GEOG 4140/6140 – Winter 2021
Lab 8: Terrain Analysis
Due Thursday, March 25th by 11:59 PM

Overview

Terrain analysis can be used for many different purposes, from delineating watersheds to estimating construction costs, and much more. In this lab, you will be analyzing the flood risk for areas in the Salt Lake Valley if the Red Butte Reservoir dam were to fail. This instance is a highly simplified version of the task, but similar analysis is often conducted prior to the construction of a new dam to properly understand the risks posed to populations living downstream of the proposed dam. In completing this lab, you will start with only an elevation raster from which you will create a feature class representing Red Butte Creek, and generate a product representing flood risk in the watershed of the creek.

The following resource may be of use in completing this assignment:
How Fill works
Fill
How Flow Direction works
Flow Direction
How Flow Accumulation works
Flow Accumulation
Identifying stream networks
Conditional evaluation with Con
Con
How Stream Order works
Stream Order
How Stream to Feature works
Stream to Feature
Understanding Euclidean distance analysis
Euclidean Direction
How cost distance tools work
Cost Distance function
Understanding path distance analysis
How the path distance tools work
Path Distance
How Watershed works
Watershed

Required Data (*Sources*)

1. Elevation raster (*Lab data on Canvas*)

Workflow

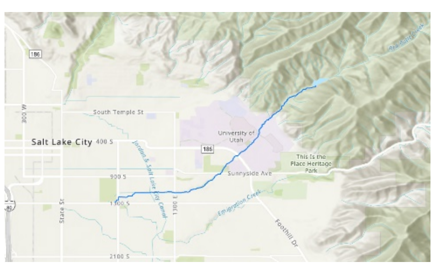
1. Open ArcGIS Pro and create a new project titled *Lab08YourLastName* in your working directory for this lab.
    a. Export the Lab 8 elevation raster to your Lab 8 geodatabase, and add the raster to a new map.

2. When analyzing surface water flow, cells lower than all the surrounding cells (called sinks) will prevent various analysis tools from working properly.
    a. To avoid such issues, use the **Fill** tool to eliminate the sinks in your elevation raster.
    b. Use the filled raster for the next step.

3. To delineate a stream network, we need to calculate the flow accumulation for each cell; flow accumulation represents the number of upstream cells in a raster that flow into each respective cell.
    a. Before using the Flow Accumulation tool, we need to run the **Flow Direction** tool using the raster created in step 2.
    b. The number of upstream cells can be calculated using the **Flow Accumulation** tool.
        i. Utilize only the required fields for the Flow Accumulation tool, and leave the other fields as blank or default.

4. From the flow accumulation raster you can now begin to delineate the stream network. Information on this process can be found at the *Identifying stream networks* link provided above.
    a. A threshold value is needed in the multistep process of delineating the stream network. For this assignment, a threshold of 15,000 should work well.
    b. Once the stream network is delineated, order the streams using the **Stream Order** tool.

5. To continue this analysis, convert the ordered stream raster to a vector layer.
    a. There are several options for converting a raster layer to vector layer, but the **Stream to Feature** tool is designed for this and will provide the best result.
    b. After converting the data from raster to vector form, delete all streams that are not Red Butte Creek.
        i. Make sure that the line feature for Red Butte Creek runs from the Red Butte Reservoir to Liberty Park as shown in the image below.



        ii. If your line feature is split into two segments, consider running the **Dissolve** tool.

6. To approximate flood hazard, you will need to analyze the cost of moving outward from the stream. This will require multiple inputs, one of which is the filled elevation raster you created in Step 2, the other is a raster representing whether a given cell slopes towards or away from the stream.
    a. First, you will need to calculate the **aspect** of each cell in the elevation raster.
        i. Set all areas where the aspect is flat to a **null** value before proceeding.
    b. You will also need a raster that represents the **direction** from each cell to the closest part of the stream layer.
    c. After creating these two rasters, you will need to use the **Raster Calculator** to convert them from degrees to radians so we can use them for further analysis. (Radians = Degrees * 0.0174533)
    d. Once you have converted both rasters to radians, the cost input parameter can be created using the following steps:
        i. Using the **Raster Calculator**: Cost=(Sin(Aspect)*Sin(Direction))+(Cos(Aspect)*Cos(Direction))
        ii. Use the **IsNull** tool, followed by the **Con** tool, to set all the areas that are currently null values to 0.
        iii. In order to use this as an input in future steps, all the values need to be positive. Use the **Raster Calculator** again to change all the values in the raster so they range from 0 to 2, rather than -1 to 1. ("input_raster" + 1)

7. Now that you have created the cost parameter, you can calculate the cost of traveling from the stream to each cell in the raster, which corresponds roughly to the flood risk posed by a breach in the dam of Red Butte Reservoir. This output can be created using either the **Cost Distance** or the **Path Distance** tool; for this lab you should use the one that takes ground distance into account.

8. Create a polygon representing the watershed for Red Butte Creek using the **Watershed** tool.
    a. The Watershed tool requires two inputs: the flow direction raster (step 3) and the Red Butte Creek line feature (step 5).
    b. Use the Extract by Mask tool to clip your output from step 7 to the watershed boundary.

9. Create a layout map showing Red Butte Creek and the calculated flood risk. Make sure that your symbology for the flood risk shows variations in risk between locations in the valley, rather than just between the mountains and the valley. Be sure to include all required map elements. **(Deliverable 1)**

Deliverables

1. A map of Red Butte Creek and the flood risk calculated for its watershed. (18 points)

2. Describe some additional data that might help increase the accuracy of this analysis. (2 points)

3. Why might displaying the flood hazard for only the watershed be a limited choice for this specific scenario? (1 point)