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Volcanic Hazard Assessment of Southern Iceland

Helper, GIS 327G

Introduction:

Iceland is an island nation far in the northern hemisphere, with a portion of the country included in the Arctic Circle. Its position over a magmatic hotspot and the Atlantic mid-ocean ridge cause it to have a very unique and active volcanic setting. Because of this, Icelandic people are very accustomed to responding to volcanic hazards, and it is essential to understand the possible risks involved with living near these active volcanoes. One major hazard associated with volcanism is lahars, or jökulhlaups in Icelandic. In Iceland, these form from the rapid melting of glaciers and snow and the addition of large quantities of volcanic material. These are very large, and sometimes hot, mudslides that even occur without a present eruption and have killed many people. This project used ArcMap to predict potential flow paths of lahars from three major volcanoes in southern Iceland: Hekla, Katla, and Eyjafjallajökull. These three volcanoes were chosen due to their close proximity to each other and towns. These volcanoes also have active histories. The end goal is to produce maps that highlight these hazards, as well as towns and roads that may stand in their way.

Data Collection

- Roads, towns, rivers: <https://www.lmi.is/en/stafraen-gogn/>
- Country border: <https://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2/gis-files/iceland-shapefile>
- Volcano locations: <http://volcano.si.edu/volcano.cfm?vn=372070>
- Elevation data: gdex.cr.usgs.gov
- Population data: <http://worldpopulationreview.com/countries/iceland-population/>

Data Preprocessing

First I made a personal geodatabase where I was able to create a raster catalog. I used a 30 meter ASTER Global DEM V2 data with a GCS WGS 1984 datum on gdex (Figure 1) to get a of rasters with elevation data of Iceland. It was downloaded in 5 segments as a Geotiff file and then imported it into the raster catalog.

Then I created a new document with the layer to have the ISN_1993_Lambert_1993 coordinate system. I uploaded all of the shapefiles to a new a document with a GCS WGS 1984 datum and. In order to put import the locations of the three volcanoes being studied, I made an excel sheet to import into ArcMap. Once I imported the data I was able to convert it into a point feature class.

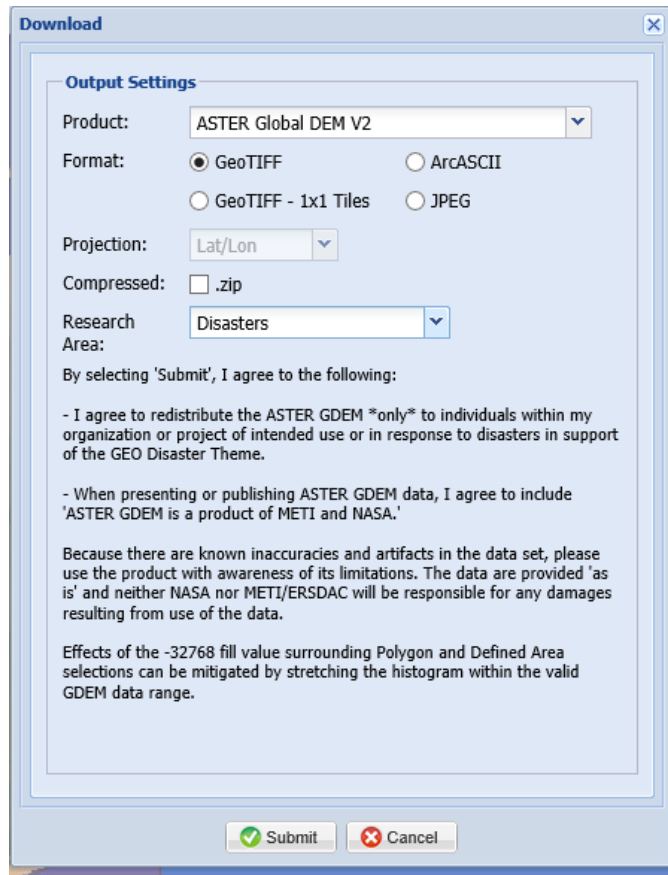


Figure 1: Settings for elevation data

Data Processing and Analysis

The highly detailed ASTER DEM was exceptional, but it also proved to be very large and slow to process. At first I combined all the rasters into one using the “Mosaic to New Raster” tool, but then ended up only using a singular raster that covered the area of interest. I made a hillshade of the southern region as well to make ArcMap run faster using the same individual raster. This was done by using the “Hillshade” tool in the Spatial Analysis toolbox (Figure 2).

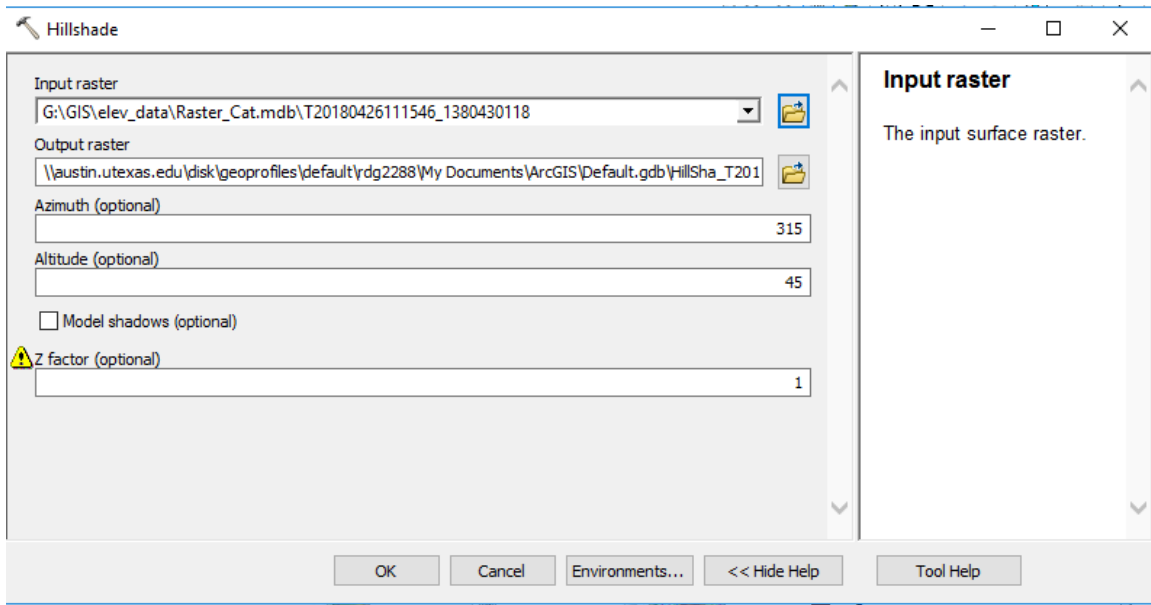


Figure 2: Creating a hillshade of the ASTER DEM in Southern Iceland

The elevation was symbolized with 50% transparency over the hillshade. This resulted for the map to look like Figure 3.

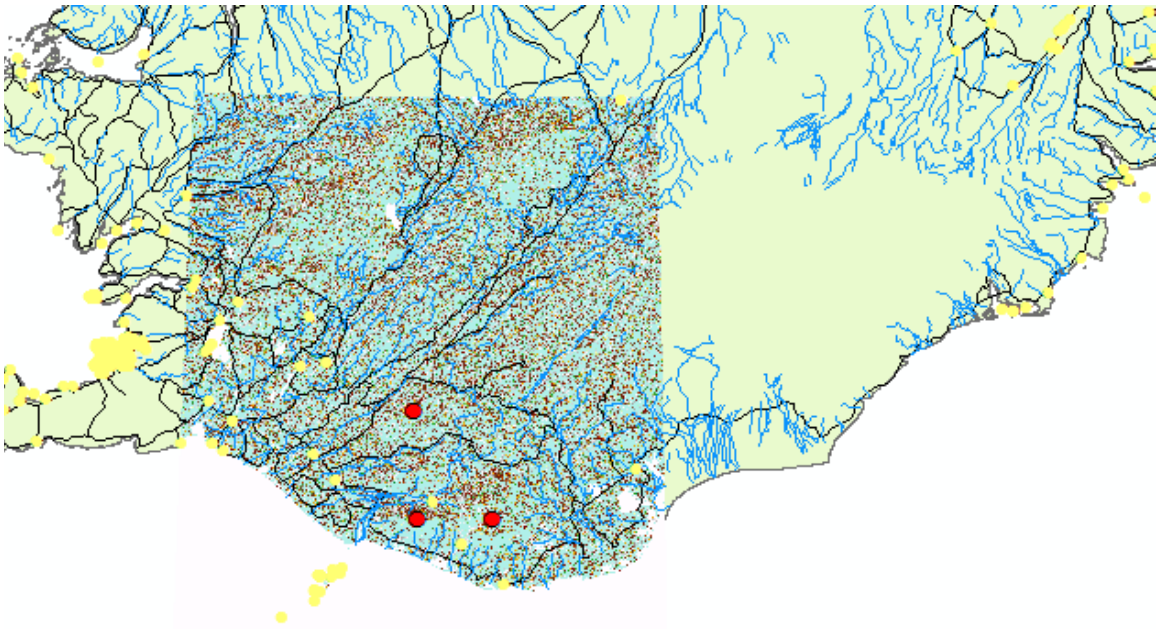


Figure 3: Results from shapefiles and hillshade

Buffers were used as boundaries for the lahar risk zones. The buffers can also be used to assess tephra fall, but it isn't as big of a hazard unlike lahars. The buffer around each volcano was set to 25 km. These were set with two things in mind: lahars have been recorded as being capable of flowing hundreds of kilometers from their source, and these volcanoes are at the southern edge of

the Icelandic highlands by the south shore. Hence, I made the buffer big enough for Katla and Eyjafjallajökull buffers will hit the sea. I also changed the method into geodesic (Figure 4), and I changed the output coordinate settings to ISN_1993_Lambert_1993 (Figure 5).

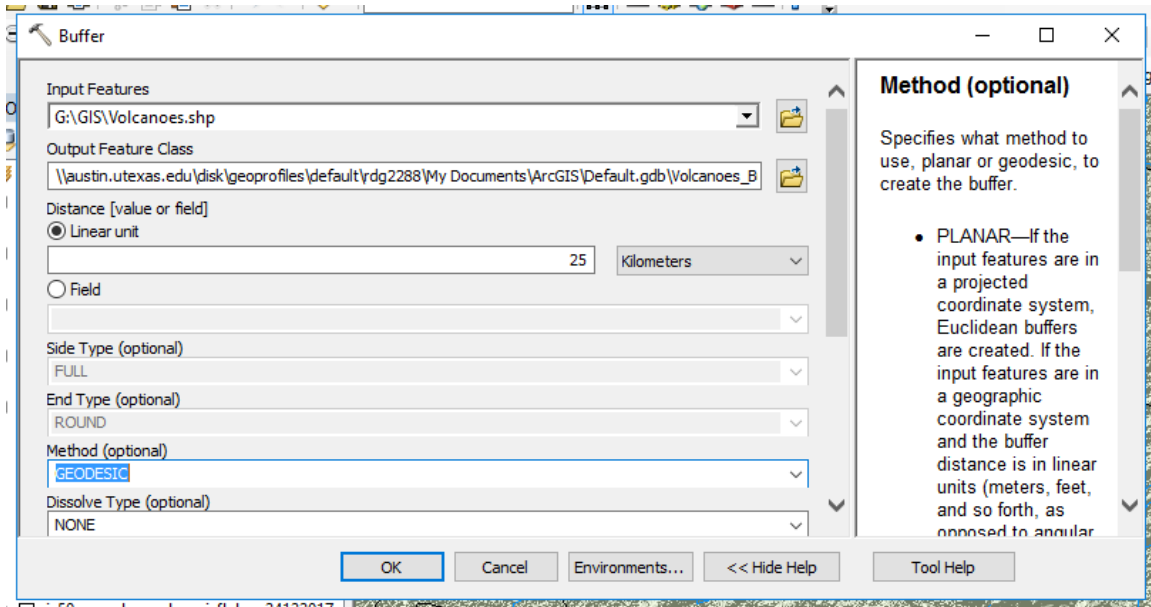


Figure 4: Settings for buffer of each volcano

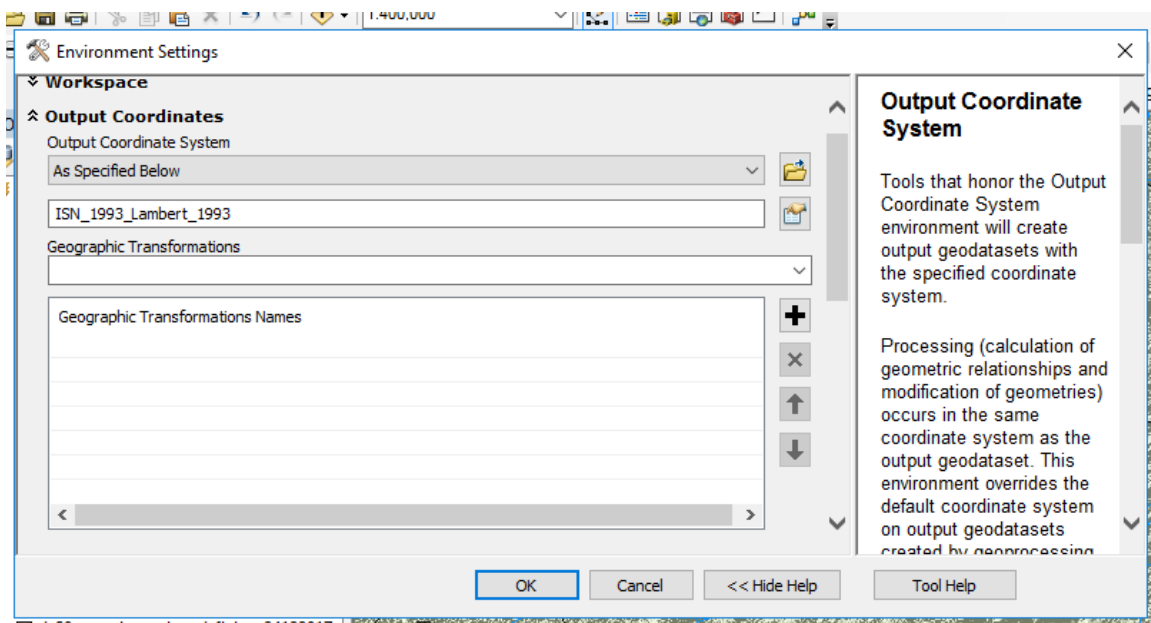


Figure 5: Environment setting for the buffer

The results from the buffer is seen in fig. 6.

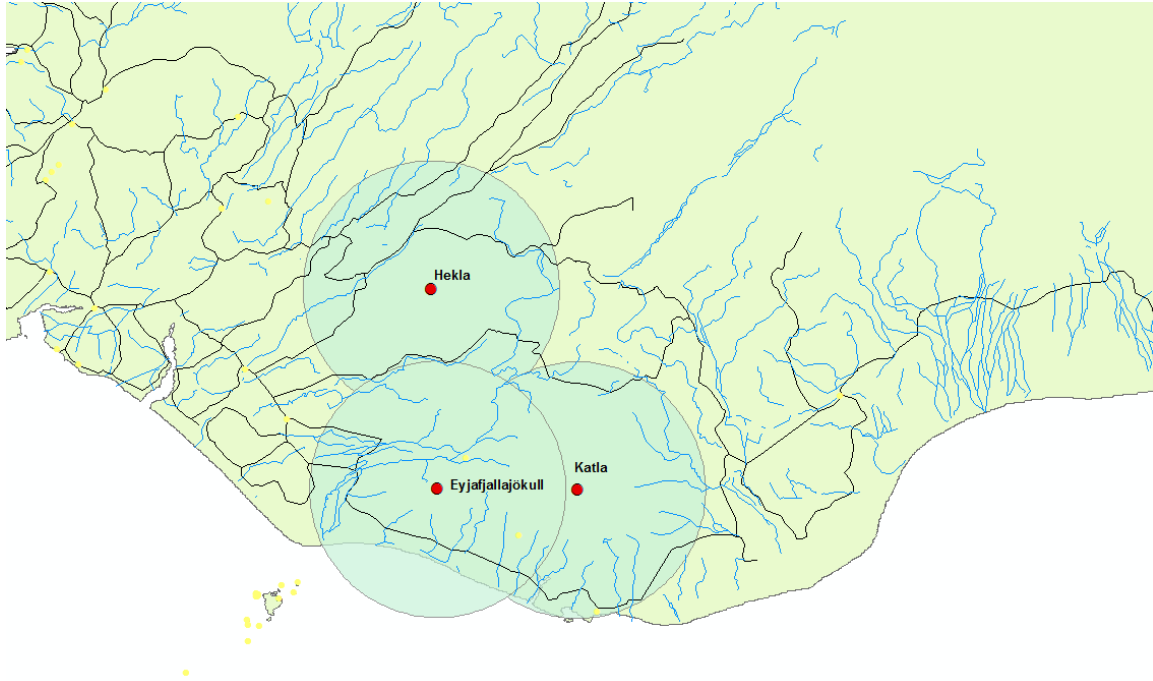


Figure 6: Results from adding buffer around volcanoes

To model the lahars, I created buffers around the channels. I chose to model small and large lahars, using the same parameters as specified in lab 10. Large lahars were assumed to be capable of traveling 80 km, and small lahars were assumed to be capable of traveling 20 km from their source. I used 1/20 of the travel distance for the width of each buffer (Figure 7).

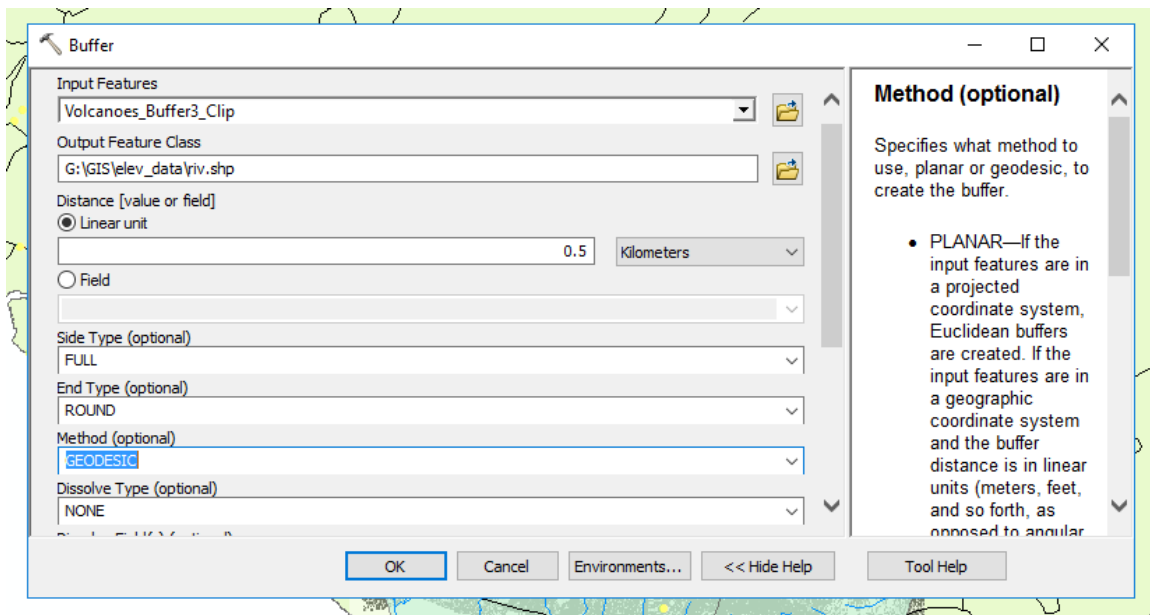


Figure 7: Buffer settings for lahar flow

These values may not be exact, but should serve as suitable estimations for a base level hazard assessment. I was able to use a basemap (Figure 8) on ArcMap to determine whether there was ice all year around. This was necessary because it helps understand if the potential hazards measured can be used all year. Looking at Figure 8, you can see that Katla and Eyjafjallajökull are covered in ice all year, but Hekla has little ice in the picture. This shows that the lahar hazards made may not be as drastic in the summer times.

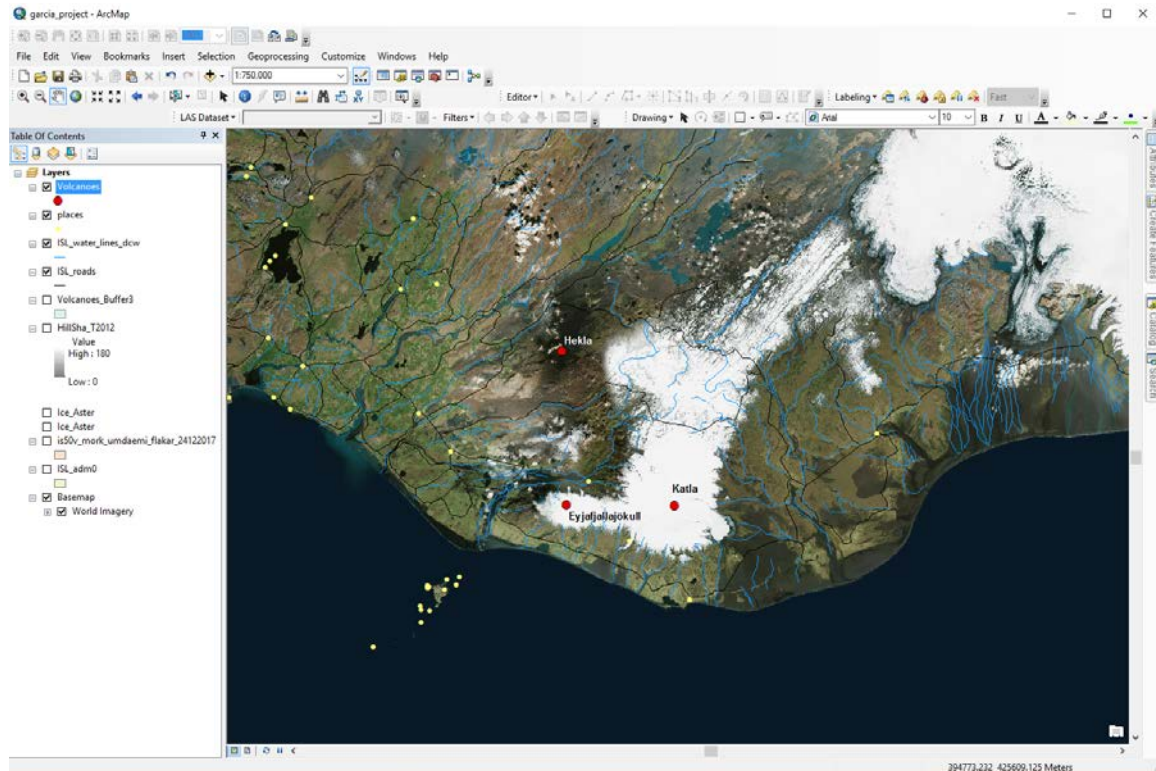


Figure 8: Basemap of Iceland

At this time, I wanted to make the hillshade smaller, so I clipped the hillshade to the volcano buffer. To do this I went into the ArcToolbox and went to Data Management to find the “Clip” tool seen in Figure 9.

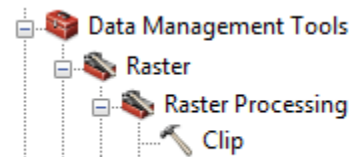


Figure 9: Tool needed to clip raster to polygon

Next I had to identify which towns were at risk, and which roads were at risk. To do this, I labeled the towns that were in the buffer. The data I used did not provide population, so I had to use a world population review to see the population of each town. One town, Þórsmörk, was directly in the lahar hazard

areas. This town has a population of 20 people. Two other towns, Vik and Sólheimajökull were also near the area and may be at risk (Figure 10). Vik has a population of 318 and Sólheimajökull has a population of 42.

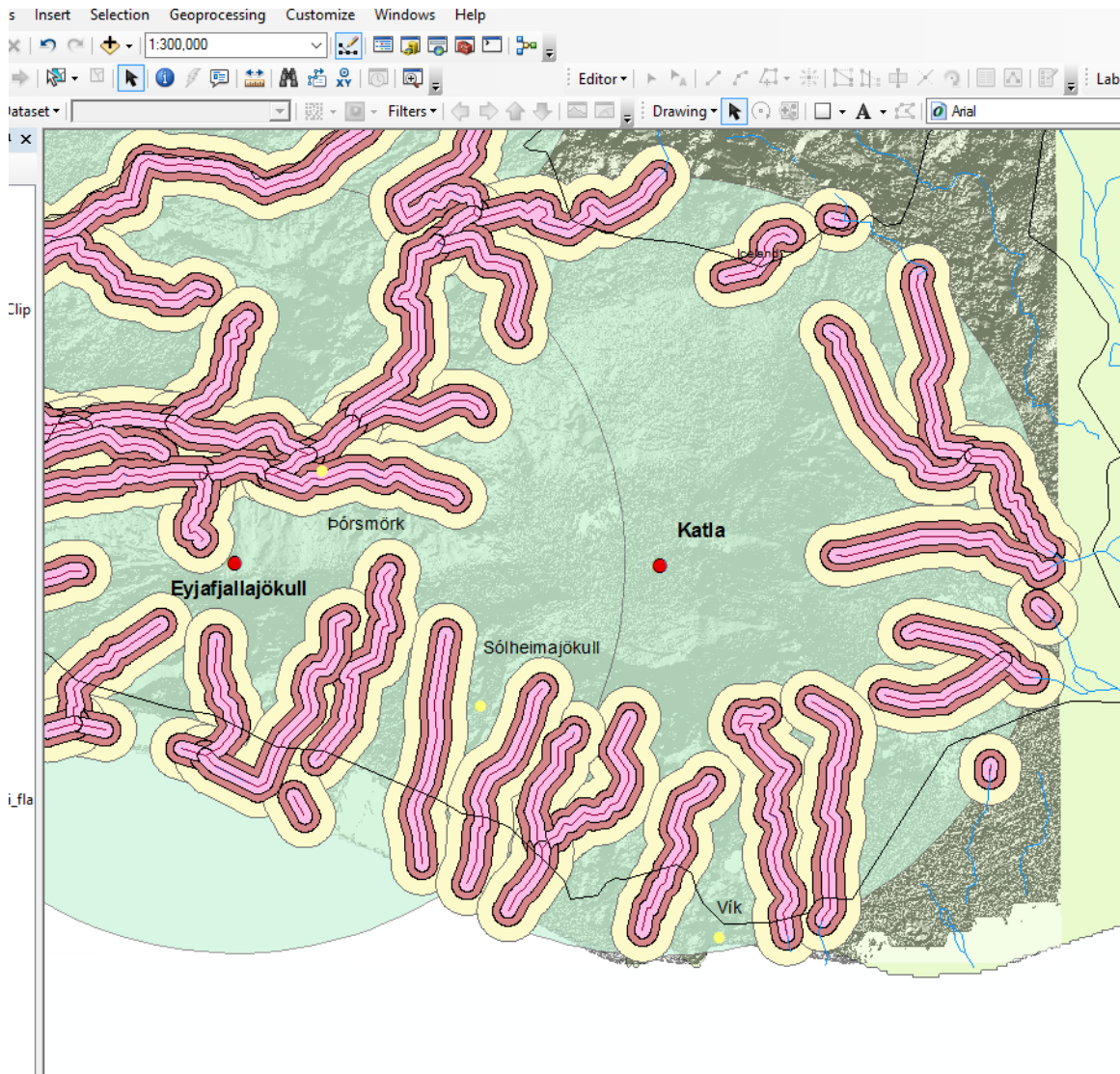


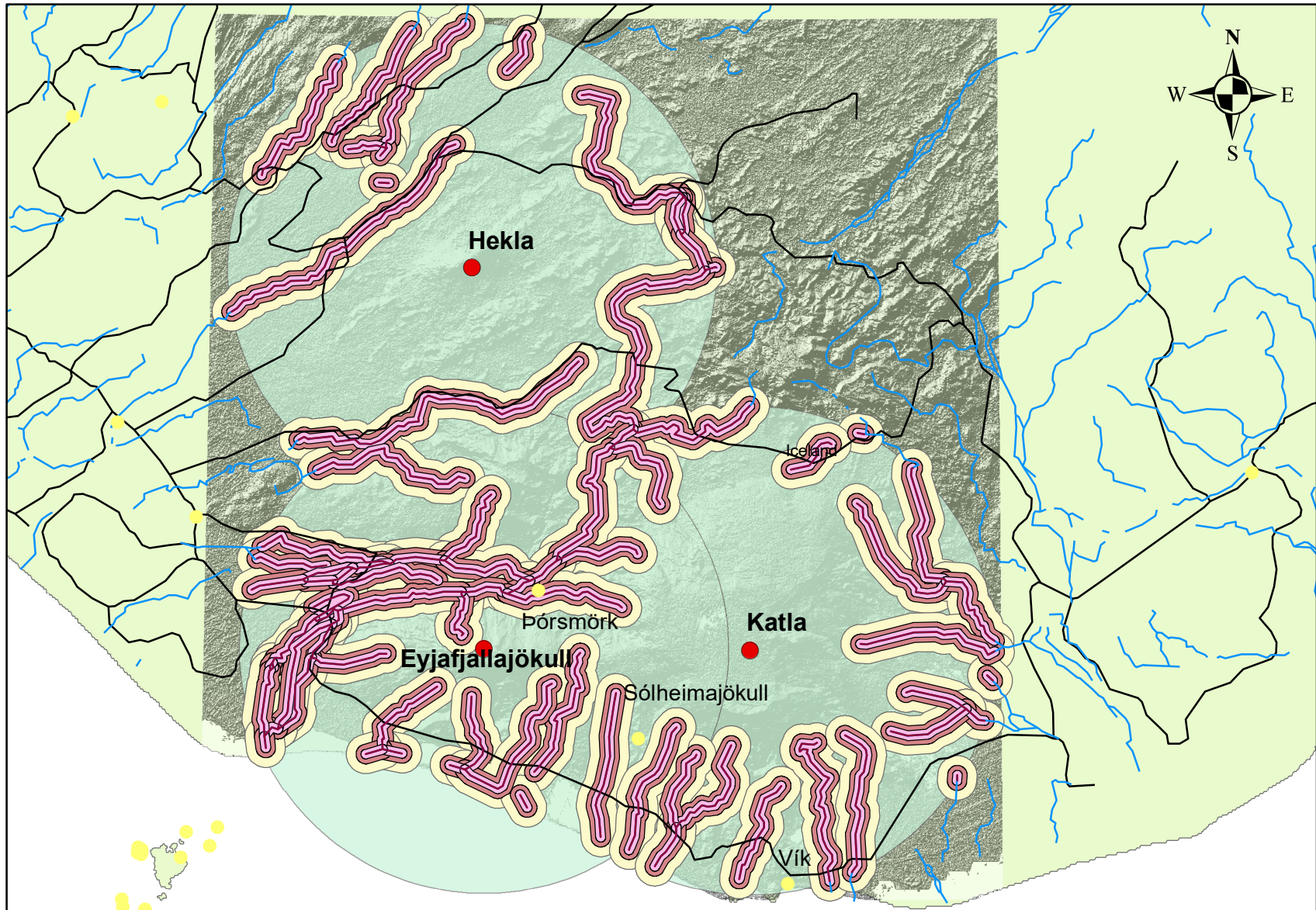
Figure 10: Towns at risk of lahars

Finally, I made map documents showing the hazards with affected towns and roads. The Iceland border shapefile was symbolized with a green background to distinguish land from ocean. These were mapped over the elevation and hillshade files as well, so a sense of topography was preserved. I also made a country scale map to show the regional significance of these hazards. I made a graticule for the final layout with markers every 1 degree.

Conclusion

ArcMap is an excellent tool for assessing potential volcanic hazards. Once the potential hazards were mapped, I was able to identify and symbolize areas of risk such as roads and towns. Studies like this are very important in a country like Iceland that has over 130 volcanoes, many of which are active. Hekla and Eyjafjallajökull have had recent activity, which is why they were selected for this study. I used the buffering tool in ArcMap to identify areas of risk near Hekla, Katla, and Eyjafjallajökull. The town, Þórsmörk, was marked as being in the hazard zone of large lahars originating from Eyjafjallajökull. The towns Vik and Sólheimajökull are really close to the lahar hazards, so residents in these town should still be prepared for any event. If residents are aware of this risk, they may be better equipped to respond when lahars do occur. Lahars can occur even without a volcanic eruption, so it is important to be constantly prepared. Lahars originating from Hekla did not appear to encounter any towns; however, it is possible that individuals live in the area, so the information may be of use for them as well. Each volcano presents a risk to Iceland's Route 1, also known as the Ring Road. This is a major transportation route for both locals and tourists, so noting these hazards is important even for those who do not live in the area. This project highlighted important hazard areas, but also has room for improvement. To take the assessment further, a more accurate model for the lahars could be used. For example, it would be ideal to map the flows such that they directly respond to topography, showing narrowing in valleys and fanning in basins.

Lahar Hazard Map for Katla, Hekla, and Eyjafjallajökull



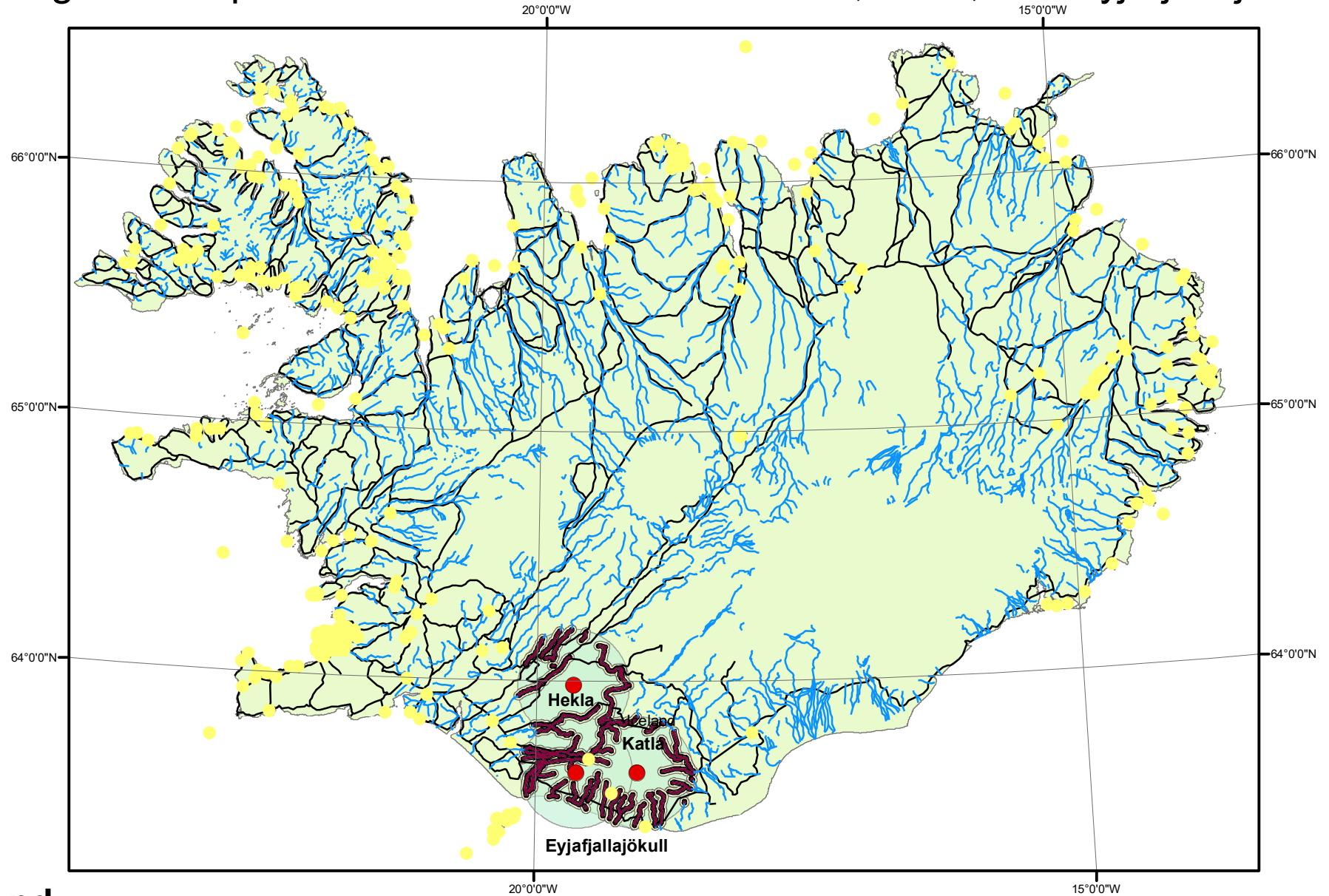
Legend

- Volcanoes
- Roads
- Rivers
- places
- Small Lahars
- Medium Lahars
- Large Lahars

0 5 10 20
Kilometers

1:600,000

Regional Map of Lahar Hazards for near Hekla, Katla, and Eyjafjallajökull



Legend

- Volcanoes
- Roads
- Small Lahars
- places
- Rivers
- Medium Lahars
- Large Lahars

0 15 30 60
Kilometers

1:2,500,000
GCS WGS 1984 datum