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# Laboratory Exercise - Calculating the Volume of Material Displaced by Mount St. Helens Eruption of 1980

Donald Anderson

Alex Fisher

Ken Lippold

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# Laboratory Exercise - Calculating the Volume of Material Displaced by Mount St. Helens Eruption of 1980

## Background

There are several active volcanoes in the state of Washington. On May 18, 1980, one of these volcanoes, Mount St. Helens, erupted. On March 1, 1980, the University of Washington set up a seismograph in the area to monitor the volcano's activity. On March 20, a minor earthquake was recorded under Mount St. Helens and the entire area was put on alert. Thanks to this warning, the locals were able to evacuate before the mountain erupted. Before fully erupting, some steam and ash was seen billowing out of the top, and on May 18, the volcano was ready to blow. The mountain bulged and exploded out to the side. Superheated gases and magma poured out to the side and in an instant, a supersonic cloud wiped out everything within 8 miles of the mountain. Afterward, a billowing 12 mile high cloud containing 540 million tons of ash drifted east across the United States.



*Figure 1 - Photo of the Mt. Saint Helens crater.*

## Problem Statement

This lab activity uses DEM data provided by the University of Washington from before and after the 1980 eruption. You will analyze the elevation change and crater area to determine the total change in volume of the volcano.

Though not required for this activity, this type of analysis can be used for more advanced applications such as calculating airborne ash volumes, and mapping topographical changes in the surrounding landscape. Depending on the quality of the DEM data, you could analyze anything from a volcanic eruption to a landslide or earthquake.

## **Spatial Considerations**

Only the crater area should be analyzed for this lab. The full area could be analyzed but for the purposes of this lab, only the change in volume of the crater is required. Additionally, the DEMs only cover a relatively small area, so analyzing anything beyond the crater will not likely provide any useful information.

Due to the quality of the available DEM data, this analysis should provide an approximate value for the volume change of the volcano and fall within a range of previously estimated values of about 2.7 to 2.9 cubic kilometers.

## **Data**

- <http://gis.ess.washington.edu/data/raster/thirtymeter/mtsthelens/index.html> OldMtStHelens DEM and q2323 30 m DEM. Use the pre-eruption Mt. Saint Helens DEM and the *new DEM* hyperlink. These are in units of 30x30 meters for each cell. These DEMs have a relatively low resolution considering the small size of the area, but they will have to be sufficient since the old mountain topography no longer exists and cannot be measured again.

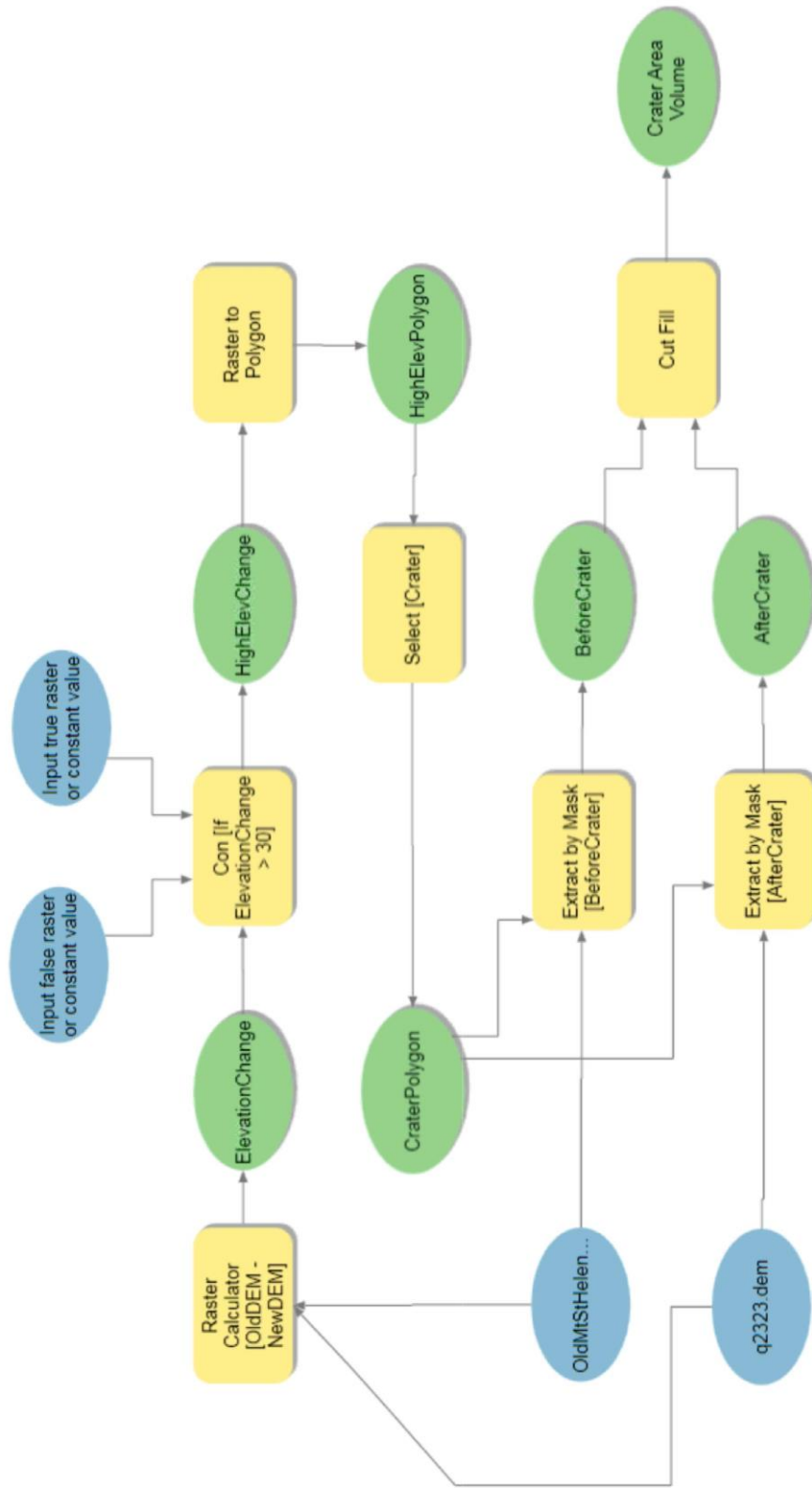
## **ModelBuilder Tools**

In this exercise you may use previous tools and will use the following new tools.

- Raster Calculator: Performs algebra on raster datasets to form a raster with the new values in each cell.
- Con: Passes a raster through a conditional statement in order to transform it. This is essentially an if-else statement.
- Raster to Polygon: Converts a raster to a polygon shapefile.
- Select: Selects a specific area or attribute among a group of items. Used to pick out the crater area from the polygon shapefile.
- Extract by Mask: Extracts an area from a raster. The mask, or cutting surface is the crater. The surface is the DEM.
- Cut Fill: Typically used for cut fill applications (such as in construction), this tool is used to calculate the volume and areas of cuts and fills based on two input rasters.



# Example Model







## Step by Step Solution

For an advanced GIS student, the information up to this point is all you need to complete the assignment and create an output map from the results. Feel free to try conducting the analysis using only the information provided above. If you need specific steps, follow the instructions.

### Step 1

To find the area of the crater, a raster calculation must be made. This calculation will be computed by subtracting the elevation values of the New Mount St. Helens DEM from the old DEM. You will end up with a DEM that shows the elevation change for each 30m by 30m cell. The formula is  $OldMtStHelens - q2323$ . If done correctly, a new DEM with a high contrasting crater should be produced. This makes sense as the crater before and after the eruption are completely different in elevation. The elevation change raster reflects this extreme change in elevation.

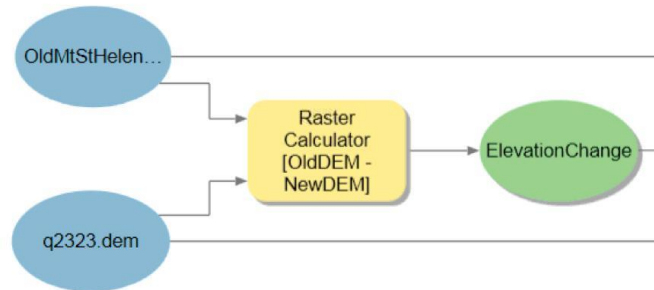


Figure 2 - Using the Raster Calculator in ModelBuilder.

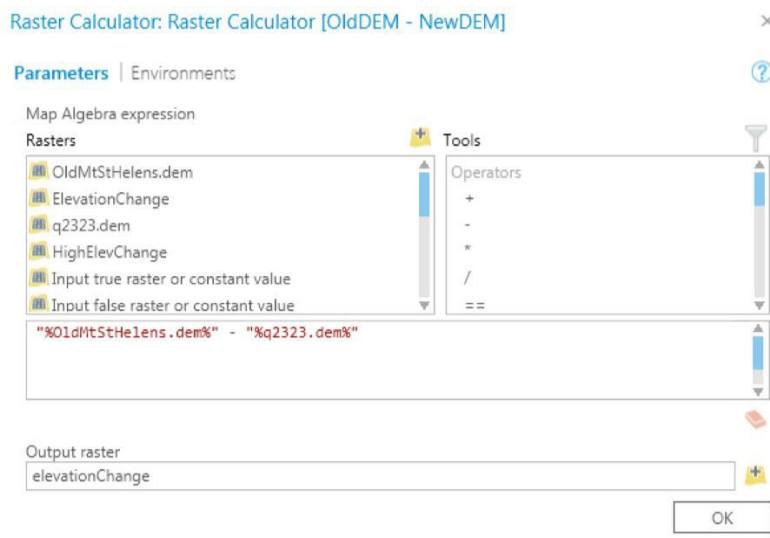


Figure 3 - Settings for the Raster Calculator tool.





## Step 2

Con, which stands for conditional, is used to highlight areas of significant elevation change. In this case, any area with a change of elevation of greater than 30m is assigned a value of 1 in a raster. All other areas are assigned a value of 0. This is one way to insert an if else statement in ArcMap. Since the crater does not have a well-defined ridge for its entire circumference, this is a useful method for defining the area of the crater.

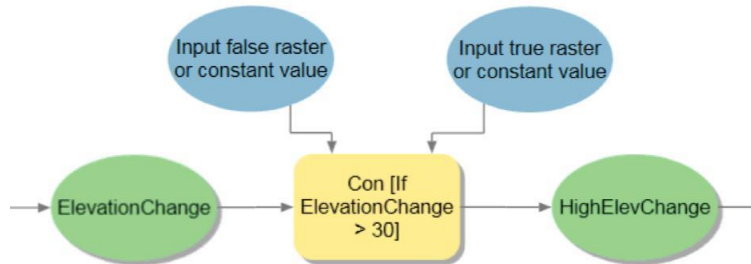


Figure 4 - Using the Con tool in ModelBuilder.

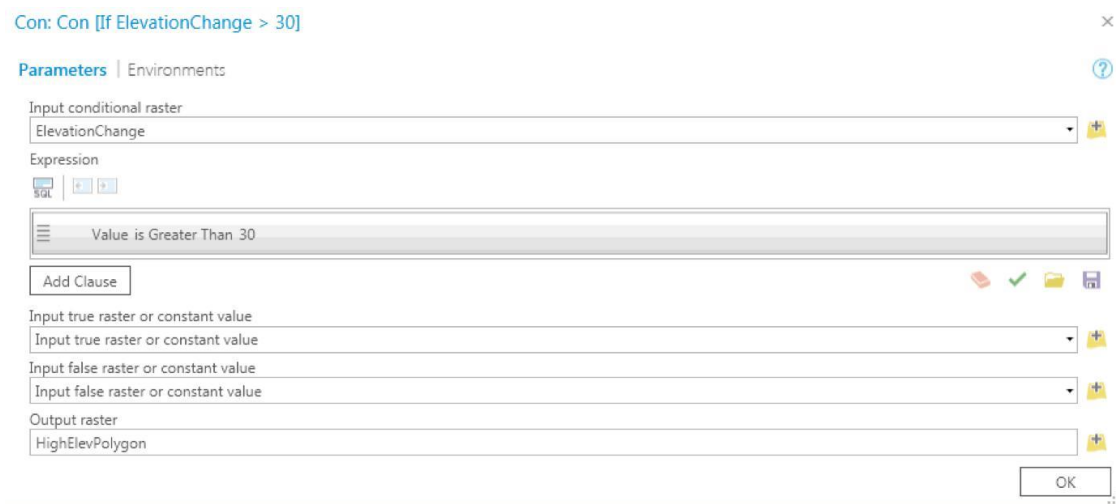


Figure 5 - Settings for the Con tool.

## Step 3

The HighElevChange raster reflects areas with significant elevation changes, i.e., areas which were ejected off the mountain during eruption. From observing this DEM, though the core of the shading is in the crater, there are a few outlying spaces which had considerable change in elevation. This lab involves the crater, so these outliers must be neglected. The raster is transformed into a polygon. At this point, you should run the model to obtain a polygon of high



elevation change areas. You should then use the select tool to select the crater, which should be the second largest polygon in the shapefile. The result is a polygon file which represents the Mt. Saint Helens crater.

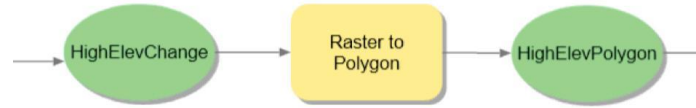


Figure 6 - Using the Raster to Polygon tool in ModelBuilder.

#### Step 4

Now that the crater area is determined, the HighElevPolygon file can be used with the extract by mask tool. In brief, the before and after DEM will be the base rasters and the crater polygon will be the mask. The extract by mask tool will cut out the polygon area from the main DEMs, which will result in two crater sized DEMs. This allows us to ignore any data outside the crater area. Now that only the crater area is left.

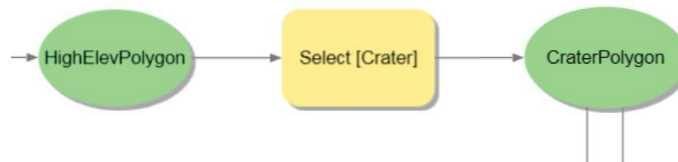


Figure 7 - Using the Select tool in ModelBuilder.



Figure 8 - Settings for the Select tool.



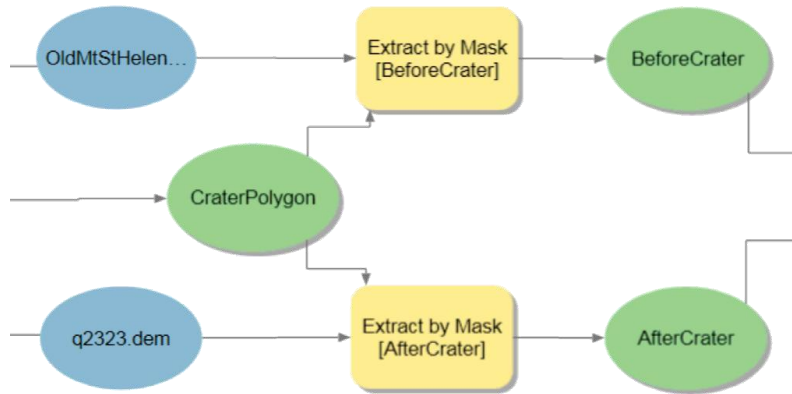


Figure 9 - Using the Extract by Mask tool in ModelBuilder.

### Step 5

The Cut Fill tool will compare the BeforeCrater and AfterCrater DEMs and determine areas which experienced a volume loss, neutrality, or gain. This by itself is not very helpful. However, by going to the Crater Area Volume's attribute table, you will see that the change in volume and crater area have been calculated.

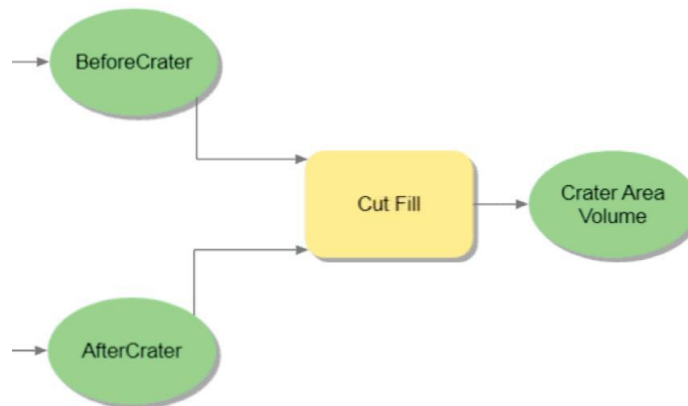


Figure 10 - Using the Cut Fill tool in ModelBuilder.



## Deliverables

Once completed, submit your Model Builder process chart in its entirety and a map that demonstrates how you analyzed the included data and the results. Your map should conform to generally accepted cartography standards and should include at minimum, a scale bar, north arrow, and legend (see the following rubric). Your report should explain your Model Builder process and how it works. Make sure to provide any equations you used in your calculations and feel free to share any challenges you faced as you performed this analysis. Make sure to review the rubric at the end of this chapter for the full requirements for the laboratory exercise.

## References

Bagley, Mary. "Mount St. Helens Eruption: Facts & Information." 2013. Web.  
[https:// www.livescience.com/27553-mount-st-helens-eruption.html](https://www.livescience.com/27553-mount-st-helens-eruption.html).

Brantley, Steve and Myers, Bobbie. *Mount St. Helens – from the 1980 Eruption to 2000*. United States Geological Survey Print.  
[https:// pubs.usgs.gov/fs/2000/fs036-00/](https://pubs.usgs.gov/fs/2000/fs036-00/).

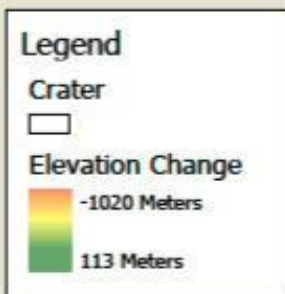
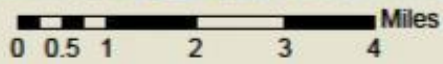
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Example Map

# Volcano Crater Volume



Volcano Lab  
Name  
Date  
Projection



