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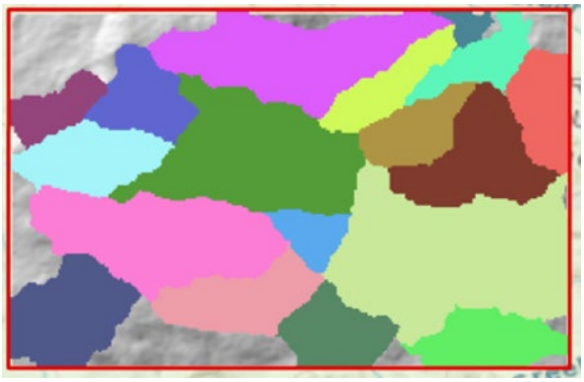
Stream and Watershed Delineation using Raster Functions – Alternative Approach



Introduction

A function chain is similar to model builder in ArcMap but it uses raster functions so the outputs are not saved. Just like model builder function chains can be reused if you are conducting the same workflow on multiple datasets and don't need the intermediate layers. In this exercise we will create a function chain to delineate streams and watersheds in our project area. We will then use zonal statistics to find the mean burn severity for our watersheds. Our project area is in the Brian Head fire which started on June 17th, 2017 and burned over 71,000 acres in southern Utah.

This is an alternative way to generate watersheds for the hydrology exercise. Everything matches the first exercise until **after** section 2.C Flow Accumulation and Mathematical Function.

Objectives

- Create a raster function chain
- Learn how to delineate watersheds

Required Data

- **BH_Fire_DEM_Clipped.tif**– Digital elevation model to run watershed delineation on
- **BH_FiresBoundary.shp –** Partial perimeter of the Brian Head Fire
- **BH_mtbs_burn_sev.tif -** MTBS burn severity layer
- **PourPoints.tif**

Prerequisites

- **Install Esri ArcGIS Pro on computer**

- **Have the Spatial Analyst extension**

Table of Contents

Part 1: Set up ArcGIS Pro and Hillshade

Open Pro and load the data for this exercise. You can also insert another map if you already have a project going (Insert tab, Project group, New Map).

A. Load the AOI

1. Launch Pro from the start menu by clicking **Start, Programs, ArcGIS Pro**
2. In the Map tab click the **Add Data** button and navigate to where you placed the course material.
3. In the Watershed_Exercise folder Select **BH_Fire_DEM_Clipped.tif, BH_FiresBoundary.shp, BH_mtbs_burn_sev.tif, PourPoints.tif** and click **Add**.

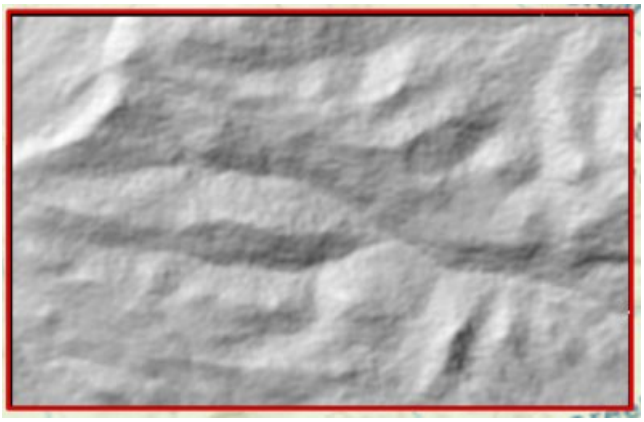
B. Change Basemap

1. Click **Map** tab, in the **Layer** group, select **Imagery**

c. Create Hillshade

Hillshade will help you visualize what the land looks like. Take a quick look around the image and see if you can find where, if present, water would flow.

1. In the Imagery tab, in the Analysis Group, select Raster Functions to open the raster functions pane. Search for **Hillshade** and click to open
2. For **Raster** select **BH_Fire_DEM_Clipped.tif**
3. Keep rest of the parameters as the **defaults**
4. Select **Create New Layer**

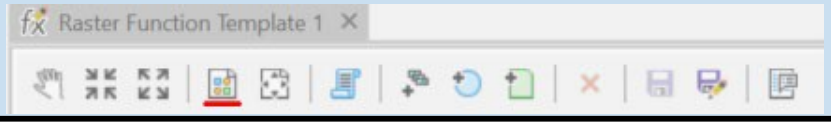


Hillshade

Part 2: Building Raster Function Chain

In this part we will build a raster function chain which is very similar to a Model Builder chain. It will allow us to combine a long process and produce a single image verse generating a single image for each step. Although we will only run this chain twice in the exercise, you can save and run the chain at any step in the process to produce a raster layer for that piece.

NOTE: *At any point in this process you can use the Auto Layout Button to automatically reorganize your function chain into clean and logical layout.*



A. Fill Function

1. **Open** the **Function Editor** via the Imagery tab, in the Analysis Group

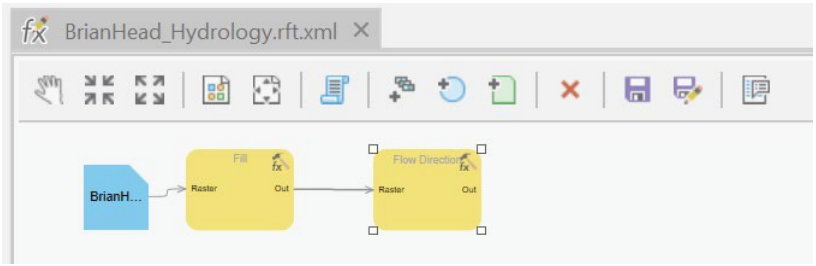
2. **Open** the **Raster Functions** pane in the same group
3. In the Raster Function pane, System section **Scroll** down to the **Hydrology** section
4. **Drag and drop** the **Fill function** into the template
   i. This tool will fill in sinks in a surface raster to remove small imperfections in the data
5. **Double click** the Fill function. Under **Raster** select the Brian Head DEM.
6. Keep the rest at **default.** The Z limit specifies a minimum depth of sinks to fill. In this case we want to fill all sinks so leave this blank.
7. Click **ok**
   i. Notice how a blue box with a dog ear corner is added to your function template with a grey arrow pointing to the input raster in the Fill Function. This is one way you can connect your chain.
8. **Save** the Raster Function Template with the name of **BrianHead_Stream**. In the description write something simple like stream delineation exercise.
9. Click **Save**
10. In the **Raster Function** pane check the **Custom tab**. You should be able to see the function chain that you just saved. This is what you click on to run/ execute your function chain.

B. Flow Direction Function

1. In the raster functions pane click on the System tab. **Drag and drop** the **Flow Direction Function** from the Raster Function pane to the function editor pane.
   i. This tool creates a raster of flow direction from each cell to its steepest downslope neighbor. Knowing which direction each cell flows, allows the flow accumulation process

to determine the number of cells that "pour" into any given cell in the flow accumulation raster.

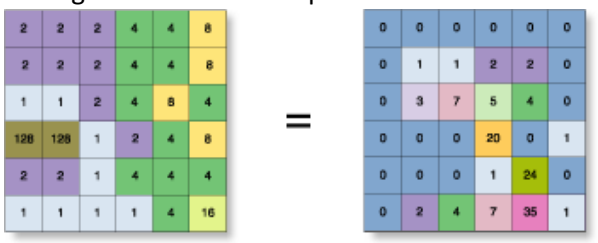
2. **Click** on the left side **(Out)** of the **Fill Function** and **drag** your arrow to the right side **(Raster)** of the **Flow Direction** function square. This is the second way you can connect functions.
   i. **Double click** the **Flow Direction** square to open the function properties. Notice how the Raster section is auto populated with the output of the Fill raster.



   ii. Click **ok**

C. Flow Accumulation and Mathematical Functions

1. Click and drag the **Flow Accumulation** function from the Raster functions pane to the function editor pane. Connect the Out of the **Flow Direction** square to the **upper left (Flow)** of the **Flow Accumulation** square
   i. This function uses Flow Direction raster and creates an accumulation grid where each cell is assigned a value that represents the total number of cells that drain into each cell.

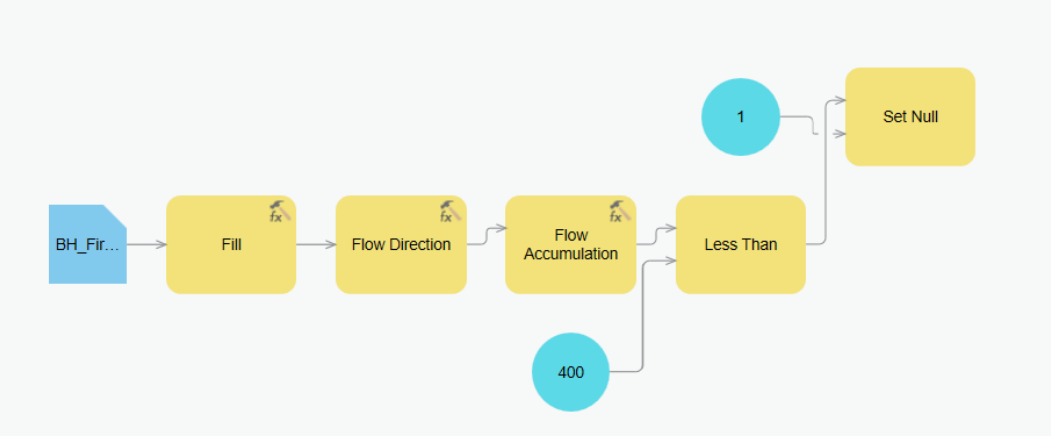


2. Next you will define the "number of cells" from upstream flow that makes something a stream. This threshold defines streams and can be defined so that only large, primary streams are captured, or so that smaller, more ephemeral streams are also included. The result is a binary image that outlines what the water course network would look like.
3. In the Raster Functions pane, Math: Logical section add the **Less Than** function and **connect** the **Flow Accumulation (out)** to the top left side **(Raster)** of the Less Than square

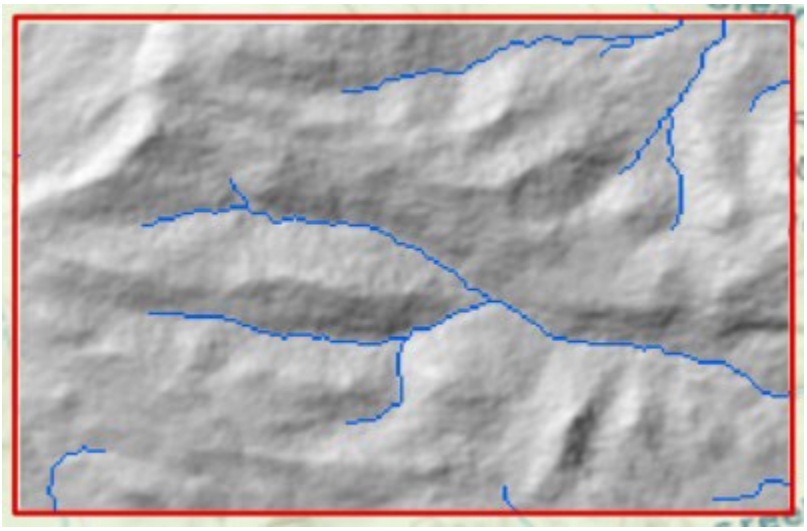
4. **Add** a constant by **selecting** the circle from the function chain editor.
5. **Double click** on the circle and type in **400**

Note: A good rule of thumb for this value is to start with 1% of the overall area. If this does not produce a detailed enough stream network, then try using a lower number—thus requiring a lower threshold of cells flowing into a cell to call it a stream

6. **Connect** the **400 constant circle** to the lower left side **(Raster2)** of the Less Than square
7. **Add** the **Set Null** Function from the Math: Conditional section
8. Add another **constant circle** and fill in the circle with a 1.
9. **Connect** the **1 constant circle** to the lower left side **(False)** of the Set Null raster function



10. **Connect** Less Than **(Out)** to the Set Null **(Raster)**
11. **Click AutoLayout** from the Function Editor window
12. **Save** the chain.
13. View your results so far by going to the Custom tab in the raster function pane. Click on your Brian Head Hydrology tool and click **Create new layer** to view your results.



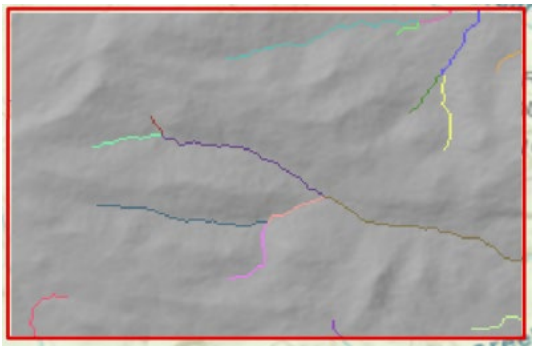
Result of the flow accumulation raster after the less than and set null functions were applied. It's draped over the study area hillshade.

A. Stream Link Function

1. **Add** the **Stream Link** Function

i. Assigns unique values to sections of a raster linear network between intersections.

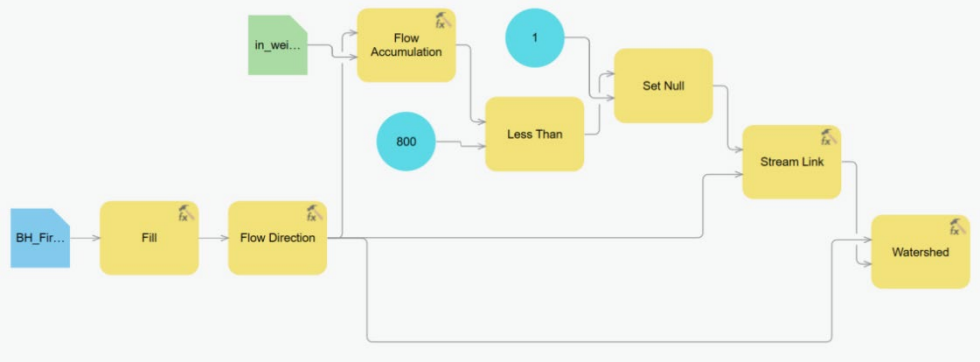
2. Connect **Flow Direction (Out)** to the lower right side **(Flow)** on the Stream Link box
3. Connect the **Set Null (Out)** to the upper right side **(stream)** of the Stream Link box
4. **Change** the **400** constant circle to **800**



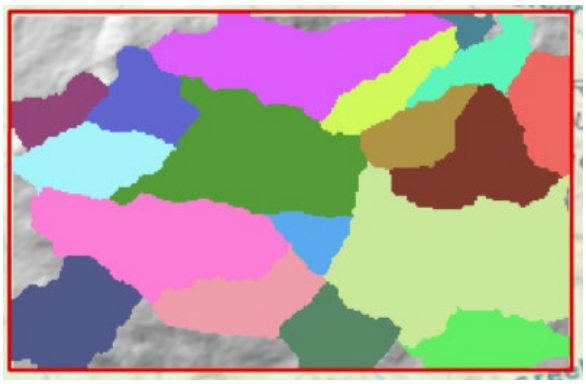
Result of the stream link function showing 18 different stream tributaries.

B. Watershed Function

1. **Add** the Watershed function next
   i. This Function determines the contributing area above a set of cells in a raster.
2. Connect the **Stream Link (Out)** to the lower left side **(Pour)** on the Watershed box
3. Connect the **Flow Direction (Out)** box to the top left side **(Flow)** on the Watershed Box
4. **Double click** on the Watershed box and make sure **Value** is selected for the **Pour Point Field**



5. **Adjust** your layout if needed and **Save** the Chain
6. In **Custom** on the Raster Functions **double-click** the BrianHead_Hydrology chain you are creating and click **Create new Layer**



Watershed function result with 18 different watersheds.

14. visualize how water flows across the landscape (See result below)

Part 3: Apply Zonal Statistics

Now that we have our watersheds, we can run zonal stats to assess the burn severity for these three areas from the Brian Head fire.

A. Zonal Stats Function

1. In the Raster function pane search for **Zonal Statistics.** Zonal statistics allows us to calculate statistics of an input raster inside our features or "zones" of interest. In this case we are interested in finding mean burn severity for our watershed output.
2. Open the **Zonal Statistics** Function
3. For **Zone Raster** select **BrianHead_Watershed**
4. In the **Zone Field** select **Value**
5. For the **Value Raster** select **BH_mtbs_burn_sev.tif**
6. Make sure **Statistics Type** is set to **Mean.**
7. Leave the rest as the default.
8. Click **Create new layer**

B. Apply Symbology

Let's apply an easier to understand symbology to our zonal stats layer

1. In the Table of Contents, right click on the color ramp under your Zonal Stats layer

2. Use the drop-down menu to change the color ramp to something more intuitive such as green to red.
3. Inspect your results. We can see that the northern area has more high burn severity than the southeast. And there is moderate-high severity throughout the mid-section watersheds.

Congratulations! You have successfully completed this exercise. You now know how to use function chains to easily save and replicate workflows! You also learned how to delineate streams and create watersheds using faster functions. Hydrology geoprocessing tools can take a long time to run. Using raster functions is an excellent way to quickly visualize streams and watersheds. If you were interested in conducting more robust hydrologic modeling you may want to use geoprocessing tools, but this workflow can easily be replicated with geoprocessing.