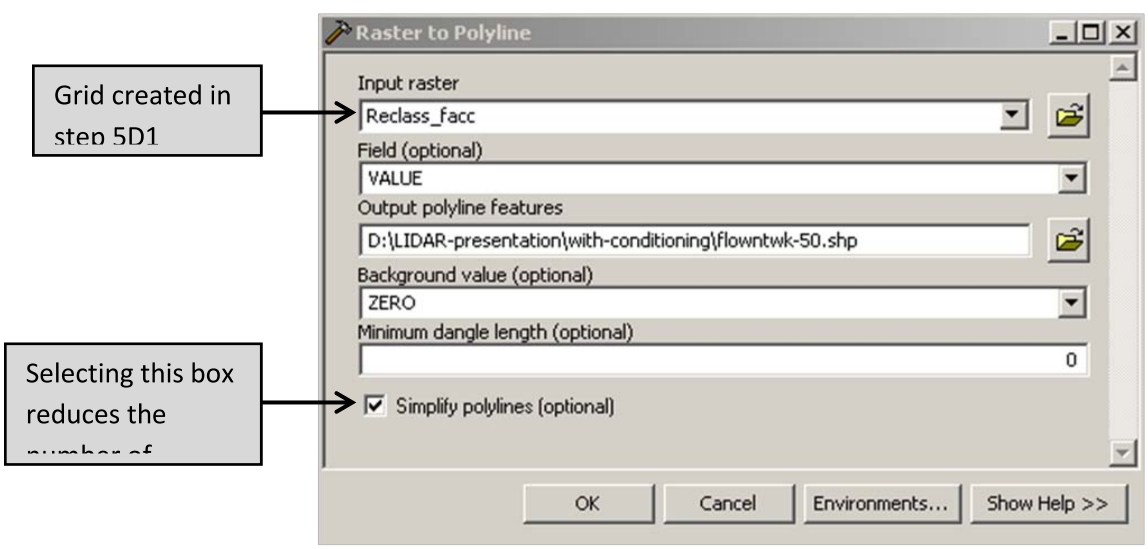


D. Flow Network

(1) From ArcMap toolbox, open **3d Analyst Tools : Raster Reclass : Reclassify**. Make the appropriate entries as shown below and select “OK” to run the routine.



(2) From ArcMap toolbox, open **Conversion Tools : From Raster : Raster to Polyline**. Make the appropriate entries as shown below and select “OK” to run the routine.



6. Iterative process

Review results, repeat steps 3 through 5 as many times as required to achieve desired results. As time and desired level of accuracy dictates, extend to smaller tributaries including road ditches. In lieu of a detailed culvert inventory, field inspection may be required to determine actual flow patterns in some locations.